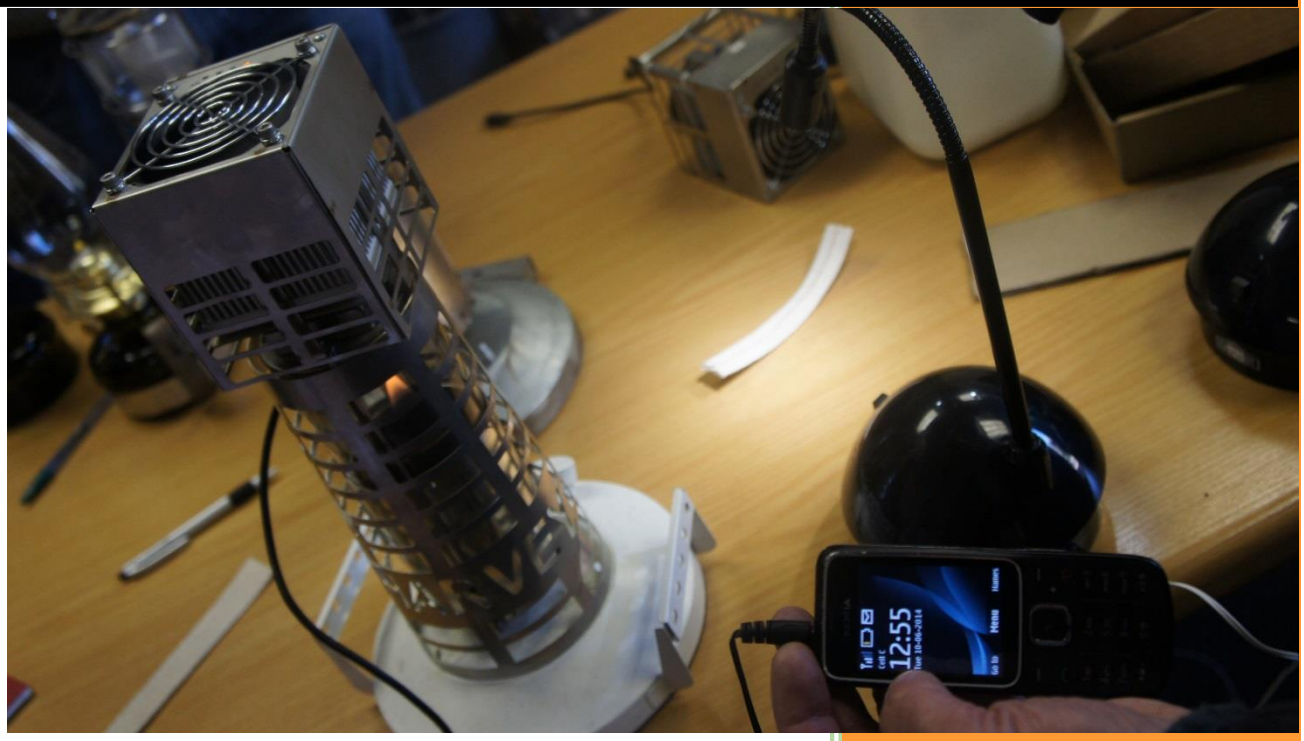
SeTAR Sustainable Energy Technology and Research Centre

UNIVERSITY OF JOHANNESBURG

2014

Laboratory Test Report of iHarvey® Thermal Generator



Tested at the Sustainable energy Technology and Research (SeTAR) Centre, University of Johannesburg, a facility supported by the Global Alliance for Clean Cookstoves (GACC)

TEAM: Harold Annegarn, Tafadzwa Makonese, Thoko Sithole

STOVE MANUFACTURER	**TEQDAS Ltd, Allan Goldberg**
PROTOCOL	Heterogeneous Testing Protocols
FUEL USED	Illuminating Paraffin
POT USED	None
TEST DATES	25 – 27 June 2014
REPORT NO.	S/2014/002

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GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

1. Introduction

The iHarvey is a paraffin-fuelled thermal generator (Figure 1) that converts heat from paraffin combustion into electrical power for lighting, radio and cellular phone charging. The device was tested at SeTAR Centre laboratory, University of Johannesburg, in mid-August 2014. The key performance parameters under investigation were emission rates of CO and $PM_{2.5}$; combustion efficiency; and fuel consumption during the burn cycle. A commercially available paraffin wick lantern and a glass lamp (the glass lamp is an inferior version of the lantern and sells for a lower price) were tested alongside the iHarvey generator for comparison purposes. The two lanterns are the commonly used paraffin-fuelled light sources in poor households.

