Wall Building

Wall Building
Case Study

BUILDING ADVISORY SERVICE AND INFORMATION NETWORK
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Small and medium scale brick and tile production in Ghana – 3 Energy alternatives

Introduction

Based on a study undertaken at the end of 1996, the first paper on small and medium scale brick and tile production in Ghana gives an overview of the current situation in this industry, and the second paper deals with the different levels of technology applied. This paper focuses on the energy inputs required in the manufacture of bricks and tiles, which constitutes 30 - 48% of brick production costs in Ghana. It is required for the winning and preparation of the clay, moulding, drying and firing of the green bricks and tiles, as well as for lighting the factory. This paper will concentrate mainly on the energy required for firing.

Energy types

The 1980s have been termed "the lost decade for Africa", partly because during this period African countries failed to come to terms with the energy crisis between 1974 and 1983, when there was a steep increase in global oil prices. Although the oil crisis adversely affected the economies of many African countries, including Ghana, it generated interest in alternative energy sources. For example, research and development of methanol through production of short rotation forestry or production of ethanol through production of cereal and root crops were initiated. Both of these alcohols can be used as ingredients of motor fuel and may result in reducing the bill on crude oil. Research and development into the use of solar energy is an area which African countries should have embraced seriously during the early 1980s, but did not. Many opportunities to research and develop alternative fuels were lost during this period.

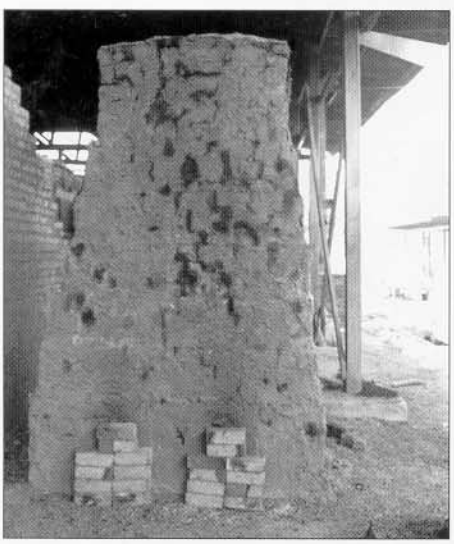

Figure 1 Small scale factory using clamp firing with firewood

Globally, the oil crisis increased interest in alternative energy sources. It also increased the importance in alternative non-OPEC oil sources, like Mexico and the North Sea. This and other factors resulted in an oil glut which caused the slowing down or total abandonment of many very promising research and development projects in alternative energy. The effect of the oil crisis on developing countries was so serious that they could not even benefit fully from the oil glut. Consequently, they have had to go back to the traditional sources of energy, namely firewood and petroleum products.

Firewood and agro-waste

Firewood is the most common source of energy and is used by all the surviving small scale and medium scale factories. In the Ashanti and Brong Ahafo regions, practically all factories use solely firewood for burning the bricks. In Northern and Southern Ghana it is rather difficult to obtain firewood for the factories, and so in Accra, for example, the energy source for firing brick is residual oil. In fact, the collapse of some of the factories in these areas may be partly due to difficulties in obtaining firewood or due to its rising cost.

The industry has used limited amount of agro-waste to supplement the fuelwood supply. The most common agro-waste, used by both the small and medium scale factories, is palm kernel shells. They are available in areas where palmnuts are processed for oil. Normally, the shells are used to start the fire or to rekindle it. Where the shells have been the sole fuel for firing the bricks it has proved to be cost effective. Some clamp firing trials with palm kernel shells undertaken in the 1980s at the Building and Road Research Institute (BRRI) in Kumasi gave very satisfactory results. Table 1 gives a comparative cost analysis of the trials.

Cost elements	Fuel type	
	Firewood	Palm kernel shells
Cost of fuel	100 US$	16 US$
Transportation and labour	18 US$	18 US$
Setting up clamp, firing of bricks and unloading	79 US$	75 US$
Total	**188 US$**	**108 US$**
Unit cost of brick (12,000)	1.56 cents	0.9 cents

Table 1 Comparative cost analysis of firewood and palm kernel shell for firing 12,000 solid bricks

Comparing the cost of firing the bricks with firewood, palm kernel shells were found to save 42.3 % of the costs. However, the efficiency of firing with palm kernel shells was found to depend on three factors, namely the size of the fire boxes, the dryness of the palm kernel shells and the ease with which air flows within the clamp.

