Methanol stoves for indoor air pollution reduction in Delta State, Nigeria – addressing the needs of people for clean energy

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Background

Delta State, one of five states that make up the Niger Delta, is possibly the richest place for oil and gas wealth in sub-Saharan Africa. Endowed with 40% of Nigeria’s total oil and gas resources, or some 10 to 16 billion barrels of oil and some $10^2$ cubic feet of natural gas, Delta State is awash in oil and gas wealth. Despite this enormous wealth in energy resources, the vast majority of the population, some 5 million people or 1 million households, are not only extremely poor economically, but energy poor as well. An estimated 98% of households lack access to quality cooking and lighting fuel. This situation compels families to depend wholly on inferior and health-damaging fuelwood and kerosene fuels. The people of Delta State are desperate for energy.

The problems with woodfuel

As one travels throughout Delta State, wood gathering from the tropical forest together with long queues of people waiting to purchase kerosene is in evidence everywhere. For the most part, women are seen in the afternoon returning home carrying enormous bundles of fuelwood on their head after a full day’s drudgery of wood gathering. Some of these bundles weigh up to 70 kg. The task of wood gathering also falls to young children and to old men who can no longer obtain waged labour for cash earnings. Some of the men own bicycles, which they load with great bundles of fuelwood.

It is estimated that a typical rural woman in Delta State spends six hours gathering fuelwood. The community forests are being depleted of valuable trees. Back home, she spends another six hours exposed to smoke as she chops up and cooks the firewood on a smoky and inefficient traditional 3-stone open fire called a mgbaebo, or at best she uses the tripod-supported rim stove, which wastes fuelwood that is already in short supply. The stove is usually in the corner in a poorly ventilated kitchen. The stove emits dangerous particulate matter, carbon monoxide, nitrous oxide, sulphur dioxide, formaldehyde, acetaldehyde and benzene.

Fossil fuel issues

In the peri-urban towns, of low to medium income families, up to 9% of the households depend on kerosene to supplement fuelwood. In the cities, about 1% of families depend on LPG. The use of kerosene in the peri-urban towns has been hampered by a corrupt distribution system, poor quality kerosene that burns with high emissions of soot and volatile organic compounds (the kerosene is high in toxic aromatics including benzene, toluene, xylene, sulphur and olefins), as well as prohibitive pricing occasioned by the government’s withdrawal of subsidy beginning in October of 2003 in its effort to deregulate petroleum products in Nigeria. Contaminated kerosene (often adulterated with gasoline when this fuel is cheaper) has, since 2001, become an issue of national concern, having claimed more than 2000 lives in Nigeria, with Delta State worst hit.

All refined petroleum products sold in Nigeria today are imported, because Nigeria’s refineries are shut down or operating at a fraction of capacity. Nigeria’s refineries were built to refine Nigerian crude, which is extremely low in sulphur. Because Nigeria’s low sulphur crude commands a premium on the international market, the federal government sold its oil abroad and purchased high sulphur Venezuelan crude to process in its refineries for the Nigerian market. This aggravated maintenance problems at the refineries and resulted in their deterioration. Maintenance was neglected in the 1990’s and renovation (‘turn around maintenance’) of the refineries has been stalled in recent years. As a result, the Nigerian refineries have become virtually inoperable.

This placed the Nigerian government in a difficult position. It had to purchase all of its refined products abroad for its domestic market. The government has and continues to ship crude to other African countries for refining and return to Nigeria. All of this has created economic pressure on Nigeria to deregulate its domestic fuels pricing and remove fuel subsidies, a decision which the Obasanjo government has now pushed through. Before deregulation, kerosene prices hovered around 30 cents US. After deregulation kerosene was set at various prices, now around 64 cents. But with the scarcity of refined products and no domestic production, product scarcity has pushed kerosene into the informal market and prices in this market are normally at or above US$1.00. The temptation in this unregulated market to adulterate the fuel has also resulted in poor product quality. While these problems are not new, the rapid price inflation has occurred since early 2004.

These problems are compounded by pollution from years of uncontrolled gas flaring from an estimated 50 gas flare sites scattered over Delta State. Emissions from the flares impact nearby homes and communities. Most communities situated around the gas flare sites in Delta State are inhabited by poor families whose means of subsistence are fishing and farming. These families are constantly impacted by emissions from the flare sites and oil flow stations. An estimated 80% of the 2 billion standard cubic feet of natural gas that Nigeria flares is flared daily from the gas fields of Delta State. It is ironic that the people of Delta State must cut down their valuable forests to
cook, literally in the sight of the oil rigs and flow stations! (Figure 1)

**CEHEEN indoor air pollution interventions in Delta State**

Prompted by a 1997 World Health Organization (WHO) report, which revealed that the greatest exposure to air pollution occurs indoors in the kitchen in developing countries, the Centre for Household Energy and Environment (CEHEEN) embarked on a two-year study of household energy in Nigeria, looking particularly at human health, the environment and gender. The results showed that Nigeria is in a crisis. Topics covered by baseline study monitoring questionnaire are shown in Table 1.

Table 2 shows the average monthly cost of different types of fuel before price deregulation. Most houses that used kerosene also used fuelwood.

