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World Bank/UNDP/Bilateral Aid
Energy Sector Management Assistance Program

Activity Completion Report

No. 097/89

Country: UGANDA

Activity: ENERGY EFFICIENCY IMPROVEMENT IN THE BRICK AND TILE INDUSTRY

MARCH 1989

Report of the World Bank/UNDP/Bilateral Aid Energy Sector Management Assistance Program

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) was started in 1983 as a companion to the Energy Assessment Program, established in 1980. The Assessment Program was designed to identify and analyze the most serious energy problems in developing countries. ESMAP was designed as a pre-investment facility, partly to assist in implementing the actions recommended in the Assessments. Today ESMAP carries out pre-investment activities in 45 countries and provides institutional and policy advice to developing country decision-makers. The Program aims to supplement, advance, and strengthen the impact of bilateral and multilateral resources already available for technical assistance in the energy sector. The reports produced under the ESMAP Program provide governments, donors, and potential investors with information needed to speed up project preparation and implementation. ESMAP activities fall into two major groupings:

<u>Energy Efficiency and Strategy</u>, addressing the institutional, financial, and policy issues of the energy sector, including design of sector strategies, improving energy end-use, defining investment programs, and strengthening sector enterprises; and

<u>Household, Rural, and Renewable Energy</u>, addressing the technical, economic, financial, institutional and policy issues affecting energy supply and demand, including energy from traditional and modern sources for use by rural and urban households and rural industries.

FUNDING

The Program is a major international effort supported by the UNDP, the World Bank, and bilateral agencies in a number of countries including the Netherlands, Canada, Switzerland, Norway, Sweden, Italy, Australia, Denmark, France, Finland, the United Kingdom, Ireland, Japan, New Zealand, Iceland, and the USA.

INQUIRIES

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UGANDA

ENERGY EFFICIENCY IMPROVEMENT IN THE BRICK AND TILE INDUSTRY

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ACRONYMS AND ABBREVIATIONS

Acronyms

EIL	Experiment in International Living
GOU	Government of Uganda
IPF	Indicative Program Funding
KCI	Kiteredde Construction Institute
MCM	Ministry of Cooperatives and Marketing
MHUD	Ministry of Housing and Urban Development
MOE	Ministry of Energy
MOEPF	Ministry of of Environmental Protection and Forestry
MOIT	Ministry of Industry and Technology
MPED	Ministry of Planning and Economic Development
UNDP	United Nations Development Programme

Abbreviations

kg	kilogram
m	meter
MJ	megajoule
mm	millimeter
N	Newton
RFO	Residual Fuel Oil
t	metric tonne
toe	tonne of oil equivalent
tonne	metric tonne
USh	Uganda Shilling
US$	U. S. Dollar

CURRENCY EQUIVALENTS
(as of September 1987)

USh 60 = US$1.00

ENERGY CONVERSION FACTORS

1 metric tonne (t)	=	1,000 kilograms (kg)
1 tonne of oil equivalent (toe)	=	10 million kilocalories (kcal)
1 tonne of oil equivalent (toe)	=	41.9 megajoules (MJ)
1 tonne of oil equivalent (toe)	=	7.33 barrels of oil equivalent (boe)
1 kilocalorie (kcal)	=	0.00419 gigajoules (GJ)
1 megajoule (MJ)	=	1 million Joules (J)
1 megajoule (MJ)	=	239 kilocalories (kcal)
1 megajoule (MJ)	=	0.0000239 toe

FUEL CONVERSION FACTORS

Fuel	Unit	Density as Used (kg/unit)	Lower Heating Value (MJ/kg)
Fuelwood (air-dried Eucalyptus)	m^3 stacked	510	15.0
Coffee Husk	m^3 stacked	410	15.5
Rice Husk	m^3 stacked	105	13.0
Papyrus Stalks	m^3 stacked	240	15.0
Residual Fuel Oil (RFO)	litre	0.98	38.6

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EXECUTIVE SUMMARY

1. The availability of energy is an important determinant in Uganda's economic development, and measures for developing energy supply and managing demand need to be planned and implemented in order to prevent energy bottlenecks from restraining economic recovery. The 1983 Energy Assessment Report, prepared under the joint UNDP/World Bank Energy Assessment Program, outlined a number of issues which needed to be addressed to enable the energy sector to play an effective role in the economic recovery of Uganda. One of the issues was the need to improve energy efficiency of rural industries to alleviate the pressure on existing fuelwood resources.

Objectives

2. The overall goal of this ESMAP activity is to identify and evaluate technically and economically feasible means for improving the energy efficiency of the brick and tile industry in Uganda. Reduction of fuelwood demand would be expected to directly contribute to stemming the erosion of Uganda's wood capital. In addition, as fuelwood supplies to the brick and tile industry are obtained at significant financial cost, energy efficiency gains should translate into greater production at lower cost.

Woodfuels Sector

3. Woodfuels account for 96% of Uganda's current energy consumption, including approximately 70% of commercial energy. Current consumption is estimated to be around 18,300,000 m^3 of fuelwood equivalent, and is expected to rise to 27,500,000 m^3 by the 2000.

4. Growth of the woodfuel economy has precipitated the development of a number of discrete areas where woodfuels have become in short supply, most especially in parts of West Nile, Soroti, Mbarara and Rakai districts. This trend is very likely to accelerate. Current annual production of woody biomass in Uganda is estimated to be around 15,600,000 m^3 of fuelwood equivalent; demand thus exceeds sustainable supply by around 17%. This picture is expected to change dramatically over the next 15 years. By the year 2000, demand for woodfuel is expected to exceed the 1985 sustainable supply by nearly 80%. Of this estimated future demand, commercial woodfuels will account for 19%, compared with 14% in 1985.

Brick and Tile Industry Structure

5. Brick manufacturing methods in developing countries range from traditional artisan production units to medium-scale, capital intensive plants. In Uganda, considering the scale and technique of production, the brick and tile industry could be classified into artisan, small-scale

and medium-scale production units. Table 1 summarizes the production techniques used by the various producers.

Table 1: CLASSIFICATION OF BRICK AND TILE INDUSTRY

Scale of Production	Number of Bricks/day (average) a/	Process Used	Market Area
Artisan b/	1,000	Hand-made, clamp-fired	Rural villages
Small	10,000	Semi-mechanized	Near towns
Medium c/	40,000	Mechanized, extruded, wire cut continuous ring kiln	Near industrialized areas of high demand

a/ Annual production per unit depends on the number of days in operation considering weather conditions and other constraints.
b/ Artisan producers are major suppliers of brick in Uganda.
c/ Presently Uganda Clays is the only medium scale brick and tile producer in Uganda.

Brick and Tile Supply and Demand

6. The demand for building materials (e.g. bricks and tiles) is more complex than simply pressure from population expansion. Knowledge of Uganda's recent history emphasizes the importance of demand for bricks and tiles caused by a large backlog in housing stock, plus reconstruction and maintenance of damaged and neglected buildings. Simultaneously, after years of stagnation, the construction industry has enormous building material requirements for new construction, reconstruction and maintenance in the industrial, commercial, clerical, private and public sectors.

7. Even cursory analysis of supply and demand figures reveals that there is an extreme shortage of brick and tile in Uganda. At the current rate of production, the gap between supply and demand will continue to widen, resulting in higher prices for these products to final consumers. A summary analysis of the current supply/demand situation is given in Table 2.

Table 2: BRICK AND TILE SUPPLY/DEMAND ANALYSIS
(millions)

Product/Scenario	Estimated 1987 Demand	Supply @ 100% Capacity a/	Present Supply	Supply/Demand Gap @ 100% Capacity	Present Supply/Demand Gap
Bricks					
Low Case	350	58	23	292	327
Optimistic Case	1,821	58	23	1,763	1,798
Tiles					
Low Case	97	8	0.1	89	97
Optimistic Case	501	8	0.1	493	501

a/ Including six plants proposed for establishment.