A charcoal briquette made from sawdust is a popular source of fuel in the Western Region of Ghana, but it is very expensive. Most of the factories use it to start the fire or to rekindle it. The main source of energy for the firing, however, is firewood.

Since the "Earth Summit" in Brazil in June 1992, Ghana has become more sensitive to environmental issues and has taken measures to understand how the current environmental problems affect the lives and social and economic developments of different communities of the country. The impact of the activities of farmers, fishermen, the timber industry and the construc-

Type of energy	Year								
	1986	1987	1988	1989	1990	1991	1992	1993	1994
Petroleum products	729. 96	717. 56	806. 91	933. 53	881. 77	676	831	893	973
Electricity	288. 46	330. 54	359. 33	373. 54	410. 71	408	438	459	436
Wood fuels	2,603. 82	2,683. 88	2,766. 88	2,852. 42	2,941. 19	2,988	3,083	3,181	3,283
Total consumption	**3,622. 24**	**3,731. 98**	**3,933. 12**	**4,159. 49**	**4,233. 67**	**4,072**	**4,352**	**4,533**	**4,692**

Table 2: Energy overview 1986-1994, given in Tonnes Oil Equivalent (TOE) x 1,000. Sources of data: National Energy Statistics, Vols. 1 and 2, Energy Information Centre, Ministry of Mines and Energy, Accra (1993 and 1996).

tion industry on the environment has been monitored and measures taken to arrest environmental degradation. Specifically, the cutting away of timber without a conscious programme to replant has a very serious consequence on the environment and therefore afforestation is encouraged.

In most developing countries the energy economies are dominated by firewood and charcoal. For example, 75 - 80 % of Ghana's energy needs are met from these two sources. Table 2 gives an energy overview from 1986 to 1994. The growing pressure to cut down more wood to meet the basic energy needs of a rapidly growing population is making the problem of environmental degradation worse, and it will be impossible to sustain the natural ecosystem, especially the tropical rain forest, if nothing is done to halt this process. In fact, the degradation process has more serious implications. The unwanted carbon dioxide that is generated from burning petroleum products and firewood are absorbed by the plants and trees of the forests. But as we cut down trees for firewood without replanting, we are destroying the natural mechanism for controlling the quantum of carbon dioxide that is emitted into the atmosphere. The consequence is the "greenhouse" effect, resulting in global warming. This is a dilemma to all developing countries and also a challenge for the whole international community. The dilemma is how to stop overrelying on the natural forests to meet basic energy and food needs. It is extremely tempting to follow the well-proven example of the developed world by promoting a massive shift from wood fuels to fossil fuels to achieve real economic and social development in developing countries. In many ways, this course of action cannot be avoided by developing countries, including Ghana, given that no substantial development can be achieved without adequate increases in the quantity and quality of energy use at all levels of activities.

Now, what policy options are available to Ghana and other developing countries if the current international view is that the fossil fuels' path to development must be avoided or moderated to save mankind from itself? Happily, wood fuel is a renewable resource. A massive afforestation programme will be a long term policy as well as researching and production of methanol and ethanol from agro-forestry products as partial substitute for fossil oil. In the late 1970s and early 1980s the firewood crisis was anticipated and all the brick and tile factories operating then were urged to establish wood lots or wood farms for their factories. Sadly, it was observed during the study that they did not take the advice seriously or took action too late. Many factories planned to phase out the use of firewood, but could not, because the anticipated production levels were not met, working capital was dwindling and interest rates for borrowing from the banks were going up, not to mention inflation and the unstable exchange rate of the cedi.

