CONFERENCE PAPER

A pilot test of ethanol gel as a paraffin replacement in a low-income urban environment

Philip Lloyd
Energy Institute, Cape Peninsula University of Technology, Cape Town, South Africa

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Abstract
This paper describes the results of a pilot programme to introduce ethanol gel as a replacement for paraffin for cooking in a low-income informal settlement, Samora Machel, in the Philippi district of Cape Town. A baseline study had shown that paraffin was the dominant source of energy in this community, and that the community knew that its use was both hazardous and unhealthy, but they had no apparent alternative. A gel fuel meeting the requirements of SANS 448 was identified and supplies ordered. A burner system meeting the requirements of SANS 666 was not available on the market; instead it was necessary to use all that could be found. The Agrifood Technology Station at the Cape Peninsula University of Technology (CPUT) was tasked with finding ways to cook using ethanol gel, with accent being placed on cooking safely and using the least possible quantity of gel for a standard menu. After several fruitless attempts to launch a programme, a successful meeting was held at the crèche in Samora Machel at which a number of residents agreed to take part in the pilot programme. Soon thereafter, there was a fire in which many residents lost all their possessions, and when stoves were distributed free of charge, and five litres of gel sold at a subsidised price, all stoves were eagerly taken. The demonstration of how to cook using the gel was held at the point of distribution, and people taking stoves were shown how they worked and how to keep them clean. Every week for four weeks, a sample of the participants was contacted to determine their response to cooking on gel. Virtually every response was most positive, and at the end of that period the participants in the pilot programme requested that the supply of gel should continue as long as possible.

1. Introduction

Ethanol gel fuels have been studied for several years as a possible replacement for paraffin (Utria, 2004; Dioha et al.; 2012). .However, Lloyd and Visagie (2007) found that many of the gels available on the market and that all of the burners gave poor performance. Subsequently the South African Bureau of Standards (SABS) produced standards for gels (SABS, 2010)] and burners (SABS, 2008) that addressed many of the problems Lloyd and Visagie had identified.

Ethanol gel has a number of obvious advantages over paraffin. It should burn more cleanly; it should not flow far if spilled; and it should be far more readily extinguished than paraffin, for example. However, a number of large-scale attempts to introduce ethanol gel have not met with success. For instance, at Umdoni in Natal, a community of 4 000 households was supplied free of charge with gel for several months. Once they were asked to contribute towards the cost of the gel, they reverted to using paraffin (McKenzie and Botes, 2012).

CPUT was asked by the Department of Economic Development and Tourism of the Western Cape Provincial Government to look at the possibility of using ethanol gel as a replacement for paraffin, partly because the economic and social costs of using paraffin were so high, and partly because there was the potential to create jobs in the local production of both fuel and appliances. The study will cover a number of phases; this report describes the outcome of part of the first phase, in which a sample of 150 households was selected to test the best available gel and cooker.

First, it was necessary to identify a suitable community for the test. This task has been described in another paper at this conference (Lloyd, 2014). In essence, the Mustadafin Foundation, a charitable NGO who were active in several low-income communities in Cape Town, were contracted to assist.

Figure 1: The crowd of volunteers waiting to sign up for the pilot test, crèche, Samora Machel

Figure 2: Completing consent forms to take part in the pilot test

They undertook to identify a suitable community and households within that community willing to take part in the experiment. This paper takes up the programme at that point.

2. Identification of households

Identification of households proved much more challenging than at first appeared. Mustadafin arranged a meeting at the local school with the help of the local Councillor; pamphlets describing the programme were distributed; but when we arrived at the school, the headmistress informed us that she had not been asked to host a meeting, and in any event, it was impossible to hold a meeting at that time because the school was in progress. Refreshments intended for distribution after the launch were given to the waiting crowds, and what was left over was distributed to the learners

A second pamphlet drop, and liaison with the headmistress directly, saw the team gather in the great hall at the school, erect banners, put out flowers, and wait .... After two hours, three or four curious people wandered in. 'Oh no! Saturday morning was a terrible day to hold a meeting. Everyone is down at the supermarket.'