8. Since various type of fuels are used to fire bricks, energy consumption has been determined in terms of cubic meters of stacked firewood equivalent for all fuels used, including coffee and rice husk. Total energy consumption in the brick and tile industry is determined using this equivalency as 73,000 m^3 of firewood per annum at present production rates. Approximately 91% of this energy demand is met by firewood as opposed to agricultural waste substitutes.

9. The significance of total wood demand by the industry may be realized by noting that production as a level to meet maximum forecast demand would require a hundred-fold increase in brick and tile output. Scaled by this factor and converted into solid wood equivalent terms, the implied future wood demand is 4,380,000 m^3. While the estimates are proximate, this is roughly 28% of annual woody biomass production in Uganda. Ignoring residential backlog still results in a forty-fold increase over present supply to meet annual demand, requiring some 11% of national wood biomass production at present industry energy efficiency.

Proposed Measures to Improve Energy Efficiency

10. Energy consumption parameters demonstrate that there is up to a 9:1 variation in the energy efficiency of brick and tile manufacture in Uganda. The few small and medium scale production units are functioning at 20-25 percent of their installed capacities, and, in the case of small scale plants, are highly energy inefficient. Consequently, the traditional artisan brick producing units are furnishing the bulk (7 times the output of semi-mechanized plants) of Uganda's burnt bricks. Unfortunately, these artisan production units are also using the bulk of the energy in the form of fuelwood, which is leading to national concern over deforestation. The country can ill afford continuing inefficiencies

in brick and tile production at inadequate production rates. Yet, Uganda requires locally produced building materials to support any positive reconstruction effort. Possible energy solutions take two forms: (a) Low-cost energy efficiency enhancements through improved kiln design, maintenance and operation; and (b) Substitution of available alternative fuels, especially agricultural residues, for firewood.

11. Artisan Producers. Artisan brick producers will remain the prime suppliers of brick to the residential and, often, the industrial and commercial sectors for the forseeable future. In view of the scale of future wood demand from this sub-sector and the magnitude of potential energy savings, a national dissemination/extension effort is warranted. A suitable program would include the following components:

(a) Research/Pilot Demonstration to test and adapt proposed energy conservation measures in optimized brick structure and composition, and improved kiln construction and firing;

(b) Training to sustainably transfer the knowledge and potential benefits of the research component; and

(c) Dissemination to ensure popularization of the improved techniques throughout Uganda.

The first two make up the pilot phase activities which would be overseen by a steering committee sponsored by the Ministry of Energy and made up of interested governmental representatives. Assuming satisfactory results from the pilot phase, a 3 1/2 year country-wide dissemination program will begin.

12. The program should be targeted at traditional rural-based artisan brickmakers as well as those located in medium cities, rural towns and institutionally-sponsored integrated development programs. While the basic rationale for the effort is based on energy conservation, program goals should be extended to encompass the promotion of improved local materials and the upgrading of standards of basic building materials. Because of their extensive prior experience in training artisans for the construction industry in Uganda, it is recommended that the day-to-day implementation of the proposed program for upgrading artisan brick production methods be placed under the supervision of the Kiteredde Construction Institute (KCI). Technical assistance, especially on administration and management aspects, should be provided to the KCI.

13. Small Scale, Semi-mechanized Producers. The small scale brick production units promise to be highly beneficial to the country's reconstruction efforts. The semi-mechanized units require modest capital investment, can service specific markets without extensive transport costs and are of a scale that is relatively easy to manage. A program to address inefficiencies in management and fuel consumption while promoting pilot scale improved brick production is therefore recommended. Measures

include improved kiln draft control, replacement of manufacturing equipment, and provision of spare parts.

14. The proposed assistance to the small-scale brick production sector would also be coordinated by the steering committee, in close collaboration with other local agencies such as the Uganda Development Bank, that have some in-house capabilities to assist prospective small-scale brick makers on a number of critical tasks. Such tasks would include: (a) expediting 'clearing house' types of operations, related specifically to identifying and arranging the procurement from abroad of spare parts and other accessories for their equipment (i.e., to reburbish or retrofit their plants); and (b) completing project feasibility and appraisal studies in respect of ventures to retrofit individual plants.

15. Medium Scale Producers. Uganda Clay Works, Ltd., a parastatal organization, produces the best clay masonry units and the only clay roofing tiles in Uganda at a rate of fuel consumption that is on par with more mechanized European plants. The factory is well located to major markets and has an order backlog of six months. Nevertheless, the plant is three decades old with severe needs for renovation and spare parts. Due to interrupted electrical service and lack of transport and spares, the plant is operating at 30-40% of installed capacity and is undoubtedly at a production cost disadvantage from the full payroll being carried.

16. If and when foreign exchange becomes available through the economic recovery program, Uganda Clay Works should be placed high on the list of critical industries. The longer term goal should be to increase Uganda Clay's production capacity through the addition of another production line to produce preferentially for the public sector. Initially, technical assistance will be needed to define and substantiate the amount of spare parts required. In later phases, expertise will be required to study the feasibility of adding a new production line.

Project Costs

17. Implementation of the recommended action plans is estimated to cost a total of approximately US$2,900,000. These costs cover:

(a) Establishment and operation of a research and training/dissemination program for the artisanal sub-sector;

(b) Establishment of a revolving fund for provision of spare parts to the small scale producer sub-sector;

(c) Pilot installation of an improved downdraft kiln at Kizubi Brickworks, and follow-on extension to four other small scale producers;

(d) Feasibility evaluation of the addition of a new production line at Uganda Clay Works, Ltd.; and

(e) Provision of technical assistance to all three sub-sectors in kiln design and construction, firing techniques, fuel substitution, and enterprise management.

About 70% of the total cost will be in foreign exchange and the balance in local currency.

18. In addition to these expenditures, the mission envisions in the longer term an investment of US$4 million for equipment, installation and technical services at Uganda Clays. The feasibility of the investment in the proposed new production line will be established in component (d) above.

Project Benefits

19. Benefits of a project to improve the energy efficiency of Uganda's brick and tile industry take both direct and indirect forms. Efforts to improve energy efficiency through rehabilitation and training will have numerous spin-off benefits to the construction industry, such as reduced equipment down time and higher capacity utilization, increased operator skill levels, and improved overall management. These benefits should all favorably impact on productive efficiency, enhancing the industry's important role in supporting economic recovery.

20. The main quantifiable benefit of the proposed project is an expected major reduction in fuelwood demand by the brick and tile industry, both through gains in end-use efficiency and substitution of agricultural residues. The total fuelwood savings at present production levels is estimated as just under 40,000 m^3/year, fairly small in absolute terms relative to demand in the household sub-sector. However, given the great brick and tile supply/demand gap and the expansion potential of the industry, the 60% economies achievable in the artisan and small scale sub-sectors are very significant.

Project Justification

21. Artisan Sub-sector. Returns in the economic analysis shown in Table 3 are favorable for all but the most pessimistic brick production scenario, indicating ample justification for a national research and training/extension program targeted at artisan producers.

22. Small Scale, Semi-mechanized Subsector. Results of the economic analysis of the small scale producer component are also shown in Table 3. With returns averaging 20 percent across all kiln dissemination scenarios, the kiln replacement program is similarly well justified.

Table 3: PROJECT ECONOMIC RATE OF RETURN

Sub-Sector/Scenario	EIRR (%)
Artisan	
No growth in current production	7
10% annual increase in years 6-20	15
20% annual increase in years 6-20	22
Small Scale, Semi-mechanized	
Replacement of 1 kiln	21
Replacement of 5 kilns over 5 years	19
Replacement of 5 kilns over 3 years	19
Replacement of 5 kilns over 2 years	20

Source: Annex 17.

Project Risks

23. The major project risks rest primarily in the artisan sub-sector. As with any national training and extension effort, implementation is subject to delay or failure to reach target populations. Renewed deterioration of the security situation could compound these difficulties. The risk is minimized through careful choice of implementing agents and use of a two-phased pilot/wide-scale dissemination approach to project scheduling and oversight.

