Field Document No.35

REGIONAL WOOD ENERGY DEVELOPMENT PROGRAMME IN ASIA
GCP/RAS/154/NET

STATUS AND DEVELOPMENT ISSUES

OF

THE BRICK INDUSTRY IN ASIA

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Bangkok, April1993

This publication is printed by
the FAO Regional Wood Energy Development Programme in Asia,
Bangkok, Thailand

For copies write to: Regional Wood Energy Development Programme in Asia
c/o FAO Regional Offcie for Asia and the Pacific
Maliwan Mansion, Phra Atit Road,
Bangkok, Thailand
Tel: 66-2-280 2760
Fax: 66-2-280 0760
E-mail: rwedp@fao.org

FOREWORD

Improving the efficiency of wood energy use in rural industries is one of the objectives of the Regional Wood Energy Development Programme in Asia. From the various national surveys on wood using industries carried out by the project it has become clear that the brick industry in Asia's developing countries is the largest industrial consumer of fuelwood and would deserve priority attention of the project. However, before embarking on a programme dealing only with the wood energy aspect of the brick industry it was considered useful to have a review of all aspects of the industry.

Among the basic needs of rural and urban populations, shelter is perhaps most difficult for the poor and even the average people to afford in developing countries since most often it requires a life-time effort, even for a very modest type of housing. It is not surprising, therefore, that the majority of people in Asian developing countries still live in dwellings that do not provide a decent living by any standards.

While most governments are trying to alleviate this situation, for example by strengthening rural economic base, these efforts are far from satisfactory since rural development takes time and requires more expertise than normally available locally. Housing development both for urban and rural poor may require a special approach and a sizable resource support for which most governments are as yet poorly equipped.

Local materials traditionally used for permanent construction as timber and stones have become very scarce while modern building materials like cement and steel are more expensive and have to be imported to rural areas and are often in short supply in many Asian countries. Clay based material like bricks can be appropriately and effectively used as a main alternative material for low cost permanent construction both in rural and urban housing as well as public buildings. Due to its localized nature brick production provides opportunities for rural employment as clay excavators, brick workers, traders, biofuel producers and suppliers, etc. The external capital and technological inputs in brick making are further relatively low.

Despite its development advantage, there are also a number of constraints and issues in the brick industry, that have to be addressed, e.g. energy, labour, product's standard and quality, choice of appropriate technology, environment implications, market, entrepreneurial skills, etc. If the manufacturing of bricks is to be a part/parcel of rural development, the development planner should be fully aware of such issues. This report was prepared with the main purpose of addressing such issues.

Messrs. Auke Koopmans of Greenfield International, Thailand and Stephen Joseph of Biomass Energy Systems and Technology, Australia who prepared this report have much experience in brick industry and other ceramic material development. This project wishes to express its sincere thank for their contributions. Acknowledgements are also due to Dr. Aroon Chomcharn, Wood Energy Conversion Specialist of this project who provided supervision and assisted in technical editing. Ms. Pimpa Molkul and Panphicha Issawasopon provided editorial support and text layout.

It is hoped that this report will be useful for the field practitioners and concerned development planners. Any comment and feed back from the readers will be highly appreciated.

Egbert Pelinck
Chief Technical Adviser
GCP/RAS/131/NET

TABLE OF CONTENT

1. DEVELOPMENT BACKGROUND

1.1 Housing needs

Asia is the most densely populated continent in the world and home to close to 60% of the world's population as shown in figure 1.1. According to recent studies, Asia's population is gradually shifting from rural to urban regions. While in 1960 an estimated 75-80% of the population in Asian developing countries lived in rural areas, this is expected to change to about 50% by the year 2020, as shown in table 1.1 (United Nations, 1986). The reasons for urbanization are manifold. There is a lack of job opportunities in rural areas and a disparity in income compared with urban areas. Because agricultural land is becoming scarce, existing plots have to be divided and subdivided. There is also a lack of facilities in rural areas. In Pakistan, Karachi is home to only 6% of the national population but the city generates 42% of industrial profits and holds 50% of all bank deposits. In Senegal nearly 80% of industrial enterprises, 66% of salaried employees and 80% of all doctors are concentrated in the Dakar area (the capital) where 16% of the population live (UNCHS, 1986).

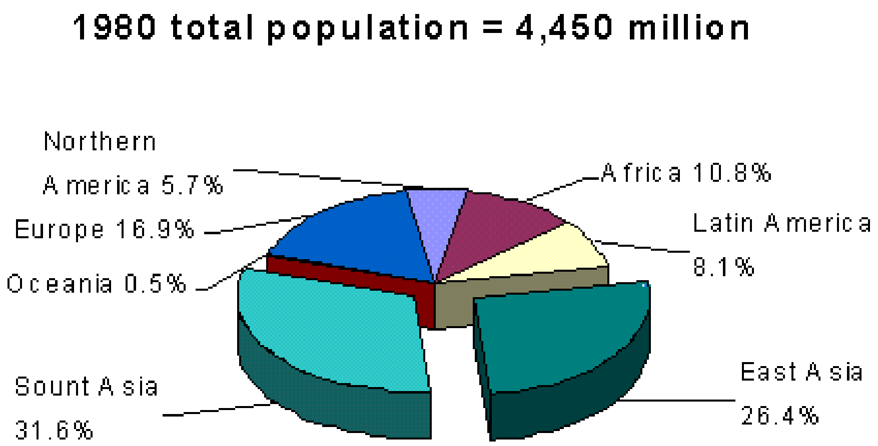


Figure 1.1 World population distribution

Table 1.1 Urban and rural population trends in Asia (1960 - 2020)

Year	All world		All Asia		Urban Asia		Rural Asia	
	Millions	%	Millions	%	Millions	%	Millions	%
1960	2,019	100.0	1,668	55.2	359	23.3	1,309	76.7
1980	4,450	100.0	2,584	58.0	688	26.6	1,896	73.1
2000	6,122	100.0	3,549	58.0	1,242	35.0	2,307	65.0
2020	7,822	100.0	4,365	55.8	2,151	49.3	2,214	50.7

Source: United Nations, 1986

Although the conditions from country to country may show differences, there is at least one common issue: all people need adequate shelter and housing. The provision of affordable housing for the low-income households who are the majority of the population is a serious problem in almost all countries. This is particularly true in urban areas. At present many people are forced to live in slums and squatter settlements and these, given the expected continuing shift of populations from rural to urban areas, will only proliferate. Another study in Addis Ababa estimated that in 1980 a staggering 85% of the population lived in informal settlements. Some Asian cities have only slightly better conditions. In Manila and Karachi respectively 40% and 37% of people live in informal settlements (United Nations, 1980). Of the world's housing stock, 17% consists of one-room shelters, and three quarters of these are to be found in developing countries. In Asia this results in an average of 2.17 persons per room, although in nearly one third of all dwellings there are three or more persons per room. Such statistics conceal more than they reveal, since, as averages, they underestimate the housing conditions of the poor in urban and rural settlements. One-half of Calcutta's families live in one-room shelters devoid of almost all amenities, while in Greater Bombay an estimated 77% of households, with an average size of 5.3 persons, live in one room (UNCHS, 1986).

Even though many countries are making great efforts to provide decent shelter for their people, they are finding it increasingly difficult to keep pace with the demand for housing, be it new housing or replacement housing. Nor can they diminish the backlog. For instance in Pakistan the backlog in housing has been estimated at 6 million units, while the yearly demand, due to population increases, is 240,000 rural houses and 175,000 urban units (Turkpak, 1991). In India the backlog in housing has been estimated at 15-20 million units (Gandhi, 1986). In Thailand the demand for low cost housing in Bangkok was estimated at 250,000 units from 1987 to 1991, however the government sector was only able to provide around 22,000 (CPTRHE, 1988).

Table 1.2 Estimated housing requirements and GDP growth rate

Country	Population in 1989	Pop. annual growth rate (1986)		Est. number of houses required	Annual growth rate GDP % (1986)
		%	millions/yr		
Bangladesh	109.6	2.7	2.959	590,000	3.7
Bhutan	1.4	2.0	0.003	5,000	5.5
India	816.6	1.7	13.959	2,792,000	5.5
Indonesia	176.5	1.7	3.040	608,000	3.8
Myanmar	39.6	1.9	0.767	153,000	5.5
Nepal	18.6	2.3	0.444	89,000	3.4
Pakistan	107.9	2.2	2.427	485,000	6.4
Philippines	59.9	2.3	1.398	280,000	0.5
Sri Lanka	16.8	1.5	0.254	51,000	5.1
Thailand	55.4	1.6	0.899	180,000	5.1
Vietnam	65.4	2.0	1.306	261,000	6.1
China	1113.9	1.2	13.367	2,673,000	9.8

Source: Asia Week (May 1989) and UN World Statistics, 12th Ed.(1988) and consultants estimates.

Photo 1: Semi-permanent house in the Red River Delta, North Vietnam.

Photo 2: Aesthetic building using bricks in Thailand.

Unfortunately, although some data may be available on housing needs for urban areas, similar data are not readily available on the demand for housing in rural areas. However rough estimates can be made of the total demand (urban + rural), which take into account the population increase and assume that the average size of the household is 5 people. Table 1.2 gives an overview of these annual housing requirement estimates. The growth rate in the gross domestic product (GDP) of the countries covered by the Regional Wood Energy Development Programme of FAO is also given.

It is evident, albeit based on an assumption, that the demand for housing is staggering with an estimated 5.5 million units needed for the 11 countries shown in table 1.2 and roughly 10 million units required for the whole of Asia. Besides, given the relatively high growth rates in the GDP in many countries, it can be assumed that a strong demand will continue for institutional, office and industrial buildings.

1.2 Housing and building materials

Economic growth is directly related to the level and efficiency of fixed capital formation. In developing countries, the share of such fixed capital formation in construction is often about 50% of the total but can be as high as 80% (UNCHS, 1986). Therefore, the construction sector may be regarded as one of the backbones of the development process mainly because of its multiplier effect in other sectors of the economy. In many developing countries the annual growth rate in construction is often considerable higher than the growth of population and the gross domestic product. Table 1.3 provides some information on annual growth rates in the construction sector versus GDP and population growth, for a few Asian countries.

Table 1.3 Average annual growth rates of the construction sector and GDP in some Asian countries from 1975-1980 (in percentages)

Growth rate %	Bangladesh a)	India	Korea	Malaysia	Thailand	Vietnam b)
Population	2.3	2.0	1.6	2.4	2.4	2.3
GDP	4.0	3.4	7.6	8.6	7.6	6.1
Construction	5.5	1.8	12.2	12.6	14.3	2.3
GDP/Capita	2.0	1.4	5.9	6.0	5.0	3.7
Const./Cap.	4.4	-0.2	10.5	10.0	11.6	0.0

Source: UNCHS, 1986; BBS, 1990 and SPH, 1990
Note : a) 1985-1987 and b) 1980-1989. Growth in GDP and construction calculated at constant prices

Building materials form the single largest input in construction, accounting for about 50 to 80 per cent of the total value of construction. Although part of the building materials may be imported, there is considerable production of building materials at the local level in developing countries. For many types of building materials, developing countries have improved their share of global production. For example from 1970-1980, cement production in the Asian region increased by 136%, with Indonesia showing a tenfold increase.

For locally produced building materials, notably those produced at the rural level, much less is known. Fired and unfired bricks, clay roof tiles, lime, timber, bamboo, etc. are the building materials widely produced and used within the region. For instance, in Sri Lanka, small scale traditional units produce bricks, tiles, sand, and lime totalling more than 35% of the building materials used in the country, while in China, 80% of building materials, including bricks, tiles, sand, stone, etc. are produced by the traditional sector (UNCHS, 1986).

Bricks in particular as well as bamboo, wood and natural fibers, are important building materials in both urban and rural areas. For instance, in Bangladesh out of about 14.8 million households, 3.7 million or about 25% used bricks (fired and unfired) as wall material, while 9.4 million or about 63% used bamboo and natural fibers such as straw, jute sticks, etc. (SDC-SKAT, 1991). In Indonesia a study showed that in 1976 about 35% of the households studied used bricks as wall material while 63% used wood and/or bamboo (CBS, 1976). Tables, 1.4 and 1.5 show the building materials used for walls as well as roofs in Bangladesh and Indonesia, respectively.

Table 1.4 Housing in Bangladesh specified by wall and roof material (1981)

Roof material	Wall material Total households	Straw, Bamboo	Mud/Unfired brick	C.I.Sheet Wood	Cement, Bricks
All households	14,875,048	9,370,581	2,957,239	1,718,691	738,537
Straw, Bamboo	8,768,975	6,729,353	1,933,904	95,410	19,308
Roof tiles	350,723	73,447	214,230	29,955	33,091
CI Sheet, Wood	5,248,878	2,576,781	809,105	1,593,326	269,666
Cement	416,472	---	---	---	416,472
All urban	2,041,933	1,075,182	223,856	255,139	487,766
Straw, Bamboo	818,931	689,467	108,830	11,619	9,015
Roof tiles	55,787	20,159	18,057	6,774	10,797
CI Sheet, Wood	846,124	365,556	96,959	236,746	146,863
Cement	321,091	---	---	---	321,091
All rural	12,743,115	8,295,399	2,733,383	1,463,552	250,771
Straw, Bamboo	7,950,044	6,030,886	1,825,074	83,791	10,293
Roof tiles	294,936	53,288	196,173	23,181	22,294
CI Sheet, Wood	4,402,754	2,211,225	712,146	1,356,580	122,803
Cement	95,381	---	---	---	95,381

Source: BBS, 1990

Table 1.5 Housing units in urban areas in Indonesia specified by building materials used for wall and roof construction (1976)

Roof material	Wall material Bricks	Wood	Bamboo	Earth	Others	**Total**
Concrete shingles	16,451	697	131	---	101	**17,389**
Wood	33,193	166,081	1,818	158	331	**201,581**
Alum./GI Sheets	152,937	391,340	1,342	44	7,393	**533,055**
Clay tiles	1,363,795	643,760	1,159,615	7,886	11,707	**3,186,763**
Thatch, etc.	16,034	292,927	184,095	9,664	19,366	**522,086**
Other	15,257	10,510	8,170	1,048	5,366	**40,351**
TOTAL	**1,597,667**	**1,505,315**	**1,355,171**	**18,800**	**44,272**	**4,521,225**

Source: CBS, 1976

1.3 Building materials and construction

Building activities can be grouped into three main categories[1]: Modern, Conventional and Traditional. Each category makes its own pattern of demand for building materials. The first category often requires sophisticated and costly building materials. For the other two, the structure of the demand is somewhat different and diversified. The use and choice of building materials by the traditional sector, generally associated with rural areas, is largely influenced by the suitability and local availability of such materials and may show regional variations due to climatic conditions, etc. The conventional sector, often found in urban and semi-urban areas is based partly on traditional methods and materials but mostly influenced by modern sector materials such as cement, reinforced concrete, aluminum, gypsum, etc.

Many developing countries have geared their construction efforts towards the establishment of the infrastructure needed for economic development in the form of highways, major townships, irrigation works, bridges, office buildings, etc., for which building materials often had to be imported. Subsequently, local production capacities were developed in varying degrees, but, as the major construction activities were in the modern sector, production capacities were mainly directed towards more sophisticated capital and energy intensive products such as cement, steel and glass. These production capacities, in general, are large scale, using imported components such as expertise, equipment, and sometimes even raw materials and they are often owned by the government sector. Much less development effort has been geared towards the traditional building materials sector which, again in general, is small scale, locally/privately owned and uses local raw materials and equipment.

Photo 3: Peri-urban low cost housing utilizing soil/lime wall blocks.

This phenomenon is also evident from the energy requirements for the production of building materials. At present aluminum, one of the "modern" building materials requires about 26-30 GJ per ton output, while in the year 1900 about 100 GJ per ton was required (Martyn et al, 1990). Steel and cement have shown similar changes in energy input requirements but here the technological advances have not always trickled down to the field. Steel producers in India and China use about 50 GJ per ton output while their counterparts in Japan and the United States require only about half that amount (WRI, 1992). For the production of bricks however,

[1] The "Modern" construction has been defined as that sector which uses predominantly modern construction materials like aluminum, steel, concrete, glass, etc. "Traditional" construction uses traditional building materials like wood, mud, bamboo, etc. while the "Conventional" building sector uses both types of materials.

the developments have been less spectacular, if there have been any at all. Although in developed countries more energy and labour efficient, computer controlled tunnel kilns have been introduced, in the developing countries hardly anything has changed over the last few decades.

Energy is a critical factor in the production of building materials and may account for up to 50% or more of the production cost of steel, cement, brick, lime, etc. The impact of rising energy prices on the cost of building materials, even in industrialized countries like France and Finland, led to the price of cement increasing by 300 to 400% between 1970 and 1980. Because of their low value/weight ratio, the cost of transporting materials over long distances from production points to consumption points can be as critical as the initial production cost. Developing countries are particularly vulnerable due to the underdeveloped nature of their transportation infrastructure. Thus, it is estimated that in countries like Sudan, Botswana and Honduras beyond about 100 miles, the cost of transportating cement exceeds its production cost (UNCHS, 1986).

The strategy of developing more sophisticated building materials has benefitted mainly the modern, and to a lesser extent, the conventional building sector, e.g. government construction and the more affluent sections of the urban and rural population. The low-income and subsistence sectors are more or less excluded, depriving them of the benefit of the development of improved building materials which are appropriate and affordable for the majority of local people. One could possibly also say that the more affluent section of the population builds houses which last and appreciate in value, while the poorer section of the population builds semi-permanent or temporary shelters that require continual repairs and maintenance and appreciate much less, if at all, in value.

1.4 The use of local building materials

Photo 4: Typical hut made of bamboo and thatch in rural S.E. Asia.

The changes in the building materials industry have had a distinct influence on the way buildings such as houses, etc. are built and the type of materials used, not only in Asia, but in other parts of the world as well. Formerly, most housing and other buildings were constructed out of locally available natural materials and/or materials manufactured locally. These include wood, mud, brick, stone, lime, clay-tile, bamboo, thatch, etc. Although still widely used in rural areas, many of these traditional materials, have been gradually replaced by cement, steel, aluminum, asbestos cement, gypsum board, glass, plastics, plywood, particle board, etc., especially in urban areas.

However, there is still a strong demand for more traditional building materials such as lime, fired clay bricks and timber, although the growth rate in the use of these materials may be lower than cement and iron roofing sheet. Unfortunately, little is known about the traditional construction sector's use of locally-available building materials. In most countries, statistics on the production or use of traditional building materials, as well as construction activities in the traditional (rural) sector are almost non-existent and figures, which are available, are often based on estimates. For instance, for Bangladesh some information is available, based on a study carried out for the World Bank which is shown in table 1.6.

