Kerosene Revisited – Fuel for Rural Households[1]

Anil K. Rajvanshi
Director, Nimbkar Agricultural Research Institute (NARI),
PHALTAN-415523, Maharashtra, India
Email: anilrajvanshi@gmail.com

Introduction

Majority of rural households world over lack clean cooking fuel and electricity for lighting. For example in India alone around 60% of rural population lives with almost non existent electricity and uses ~ 200 million tons/year of biomass to cook on primitive cook stoves. For most of these households the only light they get is that coming out from cook stoves! Lighting which is a basic necessity and the fundamental need of humans is missing from the lives of this rural population.

Wherever there is no electricity, old and inefficient kerosene lanterns are used. These lanterns by and large produce inadequate light besides producing harmful indoor air pollution. It is estimated that 1.5 million people die every year worldwide because of indoor air pollution created by inefficient kerosene lanterns and biomass cook stoves.

Thus there is a need to develop an efficient device which works on readily available liquid fuel to produce high quality light for illumination purpose and heat for cooking. This paper presents one such lantern running on kerosene which produces very high light output (almost equivalent to that from 200-300 W bulb) and also cooks in the heat of the flue gases.

The device christened Lanstove™ (lantern combined with cook stove) is to our knowledge the first such device where both lighting and cooking are combined together resulting in tremendous energy efficiency and saving of fuel. **The word Lanstove™ has been coined by our Institute NARI to denote the dual purpose nature of this device.**

Kerosene as household fuel

Kerosene has been used as household fuel for hundreds of years. However with the advent of electricity for lighting and natural gas for cooking it receded from the horizon of western countries and hence became a fuel for developing countries. This naturally had the affect that no worthwhile improvement in technology was carried out in the last 70-80 years with the result that the cooking and lighting devices running on kerosene are very inefficient and environmentally unfriendly. In early 1920s when the maximum research efforts took place in improving kerosene devices, the air pollution standards had not been enacted and hence the design got frozen in that time frame.

Our Institute NARI was probably the first Institute in early 1980s to make a serious effort in improving the efficiency of kerosene lamps. This resulted in the invention of an efficient pressurized mantle lamp called Noorie. It was also shown for the first time that the heat of the flue gases could be used to do small amount of cooking such as making tea or boiling eggs. Feedback from the users had showed that they would like to do more cooking if adequate heat is available.

[1] A version of this article has been accepted as a paper in the 2011 Indoor Air Conference (5-10 June) in Austin, Texas.

© Anil K Rajvanshi, December 2010

NARI then embarked on the program of developing the kerosene Lanstove with the added advantage of storing the fuel in a pressurized cylinder, thereby overcoming the drawback of existing pressurized lanterns (including Noorie) where frequent pumping is required. Frequent pumping resulted in shaking the lantern and thus breaking the fragile mantle. Besides it led to over pressurizing the storage tank which sometimes resulted in explosions and fires. The pressurized kerosene storage in cylinder therefore made the Lanstove as convenient as LPG cooking where with the flip of the valve the flame is lit and cooking is done very easily on clean burning flame.

Lanstove attributes

NARI Lanstove consists of a 9 liter pressurized kerosene cylinder, the high light output lantern and very efficient steam cooker which is based on heat pipe principle. Fig. 1 shows the cooker on lantern and Table 1 gives the details of the Lanstove.

Table 1

Sr. No.	Item	Attributes
1.	Lanstove unit	The unit consists of high light output lantern; novel cooker with insulated jacket; and pressurized (2-3 atm pressure) 9 liter kerosene cylinder. Items made of mild steel and stainless steel.
2.	Light output	3000-3200 lumens from thermoluminescent mantle (used in Petromax lamps). Existing hurricane lantern produces 65-70 lumens only.
3.	Efficacy of lantern	1.5-2.6 lumens/W
4.	Efficiency of stove	40-45 % (water boiling tests)
5.	Heat output	1200-1500 W
6.	Kerosene consumption	1.7-2.5 g/min
7.	Specific fuel consumption	1.5 to 2 kg of food cooked/100 g of kerosene
8.	What it does in 4 hours of running	Provides excellent light; cooks complete meal for a family of 5; and boils 10 liter of water for drinking. **Besides it is silent as compared to Petromax lamps.**
9.	Cooking - rice, dal and vegetables - chapatti/bhakari	 Via very efficient steam cooker with 3 or 4 pots. The cooker works on the principle of heat pipe. **Unassisted cooking so no fear of burning of food.** On specially designed griddle (tava) put over the Lanstove.
10.	Water boiling	5 liters of water is boiled in 45-50 minutes.
11.	Expected usage	4 hours at night and 2 hours in the morning.
12.	Pollution parameters	- No smoke, smell or burning in eyes. - CO levels < 3 ppm even after 3-4 hours of working in a very small enclosed room (with chulha it is ~ 20-200 ppm). - 2.5 and 10 microns particulate emissions less than WHO standards (inferred – see note below).
13.	Controls	A valve controls the light output and hence heat from the Lanstove.