24. The second major risk is failure to obtain anticipated energy savings. Especially in the artisan sub-sector, this could be the result of producers failing to follow technical advice and new techniques. However, purchased fuelwood makes up a substantial portion of brick and tile production costs, so there thus appear to be adequate incentives for adoption. In addition, the training/extension design incorporates in-field, community-level demonstrations in order to illustrate the new techniques under plausible operating conditions.

I. INTRODUCTION

Project Development

1.1 The availability of energy is an important determinant in Uganda's economic development, and measures for developing energy supply and managing demand need to be planned and implemented in order to prevent energy bottlenecks from restraining economic recovery. The 1983 Energy Assessment Report, prepared under the joint UNDP/World Bank Energy Assessment Program, outlined a number of issues which needed to be addressed to enable the energy sector to play an effective role in the economic recovery of Uganda. 1/ One of the issues was the need to improve energy efficiency of rural industries to alleviate the pressure on existing fuelwood resources. In 1984, a follow-up to the Energy Assessment carried out under the joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) recommended that immediate steps be taken to improve energy efficiency in Uganda's brick and tile industry.

1.2 Following a request by the Ugandan Government, agreement was reached for an ESMAP technical assistance and investment identification activity to: (a) assess fuelwood supply and consumption requirements in the country's brick and tile industry; (b) identify measures to improve energy efficiency in the industry focusing mainly on simple, inexpensive energy conservation measures; and (c) design a program of action to disseminate these measures on a nationwide basis. Funding for the ESMAP project was secured from UNDP country IPF resources, supplemented by internal ESMAP funds and in-kind contributions from the Government of Uganda (GOU). The Energy Department of the Ministry of Power, Ports and Telecommunications was designated as implementing agency.

1.3 An ESMAP mission consisting of a mission leader, a brick and tile production engineer and an extension specialist arrived in Kampala in mid-July, 1985, for a planned visit of four weeks. 2/ However, the mission's work was hampered by a worsening security situation and consequent restrictions on internal travel. The mission's activities had to be prematurely terminated and its members left Uganda as part of an official evacuation on July 31, 1985.

1.4 In order to complete the work of the above mission, a second ESMAP mission was fielded in September, 1987, with the cooperation of the

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1/ Uganda: Issues and Options in the Energy Sector, Report No. 4453-UG, World Bank, July, 1983.

2/ The mission members were Messrs. Bernard Frueh (Mission Leader), J. Van der Velden (Consultant - Brick and Tile Production Engineer), and S. Davenport (Consultant - Extension Specialist)

Ministry of Energy. 3/ The mission was able to successfully both update and extend the findings of the 1985 visit during its three week stay. This report thus represents the combined results of the original and follow-up missions.

Objectives

1.5 The overall goal of this ESMAP activity is to identify and evaluate technically and economically feasible means for improving the energy efficiency of the brick and tile industry in Uganda. These measures include kiln and process modifications to reduce the consumption of fuelwood per unit product output, as well as substitution of low-cost agricultural residue fuels where readily available. Reduction of fuelwood demand would be expected to directly contribute to stemming the erosion of Uganda's wood capital. In addition, as fuelwood supplies to the brick and tile industry are obtained at significant financial cost, energy efficiency gains should translate into greater production at lower cost.

1.6 Specifically, the activity aims to:

(a) Identify the areas of concentration of brick and tile production as well as the organizational structure of this industrial subsector;

(b) Estimate current and likely future levels of brick and tile production as well as the fuel requirements of the industry;

(c) Assess the performance of the different type of kilns and firing techniques used in Uganda, especially to determine the scope for energy savings;

(d) Assess the scope for using alternative fuels on the basis of their adaptability to regional conditions and their economic and financial competitiveness;

(e) Prepare an inventory of the various technical packages and managerial measures that could be used to improve the efficiency of energy use in brick and tile production; and

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3/ The members of the mission which visited Uganda from August 31 to September 18, 1987 were Messrs. Reza Khonsary (Mission Leader), Jan van der Velden (Consultant - Brick and Tile Production Engineer), and Stanton Davenport (Consultant - Extension Specialist). The report was authored by Mr. Charles Feinstein (Energy Planner). Administrative support was provided by Ms. Evelyn Cortez-Fusco.

(f) Formulate a financially and economically justified program of action to improve the efficiency of energy use in the brick and the tile industries of Uganda.

Scope

1.7 During the field work in Uganda, visits were made to a number of mechanized, semi-mechanized and artisan brick and tile production units in Kampala, Entebbe, Jinja, Tororo, Mbale, Luwero, Mpigi, Masaka and Arua. The mission liaised with representatives of the Ministries of Energy (MOE), Planning and Economic Development (MPED), Housing and Urban Development (MHUD), Industry and Technology (MOIT), Cooperatives and Marketing (MCM), and Environmental Protection and Forestry (MOEPF). In addition, the mission briefed officials of international and non-governmental organizations operating in Uganda, and met with owners/managers of private enterprises. A complete list of persons and institutions contacted appears as Annex 1.

II. BACKGROUND

National Economy

2.1 Uganda has substantial reserves of natural wealth, with especially favorable soils and climate for agricultural production and with a significant mineral base to support the industrial sector. At independence in 1962, Uganda's economy was strong, backed by exceptionally skilled labor resources. The production of export crops, primarily cotton and coffee, was rapidly growing. The small industrial sector provided export and consumer goods, transport and communications were good, and an extensive hydroelectric-based electrification system was developed during the years just after independence. A steady annual GDP growth rate of 2% was achieved until 1970.

2.2 The economy stagnated and per capita income fell in the succeeding decade. Long years of neglect resulting from an inability to maintain and manage basic industrial, monetary and agricultural infrastructures as well as the emigration of skilled manpower and expertise contributed greatly to accelerating the economic decline. The Ugandan economy also suffered greatly from the rise in international petroleum prices in 1973, and from the breakup of the East African Community in 1977. The period of decline reached its lowest point during the war in 1979, which resulted in widespread looting and in damage to the few remaining productive sectors of the economy.

2.3 In 1981, the GOU began a program to stabilize the economy by encouraging private investment, reviving agricultural and industrial productive capacities, and by reducing inflation. The strategy involved floating the Uganda Shilling (USh), introducing more realistic producer prices, dismantling the system of price controls, and returning nationalized industries to private ownership. Recovery programs were developed with the aim of increasing agricultural production and exports in part through this strategy and in part by targeting external assistance at the rehabilitation of the most promising sectors. These programs have been successful both in attracting foreign finance and in restoring the economy on an upward growth path.

Energy Sector

2.4 During 1980, per capita energy consumption in Uganda is estimated to have been 0.35 toe, of which only 0.06 toe was commercial. 4/ This level of commercial energy consumption, while exceptionally low by world standards, is comparable to estimates for some

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4/ Commercial energy is defined as all energy traded outside the subsistence sector.

other low-income countries in Sub-Saharan Africa. Energy use is concentrated in the household sector (80% of total energy and 37% of commercial energy in 1980).

2.5 Woodfuels account for 96% of Uganda's current energy consumption, including approximately 70% of commercial energy. Current consumption is estimated to be around 18,300,000 m^3 of fuelwood equivalent, and is expected to rise to 27,500,000 m^3 by the year 2000.

2.6 Growth of the woodfuel economy has precipitated the development of a number of discrete areas where woodfuels have become in short supply, most especially in parts of West Nile, Soroti, Mbarara and Rakai districts. This trend is very likely to accelerate. Current annual production of woody biomass in Uganda is estimated to be around 15,600,000 m^3 of fuelwood equivalent; demand thus exceeds sustainable supply by around 17%. This picture is expected to change dramatically over the next 15 years. By the year 2000, demand for woodfuel is expected to exceed the 1985 sustainable supply by nearly 80%. Of this estimated future demand, commercial woodfuels will account for 19% or 5,225,000 m^3, compared with 14% in 1985.

2.7 Commercial woodfuels are used primarily by the urban domestic sector and by a number of agroindustries. The tea, tobacco and brick-making industries are greatly dependent on fuelwood for drying, curing, and burning their products, respectively. Aggregate demand by these industries totaled about 230,000 m^3 (solid) in 1985. The ability of the tea, tobacco and brick and tile industries to expand may be severely constrained unless steps are taken on both the demand and supply sides.