Table 1.6 Gross fixed investment in construction in Bangladesh

Construction type	81/82	82/83	83/84	84/85	85/86	86/87
Pucca building a)	10,772	12,734	15,299	18,010	20,384	23,505
Kutcha building b)	4,282	4,385	4,497	4,585	4,698	4,810
Other public const.	5,694	7,031	6,686	6,753	7,344	7,044
Priv.agric. sector	1,491	1,491	1,491	1,491	1,491	1,491
Irrigation, etc.	649	833	721	440	256	261
TOTAL	22,390	26,474	28,594	31,279	34,173	37,111

Source: SDC-SKAT, 1991
Note : All figures are in constant 1981/1982 prices.
(a) : Pucca buildings are permanent buildings of bricks and/or cement
(b) : Kutcha buildings are defined as those which do not make use of cement or bricks; hence kutcha buildings are made of bamboo, mud, straw, wood, etc. and can be considered as being non-permanent

The share of the *kutcha*[2] buildings in the overall construction sector is based on the (estimated) increase in the *kutcha* housing stock and the average cost of construction of a *kutcha* house. However, no allowance is made for the costs of maintenance and repairs to *kutcha* houses. Table 1.3 also indicates that in Bangladesh about 95% of the total housing stock can be considered as *kutcha* buildings and if the cost of repairs and maintenance were included in the *kutcha* building sector, the share may be several times higher than what is shown in table 1.6. By implication, it can be assumed that traditional building materials do play a more important role than what is shown on the surface, not only in Bangladesh, but also in other countries with large semi-permanent or non-permanent housing stocks.

[2] For an explanation of the terms "kutcha" and "pucca" see the note at table 1.6

A survey carried out in Thailand (Joseph et. al. 1989) indicated that the demand for fired bricks increased by 5% a year. Growth in the demand for cement blocks in Thailand was probably running at a higher rate, while the growth in the demand for asbestos-cement and corrugated iron roofing sheet was even higher. Since corrugated iron and asbestos roofing is more durable, cleaner and safer than thatch, it is considered to be cheaper in the long run even though the first time cost (purchase) is higher. Therefore it has gained wide acceptance and is used by most rural and urban poor, who see roofing as a greater priority than long lifetime walls. It should be noted that in Thailand ceramic roofing tiles for housing are little used (except for temples, and traditionally designed houses etc.), and the only alternatives to thatch in rural housing are corrugated iron and asbestos-cement sheets and, to a much smaller extent, concrete tiles.

1.5 Changes in the use of local building materials

Despite a lack of hard data, it appears that in wood scarce-areas people are moving away from timber construction in favour of other construction materials. To some extent these changes are a result of scarcity, high(er) prices, lower quality and/or irregular supply of traditional materials and the availability of relatively cheap alternatives. But there may be other reasons as well. First the use of concrete and metal structures increases the status of the owner and is considered a sign of being modern.

There are other less obvious reasons for preferring one type of building material over others. For instance, in Bangladesh, users of corrugated iron roofing sheets state that in times of economic hardship, their corrugated iron roof sheets can be sold to raise money, unlike clay roofing tiles which appear to have no resale value. In addition, iron roofing sheets in many cases can be recovered after storms, while other roofing materials may be damaged beyond repair.

One the other hand, the skills necessary for construction with local building materials may have been partly or completely lost. For instance, earth is frequently identified as a non-durable construction material. However, with proper roof overhangs and/or an appropriate rendering of the walls, the lifetime of earth can be very long. In Central and South America massive churches have been built using earth only. Use of excessive amounts of cement to stabilize soils may turn a low-cost building material into an "industrial" product -- too expensive to be considered a real competitor to other local building materials.

Photo 5: Brick laying by unskilled labor resulting in poor quality walls.

The use of fired clay bricks in structural masonry in place of reinforced concrete can be a cost saving technique but unfortunately the use of bricks requires more skill during construction. Brick walls without plaster are cheaper, not only during construction but afterwards as well, as they do not require maintenance such as whitewashing, etc. However skilled bricklayers are necessary to achieve a pleasing look and uniform bricks (straight, no broken edges, etc.) are also needed. However, in all cases local conditions such as the climate should be taken into account. Earth construction for example is less suitable in areas which often become waterlogged. Bamboo should not be used in direct contact with the soil unless it has been properly treated. Roof tiles may have to be fastened to rafters and purlins in areas with strong wind.

Much depends on local conditions. Building materials which are appropriate and/or competitive in one country may not be suitable in other countries. For instance "pozzolana" or hollow cement blocks, widely used in Indonesia, India and Thailand, were a failure in Bangladesh because the blocks apparently were too expensive and/or were considered inferior to fired or unfired clay bricks and other building materials such as bamboo. In India, however, hollow cement blocks won a large market share because the price of clay bricks has been increasing at a much faster rate than cement blocks (per equivalent area). Jagadish (1985) notes that over a 15 year period, the cost of clay bricks has increased more than 3 times, whereas the cost of cement blocks has increased by much less. There may be several reasons for these price differentials. One may be the cost of energy. The oil crisis of the seventies influenced the prices of other energy sources as well. Table 1.7 shows the amount of energy needed for the construction of a wall, measuring 1 sq.m. and 100 mm. thick and plastered on both sides with a 10 mm thick layer of cement mortar.

Table 1.7 Energy input in bricks and cement hollow blocks used for a square meter four inch thick wall

	Brick wall	Block wall
Number of bricks/blocks per sq.m.	50	13
Energy input per brick/block in MJ	a) 6.05	b) 3.80
Total energy input in MJ	302.50	49.40
Energy input in cement for brick laying and plastering on two sides in MJ	c) 64.60	c) 32.30
Total energy input per sq.m. wall in MJ	367.10	81.70

Source: UNIDO, 1980 and SDC-SKAT, 1991
Note : (a) Based on 0.25 kg. coal per brick with a heat value of 24.2 MJ/kg coal
(b) Based on 0.95 kg. cement which requires 4 MJ energy input per kg. cement produced.
(c) Respectively 17 kg. and 8.5 kg. cement required for bricks and blocks

The table clearly indicates that, with regard to energy input, the brick wall is about 4-5 times more energy intensive than the hollow cement block wall. It should be noted that the energy used to transport materials has not been included. Cement, normally produced on a large scale, may have to be transported over much greater distances, making the transportation of cement more energy intensive than bricks, which are often available on the spot. However, even if transportation caused the energy input in cement to double, the energy input differential of cement, when compared with brick, would still be large.

Photo 6: Brick and roof tile firing with wood, Sri Lanka.

New building materials such as lime/pozzolana instead of Portland cement could in many cases, provide a cheaper and equally suitable bonding agent for bricks as well as plaster. In India, about 45% of the cement used in building construction is used in mortar and plaster, all of which could be replaced by lime and pozzolana. Global estimates made by UNIDO (1984) show that only 20% of the world-wide consumption of cement requires the full strength of international standard Portland Cement and lower and presumably cheaper grades could be used equally well. Unfortunately, although the technologies for such substitutes exist and the materials may be used in some countries, there is very little public effort to promote their use or the exchange of information between different countries and regions on their use.

To promote use of new materials, building codes (or codes of practice) in many countries may have to be adapted. In many countries new or improved building materials developed by research efforts never leave the laboratory because their commercialization is hindered by the building codes. Promoting the use of local building materials may encourage producers to increase production and improve the quality of local materials.

Cement, produced on a small scale with lower grades of limestone, can compete with cement manufactured in sophisticated factories. Experience from India shows that, even though the energy input is higher in small scale production (about 100 tons per day TPD) when compared with large scale production (1,500-2,000 TPD), the manufacturing cost is lower. This is mainly due to lower capital, raw materials, labour and transportation costs (Carr, 1988). The same is more or less true for large scale brick production. As table 1.8 shows, large scale capital intensive brick production can not compete with small production units even though the amount of energy required to fire bricks on a small scale may be 2-3 times higher when compared with large modern plants.

Table 1.8 Unit cost of brick production in US cents/brick for different scales of production

Method	Medium wage regime[3]	Low wage regime
Capital intensive, year round	6.5	6.2
"Least cost", year round	3.1	2.3
"Least cost", seasonal production	2.9	2.0

Source: Keddie, et. al. 1980

Another advantage of the small-scale production of building materials is that it often provides much more employment than the large scale sector. Comparing the small-scale manual traditional brick making technology with a moderately mechanized factory, the labour ratio is about 8-10 times higher for the traditional operation (160-200 person-years per 10 million bricks). The mechanized factory required only about 20 person-years for the same output (Keddie et.al. 1980). For cement, the small scale production unit has a labour ratio of about 2-3 when compared with a large modern factory i.e. the small unit generates about 2-3 times as many jobs for the same output as a large scale production unit (Carr, 1988).

1.6 Issues arising

It is certain that in the foreseeable future there will be an increasing need for housing, particularly in urban areas. To provide shelter for all, all construction sectors, including the traditional one should be involved in providing housing for the urban as well as the rural poor. If these poorer sections of the population are to be assisted to build durable as well as affordable housing, part of the focus of attention will have to be on the provision of suitable and affordable building materials.

Unfortunately it appears, that in developing countries the major thrust in the building materials industry has been towards the more "modern" building materials. However, in most countries there is a need for cheap, good quality local building materials such as bricks, wood, bamboo, etc. These are the materials most people are accustomed to. If locally produced using local resources, which are often renewable, the cost of transportation will be low and income will generated at the local level. **Therefore, the development of the local building materials industry should receive better attention.**

The objective of the local building materials industries should be not only to make available the materials traditionally used by the low income sections of the community, but also to modify production processes and construction techniques to enable construction of homes which are structurally more durable and functionally more adequate. As a result, the time and money now spent on continuous maintenance and replacement of non-permanent housing would be reduced or eliminated by the construction of more permanent dwellings. These homes might even eventually become valuable assets for the owners.

---

[3] Low and medium wage regimes arbitrarily set as absolute wages may not only differ from country to country but there will also be differences in wages for different skill levels. Low wage regimes have been assumed to be from about US$ 225 per person year for low skills in rural areas to US$ 750 per person year for skilled work in urban areas. For medium wage regimes wages have been assumed respectively as US$ 500 and US$ 950, both per person year.

It needs to be pointed out however, that it is not always enough to make low-cost building materials available. Secure tenure of the land on which the house or dwelling is constructed is also an important factor which needs attention. Assistance with proven designs of low cost housing, advice on construction techniques, self-help construction, as well as alternative building materials, etc. may also have to be provided to the target group e.g. the low or no-income portion of the population.

It is also clear that the production of building materials on a small(er) scale may have several advantages over large centralized production units. This is true not only with regard to manpower, but also with regard to such things as the availability and cost of the capital required to establish large scale production units, the need for higher skilled personnel, and the need for a more elaborate marketing system etc. However, there are also disadvantages to small scale production. One, and probably the most important disadvantage, is that building materials produced on a small scale are often substandard. For instance, although most countries have industrial standards for bricks, in many cases bricks are non-standardized, resulting in losses due to irregular shape, low strength, etc.. Larger amounts of cement are required, not only for brick laying but also for plastering to cover up the irregularities of the bricks.

From the environmental point of view, it appears that the traditional building materials such as bricks, tiles, timber, etc. are less of a problem than the "modern" building materials. The exploitation of the raw materials used for the production traditional building materials (clay for bricks and tiles, etc.) often requires very little energy (mostly manual). In the case of raw materials for the production of "modern" building materials (limestone for cement, bauxite for aluminum, petro-chemicals for plastics, iron ore for metal, etc.) exploitation and transport of the raw materials is in most cases energy intensive. In addition exploitation raises dust, which results in local air pollution. The production of "modern" building materials is also often associated with air pollution. Although the energy required to produce some of the traditional building materials may be higher than those for "modern" building materials, most (but not all) of the traditional building materials are produced using low or non-sulphur energy sources in the form of wood and agri-residues. Production of traditional building materials is therefore less harmful than the oil and coal used for the production of cement, iron, etc. Although indiscriminate cutting of trees for fuel and construction can be considered destructive, trees can be managed as a renewable resource, unlike coal, oil, and gas etc., which are non-renewable.

Although in many cases, bricks are more expensive than other competing building materials such as concrete blocks, bricks are often preferred. During discussions with users and contractors, bricks were often considered stronger than other wall building materials, having superior thermal properties, a long service life and they are pleasing to the eye. Besides, bricks are based on a local resource that can be easily obtained and processed, using a minimum of capital investment while employing a large number of people such as brick makers and brick layers. Compared with concrete and steel, brick is relatively cheap, although the price of the brick does depend on the quality. Bricks are also an important road base material in places like Bangladesh.

Some studies carried out on preferences for building materials have concluded that bricks are superior to other materials. A study carried out in Indonesia showed that in the Solo region (Central Java), people universally preferred bricks as a wall material. However, within the lower income group bamboo and wood were preferred possibly because these materials, in particular bamboo, could be obtained locally almost "free" of charge from homesteads, village forests, etc. (Deserco, 1981).

Bricks are produced at the cottage, village and rural enterprise levels[4] with production technologies which vary with the size and scale of the producer. At the cottage and village levels, the technology, in general, is simple; bricks are hand-molded, sun dried and then fired in a pit or clamp kiln. The thermal efficiency of the firing is low as is the quality. At the other end of the range of available technologies are those such as mechanical clay mixing and extrusion, automatic wet brick handling systems, controlled drying and continuous firing systems. However the latter are only used at the level of large rural enterprises which in general, are located near urban centres. In between the simple and the advanced methods of making bricks, are a range of intermediate technologies.

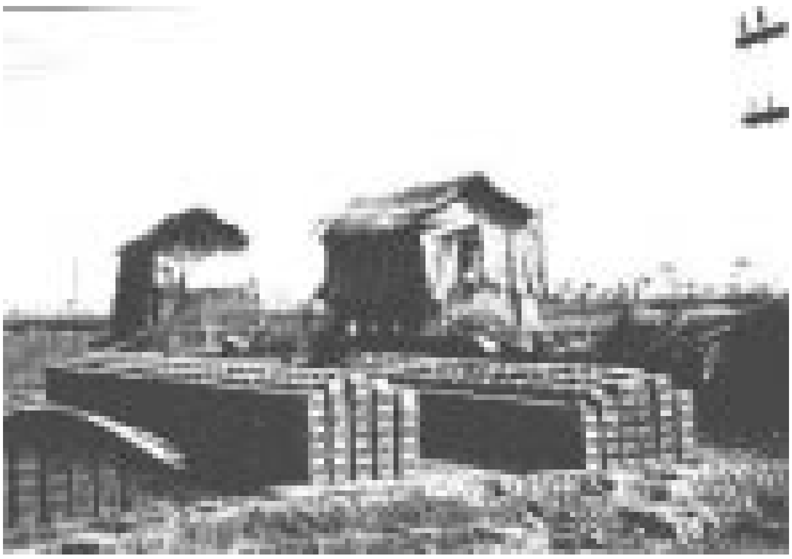


Photo 7: Small scale brick manufacturing, a recent phenomena in the urban construction boom, Hanoi.

A series of studies on wood based energy systems in rural industries and village applications in some Asian countries[5], commissioned by FAO, found that the brick industry is energy and labour intensive and it creates a large number of jobs, particularly during the slack agricultural season. Compared with the production of other materials such as metal, aluminum, etc., investments required in the brick industry are relatively low and the industry relies on local raw materials rather than imported ones. However, it was also found that the brick industry is facing a number of problems. These include increasing costs and shortages of fuelwood, increasing cost of alternative fuels such as rice husk and coal, problems finding adequately skilled labour, lack of extension services to assist owners to develop or adopt more efficient production technologies, lack of cooperation among brick makers, lack of formal training, competition from the concrete industry, etc. This constrains both the level of production and the ability of the industry to compete.

---

[4] For detail on the rural industries' classification, please refer to FAO/RWEDP Field Document No. 7 (1988).

[5] Please refer to those FAO/RWEDP publications in the reference list.

The studies also found that there were other economic, technical, institutional and social constraints preventing the brick industry from meeting the growing demand for housing. Following these studies, an expert consultation was held in Hatyai, Thailand (FAO, 1990). Participants concluded that there was a lack of data on the role of rural industries in the overall rural economy and, in particular, on energy use in these industries. The meeting recognized that the brick industry was one of the energy intensive industries that needed further investigation.

As a result of these conclusions, as well as the apparent preference for bricks as a building material, FAO decided to carry out some more detailed investigations with regard to the brick industry. Efforts to make bricks more cost effective compared to other locally available wall materials could go a long way in assisting the low-income segment of the population in acquiring affordable and durable housing. The brick industry could also provide jobs for local workers. The present study was commissioned to fill in some of the gaps in knowledge as well as to address the pressing issues and problems which concerned planners and policy makers about this industry. The issues that are considered important and need to be addressed in the brick industry are:

1) If brick is an acceptable and/or preferred material for housing, then what are the major constraints to the growth of the industry and to improvements in quality and reductions in the cost?

2) What is the environmental impact of the brick industry and can it be minimized?

3) Is energy the major constraint in the provision of building materials such as bricks, or are there other technical, social, cultural and economic factors which influence the production of building materials and the building industry?

4) Considering the constraints faced, how can public assistance be provided to the industry to overcome these constraints?

Photo 8: Firing of traditional rectangular brick kiln, S. Thailand.

2. THE NATURE OF THE BRICK INDUSTRY IN ASIA

A wide variety of brick making technologies are used throughout the developing world. These vary from very simple manual operations which use age-old clamp or scove kilns, to the sophisticated mechanized, and nowadays computerized technologies which utilize tunnel kilns. The latter, although common in developed countries, are rare in developing countries. This is mainly due to the initial cost, which may be as high as 1-2 million US$, which make bricks expensive due to the high share of capital in the overall production cost. However, in between these two extremes and slowly emerging in Asia and many other developing regions, are the semi mechanized factories, which use extruders and more sophisticated kilns. Each technique has its benefits and corresponding cost which, due to the scope of this paper, cannot be covered in depth. Table 2.1 below gives a brief summary of some of the differences between technologies in terms of output, labour requirements, investments, etc.

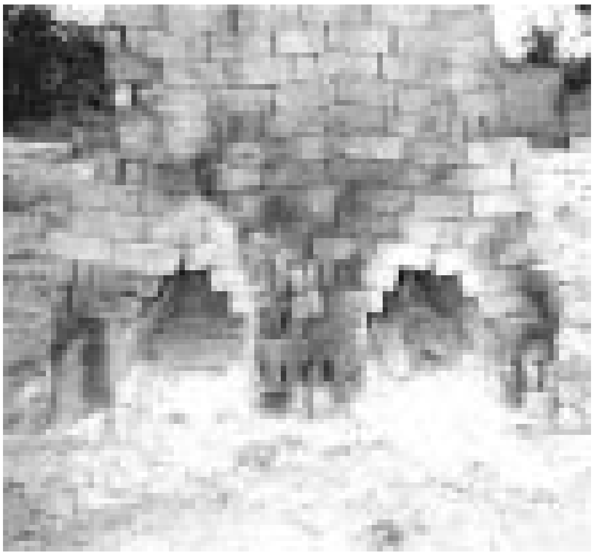


Photo 9: Very small rural brick clamp, Sri Lanka.