A change of time, a change of venue (to the crèche in Samora Machel) and about fifty people arrived. The purpose of the experiment was explained to them. If they wished to take part, it was first necessary for them to sign a consent form, recognising that as this was an experiment, there were unquantifiable risks which they would have to bear, and agreeing that any information they provided would be handled confidentially, and no individual responses would be reported.

The late delivery of gel caused a delay in the programme, and it was not until early in January 2014 that the programme could continue. Those who had already signed up for the pilot test were invited to come and collect their stoves at the crèche. When the team arrived there, the hall was full (Figure 1). A fire soon after Christmas had left many homeless, and the offer of a free stove was too good to miss. We soon signed up over 100 new volunteers (Figure 2).

3. Gel and stoves

Four samples of gel fuels were tested for compliance with the essential features of SANS 448 (SABS, 2010). Three were found compliant with the minimum heating value of 18MJ/kg. Two of the compliant samples proved to be no longer available on the market, and accordingly, 3 000 litres were ordered from the remaining supplier, Greenheat, with a specification of a minimum cv of 20MJ/kg.

All stoves tested failed the basic requirements of SANS666 (SANS, 2008). Figure 3, for instance, shows the tell-tale soot on the base of a pot, indicative of very incomplete combustion of the fuel, largely caused by inadequate mixing of fuel and air and insufficient distance between flame and pot.

Nevertheless, it seemed possible to cook using these stoves. Attempts to acquire them for the pilot test were frustrated by lack of supply. Eventually the total stock of two-burner stoves was acquired from

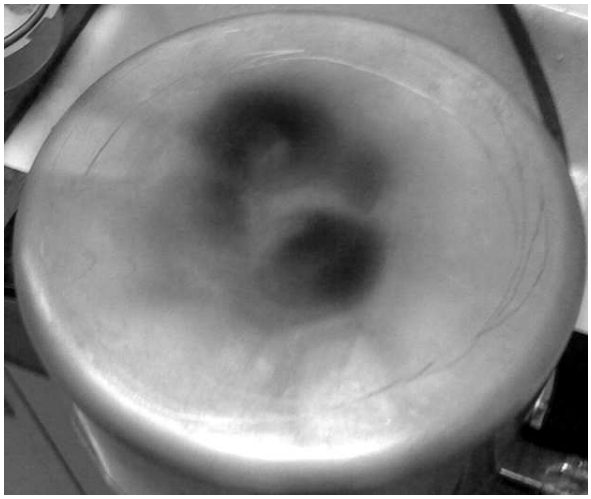

Figure 3: Base of pot after a single cooking test

two different wholesalers. In total we acquired 154 stoves, which was only just enough for the pilot test. This was most unexpected, as several years ago, when gel fuels were being promoted, there were plenty of stoves on the market. It was clear that the earlier promise had not created a significant demand.

In the light of these findings, a decision was taken to request CPUT's Agrifood Technology Station to develop a standard menu for test which was in line with the cultural preferences of Samora Machel, and to experiment with methods of cooking that menu, using the available stoves, in such a way that the fuel consumption was minimised.

4. Cooking with gel

The Agrifood Technology Station developed a menu comprising:

- A pot of 2 cups of maize meal cooked with water and half a cup of vegetable oil; and
- A stew of onions, potatoes and cabbage, a cup of vegetable oil, a packet of minestrone soup and a heaped teaspoon of curry powder.

It was found that this could be cooked using less than half a litre of gel by reducing the heat to simmer once the water had boiled or the stew reached boiling point, covering the pots, simmering for about 5 minutes, and then turning off the burners so that the food completed its cooking on the residual heat.

While the volunteers waited to sign up for the pilot test (Figure 1), a Xhosa-speaking technician from the Agrifood Technology Station demonstrated the method of cooking, including filling the fuel cups with just sufficient gel to cook the meal. The volunteers then had a chance to sample the food. One spontaneous remark was captured – translated from the Xhosa, the volunteer said 'This tastes like it was cooked on an electric stove!'

5. Distribution of stoves and gel

Once the volunteers had signed the consent form, they then purchased 5 litres of gel fuel for which they were issued a receipt; attended a demonstration of how the stoves worked and could be dissembled for cleaning and re-assembled correctly; and then presented their receipt to be checked and cancelled before collecting their stove.