Figure 1: Image of iHarvey

A pre-production model of the iHarvey was submitted by the developer for laboratory evaluation together with a supply of illuminating paraffin, sufficient to conduct the full range of tests. The owner demonstrated how the device should be operated for optimal performance in terms of fuelling, ignition, and flame control. All the necessary tests on the three devices were carried out on the same day. The test results constitute the body of this report.

2. Test Apparatus and Procedures

Test Apparatus

- An emissions collection hood
- Testo 350 flue gas analyser
- DRX dust tracker
- Computer
- Weighing scale

Test Procedure

Each device was fuelled to the maximum fuel level, weighed and ignited under the hood. The device was left on the weighing scale throughout the test to track fuel consumption. Data for the various combustion products and fuel reduction were logged on the computer every 10 seconds. The test duration was 25 minutes from flame ignition to extinction. A trial run had shown that emissions from the iHarvey reduced to undetectable levels with the generator in place (the generator has a self-powered cooling fan which dilutes and dissipates the emissions from the combustion chamber). Consequently, the unit was tested without the generator piece in place in order to get the maximum emissions possible during a burn cycle. The SeTAR Heterogeneous Testing Protocol (HTP) was adapted for these suite of tests. Figure 2 shows images of the three devices on the testing rig.

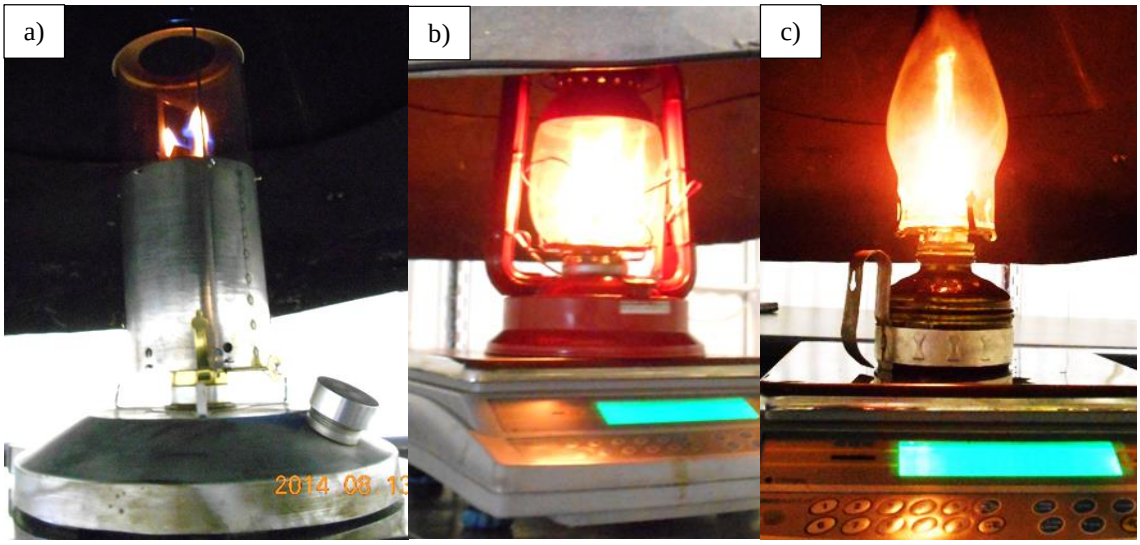


Figure 2: Images of a) iHarvey, b) Paraffin lantern, and c) Paraffin glass lamp on the testing rig

3. Results

Emissions

The emissions test results are summarised in Table 1. The first part of Table 1 gives a paired comparison of iHarvey and paraffin lantern results, while the second part compares iHarvey and paraffin glass lamp results. The results show that the iHarvey has a 14% reduction on $PM_{2.5}$ emissions per MJ of energy consumed as compared to the paraffin lantern and 32% less than the paraffin glass lamp. A *t-test* at 95% confidence level ($p>0.05$) was used to test the hypothesis that there is no significant statistical difference between the iHarvey, the paraffin wick lantern and paraffin glass lamp test results; rejected if the p-values were greater than 0.05 ($p>0.05$). The three appliances exhibited statistically different performance parameters in terms of $PM_{2.5}$ emissions. The CO emissions and CO/CO_2 ratio for the three devices did not show significant differences at the $p=0.05$ confidence level. The iHarvey has a similar fuel consumption rate to the paraffin glass lamp, while the paraffin lantern has a higher rate.