Photo 10: Large scale brick field operation, Dhaka Bangladesh.

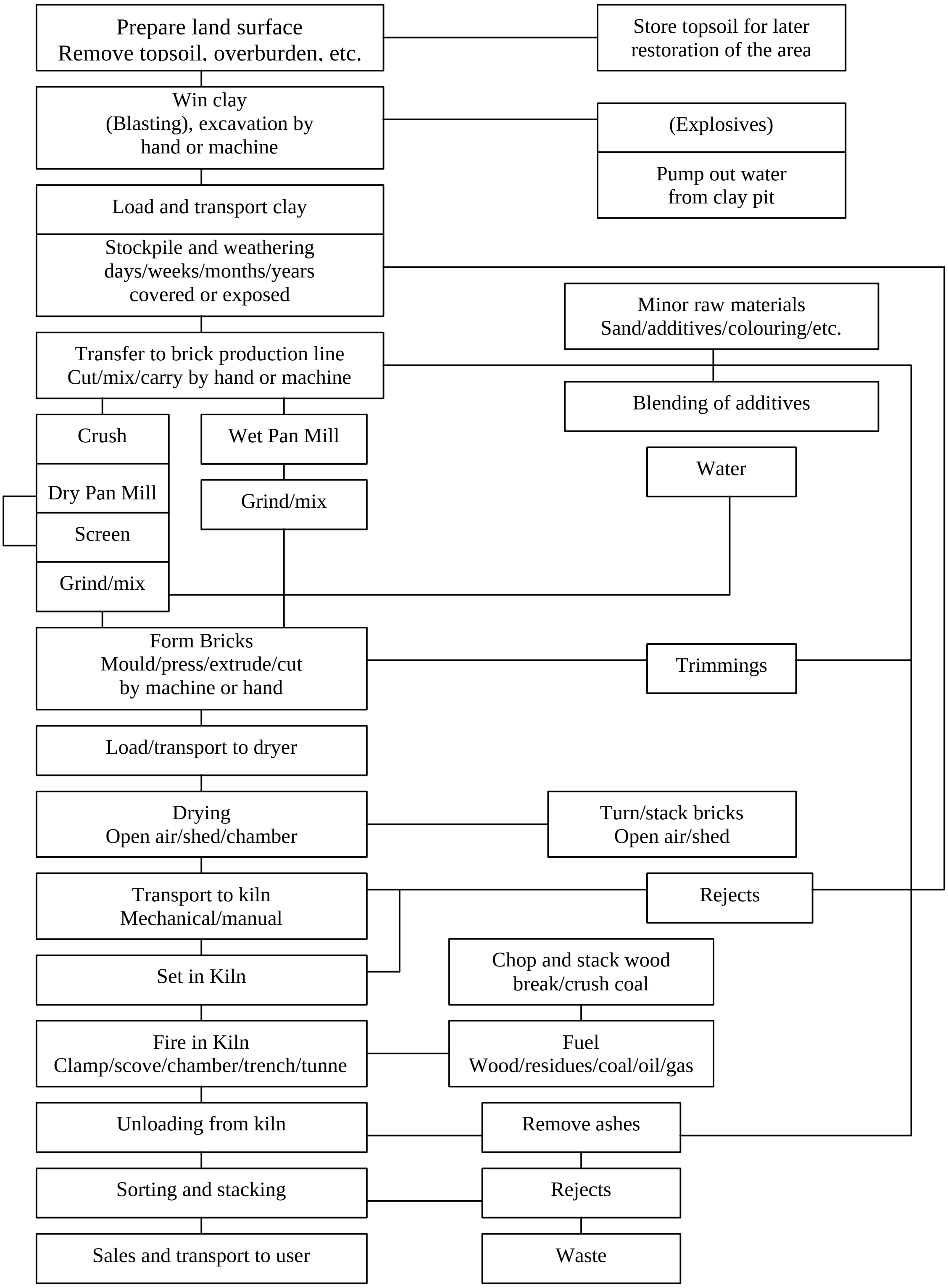
Table 2.1. Summary of basic difference between different scales of production

Input/Output	Scale of Production			
	Cottage	Village	Rural	Modern/Urban
Capital cost '000 $	< 0.5	0.5 - 10	10 - 100	> 100
Output '000 bricks/yr.	< 100	100-1,000	< 10,000	> 10,000
Labour hours/'000 bricks	40	20 - 30	15 - 20	< 5
No. of people employed	<7	< 20	< 100	> 100
Quality control	None	Little	Some	High
Fuel type used	Res./Wood	Wood/Res.	Wood/Coal	Gas/Oil/Coal

Source: ILO (1984)

The production process of bricks can roughly be divided into several major steps: Clay digging, Clay preparation, Forming or Molding, Drying, Firing and Distribution. Figure 2.0 shows the different steps with some options available for each step. It should be noted that in principle many combinations of technologies are possible. A large number of papers and monographs which describe the technologies and techniques used for brick production are available, and the most significant information sources are listed in the bibliography. For this reason, brick making technologies will not be covered in depth in this report.

Figure 2.1 FLOW DIAGRAM FOR BRICK MANUFACTURING



Source: Keddie et al, 1980

2.1 Basic statistics on brick production in some Asian countries

The Regional Wood Energy Development Programme (RWEDP) of FAO has commissioned a series of broad based field studies on wood based energy systems in rural industries and villages in Asia. These studies, which involved many country experts, however, provided only brief descriptions and statistics on the brick industry. Besides the RWEDP studies, several studies have been carried out by other organizations and these, as well as the RWEDP studies, form the basis of the information presented in Table 2.2.

Table 2.2 Data on brick industries in some Asian countries

	Country				
	Bangladesh	India	Indonesia	Nepal	Pakistan
No. of brick units	> 3,000	115,000	> 45,000	442 *	> 3,000
Production in million	3,000	> 50,000	4,100	627 *	11,000
Energy use '000 t/y					
- Fuelwood	2,000	300	1,000	N.A.	75
- Oil/Gas	N.A.	N.A.	6	N.A.	N.A.
- Coal	108	14,000	N.A.	N.A.	3,120
- Residues	N.A.	N.A.	600	N.A.	N.A.
Labours '000	130	1,500	125	50	250
Production/labour	23,000	33,500	32,800	12,500	44,000
Population in million	109.6	816.6	176.5	18.6	107.9
Brick use/capita	27	61	23	34	102

Sources: Bangladesh - SDC-SKAT, 1991; India - Gandhi, 1986 and FAO, 1989d; Indonesia - World Bank, 1987; Nepal - de Lange, 1989; Pakistan - Turkpak, 1991
*Note : N.A. No data available, * denotes formal sector only*

The data above, although limited and often based on estimates, indicate that the brick making industry in the five countries covered currently employs more than two million people directly in production, and probably many more are employed in related activities such as transportation of clay, fuel and bricks, sales, as well as in construction as brick layers. The same table also gives some information on average per capita brick consumption as well as average productivity per labour. Large variations in both averages are found, in particular in the number of bricks produced and/or used per capita. The production per labour shows smaller variations, but Nepal shows a much lower productivity. There is no real explanation for variations in the averages other than the scale of operations and the influence of other traditional building methods. Probably more important is the fact that most, if not all, of the data on the brick industry are based on estimates and sometimes "guesstimates". A major conclusion which can be drawn from this is that, in order to provide assistance to the industry, better insight will have to be gained with regard to the industry itself.

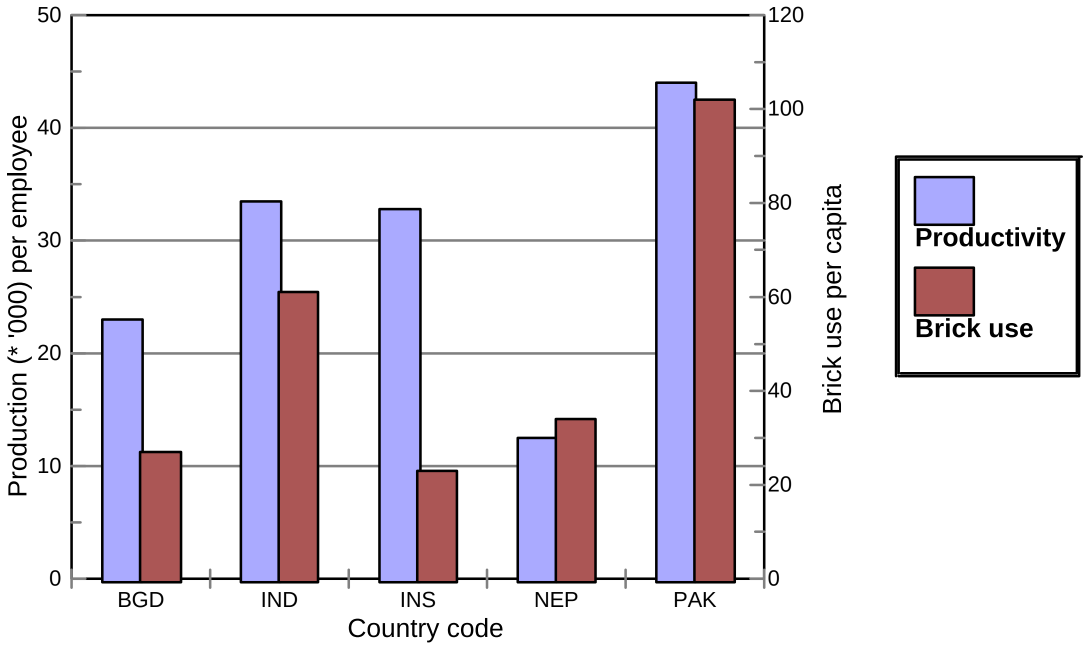


Figure 2.1 Brick productivity and brick use

2.2 The Asian brick industry: A profile

Within Asia, the brick industry is diverse, ranging from very small manually operated seasonal units, to very large mechanized units with year round operations. Although there are many commonalities, there are also distinct differences between countries which will be illustrated by some of the studies referred to previously.

2.2.1 Bangladesh

The Brick Manufacturers Association (BMA) estimates that there are approximately 2,500 brick manufactures, each producing about 1 million bricks/year on average. The largest units can each produce about 5-6 million bricks per year. Most brick production units are located in rural and semi-urban areas while the larger plants are often concentrated near urban centers. It is believed that a sizable but unknown number of smaller units are also scattered in rural areas, meeting local demand when required. The annual production of bricks has been estimated at about 3,000 million bricks per year (SDC-SKAT, 1991).

A national standard for building bricks exists in Bangladesh but most of the bricks produced do not comply with the standard on one or more of its specifications. The brick size varies not only among different manufactures but between batches produced by the same factory. While the standard size is 240 x 115 x 70 mm, the actual size may range between 225-250 mm long, 115-125 mm wide and 65-75 mm thick. Bangladesh has very limited supplies of natural stones, and bricks are widely used not only for housing construction but also extensively for construction of roads, pavements, bridges, irrigation structures and as aggregate in concrete mix, etc.

In the past, most brick factories were located very close to the areas where the clay was obtained, but at present most of the clay is transported by boat or other means to the factories which are often located close to roads or water ways. Regulations exist which prohibit the removal of more than one foot of clay from the land. However, in practice, much more is taken away. Farmers who rent out land for clay removal, in general, claim that agricultural output is only affected for one year and that by the second year, output is back to normal. This is probably due to regular flooding of the land which results in silt deposits.

Photo 11: Bull's Trench brick kiln, a common sight near urban markets.

Most of the bricks are still hand molded. Mechanical equipment driven by ox or mechanical power are almost always used in clay preparation. While almost all the brick factories operate only during the dry season, a few, mainly mechanized factories which use extrusion or dry pressing, operate year round. Bricks are dried in the open air. If sudden rains occur, a large part of the production will be spoiled. Almost all the operations are manual, ranging from bringing the clay to the pug mill, to the molding and drying ground, to the kiln and from the kiln to the warehouse. Brick production is labour intensive and it has been estimated that an individual producer can dig, mix and mould the clay for about 350-400 bricks per day. A team of two people (one clot maker and one molder) can mould about 800-1,000 bricks per day.

Photo 12: Hand molding of brick is often carried by women and children.

Few women are involved in the skilled labour aspects of brick making but some are employed in unskilled work such as transporting the bricks to and from the kiln etc. However, a large number of women are involved in the production of brick chips e.g. crushing bricks into small pieces to be used for other purposes such as aggregate for concrete, etc.

The small brick works normally use clamp kilns while the larger factories almost exclusively use Bull's Trenches. The brick industry is energy intensive in Bangladesh and energy accounts for close to 50% of production costs. Bricks are fired using various sources of energy. These include fuelwood, coal, and natural gas. Fuel oil is also used but limited to only a few factories. Natural gas is the cheapest energy source for the brick industry but it was banned for use by the non-mechanized brick industry. The ban lasted two years and gas can be used again by those brick industries which are near the gas distribution network around e.g. Dhaka and in the eastern part of the country. Fuelwood can also be a cheap fuel depending on its source, has been banned as a source of energy but it is still widely used by the industry as is evident from estimates from the 1987-1988 season when approximately 50% of total production was thought to be produced using wood as fuel. Coal is also widely used but from time to time there appear to be problems with coal's availability as well as with its quality, which apparently has deteriorated in the last few years. The amount of energy required to fire bricks varies, depending on the fuel type used. If fuelwood is used to make fired brick, 2.8-4.3 MJ/kg. is required while for all other fuels it ranges from 1.5-2.8 MJ/kg.

Photo 13: Making brick chips as a substitute for stones in concrete mix. A task often for women and children, Dhaka.

Fired bricks are visually sorted into first, second and third grades which represent 60-70%, 10-30%, and 10% of production respectively. In addition, about 10-15 % of the bricks may be over- or underfired. Bricks are normally sold at the factory to contractors and individuals, as well as at wholesale/retail shops. The average sales price (1990-1991) is approximately Taka 1,800 - 2,000 (US$ 50 - 55) per 1,000 bricks, depending on the grade, while the production cost is estimated to be around Taka 1,750 or US$ 48 per 1,000 bricks. Bricks made by the few mechanized factories are of a higher quality (straighter, smoother, stronger, etc.) than the hand molded bricks and command a price which is about 20-30% higher. These bricks, in general, are used for the more prestigious buildings as well as by the more affluent population in urban areas.

Besides the cost of energy, which accounts for about 50% of production costs, labour accounts for about 25%, while raw materials, maintenance, depreciation and overheads account for the remaining 25% of production costs.

Photo 14: Traditional clay mixing using an animal powered pugmill, Dhaka.

Most of the brick factories are owned by the private sector. In general the private owner leaves the day to day running of the unit to a manager or supervisor. A Brick Makers Association (BMA) exists in Bangladesh, in which an estimated 50% of the owners of the brick fields participate. The BMA does not provide technical or any other assistance to its members, but is basically a political lobbying group trying to convince the government of Bangladesh of the importance of the sector. However, much still has to be done because brick making is still not considered an "industry" and as a result it is subject to all kinds of restrictions. For example, the price of natural gas for brick burning is considerable higher than the price for other industries. In general it can be said that the industry is very tradition bound. Very few changes, other than the introduction of gas firing, have been introduced and/or tried out in the past, unlike in India for instance, where high draught kilns, kiln adaptations, extrusion, etc. have been introduced. However, it should be noted that there appears to be no research institute involved in the clay based industries and the brick industry has to more or less fend for itself, which may be a reason why few innovative actions have been undertaken.

It should be noted that most brick makers think short term. At the start of the season they work out their financing for that particular season. Any investment required that has a payback of more than one or two years (at most) is not likely to be seriously considered by the owner.

2.2.2 India: Delhi area

Brick production in India is widespread, and altogether an estimated 115,000 brick making units are thought to exist in India. Out of these about 15,000 are larger units, which use continuous kilns (mainly Bull's Trench). The remaining kilns are of the intermittent type e.g. clamp, scoved, scotch kilns, etc. The Union Territory of Delhi has over 300 brick making units, almost all using Bull's Trench kilns of varying types and capacities.

Local clay is used to produce bricks. Sand is sometimes added to get the right properties. An average factory which produces about 4 million bricks per season, usually has a clay pit measuring about 15 acres (from 5-35 acres). This pit has a lifetime of about 10 brick making seasons, after which the brick factory is moved and the existing kiln is abandoned. Bricks are normally produced only during the dry season, which lasts from 4-6 month.

Digging, mixing, molding, etc. are all manual operations. Both men and women are employed but, in general, the women are only employed for unskilled tasks such as the transport of bricks to and from the kiln. It has been estimated (Gandhi, 1986) that, on average on a piece rate basis, one worker can produce 1,000 bricks per day (over 8 hours), which includes clay digging, mixing as well as molding. A few factories exist which use extruders and a modified Bull's Trench kiln called a "High Draught", which saves about 30% fuel (12 tons of good quality coal versus 18-23 tons of average grade coal, per 100,000 bricks). Different parts of the kiln generally produce different qualities. Near the roof of the kiln, along the side walls and the floor of the kiln third grade or *"seyam"* bricks are produced while the core of the kiln, which is well fired produces *"avval"* bricks. In between these two, the second grade bricks or *"doyam"* are found. After sorting, about 60-65% of bricks are first grade, 20% second grade, 15% third grade and about 5% is waste (underfired, overfired, broken, etc.).

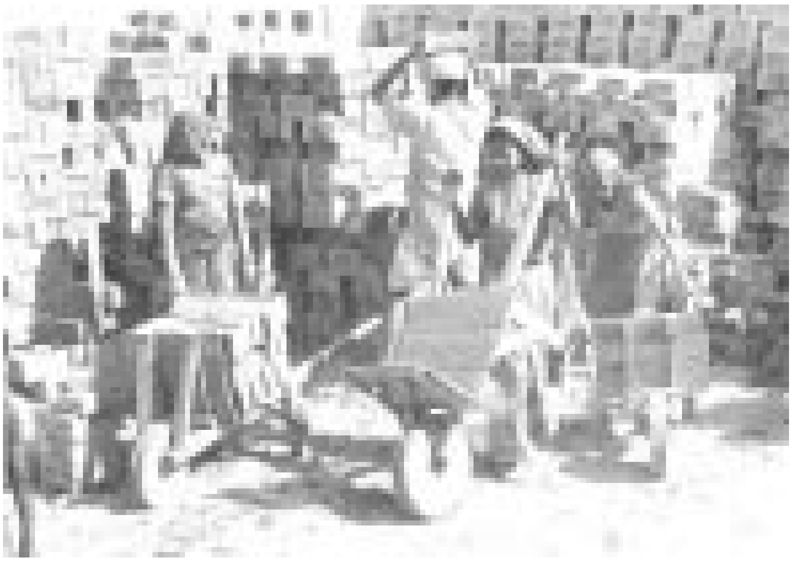


Photo 15: Unloading of bricks from kiln, Delhi.