The question remained how to re-supply the volunteers once they had used the first five litres of gel. After several false starts, Mustadafin arranged bi-weekly deliveries to the crèche, where the headmistress kindly supervised sales.

6. Survey of experience

Mustadafin researchers contacted a sample of the volunteers every week. They used a simple questionnaire (Table 1) which took a few minutes to complete. The completed questionnaires were then captured on a database at CPUT and the results analysed.

Table 1: Survey questionnaire

Name	
Cell phone number	
When did you get the stove?	
1.	Do you use it every day? Every other day? Twice a week? Once a week?
2.	How long does the gel last? <3 days? 3-5 days? 5-7 days? More than 7 days?
3.	Is it easier? The same as? Or more difficult to cook than using paraffin?
4.	Is it faster? About the same? Or slower then paraffin?
5.	Is it easier? About the same? Or more difficult to light than paraffin?
6.	Do you cough at all? Less? Or more than with paraffin?
7.	Is the smell good? None? Or Bad?
8.	It is easy to refill?
9.	Is it easy to clean?
10.	Have you had any problems with the gel?
11.	Have you had any problems with the stove?
12.	Do you need any help with anything to do with the test?

7. Results

Over the five weeks, 170 interviews were held with 92 individual volunteers. 65 volunteers were interviewed twice, eleven volunteers were interviewed three times and two were interviewed four times. There was a high level of consistency in the answers by those interviewed repeatedly, but towards the end of the survey period some volunteers were obviously suffering from response overload – 'Can you not just SMS me with all your questions?'

Question 1

Overall, 78±7% (average and standard deviation) of the responses were that the stove was used every day; 17±9% that it was used about every other day; and 8±8% that it was used twice a week or less. No trends with time were detectable. Note that the totals exceed 100% because of sampling errors. In the final sampling, when there were 55 interviews, 78% of the responses were that the stove was used every day, 19% that it was used about every other day, and 2% that it was used twice a week or less.

Question 2

Overall, 15±15% of the responses were that 5 litres of gel lasted less than 5 days; 59±13% that it lasted 5-7 days; and 21±18% that it lasted > 7 days. There was a significant trend for responses in the <3 days and 3-5 days to drop with time, presum-

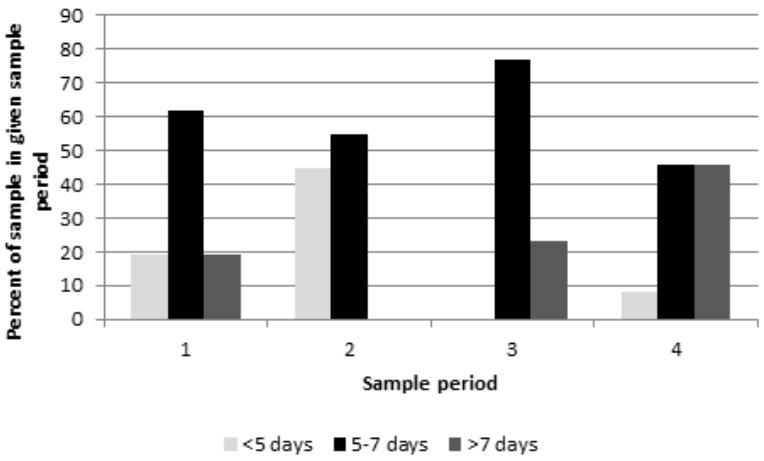

Figure 4: Changes in the estimates of the time to consume 5 litres of gel with successive samples

ably as the users became more skilled at using the gel. The trend for those reporting 5-7 days was downwards, but the trend was not statistically significant. The trend for those reporting more than 7 days was significantly up. In the final sampling, 8% reported that 5 litres lasted less than 5 days, 46% reported that it lasted 5-7 days, and 46% also reported that it lasted >7 days. These results are shown in Figure 4.

Of course, this data includes some who do not use their stoves every day. The analysis was accordingly repeated using only those who reported daily use. Unfortunately in sample periods 2 and 3, those using the stove every day were badly unrepresented, so it was not possible to estimate any trends. Overall, 16% of those who used the stove daily estimated that 5 litres of gel would last <5 days, 70% between 5 and 7 days; and 14% for more than 7 days.

