



**CENTRE FOR RESEARCH IN ENERGY AND ENERGY CONSERVATION**

# The Regional Stove Testing Centre

## Quad TLUD

### An Observation Test Report

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*July, 2012*

## 1 Introduction

The Quad TLUD stove was brought to the Stove Testing Centre at the Centre for Research in Energy and Energy Conservation to determine stove-fuel performances during laboratory tests. The following results are based on short observation tests.

## 2 Stove Description

The stoves that are considered during this test are the Quad TLUD and the Mwoto. Both stoves are top-lit updraft stoves which are batch-fed. They require dry non-carbonised fuel such as maize cobs, wood and non-carbonised briquettes. The process that takes place in the TLUD is the pyrolysis of non carbonized fuel to produce charcoal. The packed fuel is lit on the top and the primary air flows in through a door at the bottom of the bed and proceeds to the top. The flow of air is based on natural draft. Extinction occurs when all the non-carbonised fuel is converted to charcoal or when the door for primary air is closed.

### 2.1 Mwoto

The Mwoto (fig 2.1) is a TLUD made entirely from steel. Its fuel chamber can hold up to 2100g of dry eucalyptus wood. It has 3 metallic pot stands and can be handled using the two metallic handles on the outer cylinder.



Figure 2.1: Mwoto



Figure 2.2 Quad TLUD

### 2.2 Quad TLUD

Quad TLUD (fig.2.2) is a modification of the Mwoto stove. The quad name originates from quadrate as the stove has got four legs. It can hold up to 2500g of dry eucalyptus wood. The Quad TLUD is reinforced with four wooden legs and a top wooden handle that enhance stove stability and reduce the risk burns during stove use.

### **3 Testing Overview**

The Water Boiling Test (WBT) consisted of two test phases, that is, Cold Start (High Power) and Simmering (Low Power) phases. During cold-start, a pre-weighed bundle of cut eucalyptus wood was fed in the stove at room temperature. The stove was lit and the fire was used to boil 5 litres of water in a 7litre-pot.

During simmering, a fresh bundle of cut eucalyptus wood was fed to the stove was. The stove was lit and the fire produced was used to keep hot water simmering at just below boiling point for 45 minutes.

At the start of each phase, the following parameters were recorded: moisture content of wood, ambient air temperature, weight of pot and weight of charcoal container. The following parameters were recorded at the start and end of each phase: time, amount of water in pot, water temperature, weight of wood and the amount charcoal made.

The test was performed thrice in order to ensure repeatability of the results.

### **4 Results**

The recorded data was entered in the WBT\_data-calculation\_sheet\_4.1.2.xls. A comparison was made between the WBT results for the Quad TLUD and those of the Mwoto as shown in the Table 4.1. The significance of the differences between the Quad TLUD and Mwoto results, at the 95% confidence interval, was established using the Independent two-sample t-test for equal sample sizes. The results of the t-test are an indication of whether the differences noted are statistically significant.

During the cold start phase, there was a statistically significant difference in the time to boil and specific fuel consumption. In this phase, the Quad TLUD takes a longer time to boil water and consumes more fuel than the Mwoto. However during the simmering phase, the Quad TLUD consumes less fuel than the Mwoto. In this phase, there was a statistically significant difference in the burning rate, specific fuel consumption and firepower. The higher turn down ratio of the Quad TLUD suggests that its control mechanism (i.e. the primary air entry) has a greater effect than that of the Mwoto when switching from high to low power.

In both phases, the Quad TLUD has a lower thermal efficiency than the Mwoto. Overall, the Quad TLUD uses 34% less fuel than the Mwoto to boil and simmer 5 litres of water. The addition of the wooden legs improved the Quad TLUD's stability compared to the Mwoto while the wooden handle and reduced the risk associated with its use.

**Table 4.1: WBT Results for Mwoto and Quad TLUD**

		Mwoto			Quad TLUD			% difference (between Quad & Mwoto)	T test	Significance at 95%
<b>HIGH POWER (COLD START)</b>	Units	Average	St Dev	COV	Average	St Dev	COV			
Time to boil	Min	15	1.3	9%	18	0.0	0%	20%	-3.93	YES
Burning rate	g/min	15.9	2.7	17%	16.7	0.28	2%	5%	-0.51	NO
Thermal efficiency	%	41%	6%	14%	33%	1%	3%	-20%	2.50	NO
Specific fuel consumption	g/litre	48	6.9	14%	62	1.4	2%	28%	-3.28	YES
Firepower	Watts	4880	831	17%	5125	85	2%	5%	-0.51	NO
<b>LOW POWER (SIMMER)</b>		Average	St Dev	COV	Average	St Dev	COV	% difference	T test	Significance
Burning rate	g/min	16.2	2.4	15%	11.6	0.5	4%	-28%	3.17	YES
Thermal efficiency	%	35%	6%	17%	29%	3%	9%	-17%	1.61	NO
Specific fuel consumption	g/litre	269	48	18%	144	17	12%	-46%	4.28	YES
Firepower	Watts	4976	752	15%	3574	145	4%	-28%	3.17	YES
Turn down ratio	--	1.00	0.26	26%	1.44	0.08	5%	44%	-2.76	NO
<b>BENCHMARK VALUES (for 5L)</b>		Average	St Dev	COV	Average	St Dev	COV	% difference	T test	Significance
Fuel Use Benchmark Value	G	1600	213	13%	1049	76	7%	-34%	4.21	YES
Energy Use Benchmark Value	kJ	29495	3935	13%	19337	1404	7%	-34%	4.21	YES

## 5 Conclusions

The Quad TLUD uses less fuel than the Mwoto for the entire cooking task of boiling and simmering 5 litres of water. In addition, its control mechanism is more effective than that of the Mwoto. However it has lower thermal efficiency than the Mwoto and uses more fuel during the high power phase.