The selling prices vary, depending on the price of coal (subsidized or not) and first class bricks fetch Rs. 182 (US$ 14) per 1,000 bricks (government controlled price). On the free market, however, the price could go up as high as Rs. 290-300 (US$ 22-23) per 1,000 bricks. The government controlled price tends to remain the same for a period of about 2-3 years, while production costs continue to rise (Gandhi, 1986).

Coal is the most widely-used fuel in the brick industry, with almost all kilns (307 out of 312) in the Delhi area using it for brick firing. Besides coal, other fuel types are also used such as fuelwood (214 of 312 kilns), saw dust (5 out of 312 kilns), rice husks (19 out of 312 kilns) and agricultural residues or *"khali"* (6 out of 312 kilns). As is apparent, many kilns use mixed fuels, depending on availability, price, etc. and in fact, out of the 312 kilns, 2% use coal only.

Overall there appear to be problems with the energy supply. Brick makers complain that good quality coal is difficult to acquire while alternative energy sources, such as fuelwood, etc. show an increase in price. This forces the brick makers to use other alternative fuels such as rice husks and agricultural residues. However, many brick makers are of the opinion that these fuels are inferior to coal and fuelwood. Because these other fuels result in an inferior brick quality, brick makers are very reluctant to use these fuels. Some information collected in 1985/1986 summarizes the views of the owners of the brick works with regard to brick making. Table 2.3 gives an overview of these concerns, obtained during discussions with 40 different brickfield owners. This study shows that labour and energy are major problem areas.

Most kiln owners are traditionally-minded and tend to think short term. Comparisons made between firing with different fuels, as well as different types of Bull's Trench kilns (oval, round, fixed chimney, morable chimney, chimney on the kiln wall, etc.) showed that considerable savings in costs could be obtained. However, a lack of understanding of the underlying principles of combustion exists. Besides, most brick field owners think only about immediate financial returns and anything that may carry a risk and/or require additional investment, is generally not acceptable.

Table 2.3 Review of specific concerns with regard to kiln operation

Problem/Topic	Major concern	Concern	No problem
Lack of skilled labour	24	14	2
Labour shortages and strikes	39	1	--
Fuel availability	34	6	--
Fuel quality	31	9	--
Increases in fuel cost	30	10	--
Fuel efficiency of the kiln	26	7	7
Low output of first class bricks	1	36	3
Government coal distribution system	1	13	26
Government labour laws	5	24	11
Government taxation policies	10	20	10
Financing	1	26	13
Marketing	7	27	6

Source: Gandhi, 1986

2.2.3 Indonesia: Java

Photo 16: Manual brick forming works, Bali.

Most of the brick production in rural areas of Java, Indonesia, is carried out by cottage and village industries accounting respectively for 24% and 43% of total production. The remaining 33% is produced by relatively large scale brick plants. These cottage and village producers can vary from 20,000 to 200,000 bricks a year, with the average output of the cottage industry being around 40,000, and the village industry around 150,000 (World Bank 1987).

Clay is either dug up from the owners' land or from fields that have been rented from neighbours. Clay is often not transported. This is particularly valid for small scale units, which produce bricks near the clay pit. The dry bricks are either transported to the kiln or are fired in a temporary kiln built on the site. Bricks weigh from 1.3 to 2.2 kg. per piece, depending on the size, and are usually made by small teams of people, with 2 people being able to dig, mix and mould 500 bricks a day.

Small production units normally use their own labour (family members) and only occasionally employ hired labour, while progressively larger units often rely on hired labour. Although most of the hired labour is male, female workers are also common, particularly in family-run enterprises. Nearly all units, probably with the exception of the smaller units, have drying sheds as well as covered kilns and, in principle, they can produce most of the year round. However, during the rainy season and during harvesting time, owners of brick factories find it difficult to attract sufficient labour because the wages they offer tend to be low. As a result, production is often seasonal.

Updraft kilns in the form of clamps (mostly scoved clamps) and scotch kilns, are used to fire the bricks but large producers use Hoffman or Tunnel kilns. Some brick makers do not own a kiln but rent one from another producer or sell the unfired bricks to another brick producer. Fuelwood and/or rice husks are the main fuel types being used, with rice husks becoming the dominant fuel for many smaller units, while the somewhat larger units use both fuelwood and ricehusks, depending on availability. The continuous kilns normally use oil or coal. The fuel efficiency of the updraft kilns does not vary much (the average is around 2,200 MJ/ton of bricks). The modern continuous kilns consume around 1,700 MJ/ton, but are firing to a higher temperature (900°C. as compared to about 800°C. for traditional updraft kilns).

Although little data is available, it appears that fuel availability is becoming a significant problem for those enterprises that are burning wood. Rice husks therefore become more and more important, but the main drawback with this fuel is that during the firing process very little control can be exerted, which is not the case with fuelwood. Using rice husks as fuel instead of wood can be financially attractive because 1.5-2 times the amount of useful energy can be generated for the same price even when the very low conversion efficiency for rice husk firing is taken into account (Koopmans, 1986).

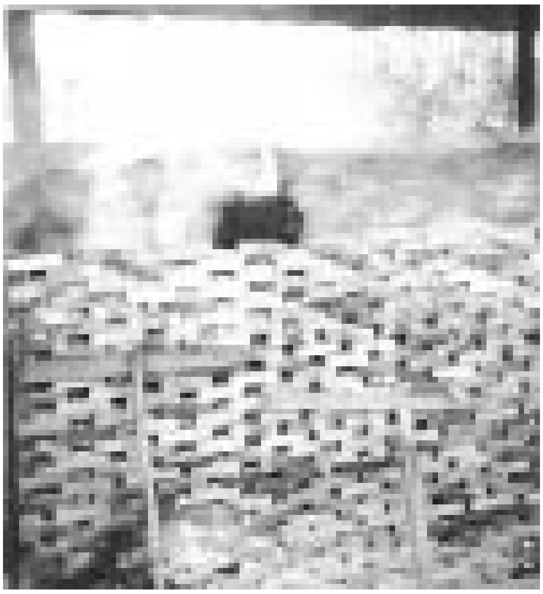


Photo 17: Ricehusk-fired clamp, Indonesia.

The industry, (particularly the small scale units), often face problems finding working capital which force producers to buy raw materials on credit, borrow from money lenders, pre-sell the bricks or produce on order only. In all cases their production costs are higher than those who do not face the same problems. Bank schemes exist to assist the small scale sector, particularly with low cost financing, but in practice, because collateral is required, the smaller producers have no access.

Energy (35%), direct labour (26%) and raw materials (13%) appear to be the principle production costs, while depreciation, maintenance and indirect labour (supervision) account for the remaining 25% of costs. For those producers who have bargaining power because they have their own resources (financing, access to their own clay and fuel, etc.) brick making may be profitable, but for most of the smaller brick makers, it appears to be a marginal business, in particular for those who have problems obtaining working capital.

No data is available on the role of women in the brick industry, but superficial observations have shown that they are involved in all stages of the brick manufacturing process as well as in management.

2.2.4 Nepal: Kathmandu valley

Brick making in the Kathmandu valley ranges from small to large scale. There are about 100-200 intermittent kilns which have capacities ranging from 40,000 to 100,000 bricks per firing, along with 80-90 Bull's Trench kilns. In total these account for about 270 million bricks per year. One factory, which uses extruders and Hoffman kilns, is known locally for its "Chinese technology" because the factory was set up with Chinese assistance. Many people prefer a house made out of "Chinese" bricks because of their bright colour and smooth surface. Because the bricks are more expensive than the hand molded ones, owners gain a certain status (de Lange, 1989). Recently a complete new type of kiln was introduced, a vertical continuous kiln, and initial experience has shown that this kiln is highly energy efficient.

Photo 18: Chinese designed vertical shaft brick kiln in trial, Nepal.

In general bricks are only produced during the dry season (December to May) but in some areas the brick-making season may be as long as 8 months. Brick making is manual although there are some semi-mechanized factories operating.

The brick factories are normally located at or near a clay pit, which lasts for about 5-10 years. When the clay pit is exhausted, the whole brick making unit is moved. Bricks are produced by small groups of 3-4 people, who are often a family. They live on the premises in temporary shelters and take care of all aspects of the manufacturing process from digging the clay to drying the bricks. A family produces about 1,000 bricks per day (250-350 bricks per person per day) and is paid NRs. 1,000 (US$ 30-35) per 1,000 dry bricks. A brick measures about 22-23 cm. by 11 cm. by 5-6.5 cm. and weighs approximately 2.05 kg. when fired. Transport of the dry bricks to the kiln and of the fired bricks to the warehouse is carried out by unskilled labour (men as well as women). Setting of the kiln and firing the kiln, important parameters which will influence the quality of the bricks, are normally entrusted to skilled teams from India.

Not much is known about energy consumption as answers obtained during a survey showed very large variations which, presumably, may have something to do with the different coal types used (low grade Nepali coal or high grade coal imported from India, mixtures of coal and fuelwood, etc.). The supply of fuel is often problematic. The fuelwood situation is an area of concern in Nepal, not only for the brick industry but for all sectors (industry, domestic use, etc.) which use it extensively. Nepal, being landlocked and having only small deposits of low grade coal, depends on India for supplies of fossil fuels. Disruptions in transport and other factors can wreak havoc on the supply as well as the price of fuel.

Photo 19: Due to scarce local energy sources, imported coal dust from India is used for firing in Kathmandu valley.

Little is known about production costs but superficial calculations show that fuel accounts for about 43% of the selling price of Nrs. 800 (about 25-30 US$) per 1,000 bricks. Labour accounts for about 23% of the selling price, while the remaining 34% covers raw material, maintenance, overhead, taxation, profit, etc.

Some "High Draught" kilns with extruders have been installed, based on a design from the Central Building Research Institute in Roorkee, India. The owners claim that a better product is produced and that the kiln is more fuel efficient, however, at least one owner has converted his kiln back to the traditional setting pattern because his workers found the zig-zag setting pattern required for the new kiln too difficult to master (de Lange, 1989).

2.2.5 Pakistan

The brick industry in Pakistan resembles those of Bangladesh as well as India. The technology used and the products made, etc. do not show large variations from neighbouring countries. A study carried out on behalf of the Government of Pakistan shows that there are over 3,000 brick making units in the country with the majority (over 50%), located in Punjab province. The industry appears to be growing at an annual rate of about 3% resulting in the setting up of numerous new factories although, for various reasons, many factories are also going out of business.

The total annual production has been estimated at over 11 billion bricks which are produced by large factories which each produces 3-4 million bricks. These factories are far larger than those encountered in other countries such as Bangladesh and, to a lesser extent, India. Over 800 factories have production capacities larger than 6 million brick per year. A slightly larger number of factories have capacities below 3 million bricks per year. The remaining 1,200 factories produce from 3-6 million bricks per year. Besides the Bull's Trench kilns, intermittent kilns, locally known as *"bathis"* or *"avis",* are also common, in particular in the more remote areas of the country.

Brick production is manual in most cases, but there appears to be an interest in mechanization, as labour, in particular skilled labour for molding, setting and firing the kiln, is becoming more difficult to find. "Bonded labour" however, is still common and bonding restricts the mobility of labourers.

The brick industry is quite energy intensive and it has been estimated that when only fuelwood is used, the cost of energy accounts for about 43% of production costs. In general, labour accounts for about 35% (Turkpak, 1991). Unfortunately no break down for the production costs of bricks fired by coal (by far the largest number) are available. Besides coal and wood, other fuel types are also used. These include saw dust, fuel oil, rice husks, etc. The selling price of the bricks, which measure about 23 by 11 by 7 cm. is quoted as Rs. 500 per thousand, which is equal to about US$ 20-21 per thousand bricks (Turkpak, 1991).

The industry is facing a number of problems. The first and probably the most important, is the supply of reasonably priced fuel in the form of fuelwood as well as coal. At present Afghan refugees supply a large part of the unskilled labour required for brick making in certain parts of the country. Once the Afghan problem is settled, these workers may leave, resulting in a serious disruption in the brick making industry. A second major problem is that the industry is not well organized and actually very little is known about it and few engineers and scientists have taken an interest in the industry. Likewise, the banking sector, as well as the Government, treat the industry as a "foreign discipline", and as a result little financing is made available to the industry in the form of loans, even though brick making accounts for about 1% of the Gross National Product (GNP), and the industry is more or less equal in size to the cement and mining industries. Part of the brick production e.g. those produced in *"avis"* or intermittent kilns are often barred from use in government construction because their quality is considered inferior to those made in continuous kilns. Various taxes, unjustified levies, etc. appear to be common, in particular for fuelwood and its transport, which is an added burden to the industry.

2.2.6 Thailand: Surat Thani

Surat Thani is a province in southern Thailand, approximately 600 km. from Bangkok by road. The province has a population of about half a million of which 90% live in rural areas. Income is mainly derived from the production and processing of rice, rubber, palm oil, coconut and timber as well as fishing. Due to low agricultural prices, the province has a much lower per capita income than other southern provinces.

The province has an established clay brick industry, with approximately 20 brick making plants of widely differing capacities (from 0.7-13 million bricks annually, each weighing about 1 kg.). The bricks are 50 or 75 mm. wide and 30-35 mm. thick. Both types have a length of 185 mm. The production share of the two different sizes is about the same. Another smaller solid brick, locally called *"mon"* brick, is also manufactured if specially ordered. After rendering/plastering, the resulting overall thickness of a wall is 100 mm. This appears to be standard for walls of 3-4 m in length.

About 700 people are directly employed in the brick industry and at least another 5,000 are employed indirectly as brick layers, fuelwood cutters/suppliers, clay miners, transport workers and brick retailers. The larger units are located near urban centres, with minor plants in the less populated areas. Overall indicators suggest that the manufacture of clay bricks is viable. The demand for the product is buoyant at present due to the promotion of tourism and rapid urbanization. This building boom has resulted in a considerable shortage of labour. A number of brick plants have shut down recently but these have been replaced by two new plants, one medium sized and the other very small. Six plants have been selected at random for further study.

All six factories have been equipped to manufacture extruded bricks. The extruders are made locally, as they are elsewhere in Thailand, and are fabricated from steel plate with power provided by second-hand diesel engines. The machine elements installed in all plants were the same, differing only in quality and size. Clay preparation machinery is not used and most extruders are fed from a pug hole which serves as a crude clay temper. Clay is fed manually to the extruder. Some of the larger plants use a small bulldozer to move the clay close to the extruder. The clay is generally very wet and sometimes it is further tempered with additional water. The presence of roots and stones in the raw clay was evident in one plant and an additional machine was being installed to reduce these contaminants. The extruded bricks are wire-cut and stacked on flat topped two-wheeled barrows and transported to the drying areas. The bricks are stacked on the ground under shade for natural air drying which takes about one week. As wet bricks are soft, damage from handling does occur. This is of little consequence considering bricks are plastered afterwards.

Photo 20: Brick moulding with locally made extruder.

All brick factories use heavy brick masonry and rectangular updraught kilns which vary in height from 2 to 4-5 meters. A series of simple fireplaces are located at ground level along the kiln's length, however without grates or control of primary or secondary air. Generally kiln firing cycles take about 6-7 days. The thermal efficiency apparently is low as heat is absorbed by the thick kiln walls and lost from the exhaust gases exiting from the top and around the combustion zone at the firing ports. In most plants, particularly during the wet season, the kiln is used also to dry as well as to fire the brick which results in more fuelwood consumption because raw brick moisture content is high (15% M.C.) compared to normally dried brick (5% M.C.). This is one reason why the time needed between loading, firing and unloading of the kiln is two to three times higher than that for a modern brick kiln. Additionally, these intermittent kilns have become larger over time to increase output. Hence they require thicker masonry walls to prevent structural failure from constant thermal stress (heating and cooling). This further decreases a kiln's thermal efficiency.

Photo 21: Despite large fuelwood cost in production, inefficient traditional firing practices persist, S. Thailand.

Brick manufacturers normally purchase fuelwood, mainly rubberwood, in the form of small logs and/or sawmill slabs from suppliers once or a few times a year. This wood will be stored under shelter or, in the dry season, out in the open, which ensures that the wood is relatively dry by the time it is used in the kilns. Bricks, after being removed from the kiln, are sold to retailers, directly to contractors and to individual end users. In many cases, bricks are made to order and most manufacturers try to keep their stocks as low as possible. A number of urban plants appear to export their bricks to other provinces in the South and a limited quantity go to Myanmar.

Labour is a constraint and a major cost in the manufacturing process. Most of the unskilled labourers are migrants, especially from the North-eastern provinces, since local people can find better paying jobs that are less arduous and dirty than brick production. One brick owner was unable to run his plant at more than 50% capacity because he could not hire sufficient labour. Many unskilled labourers are women, many of whom are married. They spend most of their time carrying bricks from the extruder to the drying area and from the drying area to the kiln. They bring their children to the factory and care for them while working. The factory owners use this fact to justify paying all women wages that are below that of their male counterparts and below the official basic wage. Men usually receive 10-20% more pay than women, as shown in table 2.4.

Table 2.4 Wage differentials in the Surat Thani brick industries

	Male Baht/day	Female Baht/day	Difference %
Skilled workers	140 - 170	90 - 110	25
Semi-skilled workers	60 - 90	60 - 80	6
Unskilled workers	60 - 70	50 - 60	15

Source: Joseph et. al. 1990 (1 US$ = 25 Bht.)

Men normally carry out the skilled work of operating the extruder and firing the kiln. In urban plants men usually fill management and supervisory positions. However, two of the plants are managed by women and here women carry out the skilled work of setting up the kiln. During time spent setting the kiln, women receive nearly double the wages of unskilled women. During the time women are not setting the kiln, they do unskilled manual work.

The majority of the brick factories were making a considerable profit (40-60 % on the wholesale price of the brick). However, there appears to be very little re-investment of the profits in upgrading plants or developing new clay products. In general, labour accounts for about 42% of the production cost, energy for about 24%, while raw materials, depreciation, maintenance, etc., account for the remaining 34%. Having their own land for clay as well as fuelwood can make a large difference in the profitability of brick making. It should be noted that large variations were found in profitability and two out of the six plants studied were running at a loss. One plant had just commenced operation. The owner of the other plant, which was also operating at a loss, kept it running to ensure that he had sufficient labour throughout the year to harvest his crops and to maintain his social standing in the community (it would be considered poor citizenship if he closed the plant). The factory also provided his wife with a satisfying management position.