III. THE BRICK AND TILE INDUSTRY

Structure

Overview

3.1 Brick manufacturing methods in developing countries range from traditional artisan production units to medium-scale, capital intensive plants. The choice of brick making technology is mostly a function of market demand (i.e. scale and location of demand, and required or minimum acceptable quality standard), and availability and cost of investment funds and other inputs (labor, raw materials, fuel, transport, spare parts, etc.) associated with alternative production techniques. In Uganda, considering the scale and technique of production, the brick and tile industry could be classified into artisan, small-scale and medium-scale production units. Table 3.1 summarizes the production techniques used by the various producers, and the following paragraphs briefly characterize the three modes of production. Annex 2 provides a detailed description of the organizational structure of the industry.

Table 3.1: CLASSIFICATION OF BRICK AND TILE INDUSTRY

Scale of Production	Number of Bricks/day (average) a/	Process Used	Market Area
Artisan b/	1,000	Hand-made, clamp-fired	Rural villages
Small	10,000	Semi-mechanized	Near towns
Medium c/	40,000	Mechanized, extruded, wire cut continuous ring kiln	Near industrial-ized areas of high demand

a/ Annual production per unit depends on the number of days in operation considering weather conditions and other constraints.
b/ Artisan producers are major suppliers of brick in Uganda.
c/ Presently Uganda Clays is the only medium scale brick and tile producer in Uganda.

Source: Mission estimates.

Artisan Producers

3.2 Artisan brick makers produce about 1,000 bricks/day and are located close to the clay sources, and within a short distance of the brick markets. This reduces the transport cost and concomitantly the amount of fuel used in transport. The production method used is highly labor intensive and the investment requirements are low, consisting of simple, locally available implements. Furthermore, when climatic conditions impede building construction, the brick production ceases. Although artisan production is particularly appropriate for rural and peri-urban areas, due to the severe shortage of building material in Uganda artisan brick producers are supplying the majority of fired bricks to the principal urban centers.

Small-scale, Semi-mechanized Producers

3.3 Small-scale, semi-mechanized brickmakers produce about 10,000 bricks/day. The production method used is relatively sophisticated although the machinery employed, especially the brick extruders, is old. These production units are usually located close to cities and have the potential to yield higher productivity per worker than the artisan units.

Medium-scale, Mechanized Producers

3.4 In contrast to the artisan and small-scale brick production, medium-scale brickworks necessitate the capital investment of millions of dollars, mostly in foreign exchange for import of sophisticated production machinery and control systems. The complex equipment requires skilled management and trained production personnel. Employment associated with mechanized techniques of brick production is often very small relative to the traditional methods, although these producers have the potential to manufacture substantial quantities of higher quality bricks at lower unit energy consumption.

Brick and Tile Demand

Components

3.5 The demand for building materials (e.g. bricks and tiles) is more complex than simply pressure from population expansion. Knowledge of Uganda's recent history emphasizes the importance of demand for bricks and tiles caused by a large backlog in housing stock, plus reconstruction and maintenance of damaged and neglected buildings. Simultaneously, after years of stagnation, the construction industry has enormous building material requirements for new construction, reconstruction and maintenance in the industrial, commercial, clerical, private and public sectors.

Estimation

3.6 Working from a number of housing sector documents, the mission assembled disaggregated estimates of brick and tile demand which incorporate assumptions of future economic growth and recovery rates in the building industry. In order to indicate the range of uncertainty in the assessments, the results are presented in two basic scenarios: Low Case and Optimistic Case. Detailed calculations supporting the range of estimates are given in Annex 3 and summarized in Table 3.2.

Table 3.2: ESTIMATED BRICK AND TILE DEMAND
(millions)

Product/Scenario	1985 Demand Component: Population Growth a/	1985 Demand Component: Residential Backlog b/	1985 Demand Component: New Construction c/	1985 Sub-Total	1985-87 Demand Growth d/	1987 Demand
Bricks						
Low Case	123	150	27	300	50	350
Optimistic Case	123	1,078	360	1,561	260	1,821
Tiles						
Low Case	34	41	8	83	14	97
Optimistic Case	34	297	99	430	71	501

a/ Urban = 5.0%; Kampala = 4.0%; National = 3.2%.
b/ Optimistic Case: High brick/tile housing density and backlog absorbed over one year.
Low Case: Low brick/tile housing density and backlog absorbed over five years.
c/ Optimistic Case: New construction, reconstruction and maintenance = 30% of residential demand.
Low Case: New construction, reconstruction and maintenance = 10% of residential demand.
d/ At 8% p.a.

Source: MHUD; UN/Habitat; UNDP; USAID; World Bank; Mission estimates.

Brick and Tile Supply

Overview

3.7 Industry capacity and actual supply estimates are summarized in Table 3.3. The combined installed annual capacity of the one medium-scale, mechanized factory and six small-scale, semi-mechanized manufacturing units is 34.5 million bricks and 1.2 million tiles per year. Due to a variety of constraints, including lack of spare parts, transport delays, electric power disruption, lack of maintenance and run-down kiln equipment, the actual combined production of these same producers is nearer the range of 3.2 million bricks/year and 0.12 million tiles/year. The combined annual capacity of six production units proposed to be established is 23.4 million bricks and 6.8 million tiles.

3.8 Excluding extremely small, ad hoc sun-dried brick and tile pilot programs sustained by international organizations, the informal or artisan brick production is estimated to supply 20 million low quality bricks/year.

Table 3.3: ESTIMATED BRICK AND TILE SUPPLY

	Production	Capacity	Capacity Utilization	Production at Full Capacity by Type of Fuel: Woodfuel	Coffee Husk	Rice Husk
	(tonnes)	(tonnes)	(%)	(tonnes)	(tonnes)	(tonnes)
Medium-scale, mechanized:						
Uganda Clays	8,750	36,500	24	--	36,500	--
Small-scale, semi-mechanized:						
Butendi	(	6,000	(	6,000	--	--
Kibimba	(	6,000 a/	(	3,000	--	3,000
Kizubi	(	6,000 b/	(	3,000	3,000	--
Mutanga Clays Ltd.	(	6,000	(18.6	6,000	--	--
Pan African	(	6,000	(	6,000	--	--
Universal Clay Works	(	6,000	(	--	6,000	--
Subtotal	6,690 c/	36,000	18.6	24,000	9,000	3,000
Artisan	117,000	N/A	N/A	117,000	--	--
Total	132,440	72,500 d/	N/A	141,000	45,500	3,000

a/ Kibimba is assumed on the average to use 50% fuelwood and 50% rice husk.
b/ Kizubi is assumed on the average to use 50% fuelwood and 50% coffee husk.
c/ Total production of the small-scale, semi-mechanized producers.
d/ Does not include capacity of artisan producers since their capacity is flexible and could be increased easily.
Source: Mission estimates.

Artisanal Production

3.9 Artisan brickmakers produce handmade weatherproof brick and blocks suitable for the walls of one-story houses. Operations are widespread, and artisan brickmaking can be found throughout Uganda wherever there is a demand. Production is therefore elastic, with no set "capacity" or capacity factor.

3.10 The solid bricks and blocks are shaped into various sizes using bottomless wooden molds. The length of the bricks varies from 220 to 295 mm, the width from 100 to 150 mm and the height from 65 to 130 mm. Weight thus varies from 2.5 to 7.6 kg per piece. The consistency of the brick dimensions in a lot is usually poor.

3.11 The air-dried (green) bricks are fired in non-permanent, hand-stacked clamps (see Annex 4) varying in design and size and containing from 30 to 180 tonnes of bricks. The fuel is firewood, mainly Eucalyptus. To save as much wood as possible, firing periods are kept short and firing temperatures low. For this reason, the quality level of bricks and blocks fired in the clamp kilns is rather poor. Generally the dry compressive strength is lower than 8 N/mm^2, and especially the bricks within 300 mm from the outside surfaces of the clamp are of very low quality and partly not even weatherproof. The proportion of these very poor quality bricks is strongly dependent on the size of the clamp and varies from approximately 25% up to 45%. Due to the low quality of the clamp kiln products, the average breakage rate to the construction sites is about 17%.