**Fuels**

**Fuelwood use**

In 1998 CEHEEN developed and promoted an improved version of the traditional *egaga* stove to help address this crisis (Obueh, J, 2001 – BP 47). It piloted this stove with 1000 families. The results were favourable, showing reduced emissions, reduced fuel use and some savings in cooking times. In 2002, a health evaluation involving clinical and laboratory tests showed that symptoms suggestive of acute respiratory infection and chronic obstructive lung disease were reduced for people in households using the *egaga* stoves as opposed to households using three-stone open fires. Prevalence of symptoms of smoke-related diseases among families using *egaga* stoves was measured at 32% versus 68% for families in households using three-stone open fires. Thus, *egaga* was apparently able to reduce the symptoms of smoke-related diseases very substantially, but this still left more to be done.

**Kerosene use**

The original data showed that 61% of the study households (total 132) used kerosene as their primary fuel. A further 31% used it as their secondary fuel, and 9% used it both for primary and secondary use. Now, persistent scarcity of kerosene has led to the product selling at an all-time high of US$1.00 per litre, an amount grossly unaffordable for 80 per cent of our sample households. Thus, the cost of fuel to cook food is marginalizing the lower income group (and perhaps even the middle income group) unless they purchase or collect fuelwood. Table 3 shows the likely monthly cost of kerosene for an average household.

Our new baseline surveys conducted during the first quarter of 2006 for our up-coming 150-stove pilot study have shown a consistent trend away from kerosene back to fuelwood. Thus, the use of the one improved fuel that was in reach of Nigerian consumers is now declining and people are returning to primary or complete reliance on fuelwood. In oil-rich Nigeria, this is indeed an irony.
Table 3 Monthly cost of kerosene for an average household

| Kerosene used per person per month | 5.1 litres |
| Average household size          | 5.94 persons |
| Fuel use per household per month | 29.76 litres = about US$30.00 |

**Methanol stoves**

It is true that by use of well-operated chimneys and hoods, smoke can be put outside the house. But in densely populated villages and towns this can lead to heavy neighbourhood pollution. Even families using cleaner fuels suffer from exposure to wood smoke. Therefore, we reasoned that unless truly clean-burning biomass stoves could be developed, the best course of action would be to eliminate the use of unprocessed solid fuels altogether. This made perfect sense for Delta State and the other states of the Niger Delta, since energy resources other than fuelwood are close at hand. The technology CEHEEN selected for further study is the alcohol-fuelled CleanCook stove (Figure 2). Table 4 shows the relative cost of this stove compared to a kerosene stove.

**Methanol stove project**

A promising ‘mini-pilot’ study with 15 CleanCook methanol stoves in 2002, supported by Winrock International, led to a Ceheen and Delta State full-scale pilot study of 300 stoves. Funding for this was obtained from Delta State Government and from the USEPA under the Partnership for Clean Indoor Air. A team of surveyors, all university graduates, was recruited and trained. They compiled baseline data for 132 households in three locations: Asaba, the capital of Delta State, Abraka, the Governor’s town, which is afflicted, like so many towns, with the pollution from uncontrolled flares, and Warri, the famous oil town.

Our full scale pilot study will begin by placing 150 stoves in homes in Delta State in the communities of Abraka, Asaba (the state capital) and Warri. The cost of the pilot study in Nigeria is being underwritten by the U.S. Environmental Protection Agency, Government of Delta State, Dometic AB, Stokes Consulting Group, and other partners.

The alcohol fuel used will be methanol with a colorant and a bitter agent to clearly identify it among other household fuels in order to render it unpalatable. To make the fuel completely safe for use in the household, the project uses a denaturing protocol that involves the addition of a special dye that colours the methanol without affecting the chemical constituents and performance of the fuel. The protocol also involves the addition of Bitrex (Denatonium Benzoate NF), an extremely bitter tasting agent that renders the methanol bad tasting and physically intolerable to swallow.

It will be distributed to the families in special canisters that do not allow people to come in contact with the fuel but only use it in the stove. Trained fuel distributors will deliver the canisters, which will be dispensed in a similar way to bottled gas – in a container that must be returned for refilling. The containers hold 1.2 litres of methanol. Each family will, for now, have four fuel containers, as weekly usage in our pilot studies has been running six to seven litres, one litre per day, and our surveyors will be visiting the houses at least twice per week. A container of fuel provides about 4½ hours of cooking at full power.

Eventually a family might have seven to eight fuel containers that transport conveniently in a sack designed for that purpose. One would expect that they would trade their empty containers in once a week for full containers. When the containers are charged with methanol, a foil seal will be placed over the evaporative surface or mouth of the container, to be peeled away when the container is ready for use. This avoids any loss from the container, however small, by evaporation.

Given the high use of kerosene and its cost in Nigeria, it seems that alcohol fuels – safe and clean-burning – may be the natural replacement for the low-quality kerosene in Delta State.

**References**

Obueh, J. Boiling Point 47: Using a household energy technology to promote small scale enterprises in rural communities in Nigeria – The egaga stove experience

Joe Obueh is the Director of the Centre for Household Energy and Environment (CEHEEN), a Nigerian household energy organisation. He is also the Project Director of Project Gaia – Nigeria, a partner of Project Gaia International working in several developing countries to promote the use of safe, efficient and clean burning alcohol fuels for household cooking and other related uses.