Many owners of urban plants learned their trade by working in other brick plants. To get the capital necessary to build a plant, start operations and market their products, the owners borrow money from the government, their own families and private lenders. Most of the owners of brick plants are innovative and leaders within their own communities. One of the entrepreneurs has built and experimented with a different type of kiln but the experiment did not work as expected. He also operates a small machine workshop to produce equipment for his brick plant, the brick plants of others and other local industries.

The total amount of fuelwood (mostly rubberwood) used in industries in Surat Thani is estimated at about 590,000 tons (green), of which 50,000 tons is used in the brick industry. Besides brickmakimg, rubberwood which is obtained from replanting programmes, is used as a feed stock for wood industries (sawmill, plymill, boardmill, furniture, crates, boiler houses, etc.) and as fuelwood in rubber smoking, fish meal processing and many other small scale local industries. A considerable amount of rubberwood is converted to charcoal and some is exported as logs to other provinces and to Bangkok for sawn timber or veneer.

Although fuel supply and price were not major constraints at the time of the survey (late 1989), there was a surplus of rubber wood which had been cut from trees uprooted in a Typhoon. This situation may change in the near future. Rubber fuelwood was priced at approximately Bht. 250/ton ($US 10), but both fuelwood sellers and brick manufacturers expect the price will jump to Bht 500/ton once the supply of typhoon affected trees is depleted. Fuelwood costs will then likely account for approximately 35% of production costs (it is now

24%). Not only will the price increase, but there will be more competition from new wood processing industries that have been fast establishing themselves in Surat Thani and the surrounding provinces. An alternative fuel is available in the form of oil palm residues (fruit bunches left after extracting the oil) but to burn it properly, specially designed furnaces are necessary because the bunches are quite wet. Approximately 160,000 tons of the residue from oil palm factories are burnt every year but, as it creates air pollution, the governor of the province banned the practice. Palm bunches are expected to be available for US$ 2-3 per ton.

Government extension services provide very little support, if any, to develop the brick industry (standardizing the products, providing technical services, introducing new products, upgrading existing plants etc).

2.3 Common issues of the brick industry

Based on the case studies presented here, it is evident that the brick industry in Asia is diverse, entrepreneurial, but not always innovative. It is also clear that there are many things in common but also factors which show distinct differences. A major problem, common to all countries, is that very little is known about the industry. This is surprising considering the industry forms an integral part of the construction industry and often contributes significantly to the economy.

A common aspect of brick factories in all countries is that operations are labour as well as energy intensive. This is also shown in figure 2.2. Almost all brick making units, at least in the countries and/or areas covered, face constraints to a greater or lesser extent in these fields. While Thailand appears to have found at least a partial answer to the labour problem (i.e. the introduction of cheap and simple extrusion equipment which is locally made), brick making in other countries still relies heavily on manual labour. With regard to energy intensity, little seems to have been done. An exception may be in India where more fuel efficient kilns have been developed and this technology has been exported to neighbouring countries in limited amounts. Overall the effect of these improved kilns appears to be small, if not negligible. In Nepal a highly efficient kiln has been introduced based on a Chinese design, and if found to be appropriate, this kiln technology could be transferred to other countries as well.

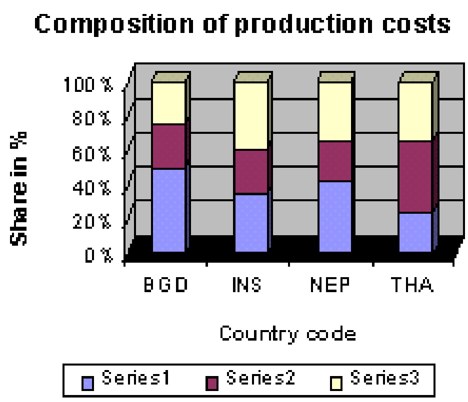


Figure 2.2 Brick production costs

Common also in many countries, is the non-involvement of the government. In most countries very little assistance in the technical as well as the financial field is available and brick makers have to fend for themselves. In fact, in some cases the government (central as well as local) appears to be more of a hindrance than a stimulating factor for the brick industry. The constraints (socio-economic, financial, institutional, technical etc.) will be covered in more depth in the next chapter, in particular concerns regarding the environment.

3. REVIEW AND ANALYSIS OF CONSTRAINTS IN DEVELOPMENT OF THE BRICK INDUSTRY

As is evident from the previous chapter, the brick industry is facing several constraints. These constraints are related to the technology, the institutional environment, the cost and supply of energy, and socio-economic and financial factors, etc. However, there are also factors outside the industry which play a role. These include institutional and policy constraints and competition from other building materials such as cement based building materials, etc. This chapter will cover these problems in more depth in order to assist in determining what strategies could be used to overcome the constraints facing brick makers.

3.1 Technological constraints

As mentioned earlier, the brick industry is very traditional and has seen few changes in the past. A hundred years ago and probably even much earlier, bricks were made by hand, dried in the open, used unfired, or were fired in simple kilns such as clamps and scoves, using wood as the main energy source. In many Asian countries centuries-old technology is still being used. This is also evident from the fact that most brick makers learned the trade from their forebears and/or from other brick makers. While in developed countries many changes have taken place in the brick industry, the opposite is true in the developing countries. Only a few countries, (notably Thailand, Vietnam and Indonesia) have changed their methods, mainly with regard to the forming of bricks.

Photo 22: Boy labourer risks injury while working with extender which saves clay and energy, Vietnam.

In Thailand as well as Vietnam, over the last 10-15 years, handmade bricks have disappeared to a large extent. Locally made extruders, which range from very simple with a low output, to basically simple but with a relatively large output, are now common in most brick manufacturing units. It is not known how extruders were introduced but it appears that this has been undertaken by the industry itself, without any support or interference from public and/or research agencies. In Indonesia extruders are also becoming common. They were introduced by the roof tile industry, basically to improve and speed up the mixing process of the clay. The same type of extruders, again locally made, are now also being used by the brick industry. In Indonesia however only a few different types of extruders are used (possibly less than 5) which are made by a few machine shops on a commercial basis. In Thailand, where brick makers copy equipment from each other, all sorts and types of extrusion equipment are in use. Consequently, no or very little standardization appears to have taken place. In Indonesia small diesel engines, and in Thailand large diesel engines (mostly old truck engines), are used to power the equipment. Imported equipment is invariably driven by electric power. The use of electricity often leads to problems because supply is not always reliable or sufficient. In most other countries in the region, brick forming is still a manual process.

With regard to other steps in the production process, very little has ch-anged. Drying still takes place in the open air, or, in the case of clays which are drying sensitive, under cover. Drying racks, to make more effective use of space, are not common. Transport invariably is manual although in Thailand, bricks are often stacked on boards which can be moved around by push carts. Some of the larger brick factories use forklift trucks to move the bricks around on stacked wooden pallets.

Photo 23: Sun drying of bricks without proper pallets and insufficient handling equipment, Lampang, Thailand.

Firing is done in kilns which again have shown few changes over time. However, there are regional differences: In India, Pakistan, Bangladesh, Nepal and Myanmar continuous kilns in the form of Bull's Trench kilns were introduced (see photo 11). The same type of kiln, which is considerably more fuel efficient when compared with the traditional intermittent kilns, could be introduced in other countries in factories with relatively large production capacities. In Indonesia a Bull's Trench kiln was tried but with no successes because this first kiln exhibited problems from the design stage. The kiln was built in an area with a high water table, and as a result, the flues which were constructed below the kiln floor, became partly or wholly flooded. This fault resulted in high fuel consumption, low output and even disruptions in the firing. In China, a highly energy efficient kiln has been developed but brickmakers in the region have not yet adopted this kiln although it would be suitable for many operations. A trial of this kiln in Nepal, financed through foreign assistance, demonstrated a very marked decrease (upto 60%) in energy use (see photo 18).

Photo 24: Medium size wood-fired Bull's Trench kiln near Yangon, Myanmar.

The differences between developed and developing countries are obvious. Labour has become a serious constraint in developed countries. As a result of high wages, people are unwilling to do heavy and dirty work, etc. As result companies have switched to mechanization. For instance, hand molded bricks are in demand in many developed countries but these are now made by a machine which throws an automatically sanded clot of clay into a mould, just as a skilled hand molder would do. In developing countries where labour is still inexpensive, there has been less need for mechanization. In both cases there have been positive as well as negative impacts. The positive impact in the developed countries has been that the quality of the bricks has improved considerably but the price is also much higher (see also table 2.3). In the developing countries, bricks are still cheap but, in general, they are of a much lower quality when compared with the developed countries.

In developed countries considerable research has been conducted to develop new and improved building materials. This has resulted in a range of brick-like products, such as clinker bricks, hollow blocks, perforated bricks, light weight bricks, fly-ash bricks, sewer pipes, vents, etc. Equivalent research and development in the brick industry has not been carried out in developing countries. Much of the research that has been conducted is related to the production of concrete, steel, fibre board and other high value added ceramic products. In most countries, possibly with the exception of India, very little research work has been carried out on the development of intermediate technologies for the production and firing of bricks. For example extruders are manufactured in Thailand, Vietnam and Indonesia but there has been no attempt to optimize these designs. Unless more research and development is carried out, the brick industry will become less competitive than other building materials industries.

The differences between countries within the region are less easy to explain. It is clear when looking from a technical viewpoint that brick making can be improved by means of simple technologies such as extrusion, drying and transport of bricks, use of more efficient kilns, etc.

These technologies are relatively simple and can be easily mastered. The extruders are inexpensive -- between US$ 2,000, for a very simple basic outfit, and US$ 20,000 for a large well constructed machine, which incorporates a clay mixer as well. Seeing the interest in mechanization in many countries, the design or even the equipment could easily be transferred from one country to another. In practice, however, very little exchange of information on such existing technologies occurs within the country let alone the region, and as a result little change in the industry takes place.

3.2 Institutional constraints

In most countries the brick industry has had very little support from national and local governments. In some countries even the ground rules set by government appear to be continually changing, usually without consultation with the brick industry. There are taxes and levies (legal as well as illegal) on the raw material in the form of clay, fuelwood and its transport. Restrictions on the use of and access to fuel types, etc. are often imposed on the industry without any consultation. It appears as if some governments perceive the brick industry as a nuisance/burden to development, rather than as an opportunity for creating rural employment, generating income and providing low cost building materials.

Besides, brick manufacturers themselves have been unable to co-operate. In many Asian countries, there is no association and/or local group that set and enforce standards, disseminate information on the latest research findings, or lobby government to ensure that they receive a similar and fair level of support compared with that of the cement industry. Nor do they organize regional and national meetings to discuss problems and develop a unified policy position. Brick makers have not been able to market their product collectively to consumers, architects and contractors. In fact most brick manufacturers feel that any contact with other manufacturers and government officials can lead to a reduction in their competitiveness and the possibility of higher taxes.

In contrast, the brick makers in many developed countries, are organized and often support specialized agencies to carry out research and development. This not only concerns brick products but the equipment used in production. Such agencies compile and evaluate information directly and indirectly relevant to the brick industry and disseminate it to their members. Technical services are often offered at cost. These include trouble shooting, assistance in choosing appropriate equipment, energy audits, etc. The industry may also be self regulating. In one instance, over production of bricks in the Netherlands forced the industry to self-impose production limits and later, when production limits were not sufficient, the industry association bought out many producers so that the remaining producers, who supplied the funds for the buy out, could remain producing at profitable levels.

Reflecting upon the information above, a few main conclusions can be drawn. One is that in principle solutions are available for most of producer's problems. Producers suffer most from **a lack of access to knowledge and information about what is going on in other countries.** When new technology has been introduced, the required expertise has not always been available, and this has resulted in failures of technically good solutions. It is therefore a lack of available expertise within developing countries that is hampering the growth and maybe even the long term existence of the industry. Another conclusion which can be drawn is that **there is a need for the**

industry to become more and better organized. In this way producers will become a force to be reckoned with, not only for presenting their views to policy makers, but also for presenting their existing products and new products to users. Only by doing so will bricks get the attention and support they deserves as a cheap, strong and appropriate building material.

3.3 Environmental issues and constraints

The industry faces considerable environmental constraints. The main constraint is the supply of raw materials in the form of clay and fuel. Clay, in many cases, is obtained from land which also has an agricultural value, such as rice fields, etc. With prudent practice there does not have to be negative impact on agriculture. Topsoil can be removed and set aside to be returned after clay removal -- an option which would have minimal impact on agriculture. However, in practice, this is often not done. In many cases, once the clay has been removed, the pit and land is abandoned. The pit is sometimes used as a fishpond but, in practice, often the land is lost for agriculture.

Many countries are facing problems due to a lack of agricultural land and several countries have therefore introduced legislation restricting the amount (depth) of clay which may be removed and requiring the land to be restored for agricultural use. In some cases the removal of clay has been banned altogether in certain areas. Although at present the industry has not yet faced large problems regarding land, this may change in the future. The industry therefore needs to look for alternative sources of raw materials which will likely require a change or adaptation in the production process.

In several countries it is already common to shift brick factories once a clay source has become exhausted. In most cases the site is just abandoned, leaving behind the kiln structure and piles of brick rubble which makes the land useless for agricultural purposes. Restoring such sites to their original condition is relatively easy but will add to the costs of the brick maker.

Another important raw material is fuel, often in the form of fuelwood. The price of fuelwood is increasing and in most countries the supplies are declining or irregular. Many countries restrict or even ban the logging of natural forests in an effort to check deforestation. Even though logging bans exist or fuelwood has been banned altogether as fuel for brick making, experience shows that fuelwood is still widely preferred and continues to be used.

Thailand has banned logging due to environmental concerns but fuelwood is still readily available at around $30-$50/ton. The wood comes from a number of sources: home gardens, land clearing sites, rubber replanting programmes, sawmill slabs, etc. However, a part of the supply of fuelwood may still come from illegal logging in forests, which puts further strain on the environment.

In Bangladesh, before 1988, approximately half of the bricks produced were fired with wood, 30% with coal and 20% with gas. In 1990 the government decided to cut gas supplies to most brick enterprises for reasons unknown, and to ban the use of firewood due to the precarious situation of the country's forest cover. This left the industry with only a few legal options: coal, oil and agricultural and industrial waste (e.g. waste tires and oil). However the price of coal has been steadily increasing while the quality of coal has been decreasing and oil has been found to be too expensive for most brick makers. The smaller brick makers, who use intermittent kilns such as clamps, scoves and scotch kilns can often easily switch to residues, but the larger units, which use Bull's Trench kilns, face difficulties if they burn residues. These kilns continue to use fuelwood which is still widely and openly available, even though a ban exists and fines are sometimes imposed.

Some countries such as Thailand, Sri Lanka and Indonesia have been able to supply fuelwood to rural industry from the agricultural sector (i.e. the removal of old coconut and rubberwood trees in replanting programmes). However these sources of wood are also in demand for furniture and as timber and poles for construction sites, as well as for other industries which use fuelwood. Most other countries rely on wood that has been grown on farms and homesteads, along roads, canal banks, etc. In Thailand the forestry Department has succeeded in encouraging ceramic water jar manufacturers to grow fuelwood (Chavalit U. 1988), but unfortunately there are no recorded successful programmes with brick manufacturers. Growing wood, solely for the purpose of fuelwood is advocated in many countries in order to minimize pressure on forests and the environment. However, unless a significant part of the wood which is grown can be sold for other purposes at higher prices than fuelwood, this practice may not be economically attractive.

In many countries where intermittent kilns are used, agricultural residues are widely used. In most cases this is because the residues are readily available near or at the production center and are the cheapest fuel available, even though their efficiency may be quite low. However, some agricultural residues also have other uses, e.g. many claim that straws and other residues should not be used as fuel but returned to the soil.

Although in theory this is true, there are other aspects to be considered. Many farmers may find it difficult to plough under large amounts of straw and stalks, the fertilizing value of these residues may be very low (as is the case with rice husks), residues may command a good price which makes artificial fertilizer cheaper, and some residues have to be removed to prevent fungi attacks (cotton stalks), etc. A definitive answer on the pros and cons of using agricultural residues for fuel therefore cannot be given without further study. The burning of residues however can also have other negative impacts on the environment because burning creates pollution (smoke, tars, suspended particles, fly ash, etc.) unless residues are burnt in a special furnace or gasifier.

The other alternatives, namely the burning of coal, oil and industrial residues, also have serious environmental drawbacks. The coal is usually of low quality and can often have a high sulphur contents. Coal and oil are more polluting than other fuels unless fluidized bed combustion units are used to ensure that most of the sulphur, nitrogen oxides and carbon monoxide are removed.

A conclusion which can be drawn is that most of the fuels normally used by the brick industry all have a negative impact on the environment to a greater or lesser extent. However, the industry itself can do little to alleviate this impact on the environment unless technically and economically suitable substitute energy sources become available on a sustainable basis.

3.4 Constraints in the field of energy and kilns

In most of the countries covered, fuel accounts for a major part (about 40% on average), of the costprice of bricks and is therefore a serious constraint to brick manufacturers. The cost of fuelwood varies from country to country and was as low as US$ 10 per ton in the southern part of Thailand (1989), but may be as high as US$ 80-100 per ton, as was the case on the free market in Nepal (de Lange, 1989). The patterns of energy supply are complex and diverse. Besides fuelwood, rice husks and other agricultural residues, sawdust, coal (of varying types and grades), and oil may all be used to fire bricks. The choice of a fuel by individual brickmakers depends more on price and availability than on its suitability for particular kiln types.

For instance, in Thailand the pattern of fuel usage has been changing dramatically. Previously, the cottage and village industries in the north and the central provinces used rice husks extensively. At present very few people use it because husks are now often more expensive than wood. This is due to the increased use of husks by many industries, including co-generation in the steam engines of the rice mills themselves. In Southern Thailand there have also been some changes in the type and availability of fuel. Previously wood was readily available from the forests. However over-exploitation of forest lands for various purposes resulted in a government ban on logging from natural forests, leading to a dramatic increase in demand from rubber plantations.

Rubber trees, once they are about 30 years old, become non-productive and they are cut to make room for young trees. Also a very destructive cyclone felled many trees. Thus there is a surplus of rubber wood at present. This rubber wood is being used locally as a fuel, processed for furniture and used in the manufacture of charcoal. The present price of rubber wood as of 1991 was about US$ 10 per ton, local brick manufacturers believe that the price may soon sharply rise.

There have been attempts to use ligwith to fire bricks but at present there seems to be considerable resistance to its use. This is because people are unfamiliar with ligwith and levels of pollution are high if low grade coal is used in existing kilns. An alternative fuel that is readily available in Southern Thailand is palm oil fruit branches. Although there was an excess of this material in 1990, palm oil manufacturers have now introduced equipment that mulches the material. It appears that in some areas there will still be a surplus available, but a special furnace is required to burn this wet and oily palm waste as fuel.