Residual oil

The next source of energy for firing bricks and tiles in Ghana is petroleum fuel. This is usually called inland fuel oil or residual oil and is supplied by the Tema Oil Refinery. The general properties of the oil are

- Viscosity (Kinematic at 50°C) 59.4
- Flash point 138°C
- Pour point 39°C
- Sulphur content 0.22% weight
- Water and sediment 0.10% volume

Gas oil is also used by the fully mechanized factories. Practically all the semi-mechanized factories use a combination of oil and firewood for firing. It is only the fully mechanized factory at Prampram that used solely fuel oil for firing. At the semi-mechanized factories such as the Clay Products Ltd. at Alajo, Accra, where oil is mainly used, the initial heating is carried out with firewood to raise the temperature of the kiln, so that when the oil cans are put in place the oil drops will ignite. As usual, slow firing is carried out from the start and as firing progresses the heat is raised. Once the fire is started in the first chamber, the success of the continuous firing operation is largely dependent on the regulation of oil flow. During the process of firing, when fire is noticed in any of the oil holes in a row, the oil can tip is set in such a way that only a thin flow of oil takes place. Higher flows are likely to subdue the fire and increase the time when the fire will burn right to the top layer of the packed bricks. When the fire is fairly well established the flow of oil can be slightly increased without any danger of extinguishing it.

Many of the difficulties with oil firing faced by the semi-mechanized factories are financial, and in several cases have led to their collapse. The only surviving semi-mechanized brick company in Accra happened to be a subsidiary of the Bank of Ghana, so it was able to substantially overcome its financial problems through help from the bank and reorganization of the company. Many technical problems also were encountered. Among the earlier ones, for which solutions were immediately found, were the collapse of packed bricks within the kiln, slow movement of fire, and cracking in the kiln walls.

- Collapse of packed bricks

This is one of the teething problems of some of the factories. Columns of bricks collapsed as heat developed in the kiln. In some cases, the collapse occurred before the actual fire reached the location. This was due to the poor control of oil flow into the kiln. Large quantities of oil collected on the floor of the kiln. This led to the soaking up and subsequent weakening of the bottom courses of bricks in the column. Consequently the bricks at the bottom layer gave way under the load of the upper courses, collapse of the brick columns ensued. Another possible cause for the collapse was the fact that some of the green bricks were not properly dried prior to packing in the kiln. Apart from causing cracks in the bricks and promoting other defects, it led to the collapse of the brick columns. This factor was found to have contributed to the low movement of fire through the kiln. The problem was solved through ensuring that green bricks were properly dried and the flow of oil carefully controlled.

- Slow movement of fire

The slow movement of the fire in the kiln chambers tends to retard the progress of the fire through the kiln, thus adversely affecting the production target. Two factors were identified as being possible causes for this problem. The first factor was in the kiln setting, which was found to be too dense, thus acting as a barrier in the flow of the hot gases. The other factor was the release of

steam from the green bricks, which were not properly dried prior to packing into the kiln. This led to the creation of a damp atmosphere in the kiln which impeded the forward movement of the fire. The problem of slow movement of fire was solved by improved drying of the green bricks and modifying the method of kiln setting to allow for satisfactory flow of the gases. The modified method involved the use of only rows of columns as opposed to alternate rows of columns and "walls". Another factor that could have contributed to the slow movement of fire was poor draught in the kiln. Waste gases tended sometimes to find their path of exit through the roof of the kiln rather than the chimney and occurred sometimes in the wake of advancing fire. Coupled with this was the fact that there were occasions when no waste gases were observed going out of the chimney even though firing was in progress. This problem was solved through efficient control of the dampers.

- Cracks in kiln walls

Some cracks were observed in the kiln walls and also that most of the kilns were not lined with refractory bricks. This is especially true in the case of small scale brick factories. The most serious cracks occurred in the central wall of the kiln. From a report from one of the factories studied, this part of the kiln was opened up to determine the depth and extent of damage caused by the cracks. The examination showed that the cracks were mainly through joints between bricks and went down to two courses only. It was observed that the composition and thickness of the mortar was not correct. This was corrected during the formulation of a new one for the repairs. The problem was thus solved through the correct use of mortar. In order to prevent heat loss by conduction, convection and radiation, all the medium-sized factories have had their kilns internally lined with refractory bricks.

Natural gas (liquid petroleum gas)

Another source of energy with great potential for the brick and tile industry is natural gas or LPG. This is obtained during the crude oil refinery process. Gas has been used extensively and for many years in Europe, America and other developed regions. In Africa, except in North Africa and perhaps South Africa, the use of gas for firing bricks is a very recent practice. In Ghana, in particular, interest in the use of gas for firing bricks started when the brick factories began to notice the effect of the sharp rise in the cost of residual oil in the mid 1980s. Many medium scale brick factories embraced the idea and attempted to convert their kilns to gas firing. The Agritree Brick Company was among the first that enthusiastically embraced the idea and involved the BRRI in the feasibility studies for the conversion. But, during this case study it was observed that Agritree Brick Company was among those medium scale factories that had collapsed. It was found that gas supply was not regular and its price was not stable. It kept moving upwards as the cedi became weaker in relation to the dollar and other hard currencies.