Questions 3, 4 and 5

The results showed users preferred gel to paraffin almost universally. In no case was gel rated as inferior to paraffin:

Questions 6 and 7

Similarly the respondents were very positive about gel having less of a smell than paraffin, and they noted they tended to cough less.

There was no significant trend in either of these results with time. However, importantly there were no reports that coughing worsened when using gel. A single report of a bad smell also noted that it was when the appliance was first used, so is most likely appliance-related rather than gel related.

Questions 8 and 9

There was absolute unanimity that the stoves were easy to fill and to clean. However, some of the comments under Questions 10 and 11 recorded suggest that some respondents were a bit too hasty in their answers.

Question 10

There were six negative comments about the gel, which are given as recorded in Table 2. Two of these are clearly appliance related, and two relate to the problem of judging the correct quantity of gel to cook the meal. The primary problem appears to be

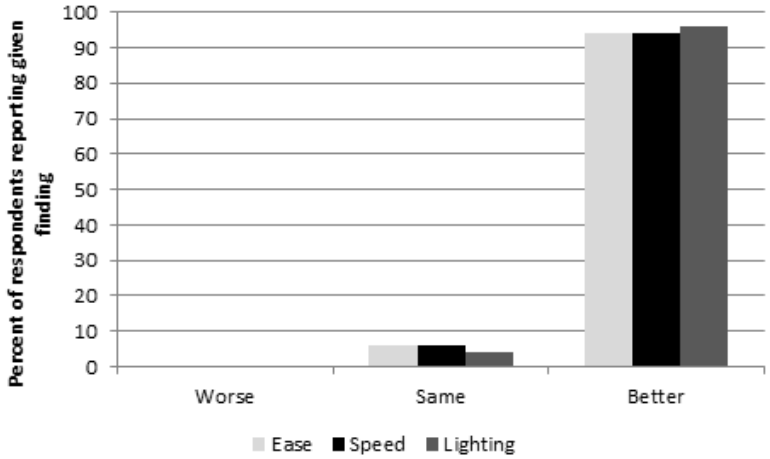

Figure 5: Is gel being better than paraffin?

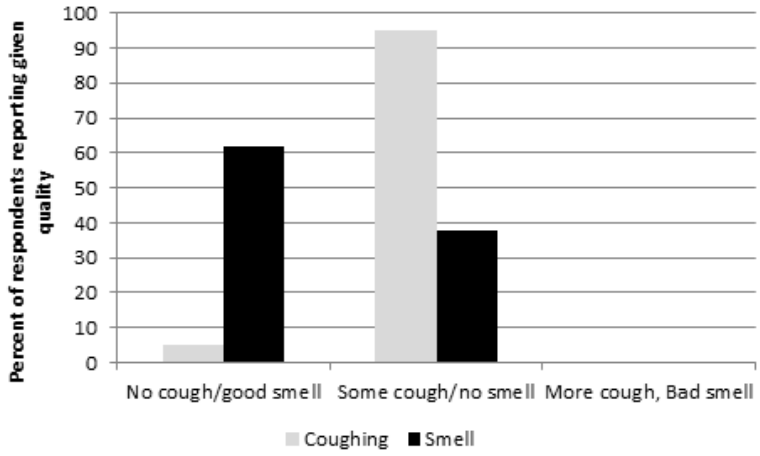

Figure 6: Answers to questions about smell and coughing

difficulty in cleaning the residue of the gel from the fuel cup.

Table 2: Negative comments about gel

I could not switch it off, took me a minute to get it off
The gel burnt faster
Could not blow out
The gel is easily to get burned in the bowl, so it makes difficult to clean the bowl
The gel stove is easy to use but to clean it very difficult for me, because the bowl gets stuck with the burned gel
Did not last full cook cycle

Question 11

There were two reports of difficulties with the stove.

Table 3: Negative comments about stoves

The stove switched off while I was cooking
Struggle to put bowl in

The first of these is clearly related to the problem of judging the correct quantity of gel to cook the meal.

However, there were also some positive reports.