© Anil K Rajvanshi, December 2010

The particulate emissions were not measured during the course of experiments but their output was inferred. A recent study done on kerosene and diesel lamps (Apple et al., 2010)[2] showed that the particulate output of pressurized lamps (Petromax type) is within the acceptable limits according to WHO standards. The efficacy of the pressurized lamps used in this study was approximately 1.2 lm/W and was much lower than 2.6 lm/W for Lanstove. Correspondingly it is assumed that the particulate emissions from Lanstove will be within the WHO standards.

A total of forty six tests have been carried on NARI Lanstove in rural homes (around Phaltan) which had no electricity. A short video of these tests is here. Below are given the feedback on the Lanstove by the actual users.

Fig. 1. Lanstove™ configuration

Lanstove™ in actual user hut

Comments of women using Lanstove

- Very bright light. Since no supervision is required during steam cooking, can do other household work like sewing, cleaning grain etc. and is also helpful for children to study.
- Very easy to light and use it. No smell or soot unlike in regular kerosene lanterns or stoves. No burning of eyes as happens in chulha cooking. See figure on next page.
- **Very silent as compared to existing pressurized kerosene stoves and Petromax lamps.**
- Very good for small businesses which can produce handicraft items in the light.
- Lanstove cooking is much faster than that from woodstove.
- Very tasty food since no overcooking or burning. Slow steam cooking.
- Chapatti or bhakari can also be conveniently cooked on Lanstove.

Chapatti making on Lanstove™

[2] Apple, J., et al. 2010. Characterrization of particulate matter size distributions and indoor concentrations from kersone and diesel lamps. Indoor Air. 20, 399-411.

© Anil K Rajvanshi, December 2010

- Will be willing to buy this stove and can give Rs. 20-30/day (US 45-65 cents/day) payment installments.
- Liked the water boiling aspect of the stove. In the morning used for heating bath water.
- Works just like LPG stove since no pumping is needed other than that required to pressurize the cylinder (done once a week) and it is easy to control the flame. The valve should be 90 degrees tunable rather than the screw valve presently used.
- The Lanstove is safe to handle and does not involve risks of fire outbreak as is the case with regular kerosene lanterns, pressurized kerosene stoves and conventional chulhas.
- The use of Lanstove can eliminate the physical exertion in collecting wood/biomass. The time saved can be used to relax at home or doing other work.
- The bright light of Lanstove makes us feel secure and comfortable, as we stay in an isolated area.

Tremendous smoke with chulha cooking

Hut condition with lanstove

Economics

1. Cost of Lanstove	Present cost (for 2-3 pieces) is Rs. 6,000-7,000/- (US$ 120-140). This cost is estimated to come down drastically in mass production.
2. Kerosene used	~ 1.0 liters/day (6 hours use; 4 at night and 2 in the morning)
3. Running cost	Rs. 450/month (~US$ 9) (PDS kerosene @ Rs. 15/l) Rs. 1200/month (~US$ 24) (open market kerosene @ Rs. 40/l)

Note: US$ ~ Rs. 50/-; PDS is public distribution system where the kerosene is available at subsidized rates for below poverty line consumers.

© Anil K Rajvanshi, December 2010

Energy Issues

Electricity is the preferred "fuel" for both cooking and lighting in modern society. Hence it is instructive to compare the overall energy efficiency of electric cooking/lighting with our Lanstove. For evening cooking and lighting only, **electric devices (electric stove and incandescent lamps) will consume about 3 times more energy than Lanstove.** This is because the efficiency of electric power plant is 30% and with 20% losses in transmission and distribution the overall efficiency of electric power at the household socket is only 24%. With the electric stove efficiency of 60% the overall efficiency of electric cooking is only 14%. Similar is the efficiency of electric lighting. Our Lanstove efficiency is ~ 40% and hence tremendous energy savings can result via the use of decentralized liquid fuel for cooking and lighting. Thus the use of Lanstove for rural applications is a step forward towards sustainable solutions for these areas.

Life Cycle Analysis (LCA)