The only surviving medium scale factory, Clay Products, attempted gas firing on an experimental basis. The gas was delivered to the factory in cylinders. It was found that, during the firing, the pressure in the cylinder diminished considerably as the gas in the cylinder became exhausted. The unsteady pressure indirectly caused the cost of gas for the firing to go up. Again it was found that to convert to gas firing required a substantial capital outlay for burners and for installation of a huge tank that will store the gas. This way the flow of the gas to the kiln could be regulated to have a constant pressure during each firing.

The use of gas will become popular when it becomes cheap and can be obtained throughout the year with a fairly stable pricing. This will be possible when Ghana begins to tap its own vast natural gas resource. Until then, Nigeria is prepared to sell natural gas cheaply to Ghana, Benin, Cote d'Ivoire and Togo. It is expected that through this joint venture between these ECOWAS countries, gas will be available cheaply and will be the main source of energy for firing bricks even in small scale factories.

Electricity

Electricity is essential source of energy for any industry. The brick and tile industry in Ghana mainly uses electricity for lighting the factories. When the fully automated Prampram Brick and Tile Company, was performing in the late 1970s and early 1980s, it used electricity to operate most of its machines and equipment. But now all brick and tile factories that have access to electricity use it only for lighting and to a small extent in operating their machines.

The source of electrical energy in Ghana is from hydro-power from Akosombo and Kpong. Until quite recently, it was thought that the electricity supply of the country was adequate. Some of the energy was therefore sold to neighbouring countries, like Togo and Cote d'Ivoire. But as the rural electrification programme progressed and prolonged draughts caused the decrease of the water level in the dam at Akosombo, it became obvious that Ghana's electricity supply needs to be augmented with a thermal electricity generator.

During the study it became clear that all the factories shied away from using electricity for firing, because it was generally thought to be expensive. The kilns at the Ceramics Department of the University of Science and Technology, Kumasi, and the BRRI use electricity for firing. In the case of the BRRI, the firing with electricity is restricted to research activities. But in the case of the Department of Ceramics, electricity is the only source of energy for firing. Perhaps they do so, regardless of the cost involved, in order to obtain art pieces in perfect shapes without distortions. Other ceramics industries, like the Salpond Ceramic and many private ceramic enterprises, also use electricity for firing. The general impression is that although electricity is available, it is expensive and the supply may not be regular.

Product quality and source of energy for firing

It is important to discuss the effects, if any, of each of the sources of energy described above on the quality of the fired products. From the study, some sources of energy were found to be associated with a particular production technology. For example, small scale factories mainly use fuelwood and agro-wastes and their products are generally found to be of low quality (variations in the brick dimensions, low strengths and relatively high water absorption). However, this is not due to the fuel used in firing the green bricks, but due to the moulding methods applied. The hand moulded bricks contain more water than those moulded by machine. As a result, hand moulded bricks contain a lot of voids, causing low strength and high water absorption. As the operator becomes tired, the uniformity of the products gradually diminishes. Fuelwood, agro-waste and sawdust briquette can produce the best of products provided the green bricks have been well made and dried.

The good quality products from medium scale factories are not promoted by the use of residual oil. Medium scale factories that have used fuelwood for firing have achieved the same results. A study conducted at the BRRI, using the same moulding techniques, but firing with different sources of energy confirmed that the firing fuel has little influence, if any, on the development of uniformity of dimensions and strength. In

the study, six sources of energy were used, namely fuelwood, palm kernel shells, charcoal, residual oil, gas (LPG) and electricity. The fuelwood was found to give a relatively higher percentage of sooty products. The products fired with electricity are devoid of soot. The residual oil may deposit some amount of scum on the bricks. Apart from these defects the source of energy has no influence on the quality of the fired products.

Summary of advantages (+) and disadvantages (–)

Fuelwood

+ It is renewable.