Small Scale, Semi-mechanized Production

3.12 The small scale, semi-mechanized production units manufacture a large variety of solid and perforated clay bricks and in some works also a limited number of roofing tiles. Kiln designs employed in this sub-sector include simple clamp, periodic (i.e. intermittently operated) up- and down-draft (refer to Annex 5), and Hoffman ring types. Brick size is typically 230 x 110 x 70 mm weighing somewhat under 5 kg per piece (211 standard face bricks/tonne). Fuels consumed are firewood, coffee husk and rice husk. The quality of brick and tile manufactured in these production units appears to be fully acceptable in the market for standard outer wall bricks.

Medium Scale, Mechanized Production

3.13 Medium scale production of a range of brick, block and roofing tile wares takes place at Uganda Clays, located on the outskirts of Kampala. The plant is jointly owned by a private company and the National Housing and Construction Corporation, a parastatal. Clay products are fired in a continuously operating Hoffman ring kiln (see Annex 6) using coffee husks as fuel, producing high quality bricks. The products are supplied to the public, commercial and industrial sectors and, to a lesser extent, to the private residential sector for large housing units. The factory is also the major supplier of tiles in Uganda.

Future Production

3.14 In addition to the above noted small to medium scale plants, there are a number of additional plants as listed in Table 3.4 registered with the Ministry of Industry since 1981. None of these factories has yet been established. However, six of the newer proposals are in the process of securing funds and have been included in the estimates of future production capacity.

Table 3.4: PROPOSED BRICK AND TILE PLANTS

Name	Location	Size
Arapai Concrete Products, Ltd.	Kampala	Small-scale
Packwach Bricks	Arua	Small-scale
Naluwoli Clays	Kamuli District	Small-scale
Matanga Clays	Masaka	Small-scale
Katakarya Blocks	Mbarara	Small-scale
Mbarara/GOU Plant	Mbarara	Medium-scale
East African Clay Products, Ltd.	Kampala	Medium-scale
10 Coffee Union Plants	Mubende	Large-scale
	Busoga	Large-scale
	Bugisu	Large-scale
	Teso	Large-scale
	Banyankole	Large-scale
	South Bukedi	Large-scale
	East Mengo	Large-scale
	Masaka	Large-scale
	Bunkord	Large-scale
	Kabale	Large-scale

Supply/Demand Gap

3.15 Even cursory analysis of the supply and demand figures reveals that there is an extreme shortage of brick and tile in Uganda. At the current rate of production, the gap between supply and demand will continue to widen, resulting in higher prices for these products to final consumers. The minimum estimated increase in supply to arrest the accelerating shortage of building construction material is 292 million bricks and 89 million tiles per year. The number of bricks and tiles needed to alleviate the existing housing backlog and support healthy public, industrial and commercial sectors is of the magnitude of 1,763 million bricks and 493 million tiles per year. 5/ A summary analysis of the current supply/demand situation is given in Table 3.5.

Table 3.5: BRICK AND TILE SUPPLY/DEMAND ANALYSIS
(millions)

Product/Scenario	Estimated 1987 Demand	Supply @ 100% Capacity a/	Present Supply	Supply/Demand Gap @ 100% Capacity	Present Supply/Demand Gap
Bricks					
Low Case	350	58	23	292	327
Optimistic Case	1,821	58	23	1,763	1,798
Tiles					
Low Case	97	8	0.1	89	97
Optimistic Case	501	8	0.1	493	501

a/ Including six plants proposed for establishment.
Source: Tables 3.2, 3.3

Energy Consumption in the Brick and Tile Industry

Overview

3.16 Since various type of fuels are used to fire bricks, energy consumption has been determined in terms of cubic meters of stacked firewood equivalent for all fuels used, including coffee and rice husk. 6/ Total energy consumption in the brick and tile industry is determined in Table 3.6 using this equivalency as 73,000 m^3 of firewood per annum at present production rates. Approximately 91% of this energy demand is met by firewood as opposed to agricultural waste substitutes.

5/ Assumes that imported roofing material (corrugated galvanized iron sheets) would be discouraged and that permanent brick buildings would have tile roofs.

6/ 1.0 m^3 stacked firewood is equal to approximately 0.6 m^3 on a solid basis.

Table 3.6: CURRENT ENERGY CONSUMPTION IN BRICK AND TILE INDUSTRIES

Producer	Total Production Bricks & Tiles b/	Energy Consumption per tonne of product c/	Total Energy Consumption by Fuel c/ Fuelwood	Coffee Husk	Rice Husk	Total
	(tonnes)	(m^3 FW equiv.)	(m^3 FW equiv.)			
Medium scale, mechanized a/	8,750	0.3	--	2,625	--	2,625
Small-scale, semi-mechanized	6,690 d/	1.8	8,042	3,000	1,000	12,042
Artisan	117,000 e/	0.5	58,500	--	--	58,500
Total	132,440	-	66,542	5,625	1,000	73,167

a/ Uganda Clays is the only producer in this category with current production estimated as: (35 tonnes/day x 5 days/week x 50 weeks/year).
b/ In tonnes based on estimated number of bricks and tiles produced.
c/ In m^3 stacked fuelwood equivalent.
d/ Based on estimated total production of 3.2 million bricks (4.73 kg each) and 0.12 million tiles (2.5 kg each) by small and medium scale producers (total production of 15,440 tonnes).
e/ Based on estimated total production of 20 million bricks (5.85 kg each).

Source: Mission estimates.

3.17 The significance of total wood demand by the industry may be realized by noting that production at a level to meet maximum forecast demand would require a hundred-fold increase in brick and tile output. Scaled by this factor and converted into solid wood equivalent terms, the implied future wood demand is 4,380,000 m^3. While the estimates are proximate, this is roughly 28% of annual woody biomass production in Uganda. Ignoring residential backlog still results in a forty-fold increase over present supply to meet annual demand, requiring some 11% of national wood biomass production at present industry energy efficiency.

Artisanal Producers

3.18 The firewood consumption of clamp kilns is usually known in terms of lorry loads of stacked wood. Inquiries among brick manufactures resulted in an average consumption of 0.5 m^3 of firewood per tonne of weatherproof bricks or blocks. Fuel consumption varies by ±20%. On the basis of a lower heating value of 7,650 MJ/m^3 of stacked, air-dried Eucalyptus wood with a bulk density of 510 kg/m^3, the average heat consumption is 3,800 MJ per tonne of product. This figure corresponds with the energy requirements for brick making with clamp kilns mentioned in the literature.

Small Scale, Semi-mechanized Producers

3.19 The firing period in the small scale, semi-mechanized kilns is much longer than that stated by artisan brick makers in order to obtain good quality brick. As a consequence, the wood consumption is also much higher, with a range at the six sites visited of 0.5-1.9 m^3 per tonne of product depending on kiln type. As the former estimate is suspect, the useful average has been taken as 1.8 m^3/tonne.

Medium Scale, Mechanized Producers

3.20 Generally, a continuous Hoffman ring kiln as operated at Uganda Clays is very efficient with respect to energy consumption. Fuel input was estimated at 0.2-0.3 m^3 per tonne of fired ware or 1,530-2,300 MJ/tonne. These are normal values for this type of kiln.

IV. PROPOSED MEASURES TO IMPROVE ENERGY EFFICIENCY

Overview

4.1 The energy consumption parameters given in the preceding chapter demonstrate that there is up to a 9:1 variation in the energy efficiency of brick and tile manufacture in Uganda. The few small and medium scale production units are functioning at 20-25 percent of mechanized and their installed capacities, and, in the case of small scale plants, are highly energy inefficient. Consequently, the traditional artisan brick producing units are furnishing the bulk (7 times the output of semi- mechanized plants) of Uganda's burnt bricks. Unfortunately, these artisan production units are also using the bulk of the energy in the form of fuelwood, which is leading to national concern over deforestation. The country can ill afford continuing inefficiencies in brick and tile production at inadequate production rates. Yet, Uganda requires locally produced building materials to support any positive reconstruction effort.