## 6 Recommendations

A safety test may be needed in order to give more conclusive comments on the effect of the wooden handle and legs on the safety of the Quad TLUD compared to the Mwoto.

## 7 Appendix: Raw Data

Stove type/model		Mwoto					
Location		CREEC					
Wood description		Eucalyptus Grandis (Rose Gum, Grand Eucalyptus)					
Wind conditions		No wind; No wind; No wind					
Ambient temperature		26; 27; 23.8					
<b>HIGH POWER TEST (COLD START)</b>	<i>units</i>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>COV</b>
Time to boil	<i>min</i>	15.5	13.5	16.0	15.0	1.3	9%
Temp-corrected time to boil	<i>min</i>	16.4	14.3	16.5	15.7	1.2	8%
Burning rate	<i>g/min</i>	17.5	17.4	12.8	15.9	2.7	17%
Thermal efficiency	<i>%</i>	36%	41%	47%	41%	6%	14%
Specific fuel consumption	<i>g/liter</i>	56	48	42	48	6.9	14%
Temp-corrected specific consumption	<i>g/liter</i>	59	51	43	51	7.9	15%
Temp-corrected specific energy cons.	<i>kJ/liter</i>	0.0094	0.0081	0.0069	0.0082	0.0013	15%
Firepower	<i>watts</i>	5367	5352	3921	4880	831	17%
<b>LOW POWER (SIMMER)</b>	<i>units</i>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>COV</b>
Burning rate	<i>g/min</i>	13.6	18.4	16.6	16.2	2.4	15%
Thermal efficiency	<i>%</i>	41%	29%	36%	35%	6%	17%
Specific fuel consumption	<i>g/liter</i>	217	311	279	269	48	18%
Temp-corrected specific energy cons.	<i>kJ/liter</i>	0.67	0.91	0.81	0.80	0.12	15%
Firepower	<i>watts</i>	4173	5663	5092	4976	752	15%
Turn down ratio	<i>--</i>	1.3	0.9	0.8	1.0	0.26	26%
<b>BENCHMARK VALUES (for 5L)</b>		<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>COV</b>
Fuel Use Benchmark Value	<i>g</i>	1382	1809	1610	1600	213	13%
Energy Use Benchmark Value	<i>kJ</i>	25474	33337	29672	29495	3935	13%

Stove type/model		Quad					
Location		CREEC					
Wood description		Eucalyptus Grandis (Rose Gum, Grand Eucalyptus)					
Wind conditions		No wind; No wind; No wind					
Ambient temperature		28.5; 34; 24					
<b>HIGH POWER TEST (COLD START)</b>	<i>units</i>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>COV</b>
Time to boil Pot # 1	<i>min</i>	18.0	18.0	18.0	18.0	0.0	0%
Temp-corrected time to boil Pot # 1	<i>min</i>	19.0	18.6	19.7	19.1	0.6	3%
Burning rate	<i>g/min</i>	16.9	16.4	16.8	16.7	0.3	2%
Thermal efficiency	<i>%</i>	32%	34%	33%	33%	1%	3%
Specific fuel consumption	<i>g/liter</i>	62	60	63	62	1.4	2%
Temp-corrected specific consumption	<i>g/liter</i>	66	62	69	66	3.4	5%
Temp-corrected specific energy cons.	<i>kJ/liter</i>	0.011	0.0094	0.011	0.01	0.0009	8%
Firepower	<i>watts</i>	5177	5027	5172	5125	85	2%
<b>LOW POWER (SIMMER)</b>	<i>units</i>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>COV</b>
Burning rate	<i>g/min</i>	11.8	12.0	11.1	11.6	0.5	4%
Thermal efficiency	<i>%</i>	32%	29%	27%	29%	3%	9%
Specific fuel consumption	<i>g/liter</i>	159	148	125	144	17	12%
Temp-corrected specific energy cons.	<i>kJ/liter</i>	0.58	0.55	0.55	0.56	0.02	3%
Firepower	<i>watts</i>	3614	3694	3413	3574	145	4%
Turn down ratio	<i>--</i>	1.4	1.4	1.5	1.4	0.08	5%
<b>BENCHMARK VALUES (for 5L)</b>		<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>COV</b>
Fuel Use Benchmark Value	<i>g</i>	1123	1054	971	1049	76	7%
Energy Use Benchmark Value	<i>kJ</i>	20693	19429	17890	19337	1404	7%