+ Wood lots can be farmed in order to have a sustained supply of fuelwood. This way small and medium scale factories can profitably fire their green bricks.

– If its supply depends solely on the natural forest it will lead to far reaching adverse consequences. The tropical rain forest may be destroyed or degraded. Forest areas may turn into grasslands and then into deserts if there is over-reliance on the natural forest for fuelwood. The unwanted carbon dioxide which results from the combustion of fossil fuels remain in the atmosphere since the forests that naturally take care of the carbon dioxide have been destroyed. The effect will be global warming with its attendant consequences.

Petroleum fuels – residual oil and LPG

+ The natural forest is preserved. At least, in theory, the tropical rain forests will be able to cope with the carbon dioxide.

– High cost of the petroleum which in Ghana is linked to shortages in supply when there is an economic crisis. The prices of these products and in fact, all imported goods are not stable because of inflation.

– To use this source of energy requires a capital outlay for burners and storage tanks. Small scale factories cannot afford this because of the initial capital involved.

Electricity

+ When used for firing bricks gives neat soot-free products.

– It is not available in every part of the country and so will be out of reach to many areas. Now efforts are being made to provide electricity to all areas of the country.

– It requires huge investment and frequent maintenance and replacement of elements.

– There are also frequent cuts in the supply which may affect production adversely.

Recommendation

Developing countries including Ghana should embrace intense research into the use of solar energy for brick production. It should also research into cultivating plants and some high energy crops, so as to develop ethanol and methanol on a large scale to substitute fossil fuels for industrial use.

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Text and photograph by
Dr. A. A. Hammond
Building Materials Consultant
2A Peach Close
P.O. Box 711
Teshie-Nungua Estates
Accra
GHANA

Published by

German Appropriate Technology Exchange
Dag-Hammarskjöld-Weg 1
Postfach 51 80
D - 65726 Eschborn
Federal Republic of Germany
Phone + 49 - 6196 - 79-3190
Fax + 49 - 6196 - 79-7352

(1997)

What is BASIN?

Building materials and construction technologies that are appropriate for developing countries, particularly in the low-income sector, are being developed, applied and documented in many parts of the world. This is an important prerequisite for providing safe, decent and affordable buildings for an ever-growing population.

But such new developments can do little to improve the building situation, as long as the information does not reach potential builders. The types and sources of information on standard and innovative building technologies are numerous and very diverse, making access to them difficult.

Thus, in order to remedy this drawback, Shelter Forum, GATE, ITDG, SKAT and CRATerre are co-operating in the Building Advisory Service and Information Network, which covers five principal subject areas and co-ordinates the documentation, evaluation and dissemination of information.

All five groups have a co-ordinated database from which information is available on Documents, Technologies, Equipment, Institutions, Consultants as well as on Projects and Programmes. In addition, printed material or individual advice on certain special subjects is provided on request. Research projects, training programmes and other field work can be implemented in co-operation with local organizations, if a distinct need can be identified and the circumstances permit.

BASIN is a service available to all institutions and individuals concerned with housing, building and planning in developing countries, but can only function efficiently if there is a regular feedback. Therefore, any publications, information, personal experiences, etc. that can be made available to BASIN are always welcome and will help BASIN to help others.

Shelter

SAS / BASIN
Shelter Forum
P.O.Box 39493
22 Chiromo Access Road
Off Riverside Drive
Nairobi, Kenya
Phone + 254 2 442108
Fax + 254 2 445166

Wall Building

WAS / BASIN
GATE - GTZ
P.O.Box 5180
D - 65 726 Eschborn
Germany
Phone + 49 6196 793190
Fax + 49 6196 797352

Cements and Binders

CAS / BASIN
ITDG
Myson House
Railway Terrace
Rugby CV21 3HT, United Kingdom
Phone + 44 1788 560631
Fax + 44 1788 540270

Roofing

RAS / BASIN
SKAT
Vadianstrasse 42
CH - 9000 St. Gallen
Switzerland
Phone + 41 71 2285454
Fax + 41 71 2285455

Earth Building

EAS / BASIN
CRATerre – EAG
Maison Levrat, Rue du Lac
BP 53
F - 38092 Villefontaine Cedex, France
Phone + 33 474 95 43 91
Fax + 33 474 95 64 21

KM 4/97