4.2 Possible energy solutions take two forms: (a) Low-cost energy efficiency enhancements through improved kiln design, maintenance and operation; and (b) Substitution of available alternative fuels, especially agricultural residues, for firewood. These enhancements are detailed in the following paragraphs.

Artisan Producers

Energy Efficiency Measures

4.3 Product Specification. The following recommendations for energy efficiency improvement concern brick structure and composition:

(a) Introduce a cavity (frog) in the hand molded bricks and blocks as illustrated in Annex 7 in order to save about 8.5% on energy consumption, and improve firing and drying behavior and the homogeneity of of the fired ceramic body. For these reasons, brick makers in many parts of the world make solid clay bricks with frogs.

(b) Investigate the use of chopped hay as a filler in the clay body for handmade bricks. Potential energy savings are 14 ±2%, based on a mix of 0.3 m^3 of loosely dumped chopped hay and 1 m^3 of prepared wet clay mass. The mechanical strength of the clay body in the fired state will be reduced as well, however. The optimum blend for a given clay and firing temperature should be determined by experimentation.

4.4 Kiln Construction and Firing. The following recommendations on kiln construction and operation should yield an energy saving of 17.5 ±2.5% on average:

(a) Improve control on the amounts of combustion air entering the kiln and reduce heat loss in waste gases by the use of roof iron sheets for partial blocking of the fire holes. At present there is no or only very poor control of the combustion air supply in clamp kilns. The energy losses through the waste gases are the most important item in the heat balance of periodic kilns.

(b) Promote the construction of clamp kilns with a square base and proper design of the kiln foot (legs and fireholes). Several factors will influence the design optimization:

(i) The heat losses of the exterior surface of a clamp kiln per tonne of fired bricks will be lower in a kiln with a square base than in a kiln of the same capacity with a rectangular base;

(ii) The heat losses by radiation from the fireholes can be reduced by minimizing the dimensions of the firehole entrance;

(iii) Transverse passages in the kiln legs benefit an even heat distribution and an equal brick quality in horizontal cross sections of the kiln body;

(iv) Base dimensions and height of well-sealed clamp kilns influence energy efficiency, firing technique and brick quality. Bases of clamp kilns in Uganda vary from 9 to 60 m^2 and the kiln heights from 3 to 5 m. Annex 8 demonstrates the extraordinarily large influence of these factors on the percentage of underfired and low quality bricks;

(c) Split firewood logs of greater than 200 to 250 mm diameter to obtain better control of heat input during firing; and

(d) Evaluate the use of inspection holes at different heights in the sidewalls of clamp kilns for visual monitoring of kiln temperature during firing.

Implementation

4.5 Artisan brick producers will remain the prime suppliers of brick to the residential and, often, the industrial and commercial sectors for the forseeable future. In view of the scale of future wood demand from this sub-sector and the magnitude of potential energy savings, a national dissemination/extension effort is warranted. A suitable program would include the following components:

(a) Research/Pilot Demonstration to test and adapt the proposed energy conservation measures;

(b) Training to sustainably transfer the knowledge and potential benefits of the research component; and

(c) Dissemination to ensure popularization of the improved techniques throughout Uganda.

4.6 The first two make up the pilot phase activities which would be overseen by a steering committee sponsored by the Ministry of Energy and made up of interested governmental representatives. Membership would include, but not be limited to, representatives of the following ministries: Industry and Technology, Housing and Urban Development, Planning, and Economic Development, Environmental Protection (Forestry Department), and Rehabilitation. Chief among the steering committee's responsibilities during this phase would be to evaluate the effectiveness of the Masaka-Rikai and Mbarara activities with a view to deciding if national extension is justified.

4.7 The program should be targeted at traditional rural-based artisan brickmakers as well as those located in medium cities, rural towns and institutionally-sponsored integrated development programs. While the basic rationale for the effort is based on energy conservation, program goals should be extended to encompass the promotion of improved local materials and the upgrading of standards of basic building materials. Because of their extensive prior experience in training artisans for the construction industry in Uganda, it is recommended that the day-to-day implementation of the proposed program for upgrading artisan brick production methods be placed under the supervision of the Kiteredde Construction Institute (KCI). Technical assistance, especially on administration and management aspects, should be provided to the KCI. Annex 9 presents further details on the KCI.

4.8 Research/Pilot Demonstration Phase. This phase of the proposed artisan brick production program will extend for 18 months and should initially be concerned with research, and product testing, and training aspects. A testing and demonstration center will be built at Nalluddugavu, a proven clay works owned by KCI located in one of the target districts and near transport centers. The center, which will comprise a demonstration shed with office and storage area, a series of molding pads, a dormitory, and auxiliary buildings, will initially be used to test kiln and firing techniques, and later for research endeavors on secondary activities such as roof tile production and more economical construction techniques. The research activities will be supervised by an international ceramics expert assisted by a training specialist.

4.9 The training component of the program will begin with refresher courses and orientation training for two groups of trainers. The first group will be based at the center and will continue to assist with testing. They will later be responsible for conducting training courses of 3-4 month duration at the center. The second group will begin by training the first group of brickmakers at the center and at their respective brick manufacturing sites. From this point on, the second group's activities will take place in the field, where they will reinforce new production concepts and organize community demonstration programs. Occasionally they will return to the center with new trainees. These activities will initially be tested in the Masaka-Rikai district, and subsequently refined for dissemination in the Mbarara district.

4.10 Dissemination Phase. Assuming satisfactory results from the pilot phase, a 3 1/2 year country-wide dissemination program will begin. Considering the availability of building materials, localized construction practices, population/backlog demands and updated market surveys, the dissemination program will commence immediately in the areas of Jinja, Kampala/Entebbe, Mpigi and Kabale (in estimated order of priority). The scheduling of the dissemination program should be flexible to react to short-term situations (e.g. rainy seasons, protracted holidays, security restrictions, etc.) and opportunities presented by large localized brick demand for specific projects.

Introduction of Brick and Block Standards

4.11 An additional benefit to the construction industry arising from the national extension program would be the promotion of standards for brick and block products. Such standardization will not only incorporate the recommended materials and brick cavities for energy efficiency, but also improve the construction materials market through tighter product dimensioning and enhanced brick durability. A provisional set of simple national standards is given in Annex 10.

Potential Energy Savings

4.12 Energy savings from a successful artisanal sector extension effort are summarized in percentage terms in Table 4.1. The estimated 35% gain in energy efficiency converted to wood demand reduction is 20,475 m^3/year at present production levels, equivalent to 28% of total brick and tile industry energy consumption.

Table 4.1: POTENTIAL ENERGY SAVINGS IN ARTISANAL BRICK MANUFACTURE

Measures	Potential Energy Savings
1) Introducing frog in the bricks	8.5 %
2) Introducing chopped hay as a filler	14 ± 2 %
3) Improving kiln construction and firing technique	17.5 ± 2.5 %
TOTAL	
Introducing measures 1, 2 and 3 successively	35 ± 3.5 %

Small Scale, Semi-mechanized Producers

Energy Efficiency Measures

4.13 Improved Kiln Draft Control. The relatively high consumption of the periodic updraft and downdraft kilns is partly caused by a lack of effective draft control. Provision of technical assistance to the small scale semi-mechanized brick and tile industry with regard to firing technique can obtain up to 20% energy savings.

4.14 Replacement of Manufacturing Equipment. Several of the kilns visited by the mission were beyond their useful service lives. Replacement of the worn-out periodic kilns by a new type downdraft kiln, which can be operated continuously as well as periodically, will save 40-60% on energy when the kiln is operated periodically and 70-80% when operated continuously. Such new kilns offer the additional advantage of multi-fuel operation. A provisional design for a model downdraft kiln is presented in Annex 11.