As stated earlier, the iHarvey was tested without the generator component and therefore the values of $PM_{2.5}$ and CO emissions shown here are likely lower in normal operation. About 90% of the iHarvey emissions are produced in the first ten minutes after ignition. Thereafter, the emissions reduce drastically to below the detection level of the test rig (Figure 3 and Figure 4).

Table 1: Trace emissions for iHarvey paraffin thermal generator and two commercial paraffin fuelled lanterns

Test Device	Fuel (g/h).	CO emitted (g)	$PM_{2.5}$ emitted (mg)	CO (g/h).	$PM_{2.5}$ (mg/h).	CO/CO_2 (%)	CO (g/MJ)	$PM_{2.5}$ (mg/MJ)
iHarvey	30	0.08	20	0.18	50	0.4	0.17	48.3
Paraffin lantern	40	0.06	50	0.14	136	0.2	0.09	85.4
% reduction (Lamp - iHarvey)/ (Lamp +iHarvey)/2	**7%**	-7%	21%	-6%	23%	-17%	-15%	14%
p-values	0.40	0	1.18	0	3.38	0.01	0.01	1.46
SIG (p>0.05)	SIG		SIG		SIG			SIG
iHarvey	30	0.08	20	0.18	50	0.4	0.17	48.3
Paraffin glass lamp	30	0.02	90	0.06	235	0.1	0.05	214.3
% reduction (Lamp - iHarvey)/ (Lamp +iHarvey)/2			32%	-25%	32%		-27%	32%
p-values	0	0	2.73	0.01	7.28	0.01	0.01	6.53
SIG (p>0.05)			SIG		SIG			SIG