In Nepal, where there is much more production of bricks by cottage and village enterprises, the main fuel is rice straw and husk. After the harvest labour is available and so is the straw. It is either purchased from farmers for around US$ 10 per ton or comes from land belonging to the brick maker or close relatives. The much larger Bull's Trench kilns use a mixture of higher quality coal from India (US$ 100 per ton) mixed with lower quality Nepali coal, purchased from the Nepal Coal Company, as well as firewood. Much of the firewood is purchased from the government run Fuelwood Corporation at around $US 30-40 per ton. Higher priced fuel is also available from the free market. Much of this wood is carried by truck from the Terai region although some comes from forest and sawmill residues. Recently the government has allowed individuals to cut trees on their own lands for sale to domestic and industrial users. It is likely that the percentage of total wood supplied by the private sector has increased considerably.

It is apparent that the brick industry uses a wide range of fuel, purchased from a number of different sources. Patterns of fuel usage are definitely changing as some fuel types become more scarce or are banned, etc. Although no hard data are available, it does appear that in all countries brick manufacturers are trying to reduce costs by looking to waste products such as rice husks, coal dust, saw dust, straw and other residues. In some cases these wastes are even incorporated into the bricks. These changes in fuel types and practice often also necessitate changes to kilns in order to improve combustion characteristics as well as end-use efficiency.

Besides these changes, there are other options in reducing the share of fuel in the production cost. These consist of improving the efficiency of existing kilns, the introduction of other and new kilns, etc. Unfortunately, there is a scarcity of reliable data on the performance of existing kilns. The data which is available is often in a form which does not allow direct comparison. In general fuel consumption is given in cubic meters or tons per 1,000 bricks, without specifications on the weight of the brick nor, in the case of fuelwood or residues, the specific weight unit or calorific value of the fuel. Brick weight can range from 0.4 kg. for very small modules to over 3 kg. for larger sizes. Most wood that is used in kilns is air dried and will have a Net Heat Value (NHV) of around 15 MJ/Kg., but wet wood, which is also often used, may provide only 10-12 MJ/kg. The NHV of coal can vary from a low of 12 MJ/kg. (local coal in Nepal) to a high of 29 MJ/kg. (quality coal used in India or Vietnam for some kiln types).

Energy consumption may vary widely depending on the type of kiln used, the capacity of the kiln, the firing temperature, etc. Figures as low as 0.8-0.9 MJ per kg. of brick fired are known to have been obtained in a vertical continuous kiln developed in China, but fuel consumption may go as high as 2-4 or even up to 4-8 MJ/kg., in large and small clamp and scove kilns respectively. In between these two kiln types, there are many other designs, each with good and moderately good properties. The continuous kiln types, like the Bull's Trench and the Hoffman, show specific energy consumption figures of about 1.5-2.8 MJ/kg. For comparison, the theoretical minimum amount of energy required for a continuous kiln is about 0.15-0.5 MJ/kg. of brick depending on the clay and the proportions of the kiln furniture (Bender et al, 1982).

However, as mentioned before, low specific energy consumption figures tell only a part of the kiln story. The type of clay used (containing organic matter or not), the moisture content, the firing temperature and firing time, the amount of first grade and rejects obtained in a particular kiln are also important parameters, but in almost all cases no information is provided on these subjects. This makes a direct comparison between different types of kilns more difficult.

In particular the amount of organic matter can make a large difference in the amount of energy required to fire bricks. For instance, a clay containing 2% organic matter by (weight), will provide, assuming complete combustion, about 0.24 MJ per kg. of brick. In many cases this would be about 10% of the total amount of fuel required. In the case of the vertical shaft Chinese kiln, however, its share would be about 30%. This incidently shows that adding combustibles to clay such as sawdust, coal dust, etc., which are often cheap and give problems for direct firing in traditional kilns, can help in lowering the amount of better quality fuels required to fire a kiln. However, there is an upper limit for these additions because only about 10-15% by volume can be added.

There have been a number of attempts to either improve existing kilns or to design kilns that have the advantages of modern tunnel and Hoffman kilns, but at a much lower capital cost. Adding roofs to clamps, providing permanent walls that are insulated with mud and a biomass residue, increasing the height of the kilns, enclosing the firebox, adding a grate to the firebox, etc. are some of the options that have been successfully tried. Svenningson (1990), Joseph et al (1990) and Jagadish (1985) all report that local brick makers themselves have developed methods for reducing fuel consumption. The simplest methods involved mixing rice husk or sawdust into the brick and placing the same material in between the bricks in the clamp. Fuelwood is then used only for initial firing and to assist in attaining a peak temperature. In one kiln in India Jagadish notes that:

"In some urban situations, attempts to improve clamp burning are made by building a somewhat more permanent structure. In this case, the clamp consists of three parallel walls with a mangalore tile covering. The bricks are stacked in between the walls and the firing done as before. The thermal efficiency for the improved kiln is 3.35 MJ compared with 4.69-5.69 MJ for a traditional clamp."

Experience of the author (Koopmans) in Sri Lanka has shown that, in one particular case, the provision of a proper grate and regulation of primary and secondary air resulted in a fuelwood saving of about 15%, while the payback period for the small investment required was less than one week.

Svenningson also notes that considerable savings can be achieved when small pieces of wood are used and the burning rate is carefully controlled. Increasing the height of the setting in a Bulls Trench kiln may also lead to energy savings. A special high draft kiln has been developed by the CBRI in Roorkee (FAO, 1989d) which is disseminated in India. The kiln is a modified version of the Bull's Trench kiln, which uses a fan to force air and hot gases around a zig zag wall pattern. The fan improves the burning and control on the kiln and allows for a greater heat transfer path. The walls inside the kiln are made from green bricks which are removed after firing, thus lowering the thermal mass of the kiln. The kiln was also introduced to Nepal but after some time it was converted to the traditional setting because workers found it too difficult to master the setting pattern as mentioned before.

A simple vertical continuous kiln has been developed in China by the Jiajiang Coal-Saving Institute and the Henan Academy of Science (Yin Fui Yin 1989). In this kiln, bricks are loaded at the top, which has a height of about 8 meters. The brick stack is supported at the bottom by a structure mounted on a screw which, when turned, lowers the stack of bricks through the kiln. A fire box is situated about a third of the way down the kiln. The waste heat dries the bricks at the top. Part of the bricks (about 4 layers high) are unloaded every 1-3 hours at the bottom of the kiln where the air enters, while at the top, the same amount of bricks are added. It takes about 20 hours for the bricks, stacked at the top, to reach the bottom for unloading. The air gets preheated as it cools the bricks that have come from the burning zone. This hot air then ignites the fuel in the burning zone.

The specific energy consumption, reported by Yin, is about 1.4-2.2 MJ per brick (brick weight unknown). The same type of kiln has now been introduced in Nepal where it is fired with coal dust which is cheap compared with lump coal. Specific energy consumption data of 0.8-0.9 MJ/kg. have been reported (GATE, 1991). The investment cost of the kiln is about US$ 3-4,000 for a kiln with a capacity of about 4,000 - 6,000 bricks per 24 hours. Six of these kilns, built back to back would have a capacity comparable to a large Bull's Trench kiln but would occupy only about 15% of the area required for a Bull's Trench kiln. The investment cost, however, would be about 3 times higher than that for a Bull's Trench kiln, counting only the cost of the kiln structures. It is stated that unskilled labour can operate the kiln, unlike the Bull's Trench kiln which is operated by a team of skilled kiln operators who are brought in from India. It appears that this kiln may have a large potential in many countries in the region. However, as the kiln has just been introduced and is still supported by staff from a foreign funded project, the long term effectiveness of the kiln is not yet known. Indications from China are that in certain areas the kiln has been abandoned due to problems with labour as well as some technical difficulties.

It has been estimated in Thailand (Joseph et al, 1990) that if all existing kilns (approximately 1,000) were replaced with either new or higher efficiency or modified traditional kilns, there could be a total reduction of 500,000 tonnes of fuelwood per year. Total investment by enterprises and the government to achieve such a reduction would be in the order of US$

2.5-4 million. To meet an equivalent demand for fuelwood, 50,000 hectares of land would have to be planted at a total cost US$ 35 million (assuming a cost of US$ 700 per hectare and a yield of 10 tonnes per hectare per year). It should be noted that there are other environmental benefits from tree planting such as reduction in soil erosion and regeneration of degraded land.

For ease of reference the following table provides a brief overview of the different types of kilns used in the regions.

Table 3.1 Basis statistics of some brick kilns

Kiln type	Capacity '000 bricks		Specific energy consumption MJ/kg.	Investment cost '000 US$
	per firing	per day		
Clamp kiln	5 - 1,000		2.0 - 8.0	--
Scove kiln	5 - 100		2.0 - 8.0	--
Scotch kiln	5 - 40		2.0 - 8.0	< 5
Downdraft kiln	10 - 40		2.0 - 6.0	< 20
Hoffman kiln		2 - 24	1.5 - 2.8	> 80
Bull's Trench kiln		10 - 48	1.5 - 2.8	> 7
High Draught kiln		20 - 40	1.2 - 1.8	> 15
Tunnel kiln		50 - 150	1.2 - 2.5	> 1,000
Vertical Chinese kiln		4 - 30	0.8 - 0.9	> 4

The conclusions which can be drawn are that the brick industry is relatively flexible in energy sourcing, but also that many brick makers prefer certain fuels above others (notably fuelwood and good quality coal). However, these are not always available at competitive prices nor on a sustainable basis and brick makers have to make do with lower grade fuels. Another important conclusion which can be drawn is that little is known about specific energy consumption in different kilns, which makes comparison and analysis of the pro's and con's of different kiln types difficult. However, there appear to be possibilities to improve the energy efficiency of an existing kiln by relatively simple measures. The newly developed kilns appear to be attractive, for those factories which have a somewhat larger production capacity, but often require larger investments. It should also be noted in particular, that continuous kiln types require areas which may be 2-3 times larger per equivalent brick output than what is required for intermittent operations.

3.5 Labour and gender Constraints

In some areas in Asia, manufacturers are finding it difficult to attract people to work in the brick industry. This is partly due to the poor working conditions and the low wages. Many workers, in particular those who are skilled, are looking for better positions. Although brickmaking is considered as a male occupation, many women are starting to play a major role in the brick industry. However, on the whole, women have the lower paid and most arduous jobs, and even when they do the more skilled work usually reserved for men, they are paid less. It is possible that women actually may be better at brick production than men as they tend to be more careful in the molding of bricks and setting and firing of the kiln. Given the problems in attracting sufficient labour, traditional rigidity in gender roles may become a major constraint.

Photo 25: Women unloading bricks from kiln, Vietnam.

Photo 26: Women's labour is still crucial in many steps of the brick production, Thailand.

In general, there is a lack of skills and basic understanding of ceramic materials. Many of the shortcomings associated with bricks from the small scale sector such as non-uniform and underfired bricks etc. can be traced back to problems during the production process. Having a good knowledge of how and how much clay shrinks, when to be careful with drying as well as with firing, etc. can alleviate or even overcome many of the problems. Workers paid piece rates tend to be less careful and make lower grade bricks than those who are paid daily wages. A basic understanding of combustion principles may help manufacturers and workers to conserve energy, etc. In almost all countries knowledge is transferred from one worker to another worker on the job, as there is no formal training available. As a result, brick making technology does not develop and little progress, if any, is made. In addition engineers and scientists in many cases are not particularly interested in basic ceramic industries such as brick making, but prefer to work with more sophisticated ceramic materials. As a result equipment such as simple extruders is not optimized and new products are not developed.

Photo 27: Status of brick labour is generally poor but with strenuous work, Dhaka, Bangladesh.

In some cases the availability of labour is becoming a constraint. Highly skilled people such as engineers are required to assist the industry to develop itself. There appears to be scope for improvements in the industry if some kind of training or apprenticeship system could be developed to upgrade the capacities of workers, especially female workers.

3.6 Socio economic/financial constraints

At present the small scale cottage and village producer is having difficulty surviving. From the small amount of evidence available (FAO, 1990) it appears that the prices of inputs are increasing faster rate than returns from the sales of the bricks. Small producers are not only being charged more for their inputs than the large producers but, in some cases, are having much more difficulty obtaining reasonable quality materials and fuel. Larger industries, which sometimes buy the unfired bricks from the small cottage level producers, in general are not in a position to, or will not, increase the price they will pay for these "green" bricks.

In countries where there has been rapid economic growth, such as Thailand, there are few cottage industries remaining and those that remain often cannot provide basic wages to workers. However, there is no doubt that the small production units provide more employment than the large units. This employment is important, particularly during periods where there are few agricultural activities. As employment generation is often a major objective of national development plans, the development or at least the sustenance of the small brick making units should be supported. Besides, unit production costs tend to be lower for "least cost" brick production, e.g. factories which are mainly manual. In general the multiplier effect of small industries is greater than the large scale production units e.g. the small units provide more employment in related activities such as fuelwood gathering and transport, local manufacturing and maintenance of equipment, etc.

Many brick makers, in particular the small scale sector, have problems with working capital. Quite a few can only produce if they have received an order and an advance on the purchase price. In some cases they have to sell their unfired bricks to larger manufacturers because they cannot obtain money to buy fuel. This often results in a low price for their product. Most lending institutions need collateral before they will extend a loan which, in the case of the smaller manufacturers, is often non-existent. In some countries brick making is not considered an industry, so manufacturers do not have access to special loan arrangements for industrial activities. Therefore many brick makers have to rely on their own funds for working capital or on the informal "banking" sector, e.g. family members, neighbours and money lenders. The latter in particular tend to charge high interest rates which effects the financial viability of brick making activities. Improvements in production systems, e.g. the introduction of simple extrusion equipment, upgrading of kilns or the construction of new kilns require funds but, as these may not be available or be too expensive, small brick manufacturers remain more or less at a standstill.

One may conclude that brick making, as practiced in the region, can have many positive effects on employment generation, not only in the sector itself but also as a result of its add-on effect. However, many brick makers are hampered in their operations due to a lack of financial resources which, if funds would be available on favourable terms, could assist the industry in providing suitable building materials to the local construction industry.

3.7 Market constraints and competition from other building materials

During the recent past the brick industry has faced competition from several other building materials. These include cement and soil/cement blocks. For instance, in Thailand cement blocks have been able to attain a major share of the housing and office building market in only 15 years.

A main reason why cement blocks have attained a large market share, not only in Thailand, but also in India and Indonesia and other countries may be because cement blocks are more uniform in size and stronger. This comparison may not be accurate because many manufacturers of cement blocks do not give proper attention to the mix ratio as well as to the curing of the blocks, and this results in weak blocks.

However, even though concrete blocks may not be as strong as fired bricks, they have a large price advantage. In Thailand, a cement block, measuring 40*18*7.5 cm. sells for about Bht. 2.80 (US$ 0.11) while bricks, measuring 18*7.5*4 cm, sell for about Bht. 0.60 (US$ 0.024). Thus about 8 bricks are required against only one block. The mortar requirement for a wall made out of cement blocks is said to be approximately 50 % less than that required for a wall made out of clay brick.

Although it is clear that walls made from clay brick are more expensive per square metre than walls made of cement blocks, there are however regional differences depending on the cost of cement, the level of mechanization of cement block production, etc. Most cement blocks are manufactured in semi-urban areas using manual equipment, similar to the CINVA ram that is used for mud block manufacture. Capital cost for these machines varies from a few hundred dollars to $100,000 for the more automated presses.

In order to make bricks more cost effective, an increase in the size of the bricks should be considered. This would mean that less cement would be required in construction and, in this way, part of the price difference between bricks and cement could be decreased. In addition making the perforations in the bricks larger or producing hollow blocks would aid in making the bricks cheaper because less clay and, even more important, less fuel would be required. Making quality bricks and offering options (colour, texture, size, etc.), would even further decrease the difference in price.

However, although such a solution sounds simple, there are also problems. These concern downstream activities. On one side are the users and the architects and on the other side, the construction industry. The user's side will have to be made aware of the potential for the product, that it can be used without rendering and offers a range of colours, textures, etc. which can result in a very pleasing surface. However, the construction industry should be informed about how to use bricks and how to handle them. Most bricklayers will need further training because most do not possess the necessary skills to properly lay the bricks. In both cases extensive information and training programmes should be set up and for this the industry will need assistance.

Other products are also available. These alternative wall materials in principle require very little energy for their manufacture. The main alternatives to clay bricks are:

a) Soil Blocks;
b) Lime Stabilized Soil Blocks (using about 5% lime as a binder), and
c) Cement Stabilized Soil Blocks (using about 5% cement as a binder).

In some countries cement blocks are widely used while in others such as Bangladesh, although attempts have been made to introduce cement blocks, there is strong resistance against their use. However, the main issue with soil blocks is one of erosion by wind and rain. Mud blocks do not withstand the heavy rainfall of the tropics and have traditionally been used in dry climates. Work by Jagadish et al has shown that mixing in waste jaggery or starch can improve the lifetime of mud blocks. The resistance to erosion can be considerably improved when either cement or lime is added and the bricks are compressed to a density greater than 1.9 grams per cubic centimeter.

For ease of comparison, some costs as well as energy intensity of different options are given on a basis of relative cost and energy intensity per square meter. It should be noted that the range of relative costs and energy intensity will vary between countries, building design and builder. Typically the amount of energy used to produce a brick and wood wall in Australia is 1,284 MJ per square meter, while that for a concrete brick wall is about 755 MJ per square meter.

For ease of comparison, in table 3.2, some costs as well as energy intensity of different options are given on a basis of relative cost and energy intensity per square meter. It should be noted that the range of relative costs and energy intensity will vary between countries, building designs and builders. Typically the amount of energy used to produce a brick and wood wall in Australia is 1,284 MJ per square meter while that for a concrete brick wall is about 755 MJ per square meter.

Table 3.2 Relative cost and energy intensity of several building materials

Wall building material	Relative cost sq.m.	Rel. energy intensity
Brick with cement render	7.0	1.0
Brick without cement render	5.0	0.8
Concrete block	5.0	0.5
Soil cement block	3.5	0.2
Soil lime block	2.0	0.2
Pressed soil block	1.0	0.01

Source: Lawson, 1990 and Jagadish et al, 1985

Throughout the world, manufacturers of heavy clay products tend to be slow to react to market change, let alone lead it. In most developed countries a range of colours (pale yellow up to dark brown), as well as textures (smooth, sanded, grooved, hand mould texture, etc.) of bricks are available as users ask for such a choice. In most developing countries, brick makers make only one type and colour of brick, leaving the user very little choice. As a result, substitute products enter the market which have the same function but are cheaper, more regular, pleasing in look etc. In short these substitutes satisfy the market better than bricks. Although, in general, the output of bricks is quite elastic, i.e. increased construction activities are closely followed by an increase in brick production, the brick industry does have problems. The cement block industry has the ability to meet the vagaries of demand by being able to produce during the rainy season when fired clay bricks are difficult to dry, which results in a marked drop in the supply, In this way bricks loose part of their market share.