4.15 Provision of Spare Parts. Lack of spare parts was a common constraint to increased capacity utilization and productivity at most of the semi-mechanized kilns surveyed. Even where kilns are in good basic condition, spare parts shortages limit the continuity of firing operations causing energy efficiency losses of 10-20%.

Implementation

4.16 The small scale brick production units promise to be highly beneficial to the country's reconstruction efforts. The semi-mechanized units require modest capital investment, can service specific markets without extensive transport costs and are of a scale that is relatively easy to manage. A program to evaluate inefficiencies in management and fuel consumption while promoting pilot scale improved brick production is therefore recommended.

4.17 The proposed assistance to the small-scale brick production sector would also be coordinated by the steering committee (para. 4.6), in close collaboration with other local agencies such as the Uganda Development Bank, that have some in-house capabilities to assist prospective small-scale brick makers on a number of critical tasks. Such tasks would include: (a) expediting 'clearing house' types of operations, related specifically to identifying and arranging the procurement from abroad of spare parts and other accessories for their equipment (i.e., to reburbish or retrofitt their plants); and (b) completing project feasibility and appraisal studies in respect of ventures to retrofit individual plants (i.e., subsequent to presenting such proposals to funding agencies).

4.18 Pilot Improved Downdraft Kiln. Considering the major recurring constraints to brick production experienced by small scale brickworks (i.e. uncertain electrical service, transport and spare parts supply), the recommended production line must be adaptable to unforeseen operational interruptions. The primary component of an improved semi-mechanized production process would be an energy efficient, multi-fuel periodic/continuous firing kiln. The proposed kiln is simple and rather labor intensive in operation. The kiln will be a downdraft eight chamber type that can be fired continuously from above using any one or a combination of biomass fuels or fired periodically from below using the same fuel possibilities. When fired continuously, the kiln has the potential for producing 130 tonnes of greenware per week (2.5 million bricks and tiles/year). Due to the manageable level of production, the design, construction procedure and production characteristics would be documented, disseminated and promoted throughout the industry.

4.19 The pilot project is proposed to be located at the existing Kizubi Brickworks near Entebbe. The plant is owned by the Kampala Catholic Diocese and supplies product for diocese, industrial and commercial projects. The present updraft periodic kilns are poorly designed and in a run-down state. However, this brickworks is well located to the market, has management and administrative potential and production experience coupled with a functional infrastructure.

4.20 In recognition of the pending applications for new small scale brickworks, the mission has included in Annex 12 a preliminary design for a model semi-mechanized brick and tile production unit. While not included in the present action plan, the model is an energy efficient alternative for future investment consideration.

Potential Energy Savings

4.21 Total energy efficiency enhancement at small scale brickworks employing improved kilns under proper management is estimated at 75%. The achievable fuel savings at the six existing plants (under the assumption of normal capacity factors approaching 50%) are approximately equal to the quantity estimated for the artisanal sector.

Medium Scale Producers

Sub-sector Status

4.22 Uganda Clay Works, Ltd., a parastatal organization, produces the best clay masonry units and the only clay roofing tiles in Uganda at a rate of fuel consumption that is on par with more mechanized European plants. The factory is well located to major markets and has an order backlog of six months. Nevertheless, the plant is three decades old with severe needs for renovation and spare parts. Due to interrupted electrical service and lack of transport and spares, the plant is operating at 30-40% of installed capacity and is undoubtedly at a production cost disadvantage from the full payroll being carried. If Uganda Clay Works fails, the country's building material industry would be severely impacted.

Energy Efficiency Measures

4.23 Lack of spare parts lowers the actual production of the unit and endangers the continuous operation of the kiln. Periodic operation of the installed Hoffman kiln would drive up fuel consumption considerably.

Implementation

4.24 Provision of Spare Parts. Considering the entire brick and tile industry, Uganda Clays has the greatest potential to positively impact the industry if renovated. It has production experience and demonstrated administrative and management skills, and the plant is the only continuous firing ring kiln producing clay products with less energy than any other process in the country. The brickworks could afford the renovation of plant and associated installation expertise, yet these inputs must be paid for in foreign exchange and sales revenues are derived in local currency. At present, there is no functional mechanism for acquiring foreign exchange. If and when foreign exchange becomes available through the economic recovery program, Uganda Clay Works should be placed high on the list of critical industries. The mission estimates that approximately US$500,000 would be needed to assure adequate spare parts supply.

4.25 Increase in Production Capacity. The longer term goal should be to increase Uganda Clay's production capacity through the addition of another production line to produce preferentially for the public sector. The secondary benefit of this second production line would be to transfer to the original older line the less demanding task of producing roof tiles exclusively.

4.26 Technical Assistance. As proposed for the small scale production units, a technical assistance component would be provided within the body of the overall brick and tile program. This technical expert would be attached to the artisan brick program but would be available to Uganda Clay Works and to funding agencies approached for new financing. Initially, technical assistance will be needed to define and substantiate the amount of spare parts required. In later phases, expertise will be required to study the feasibility of adding a new production line.

Potential Energy Savings

4.27 The level of energy consumption of a continuously operated Hoffman kiln offers no or only slight possibilities for energy savings. Preventing possible future periodic operation is very important however, as potential energy losses could amount to some 30%.

Alternative Fuels

4.28 The other major option for the reduction of firewood demand in the brick and tile industry is to substitute alternative biomass fuels such as papyrus, coffee husk and rice husk. Pursuit of this strategy will be carried out in conjunction with efforts to improve the energy efficiency of the brick and tile industry, as follows:

(a) In the artisan sub-sector, experiments regarding the use of papyrus in clamp kilns will be carried out as part of the research program centered at KCI. In addition, the use of blade-set clamp kilns fired with rice or coffee husk should be evaluated. This technique in operation in Indonesia is illustrated in Annex 13.

(b) In the small scale sub-sector, fuel substitution will be promoted through the dissemination of the improved multi-fuel downdraft kiln. The kiln is described in para 4.17 and Annex 11, and is compatible with papyrus, coffee husk and rice husk fuels.

(c) In the medium scale sub-sector, Uganda Clays is already firing their Hoffman ring kiln with coffee husk and thus no further actions are proposed.

V. PROJECT COSTS AND SCHEDULING

Summary

5.1 Implementation of the action plans described in Chapter IV is estimated to cost a total of approximately US$2,900,000 as shown in Table 5.1. These costs cover:

(a) Establishment and operation of a research and training/dissemination program for the artisanal sub-sector;

(b) Establishment of a revolving fund for provision of spare parts to the small scale producer sub-sector;

(c) Pilot installation of an improved downdraft kiln at Kizubi Brickworks, and follow-on extension to four other small scale producers;

(d) Feasibility evaluation of the addition of a new production line at Uganda Clay Works, Ltd.; and

(e) Provision of technical assistance to all three sub-sectors in kiln design and construction, firing techniques, fuel substitution, and enterprise management (amounts included in artisanal budget).

About 70% of the total cost will be in foreign exchange and the balance in local currency.

Table 5.1: SUMMARY OF COST OF RECOMMENDED COMPONENTS
(US$)

Type of Producer	Phase I			Phase II			Total Project		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Artisan	342,420	158,805	501,225	789,753	208,991	998,744	1,132,173	367,797	1,499,970
Small-scale, Semi-mechanized:									
Spare parts	100,000	---	100,000	---	---	---	100,000	---	100,000
Replacement kilns	150,000	100,000	250,000	600,000	400,000	1,000,000	750,000	500,000	1,250,000
Subtotal	250,000	100,000	350,000	600,000	400,000	1,000,000	850,000	500,000	1,350,000
Medium-scale, Mechanized: (Uganda Clays, Ltd.)									
Technical assistance	50,000	---	50,000	---	---	---	50,000	---	50,000
TOTAL	642,420	258,805	901,225	1,389,753	608,991	1,998,744	2,032,744	867,797	2,899,970

Source: Mission estimates.