Table 4: Positive comments about the stove

It works wonderful for me
It is a wonderful stove, loving it
It has saved me a lot of money so far and it cooks very well. Thank you.
Just that I'm impressed by the stove. It's wonderful
Very pleased with the stove
I still had my gel so I'm still using it. This gel is really amazing thank you for coming to us with it.
I have gel because I bought it at a shop here by us but was expensive
I use the gel stove when I have people over because it don't smell terrible
I am using mbawula now because I'm a bit broke to buy the gel

There were several comments similar to the last. This was a poor community, and the background study (Lloyd, 2014) showed that about one in every five homes would turn to wood as a fuel when the money ran out.

Question 12

The only cry for help was from a respondent who had cleaned the bowls and put them outside to dry – where they were stolen. However, there were difficulties in distributing the gel in the early stages of the test, and a number of the volunteers ran out of fuel because of this. It took about two weeks for distribution to be resolved.

8. Discussion

These results came as a surprise. Previous attempts to roll out gel fuels had not met with marked success. Instead, this pilot came to an end with the biggest question from the volunteers being how they were to be resupplied with gel now that the test was over. A more positive outcome of a pilot test is difficult to imagine.

What made the difference? It seems likely that the decision to sell the gel was key. The Steering Committee debated this at length. Some members were all for free supply. The eventual decision to sell the gel for only R4 per litre represented a compromise. It has the difficulty that such a price is not market-related, and no-one is certain that gel can be subsidised on a large scale. However, the results of this pilot are such that a strong case could already be made for an ongoing subsidy.

A second factor in the success was almost certainly the input from CPUT's Agrifood Technology Station. The demonstration that it was possible to reduce the consumption by simple changes to cooking practice meant that residents were able to cook using less than a litre a day. This translates into a monthly consumption of about 25 litres.

The background study (Lloyd, 2014) showed that the median consumption of paraffin was about

15 litres per month. The present paraffin cost of over R13 per litre, or about R200 per month, implies that a price for gel of about R8 per litre would be sustainable.

A third factor was the part played by the Mustadafin Foundation. The fact that the Foundation was known and indeed welcomed in the community made a huge difference, given some of the tensions that were known to exist in Samora Machel. These tensions only surfaced at the outset, when local politicians were involved, but they were always present. The Foundation also had a pool of Xhosa-speakers, which meant that it was possible to communicate with the community in their home language. All documentation aimed at the community was in both English and Xhosa.

A fourth factor was demonstrating to the community how to cook with the gel and maintain the stove. The fact that the volunteers were able to taste food cooked on a gel stove went a long way to convincing them that this was not some scheme developed at a university far removed from reality.

It can only be concluded that the pilot test was a success; that every effort must be made to continue supplying and occasionally monitoring the community; and that further phases in this programme should be launched without delay.

Acknowledgements

This project would not have been possible in so short a period without a significant team behind it. In particular, the Department of Economic Development and Tourism in the Provincial Government of the Western Cape is to be thanked for financial and managerial support during the course of this work. Mr Khalid Khan of the Department played a significant role in steering the project in a positive direction. He was assisted for much of the time by Mr Ivan Gabriel. The Mustadafin Foundation, and, in particular, their project supervisor, Mrs Hani du Toit, made a huge contribution to the success. The headmistress of the Kosovo Educare Creche, Mrs Zoleka Hendriks, provided invaluable assistance, not only in making available her schoolroom for meetings and the launch of the pilot, but also in acting as a centre for the distribution of fuel. My University, CPUT, assembled a formidable team. The Dean of Engineering, Prof Nawaz Mahomed, played a key role at the outset in convincing the Province that CPUT could handle the project. The Deputy Dean of Engineering, Prof Veruscha Fester, was a pillar of strength throughout, able to leap over barriers of red tape like an Olympic hurdler. Eugene Erfurt from the Department of Mechanical Engineering, Prof Stephane Bouye and Michael Petersen of the PLMCC, Larry Dolley and Lamla Spilito of the Agrifood Technology Station unit, and Francois Hoffman and Verna Jo Riddles of the EPICentre all played a significant role. Reza Williams was most useful in ensuring that liaison between the University and the Province was smooth and punctual. I must thank the University for putting up with me patiently, and creating the environment in which work of real significance to our community can be undertaken.

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