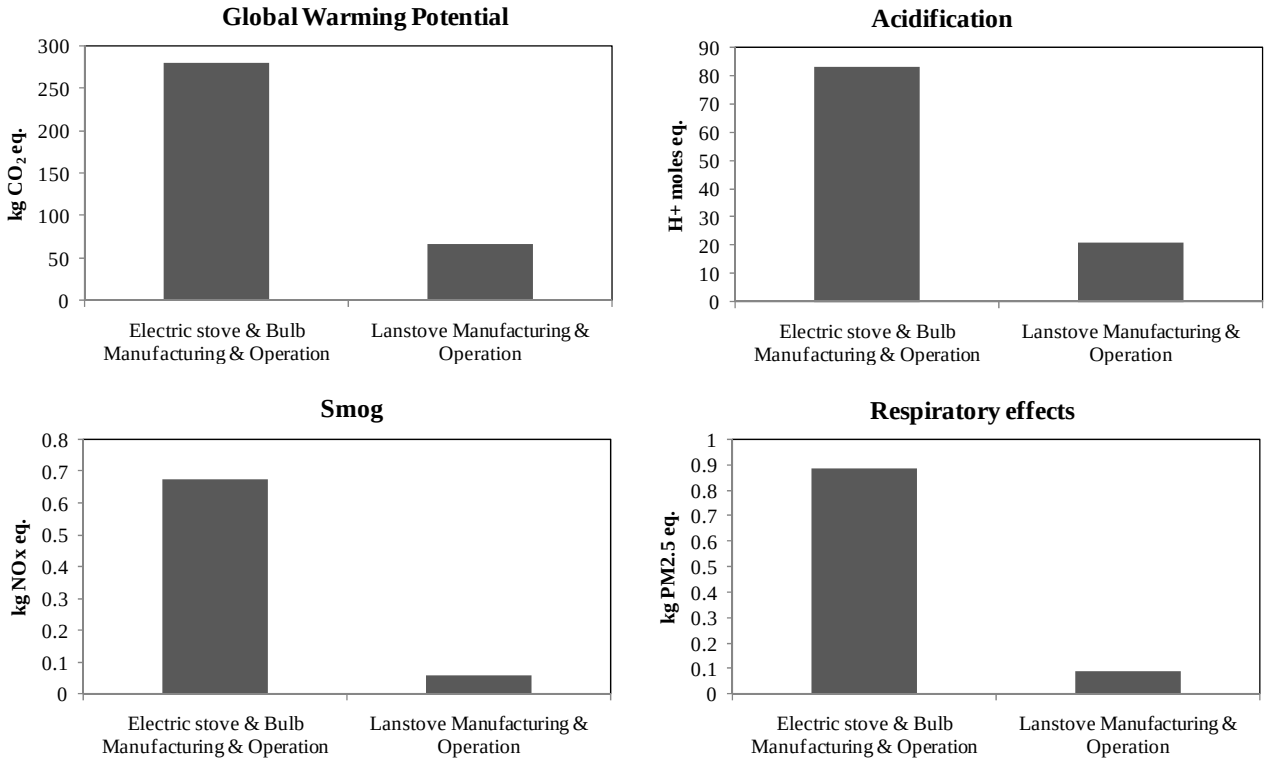
The energy efficiency of Lanstove vis-à-vis electric cooking and lighting is further strengthened by doing a Life Cycle Analysis (LCA) for both manufacturing and operations. LCA is an environmental impact assessment technique based on ISO 14040 standards and is defined as the "compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle". The LCA was done to compare environmental impacts of Lanstove manufacturing and operations with electric stove and incandescent bulb manufacturing and operation. It was performed using the software SimaPro 7.1.

Since the process involves two different parameters, viz. cooking and lighting, two interdependent functional units were used. To boil 5 liters of water on the Lanstove, it takes 50 minutes. Hence it was assumed that light from the mantle will be available for the same amount of time. One Lanstove is assumed to be comparable with a combination of electric stove and incandescent light bulb. Hence the functional unit for this study is a combination of two parameters: 1) time required to boil 5 liters of water on electric stove and 2) electricity required to light a 100W incandescent light bulb for 50 minutes.

It should be noted that in LCA, incandescent bulb data instead of that for the more efficient compact fluorescent lamp (CFL) has been used. This has been done since in rural areas of India, incandescent bulbs are used much more because of their lower initial cost – CFLs are about 20-30 times costlier than the bulbs. Besides the poor quality of manufacturing makes the CFLs last only for a year or two.

The results of LCA are shown in figure below. It can be easily seen that Lanstove scores much better in almost all parameters as compared to electric cooking and lighting.

© Anil K Rajvanshi, December 2010



LCA of Lanstove™

Conclusions

To the best of our knowledge this is the first time anywhere in the world where one device provides simultaneously light, complete cooking energy needs for a family of four or five and clean drinking water. **Also because of the excellent combustion in Lanstove, kerosene becomes a very clean fuel for rural households – almost equivalent to LPG.**

The Lanstove, therefore, has the ability to immediately improve the quality of life for bottom of the pyramid people in rural and urban areas. With the existing kerosene consumption of India, Lanstove can drastically improve the quality of life of 180 million people.

Shortly we hope to do large scale test marketing of this Lanstove in rural India.

Acknowledgements: Thanks are to S.M.Patil and his team in the workshop for fabricating the Lanstove, Dr. Noorie Rajvanshi of Columbia University, USA for providing the LCA and to A.M.Ranaware and V.J.Chopade for field testing it.

Lanstove news was recently covered in mass media such as in DNA and IBN-CNN.

©Anil K Rajvanshi, December 2010

(No material from this publication should be used in any form, either in print or electronically, without giving proper acknowledgement to the author and the Institute)

© Anil K Rajvanshi, December 2010