From this it is clear that bricks face stiff competition from alternative building materials. Also the fact that energy accounts for the largest share in the production costs is worrying. Therefore, in order to remain competitive, the clay brick industry will have to contain costs, increase module size, reduce mortar usage and improve ease of layering in order to retain and/or increase market share in the building and construction industry. Bricks in general are preferred even when of low quality because of their inherent and/or perceived characteristics of strength, moisture resistance, etc. The industry will have to stress positive characteristics and options (colour, texture, larger module design etc.) to compete with the alternative building materials which have a similar function.

3.8 Data availability

One constraint on the development of policy and programmes for the brick industry is the lack of integrated data on the present state of the brick industry. Most countries have only the barest statistics on the production of bricks in the larger rural enterprises. There have been virtually no in-depth socio-economic studies on both the large and small brick industries. There has been virtually no attempt to look at the changing demand for different building materials and the relative costs and benefits to the economy from supporting the different options. The role of the poor and of women in the brick industry has not been studied in any depth in most countries. Very few strategic studies on the rural building materials industry as a whole have been carried out. Governments have not developed the necessary policies to intervene positively in the brick industry.

3.9 Issues arising

It is apparent that the brick industry in Asia is very diverse and weak, with production taking place at the household, village and rural level. The capital to labour ratio and the output to labour ratio of the modern brick plants is very high, whereas the reverse is true for the small scale enterprises. The brick industry is a very important part of the rural economy and, as such, the introduction of other building materials/building techniques could have a negative impact.

Whereas the more modern plants produce a higher quality but also a higher cost product for the wealthy urban and rural areas, the village and household industries produce a low quality and low cost brick for the majority who are lower income earners. The high quality items require less thermal energy (although a lot more mechanical energy) to produce them than the low quality bricks. If the thermal energy efficiency of plants is to improve, then there must be a major investment programme within the industry. Seeing all the constraints, this will not be an easy task to undertake. It is also apparent that there are much cheaper and less energy intensive methods to make walls for buildings than using either clay bricks or concrete.

Reflecting upon the previous chapter as well as the constraints the brick industry faces, it appears that there is (or soon will be) a crisis in the brick industry in all countries in Asia. Similar problems are also being experienced in other sectors of the building materials industry, such as clay tiles, shingles and lime for mortar. If the industry is to maintain its market share and enjoy the fruits of a fast expanding economy, the following constraints need to be addressed in most countries.

- The large increases in the price of fuelwood caused by irregularity of supply from existing sources, the ban on forest clearing, strict regulations applying to the transport of fuelwood from other sources such as common land and village gardens, and the shortage and high cost of other fuels.

- The competition from the wood processing industries for the available supply of wood.

- The use of inefficient kilns, not only with regard to energy but also with regard to the amount of first grade products obtained.
- The use of slow turnaround kilns that prevent the brickmakers from reacting to market fluctuations.

- The availability of skilled and unskilled labourers who are willing to work in unpleasant, arduous conditions.

- Rising living standards in some countries which will affect consumer preference not only for alternative building materials but for different types of bricks as well.

- A lowering of living standards in some countries which, together with the increased cost of brick production, may result in a decline in the market for lower grade bricks.

- Government regulations which are rarely developed in conjunction with members of the rural industries.

- Lack of brickmakers' associations to assist government in policy definition, marketing and in providing technical assistance and information and training to its members.

- Lack of extension services to assist with the development of the industry, training, etc. as well as a lack of research and development organizations.

- A lack of access to credit at reasonable rates.

- A lack of skilled craftsmen and coupled with it a lack of innovation on the side of architects and building contractors in order to make better use of the products available (load bearing brick work, unrendered brick work, etc.).

4. NEW DIRECTIONS FOR THE BUILDING INDUSTRY: POLICY AND PROGRAMMES

4.1 Policy issues

Although this paper has focused on the brick industry, it is important to take a broader perspective and examine issues affecting the building materials industry as a whole. Unfortunately, within the scope of this paper it has not been possible to do an in-depth analysis and only a few generalizations could be made. An important issue has been, and most likely will continue to be, that more efforts and resources have been spent on the development of "modern" building materials e.g. cement, steel, plastic, aluminum, glass, etc. The more traditional building materials such as stone, mud, timber, bricks (fired and un-fired), tiles, etc. have received little attention and manufacturers and users basically have been left to fend for themselves. Not until an in-depth analysis has been carried out will it then be possible to determine what and how resources should be allocated to the brick industry as compared with other sectors in the building industry. Annex 1 gives some examples of questions to which answers should be sought. Such an exercise was carried out in Bangladesh (SDC-SKAT, 1991) using a multi-disciplinary team assisted by a high-level steering committee with representatives of the building materials industry, contractors, research organizations, NGO's, international organizations, etc. Over the course of a year the study team developed recommendations regarding which sectors needed assistance and prepared outlines for project proposals.

4.1.1 The importance of the rural building and building materials industry

Seeing the trend towards urbanization identified earlier, it is important to create incentives for people to remain in rural areas. The provision of local employment and improvements in the local living environment may be important parts of such incentives. An improvement in housing quality, through the provision of adequate and affordable building materials, may not only lead to an improvement in lifestyle but can at the same time lead to a significant improvement in hygiene, and consequently the health of the occupants. In addition it may lead to a reduction in the amount of work as well as expenses involved in maintaining a house.

The building industry not only uses local resources to provide employment and generate surplus income in a district, it can also generate local surpluses of higher quality building materials. These surpluses can then be reinvested in other productive activities and development of the community. It could be envisaged that the building materials industry becomes part and parcel of rural development schemes and may be integrated into local forestry and agricultural activities, and in some areas into the local manufacturing industry. For example in Thailand, Indonesia and Vietnam, much of the equipment used in the semi-mechanized brick plants, is produced and maintained by local industry. Increases in forestry activity can lead to a greater availability of timber both for housing, furniture manufacture and fuelwood. Increased rubber plantation replanting programmes can lead to surplus rubber trees to fuel the lime, tile and brick kilns, as well as provide stock for the timber and furniture manufacturing industries. Increased agricultural activities can lead to an increase in the residues available for fuel and increased income to purchase building materials. Increasing agriculture also may decrease the amount of land available for digging clay or planting trees for fuel or timber.

The encouragement of the rural building materials industry can reduce the amount of foreign exchange used to import cement, aluminum, steel, etc. and/or manufacture it locally. In the latter case imported technology, imported equipment and sometimes imported expertise are required. It has been shown that the manufacturing of local building materials is in general more labour intensive than the "modern" building materials industry. This has a national as well as a local positive impact because more jobs will be generated in more areas. Besides, the introduction of improved technology to the building materials industry may have other benefits:

- The quality of existing products may be improved;
- New markets may be developed through the introduction of new and/or improved products;
- Lowering the cost of the products and at the same time improving their quality may in itself result also in improved market conditions as well as improvements in earnings;
- More job-opportunities for skilled labour may become available which will improve the earnings of the male as well as the female labour force;
- Working conditions such as the amount of bending, heavy lifting and dirty work may be improved;
- The amount of wood/biomass energy required may be reduced which can have a positive impact on the local environment as well as production costs;
- The level of air pollution may be reduced, thus improving the health of the workers and the community.

4.1.2 Considerations for support to the building and building materials industry

Many different groups involved in the building industry or end users of the building industry's products are requesting assistance from Governments. Those requesting assistance include:

- Poor urban and rural people who need affordable and adequate housing;
- Consumers who want better and cheaper building materials such as cement products, clay bricks, tiles, etc. (However, consumers do not want to be saddled with new and unproven building materials and construction technologies);
- Architects and other experts who want alternative building materials that are both durable and require low energy inputs. (e.g. cement stabilized earth blocks, well preserved wooden components);
- Forestry departments and conservationists who want logging for timber and fuel stopped and more resources given to local replanting efforts;
- Conservationists and environmentalists who want to stop the burning of large amounts of residues at industrial sites;
- Women's groups who wish to improve the poor working conditions and low pay rates for women working in the building materials industry.

Given the complexity of issues and competing demands, governments and aid organizations have traditionally chosen interventions that have well defined inputs and outputs, have tangible benefits and work with people who are relatively sophisticated. However, the time may have come to develop more sophisticated multi-sectoral programmes, where the risks are higher but where the potential benefits are much greater than is the case when a number of single sector projects are implemented. Before assistance is given, it is important to carry out multi-sectoral studies, as mentioned in section 4.1, to determine:

- What type of locally available building materials require minimum energy input, use renewable and sustainable sources of energy and provide acceptable shelter to different groups of people in the society;
- If there are alternative building materials and/or products which are acceptable to the end user, and which could fulfil the same functions but at a cheaper price/using less energy/employing more local labour;
- How can these different building materials be produced more cost effectively so that they can compete with existing capital and energy intensive building products produced from outside (e.g. cement, steel, aluminum and plastic).
- Could more effective, better quality and/or lower cost shelter be provided through training and/or retraining of existing architects, contractors, craftsmen and end users.

These studies will need to provide answers to governments to determine where assistance should be given. Should support be given only to the (few) larger industries, where management skills are greater and there is the capital to purchase new equipment; or should support go to the (many) small industries which have little capital, encounter difficulties in access to government assistance and often lack management and marketing skills, etc.; or should resources go to both. The focus of assistance probably will differ from country to country and may reflect the relative weight that is given to different national problems, such as deforestation, unemployment in rural areas, provision of shelter, etc.

4.1.3 Considerations for support to the brick industry

Assuming that the studies mentioned in the previous section conclude that bricks are one of the most cost effective methods of providing adequate shelter to both poor and average income earners in urban and rural areas, then the following questions need to be answered:

- What type of bricks need to be produced?
- Who should produce them?
- How should they be produced?
- What type of kiln should be used?
- What type of fuel should be used (fuelwood, residues, non-renewable energy sources) and how should its supply be assured?
- How can environmental impacts be minimized?
- What types of assistance and/or incentives can be given to the brick industry to ensure that they have a fair and level playing field for competing in the building materials market?

It is apparent that many issues will have to be considered and looked into. Different types of products require different types and qualities of raw materials. Existing markets may not readily accept new and/or improved products. There may be no experience with alternative energy sources. Governments and Non Government Organizations (NGOs) may be able to assist the building and building materials industry by providing the following types of assistance:

a) Research, Development and Demonstration.

Government, in collaboration with the industry and NGOs, may assist to set R&D priorities. It will be important to determine if R&D is justified for the larger industries, where management skills are greater and there is the capital to purchase new equipment, or should research aid the many smaller industries who often produce a much larger percentage of the total brick production but have little capital and often lack management and marketing skills.

It may be necessary to develop improved equipment for processing, drying and forming the clay. To reduce the cost and the time involved, organizations such as UNIDO, ILO, etc. and brick associations in other countries, may make available their information sources, data bases, etc. Work could be undertaken to develop new products. It will be important to tap into the expertise of countries where brick industries make a range of products.

Governments may provide the necessary funds and technical assistance to both improve existing kilns and work with a few selected manufacturers to develop and demonstrate this new technology. Any research programme should work closely not only with the owners of the brick plants, but also with the personnel involved e.g. the kiln setters and the fire men. Many of them will have ideas on how to improve not only the performance of the kiln but also the operation.

There is a need to implement demonstration programmes. These programmes should not only focus on the introduction of more fuel efficient and cleaner burning kilns and furnaces but also explore the feasibility of introducing new fired and unfired clay products. A multi-disciplinary approach should be taken, with social scientists, marketing experts, architects, engineers and contractors participating in the demonstration programme. Monitoring and evaluation of such programmes must be given sufficient resources in order that costs and benefits can be clearly ascertained and that policy formulation can be undertaken after the demonstration programme has been completed.

b) Integrating Forestry Programmes with Building Industries Development Programmes.

There are now many programmes to increase tree cover in rural areas and even in urban areas. In one such innovative programme carried out in Thailand, factories producing ceramic water jars (which formed an association for this purpose), were assisted by the Forestry Department to develop fuelwood plantations (Chavalit, 1987). These plantations combined the growing of Leucaena, Casuarina and Eucalyptus. The leaves from the Leucaena were sold for animal feed, the branch wood and tops were used for firing the kiln, while the Eucalyptus and Casuarina trunks were sold as building poles.

Owners of brick plants, if properly organized, may be interested in participating in such a programme as well. However, suitable models need to be found to attract active participation from farmers who would grow wood as well as for the brick plants. Care should be taken that there is a market for all wood including the timber and poles, because pure fuelwood planting programmes rarely show a positive return on investment. Recent research (FAO, 1989d) has indicated that in areas in India where there have been successful social and community forestry programmes, a surplus of wood is now available. However, there is a very limited market for the wood as there has been no concurrent development of industries that can use this surplus. Opportunities have been lost and people are becoming disillusioned with the tree growing programmes.

Other options would be for brick enterprises to assist individual farmers to plant trees on a contract basis. This may involve paying the establishment cost and providing them with a wage, but they would guarantee a minimum price for the fuelwood. Extension could be provided by the government forestry service and/or by NGOs.

c) Integrating Women's Development Programmes with Building Industry Development Programmes.

It will also be important to involve women's organizations in building industry development programmes, since many of the innovations may affect women. At present women have a great deal of flexibility in work hours and child care in many rural industries. Whole families work in the enterprises and mothers are able to stop to feed babies or to attend to other chores. It will be important that government or NGO women extension workers are involved to ensure that the net benefits to women outweigh any of the costs associated with the introduction of new technology. Thus, Government should become involved in not only setting energy policy that affects the brick industry but also policies related to land use, social development, working conditions, safety, and product standards, etc.

d) Subsidies and Credit

There is little evidence, at present, that the provision of direct subsidies will be necessary to assist the brick industry, but a removal of subsidies from other competing products, produced in large centralized industries, should be considered instead. Although financing schemes for the small scale industries exist in many countries, brick manufacturers may not always be able to avail themselves of this financing for various reasons including bureaucratic red tape, the fact that brick industries are not considered as "industry" due to their lack of registration, etc. Governments may assist by recognizing these small entrepreneurs and providing inexpensive financing by amending rules and regulations or making special purpose funds available.

e) Training and Promotion

To rejuvenate the rural building materials industry training is essential for contractors, tradesmen, architects, craftsmen and employees of building materials enterprises. This training would be most effective if it was channelled through industry groups such as a national brick producers association. It will also be important to ensure that there are regular seminars for all professionals and industry owners to discuss issues such as the use of alternative building products, standards etc.

4.1.4 Regional co-operation

Widespread diffusion of both technologies and products to reduce energy consumption in the brick industry and to develop alternative building materials is needed. Co-operation and networking at the national as well as regional levels will also be essential. This co-operation could take a number of forms. Existing organizations such as the Regional Network in Asia for Low-cost Building Material Technologies and Construction Systems (RENAS-BMTC) could be strengthened. New national or regional programmes could be established to collect and disseminate information and to prepare a more comprehensive strategy to improve the quality of building materials, while reducing energy consumption and cost. Appropriate regional training programmes could be organized for public and association officials, etc. Information could be disseminated through the existing regional publications such as "Wood Energy News", "Technology for Development", and "Techno-forum" or through other means.

Within the framework of technical cooperation programmes such as Technical Cooperation between Developing Countries (TCDC), planners, researchers, engineers, etc. from countries that are less knowledgeable and experienced in energy conservation and building materials development could work in countries where there is an already existing programme. Architects in one country could work with engineers in other countries.

Joint meetings between FAO, UNIDO, ILO, UNDP, ESCAP, etc. could be organized with organizations that deal with shelter such as UN Habitat. Countries such as Australia that have already made the transition from traditional wood fired clamp kilns, to modern technologies, could share their experiences with Asian Countries. Many developed countries have schemes available where retired engineers, managers, scientists, etc. can be seconded to industries or organizations in developing countries for short periods to assist with specific problems (at little cost to the recipient factory or organization).

4.2 Programme issues

Once feasibility studies have been completed a promoting organization will need to develop programmes. In this section guidelines for the establishment of programmes will be outlined.

4.2.1 Setting development objectives

At the beginning of the programme it will be necessary to set objectives. Possible objectives that could be set include:

1) Environment and Energy
2) Equity
3) Employment
4) Women's Development
5) Industrial development
6) Institutional strengthening

Specific objectives could be:

a) To help relieve the pressure on the remaining forests by introducing to the brick industry more efficient wood and other biomass waste fired kilns and/or to assist in the establishment of fuelwood resources;

b) To improve the working conditions and level of skills of women working in the brick industry through the introduction of new technology and/or new high(er) value added products;

c) To ensure the survival and growth of the local brick industry by improving the technology, management of individual enterprises, skills and knowledge of builders/bricklayers and co-operation between manufacturers;

d) To increase the level of employment and skills in rural areas (to stem urban migration) through the upgrading of the existing building materials industry and forestry/farm related activities;

e) To promote rural equity through the processing of local resources, by rural people in an environmentally sound manner. In particular to assist disadvantaged groups to produce building products that improve the houses of all socioeconomic groups.

4.2.2 Programme outputs and target groups

The specific outputs of the programme will depend on who is to benefit from the programme, and the programme objective(s). To date most programmes have concentrated on assisting the larger brick makers. Although this appears to have the greatest financial return, it may not have the greatest socio-economic impact. It is the author's contention that a project should try to involve both the small and larger scale producers and in some cases establish new production units that are run as a co-operative effort amongst disadvantaged groups of people. The specific outputs of such projects can be:

1) The introduction and commissioning of new kilns that reduce fuel consumption, lower levels of pollution, improve quality and ease the burden of the setters and operators;

2) The introduction and commissioning of modified existing designs;

3) The introduction of new products that can be manufactured by the brick manufacturers. These products would be manufactured by skilled workers (at least 50% being women). Along with the introduction of products would be improved methods of processing and drying the raw clay products;

4) The introduction of either a new fuel that at present has no alternative use or enhancement of degraded land through the planting of trees;

5) The establishment of a cooperative venture to manufacture quality ceramic products for buildings. This new venture would use more efficient appropriate technology;

6) The training of men and women to run the new kilns and produce the new products;

7) The training of ceramics engineers and extension workers who can continue to develop new products for the brick industry and who can train women to set the kiln and men to operate the kiln;

8) The training of brick plant owners in improved management techniques, finance and cost accounting and builders/bricklayers in the more effective use of bricks and other ceramic building products;

9) The establishment of fuelwood resources by the brick plant owners or local groups working with owners of the plants, where possible;

10) Development of a capacity by local engineering companies to produce new kilns and efficient biomass combustors;

11) Supporting a formation of Brick Producers Association(s) and/or cooperatives and national marketing campaigns;

12) Research, development, testing and dissemination of alternative, low energy input building materials and technologies;

13) Specific manuals to build and operate an efficient kiln and combustor;

14) A National Seminar and Training Workshop on the results of this programme;

15) Documents reporting the results of this programme;

16) Extension of new kiln design(s) and technology to other sectors of the ceramics industry.