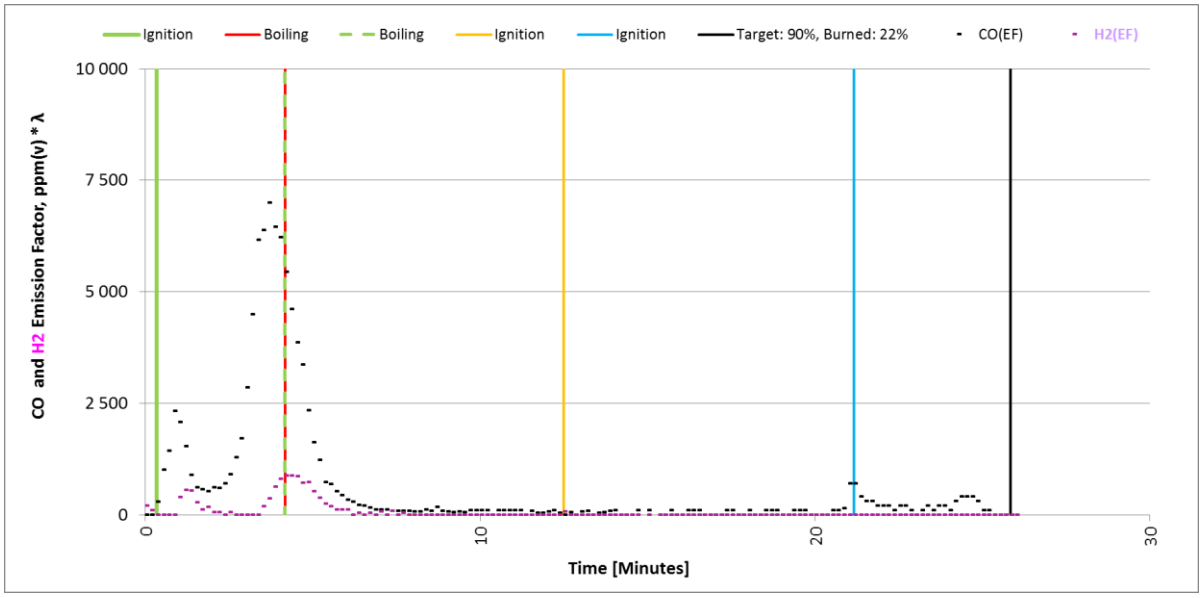


Figure 3: CO emission profile for the iHarvey

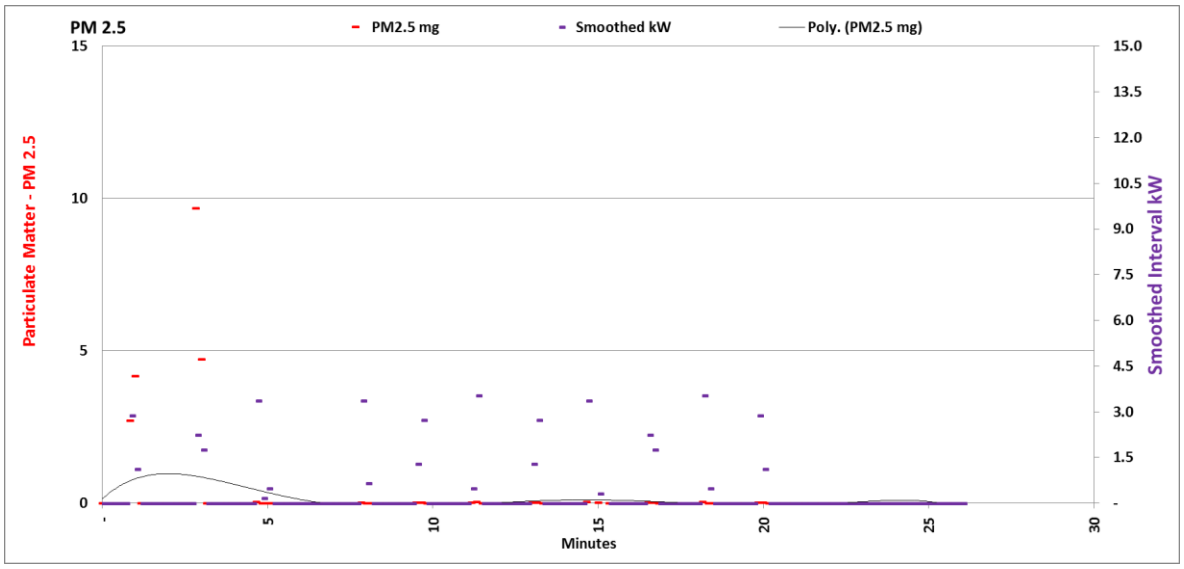


Figure 4: $PM_{2.5}$ emission profile for the iHarvey

Safety

The fuel tank of the iHarvey did not get hot during the test – one could touch it without danger of blistering (implied that surface temperature was below 40°C), even after 30 minutes of operation. The only part that gets hot is the chimney area but this is protected from direct contact by a mesh shield during normal operation.

4. Discussion and Conclusions

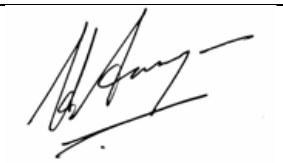
The test results show that the iHarvey has a fuel consumption rate that is similar to conventional paraffin lamps, yet it performs significantly better in terms of particulate matter emissions. When compared to the paraffin lantern and paraffin glass lamp, the iHarvey demonstrates 14% and 32% reduction in $PM_{2.5}$ emissions per MJ of energy consumed, respectively. The iHarvey is designed primarily as a device for generating thermo-electricity for charging cellular devices and other low power devices, such as LED lamps. In this respect it is a unique device, so the comparison is made with similar paraffin burning devices in terms of emissions per unit of energy consumed (mg $PM_{2.5}$ per MJ of energy consumed).

The test results show that the iHarvey had a CO/CO_2 ratio of 0.4%, which is lower than the SABS requirement of 2% for indoor combustion appliances (SABS, 2013). The iHarvey generator is thus acceptable for continuous use indoors in an unventilated room (i.e. no chimney required).

The iHarvey exhibits lower risks of fires and contact burns since there is no exposed flame. The iHarvey, when used as designed with an LED lamp, is therefore a safer option for lighting services in off-grid households that hitherto used paraffin glass lamps, tin lamps, and/or candles for lighting. The

developer demonstrated that the device could generate an equivalent light output from an attached LED lamp, but evaluation of light output did not constitute part of this test procedure.

Household air quality monitoring studies (WHO, 2014) show that particulate matter emissions are still significant in some households that have adopted clean cookstoves. The source of pollutant emissions in such households is attributed to use of polluting paraffin lamps. The iHarvey would come handy for such households and help to bring about a net reduction in household air pollution.

Signature	
Name and designation	Harold Annegarn, Prof and Director of the SeTAR Centre

Notes:

A copy of the written Heterogeneous Test Protocol is available from the SeTAR Centre website: www.setarstoves.org