4.2.3 The training of engineers, managers and labour

In order to assist programmes for the development of the building industries, skills may have to be introduced. This may be in the form of formal training but, in many cases could also be imparted by on the job training, short courses, seminars, etc. Several levels of training can be undertaken:

1) Engineers may require training in:
   a) Modern practices of brick manufacture;
   b) Upgrading and optimization of existing equipment and production technologies;
   c) Developing new equipment and accessories for brick production, etc.;
   d) Principles of modern kiln and biomass combustor design, construction and operation;
   e) Development of new ceramic products.

2) Factory managers may require training in:
   a) Management of an efficient brick manufacturing plant using improved kilns and clay drying and preparation techniques;
   b) Development and marketing of new products;
   c) Introduction to modern brick making technology;
   d) The rationale and means of establishing a brick manufacturers group.

3) The labour may require training in:
   a) Production of new products;
   b) Setting of the new kiln;
   c) Firing of the new and improved kilns.

4.2.4 Monitoring and evaluation of the project.

During the implementation of the project a monitoring programme will need to be established. This programme will collect information not only on the performance of the kiln, but also on changes in:

- the management of the enterprise;
- the profitability of the enterprise;
- the working conditions of the men and women labourers;

- the status/role of the women;
- the marketing strategy and prices of inputs and outputs;
- access to extension services and credit facilities.

Evaluation will be a very important part of the programme. At the end of the demonstration project an evaluation should be undertaken. This should determine:

1) The present benefits and costs to the enterprises that have taken up the new technologies;
2) The impact of the technology on the workers and the owners of the enterprise;
3) Whether the initial assessment (and the objectives and tasks that were developed from this assessment) was realistic and if not why;
4) Whether a full scale dissemination programme should be undertaken, whether the project should be abandoned or whether further research and development (R&D) work should be undertaken.

5. CONCLUSIONS AND RECOMMENDATIONS

From this study, several conclusions can be drawn and recommendations made. The two sectors, the construction and building materials industry and the brick industry, in principle could be covered separately but, as most of the conclusions and recommendations are valid for both, they will be covered together.

An important point to consider is that there is a growing need for housing in urban as well as rural areas. This in particular is valid for the low-cost housing sector which, in almost all cases, is the only option open for adequate housing for the majority of the population e.g. the poor and low-income and/or minimum income earners. Seeing the urbanization trend, which is growing due to a perceived or actual development imbalance between urban and rural areas, the housing situation in urban and semi-urban areas, in many cases, has already faced a serious problem, which will only become worse.

The growth in the construction and the building materials sector has in quite a few countries outstripped the growth in Gross Domestic Product. It should be noted that most of the construction activities have been in the "modern" sector e.g. infrastructure, large buildings, etc. with many of the workers involved in these construction activities being migrants from rural areas. As migrants are often poorly paid with little job-security, they may never be able to acquire adequate housing for themselves. Unless effective solutions are put into place, this may lead to further injustices for the poor not only with regard to housing but also with regard to basic amenities e.g. access to clean water, electricity, sanitation, etc.

It has also been shown that the traditional building materials sector e.g. bricks, mud, bamboo, etc. plays an important role, in particular in the low cost housing sector in rural as well as urban and semi-urban areas. Public support to this sector is therefore considered important in order to provide affordable building materials. These traditional building materials are often produced in rural areas as these are the places where the raw materials in general are often abundantly available.

The importance of the building and building materials industry with regard to providing employment to many people in rural areas, often in the off-farm season when other employment opportunities are almost non-existent, should not be underestimated. The survival and growth of the traditional building materials industry based on the harvesting/mining and processing of local materials (wood, clay, lime) and supporting activities such as the manufacturing and maintenance of equipment, etc., is therefore essential to the social and economic growth of rural areas. It may be possible to improve or even redress the imbalance between urban and rural areas by providing employment opportunities in the rural areas.

Providing housing for the poor would be a simple solution but, unfortunately, this would be very costly. Not only would funds not be sufficient, there is a very complex network of issues and competing demands for scarce resources. Therefore, in order to provide policy makers with a better insight into the pros and cons of supporting the building and/or building materials industries, in-depth multi-sectoral studies need to be carried out.

Such studies, should preferably be carried out by a local team which would include building and building material specialists from all sectors including marketing specialists, economists, social scientists, end-users, etc. They should determine: a) what type of building materials are locally available and/or could possibly be locally produced, b) which of these requires a minimum on energy input, c) which result in the maximum labour input, d) which use renewable sustainable resources, e) which are environmentally friendly and f) which would provide a cheap, acceptable and proven building material for housing for different groups of the population. Due consideration however, should be given to the fact that end-users too often have been saddled with new building materials, developed elsewhere, but not proven under local conditions.

Having carried out such a review, the team should also look into production mechanisms and methods and determine if changes in the production would lead to lowered production costs and/or quality improvement. Besides, it should be determined if quality housing at a lower cost could be provided through training and/or retraining of architects, contractors as well as craftsmen and end-users.

Only when information from such studies is available will it be possible to determine what interventions are likely to lead to both an improvement in the quality of rural as well as urban low-cost housing and add to the economic activity of the local area without further stressing the environment.

Careful consideration should be given to set priorities and to determine the level of public resources allocated to the different building materials industries (timber, heavy clay, mud, stone, lime, cement, slate, etc.), which individuals or group should be assisted, what type or kind of assistance should be given and how and by whom should the assistance be administered. Pilot and demonstration programmes may need to be undertaken to determine what type of programmes should be undertaken to reduce energy consumption, improve profitability, reduce product prices and improve quality. In particular it will be important to determine if the greatest benefits are to be achieved by helping the very small entrepreneurs who work at the village or household level or the larger rural industries, which have greater technical expertise, more capital and are often prepared to take risks with innovation or new technology.

With regard to energy, efforts should be made to introduce energy conservation measures as well as to promote the use of non-polluting energy sources. However, due consideration should be given to what energy sources like fuelwood, residues, etc. may have competing end-users and, although renewable, are finite unless steps are taken to ensure a continuous supply. There is therefore a need to co-ordinate policies between the industry and fuel suppliers e.g. the forestry and agricultural sector. It will be important to carefully consider the effect changes in land use will have on the different sectors involved. For example what will happen if all the local forests are closed to exploitation. Similarly, if large scale tree planting activities are undertaken, it will be necessary to consider if there is a market for all types of wood generated (trunk, branches, twigs, tops, etc.), whether the local building materials industry can utilize the surplus with or without assistance, and what the effect will be on agricultural output, etc.

Energy conservation measures developed in one country could possibly be introduced to other countries. However the local situation (energy supplies, practices, etc.) should be taken into account. An example is the highly energy efficient vertical shaft kiln, developed in China, now being pilot tested in Nepal and which may be suitable for other countries as well. However, in order to introduce such a kiln, and other technologies as well, the transfer of technology should be carefully promoted especially through technical cooperation and exchange of information on a national and/or regional basis.

Unfortunately, most building research institutions in developing countries lack the comprehensive structure required to translate their findings into commercial production and/or transfer their knowledge to the private sector. In many cases the link between investors and manufacturers on one side and the research institutions on the other side is non-existent. With a proper public policy, this gap could be minimized.

There is therefore a need for a strengthening the existing networks like the Regional Network in Asia for Low-cost Building Material Technologies and Construction Systems (RENAS-BMTC), etc. Activities recommended might include improving the dissemination of information through existing news letters. Where necessary, new networks could be established linking building material producers' organizations like the Brick Makers Associations, with similar organizations elsewhere, not only within the region but possibly also outside.

Further such cooperation should not be limited to an exchange of information but should include exchange of personnel, training programmes, the provision of particular technical inputs, etc. Where possible use should be made of opportunities offered such as the possibility of seconding retired engineers, scientists, managers, etc. to industries or organizations in order to solve particular problems.

6. BIBLIOGRAPHY

Ahmed, A. and E. Elmagzoub, 1985. Survey of Fuel Consumption in Khartoum Province Industries, SREP, Khartoum.

Anon, 1986. A comparative Analysis of the Clamp and The Bulls Trench Kiln. Mimeo IIT Bombay.

Arnold, J., No date Energy in the Brick Industry in Thailand. Part of a report for NEA by Meta Systems.

Basu, S.C., V. Menon and K.S. Jagadish 1985: Thermal Energy Consumption in the Brick and Tile Industry; ASTRA IIT Bangalore; mimeo.

BBS, 1990. Statistical Pocketbook of Bangladesh, 1990. Bangladesh Bureau of Statistics, Dhaka.

Beamish, Anne and Will Donovan, 1988. Village Level Brickmaking, GATE/GTZ, Vieweg Verlag, Wiesbaden, August 1988.

Bender, W. and F. Haendle, 1982, Brick and Tile Making, Vieweg Verlag, Wiesbaden and Berlin.

Bollard, A.E. 1982 Brick work: Small plants in the brick industry. Alternative industrial framework for the U.K. Report no.3, IT Publications, London.

Box, J. de la Rive, 1981 Small scale brick making in Aceh Development Area, Industry Sector Report No. 4, Institutional Development Assistance Project IDAP/JTA-9a-21, Regional Development Planning Board Special Territory Aceh, Indonesia.

Buchanan, W. 1985, Labour intensive and small scale brickmaking. Prepared for UNIDO Vienna (UNIDO/IO.616).

Carr, M. 1988. Sustainable Industrial Development; Seven Case Studies. IT Publications, London.

CBS, 1976. Household conditions in Indonesia, Sept. - Dec. 1976. Central Bureau for Statistics, Jakarta.

Chavalit, U., 1988. Water Jar Industry and Fuelwood Production Links in Thailand, Dept. Forestry, Bangkok.

Clews, F.H., 1969. Heavy Clay Technology. Academic Press, London and New York, for the British Ceramic Research Association.

CPTRHEP 1988. Housing Development in Thailand; Technology for Development Vol. 6 (2):1.

Deserco, Gajah Mada University, 1981. Preference for building materials in the Solo region. Deserco, Jakarta and Gajah Mada University, Socio Political Faculty, Yogyakarta.

DoE and DoI, undated Energy conservation and utilization in the building brick industry. Energy audit series no. 2, Building Brick Industry. Mimeo Department of Energy, London.

DoME, 1990. Reducing Fuel and Electricity Costs in Brickmaking. Energy use in Industry Booklet No. 9. Department of Minerals and Energy, Sydney.

Donovan, D., 1980. Research Trials in Rural Nepal, mimeo, Institute of Current World Affairs.

Duerre, A. 1980. Pedoman Pengelolaan Ring Kiln. Keller Ofenbau GMBH, 4530 Ibbenburen-Laggenbeck, Germany.

FAO, 1986a. Wood Based Energy Systems in Rural Industries, Sri Lanka; Field Document No. 4, FAO/RWEDP, Bangkok.

FAO, 1986b. Wood Energy for Rural Industries, Thailand Field Document No. 13, FAO, Bangkok.

FAO, 1988 a. The Use of Wood in Rural Industries in Asia and the Pacific; Field Document No. 7, FAO/RWEDP, Bangkok.

FAO, 1988 b. Wood Based Energy Systems in Rural Industries, Nepal; Field Document No.11, FAO/RWEDP, Bangkok.

FAO, 1989 a. Wood Based Energy Systems in Rural Industries, Philippines; Field Document No. 12, FAO/RWEDP, Bangkok.

FAO, 1989 b. Wood Based Energy Systems in Rural Industries, Pakistan; Field Document No. 13, FAO/RWEDP, Bangkok.

FAO, 1989 c. Biomass based energy systems in Rural Industries and Village Applications. Bangladesh; Field Document No. 17, FAO/RWEDP, Bangkok.

FAO, 1989 d. Wood Based Energy Systems in Rural Industries, India; Field Document No.18, FAO/RWEDP, Bangkok.

FAO, 1990 Status of Wood Energy in Rural Industries in Asia, Report from the Regional Expert Consultation hel in Hat Yai, Thailand in 1990 on wood based energy systems in rural industries and village application, FAO-RWEDP, Bangkok.

GATE, 1991, GATE, Questions and Answers, information, No. 4, 1991, pp38-40. GTZ, Eschborn.

ILO, 1984. Small Scale Brick Making, ILO/UNIDO Geneva.

ILO, 1987.Small Scale manufacture of stabilized soil blocks, Technical memorandum no. 12, Technology series, ILO-Geneva.

Jagadishh 1985: Alternative Building Technologies for Rural Housing, in "Perspectives in Technology" Vol. 3, KSCST, Bangalore.

Joseph, S., W. McGarry, O. Sopchokchai and B. Sajjakulnit 1989. A study of the Brick Industry in Thailand. A draft Report for AIDAB, Canberra.

Keddie, J. and W. Cleghorn 1980: Brick Manufacture in Developing Countries, Scottish Academic Press.

Knizek, I., 1970. Resources for the Anticipated Development. Mimeo UNIDO.

Knizek, I. and A. Koopmans, 1981, An inquiry into the small-scale structural clay products industry of Java; Situation, Conditions and Recommendations. Technical Paper 67 of Unido project INS/74/034, Bandung, Indonesia.

Koopmans, A., 1987. The Use of Wood as an Energy Source in the Rural Clay and Brick Industry in Indonesia. Mimeo FAO.

Lange, D. de, 1990. Brick Industry in Kathmandu Valley, mimeo, Twente University.

Lawson, W., 1990. Energy Efficiency in Housing Construction in Developing Countries, University of N.S.W., Sydney.

Martyn, P., Y. Lallemant and J. Delay. Aluminium and Energy. in UNEP Industry and Environment, April-May-June 1990, pp 43-46.

Quabili, R.T. 1987. Study report on bricks and brick manufacture in Bangladesh. Rural employment sector programme-Bangladesh, TAT-IDP, Norad/Sida, Dacca, Bangladesh.

SDC-SKAT, 1991. Sector Study Building Materials in Bangladesh, Final Report. St. Gallen, Switzerland.

Shi Junjie 1989: Dissemination of Small Vertical Brick Kilns with Low Energy Consumption in China, Rural Energy, FAO, Bangkok.

SPH, 1990. Statistical data of the Socialist Republic of Vietnam, 1976-1989. Statistical Publishing House, Hanoi.

Stulz, R. and K. Mukerji, 1988. Appropriate building materials. A catalogue of potential solutions. Revised, enlarged edition. SKAT Publications, St. Gallen, Switzerland.

Svenningson, J. 1990: Study of the Use of Fuelwood in Brick Making Industry in Guayaquil, Equador, in Status of Wood Energy in Rural Industries in Asia, FAO, Bangkok.

TEAM 1986: Wood Energy Systems in Rural Industry and Village Activities, mimeo, FAO, Rome.

Thorburn, C., 1982 Technologies for the Utilisation of Rice Husks, mimeo, Dian Desa Jogyakarta.

Thun, R.A. 1986 Technical end economic aspects of using wood fuels in rural industries, Mimeo, FAO, Rome.

Turkpak, 1991. Wood use in the brick kiln industry of Pakistan. Turkpak International (Pvt.) Limited for The Government of Pakistan and the United States Agency for International Development.

UNCHS, 1986 Global report on Human Settlements. UNCHS (Habitat), Nairobi, Kenya.

UNIDO, 1969. The establishment of the brick and tile industry in developing countries. UNIDO, Vienna, (E.69.II.B.19).

UNIDO, 1980. Monographs on Appropriate Industrial Technology; No. 12. Appropriate Industrial Technology for Construction and Building Materials. (ID/232/12) UNIDO, Vienna.

UNIDO, 1984, Optimum scale production in developing countries. Sectoral Studies Series no. 12. Vienna.

UNIDO, 1985, The Building Materials Industry in Developing Countries; An Appraisal, UNIDO, Vienna.

United Nations, 1980 Patterns of Urban and Rural Populations Growth. Population Studies 86. UN, New York.

United Nations, 1986 Urban and Rural Population Projections 1950-2025. The 1984 Assesment. UN, New York, 1986.

World Bank, 1987. Energy Efficiency Improvement in the Brick, Tile and Lime Industry in Java. Washington.

WRI, 1992. World Resources Report 1992, World Resources Institute, Washington, USA.

Yin Fu Yin, 1989. Brief Introduction to MODEL SJY I, Improved Brick Kiln. Mimeo, Henan Academy of Science.

ANNEX

CHECKLIST FOR USE WHILE MAKING AN ASSESSMENT OF THE BRICK INDUSTRY

The following questions need to be asked when assessing the brick industry. It should be noted these are just guidelines and any other relevant information which is available or could be easily be acquired, should be collected. This may make the subsequent analysis of the results easier.

- How are houses being built, what materials used, what are prices, who buys, how is financing found for construction?

- Why are some building materials preferred by builders and do builders' preferences mirror consumer preference?

- What building materials that are locally available require minimum energy input and use renewable sources of energy and will provide acceptable shelter to different groups of people in the society?

- Are there alternative building materials/products that could fulfil the same function but at a cheaper price/require less energy to produce and/or provide more job opportunities?

- How can these different building materials be produced more cost effectively so that they can compete with existing capital and energy intensive building products such as cement?

- How are bricks being produced; how is the plant laid out, how many bricks are produced, by whom, and at what cost?

- Where do the industries get their clay, at what price and how?

- What types of energy are now used, what is the energy consumption and cost in individual enterprises, where are they getting the fuel from, at what price, how are kilns built and operated and how could their performance be improved?

- Could more effective and lower cost shelter be provided through retraining of the existing builders?

- What are the gender relations of production, what are the relative wage rates, and what are working conditions like for men and women? Who manages the enterprise and how is management carried out?

- How profitable is the enterprise, what are the major production costs, what is the capital investment, what interventions does government already have in the industry, is training undertaken, what is the productivity of labour?

- Are there subsidies in the building industry, what are they and to what extent do they distort the market?

- What are the differences in the marketing of different building materials, what market share does each building material have.

In case intervention in the brick industry is considered, answers to the following questions should be sought:

- What type of bricks need to be produced to stay competitive with other building products and meet the changing needs of consumers?
- Who should produce them?
- How should they be produced?
- What type of energy savings can be achieved and what methods/equipment should be introduced to achieve these savings?
- Can brick producers become involved in growing their own fuel or is there a source or residue that at present has no other alternative use?
- How can the position and pay of women be improved?
- Is there a market for new ceramic products that can be manufactured and marketed by brick producers?
- Is there an export market (outside the production district) for higher quality bricks?
- What types of assistance can be given to the brick industry to ensure that it has a level playing field on which to compete in the building materials market?
- What are the costs and benefits of supporting the brick industry as opposed to other building materials industries?