5.2 In addition to these expenditures, the mission envisions in the longer term an investment of US$4 million for equipment, installation and technical services at Uganda Clays. The feasibility of the investment in the proposed new production line will be established in component (d) above.

5.3 Implementation of the action plan will require five years and will proceed in two phases. The first phase consists of pilot activities aimed at demonstrating proof of concepts and designs and is estimated to require 1 1/2 years. Following a program review, a 3 1/2 year long national dissemination phase is anticipated. A more detailed cost and schedule breakdown is discussed in the following paragraphs.

Artisan Producers

5.4 Total costs of the research/pilot demonstration, training and dissemination phases of the artisan program are estimated as US$1.5 million. Activities preceding the nationwide dissemination effort consume approximately one-third of this total, with the balance of US$1.0 million expended in the ensuing national dissemination phase. Included in these amounts are provisions for technical expertise to be shared with the other, larger scale sub-sector producers. Line item costings are furnished in Annex 14.

Small Scale, Semi-mechanized Producers

5.5 Project components directed at the small scale sub-sector account for US$1.35 million of the project budget. A spare parts revolving fund will be capitalized in the first phase with US$100,000 in foreign exchange. Additionally, the installation of an improved down-draft kiln is scheduled for Phase I at a cost of US$250,000. Detailed costs of equipment, materials, labor and supervision are given in Annex 15. If the Kizubi installation proves successful, it will be replicated at four other sites at comparable unit cost in Phase II.

5.6 Investment requirements for the "greenfield" construction of the model small scale brick and tile production unit described in Annex 12 are on the order of US$1.25 million. Financing for these new ventures is to be arranged by the entrepreneurs and is not included in the project costing.

Medium Scale, Mechanized Producers

5.7 A feasibility study of the proposed production line addition at Uganda Clays is estimated to cost US$50,000 and to require four man-months of consultant time. The study will lay the groundwork for a US$4 million investment which, along with US$0.5 million in short-term renovations, is likely to be financed through GOU foreign exchange allocations under the World Bank Economic Recovery Credit.

VI. PROJECT BENEFITS, JUSTIFICATION AND RISKS

Project Benefits

6.1 Benefits of a project to improve the energy efficiency of Uganda's brick and tile industry take both direct and indirect forms. Efforts to improve energy efficiency through rehabilitation and training will have numerous spin-off benefits to the construction industry, such as reduced equipment down time and higher capacity utilization, increased operator skill levels, and improved overall management. These benefits should all favorably impact on productive efficiency, enhancing the industry's important role in supporting economic recovery. However, the indirect benefits are difficult to quantify, and the mission has therefore focused on the more direct measures of project value.

Direct Fuelwood Savings

6.2 The main quantifiable benefit of the proposed project is an expected major reduction in fuelwood demand by the brick and tile industry, both through gains in end-use efficiency and substitution of agricultural residues. The total fuelwood savings at present production levels is estimated as just under 40,000 m^3/year, fairly small in absolute terms relative to demand in the household sub-sector. However, given the great brick and tile supply/demand gap and the expansion potential of the industry, the 60% economies achievable in the artisan and small scale sub-sectors are very significant. The breakdown of these savings is given in Table 6.1.

Table 6.1: FUELWOOD SAVINGS DUE TO PROPOSED ENERGY EFFICIENCY MEASURES FOR ARTISAN AND SMALL-SCALE PRODUCERS AT VARIOUS LEVELS OF PRODUCTION

	Unit	Artisan Production			Small-Scale Production		
			Assumed Increase			Present	One Replaced
		Current	10%	20%	Current	Capacity	Kiln
Total brick and tile production	Tonne	117,000	128,700	140,400	6,690	24,000	6,500
Fuelwood consumption a/	m^3 stacked	58,000	64,350	70,200	8,042g/	43,200	11,700
Fuelwood savings due to efficiency (1) b/	m^3 stacked	20,475	22,523	24,570	6,032	32,400	8,775
Fuelwood savings due to substitution (2) c/	m^3 stacked	9,506	10,457	11,408	503	2,700	731
Fuelwood savings due to less product breakage (3) d/	m^3 stacked	2,852	3,137	3,422	75	405	110
Total fuelwood savings (4 = 1+2+3)	m^3 stacked	32,833	36,117	39,400	6,610	35,505	9,616
Value of fuelwood savings (5) e/	US$	243,949	268,349	292,742	49,112	263,802	71,447
Cost of coffee husk substituted for fuelwood (6) f/	US$	37,986	41,786	45,586	2,010	10,789	2,921
Total savings (5-6)	US$	205,963	226,563	247,156	47,102	253,013	68,526

a/ Fuelwood consumption is estimated at 0.5m^3 stacked for artisan producers and 1.8 m^3 stacked for small-scale producers.

b/ Average fuelwood savings due to efficiency measures is estimated at 35% for artisan producers and 75% for small-scale producers.

c/ Fuelwood savings due to substitution by coffee husk is estimated at 25% for both artisan and small-scale producers.

d/ Fuelwood savings due to reduction in breakage is estimated at 10% for artisan and 5% for small-scale producers.

e/ The cost of fuelwood per m^3 stacked is estimated by adding the average cost of fuelwood (m^3 stacked) at roadside, the royalty to be paid to the government, $2.57, and the transportation cost of US¢ 10/km for 20 km round trip, or a total of $7.43 (446 USH)/$m^3$ stacked.

f/ To estimate the cost of fuelwood saved due to substitution by coffee husk, it is assumed that the heating value of 1m^3 of stacked, air-dried Eucalyptus wood with a bulk density of 510kg/m^3 and a heating value of 7,650 MJ/m^3 to be equal to the heating value of 1.2 m^3 of black coffee husks. Coffee husk is assumed to cost US$3.33 (200 USH)/$m^3$.

g/ This is the fuelwood part of the energy consumption only. Total energy consumption including coffee husk and rice husk is estimated at 12,042 m^3 stacked fuelwood equivalent.

SOURCE: Tables 3.3, 4.1; Mission estimates.

6.3 Improved Fuelwood Consumption Efficiency. Reduced fuelwood consumption due to improved combustion and heat distribution in kilns accounts for the largest share of savings. These reductions are estimated at 35% in the artisan sub-sector, and some 75% for the small scale producers.

6.4 Fuelwood Substitution. The mission estimates that an additional 25% reduction in wood demand is possible through the substitution of coffee and rice husk for fuelwood. This substitution is well underway at the medium and small scale producers, but virtually unknown in the artisan sector even though quite common in other countries where clamp kilns are used.

Improved Product Quality

6.5 Better kiln construction, draft control and firing techniques can all be expected to improve the quality of the brick and tile "ware". Reduction of kiln "hot spots" will lower the quantity of under- and over-fired bricks produced per firing cycle while simultaneously reducing the breakage rate experienced during delivery of product to construction sites. The fuelwood savings due to these improvements has been conservatively taken as 10% for the artisan and 5% for small scale producers.

Project Justification

Financial Analysis

6.6 Financial Cost of Fuelwood. The key variable in the financial analysis is the unit value of the fuelwood savings. Obviously, a single value for fuelwood will not represent the market price paid by every brickmaker. The figure chosen, 446 USh/m^3 (US$ 7.43/m^3), is based on an average roadside price for stacked fuelwood plus the government levied stumpage fee and transport charges for a 20 km round-trip haul. The price build-up is shown in Table 6.2. Conservatively, no real price inflation over time has been included. While this is in accord with recent historical experience in Uganda, the pattern is unlikely to continue in the face of predicted growing actual and perceived scarcity of the more accessible fuelwood resources.

Table 6.2: FINANCIAL COST OF FUELWOOD

Component	US$/m^3 Stacked
Imputed Residual Stumpage	1.90
Entrepreneurial Factor (25%)	0.47
Felling and Extraction a/	0.49
Roadside Price:	2.86
Stumpage Royalty (paid to Government)	2.57
Transport b/	2.00
Total at Plant Gate:	$7.43

a/ Estimate of one man-day per m^3 stacked.
b/ 20 Km round-trip at US10¢/Km.
Source: Mission estimates.

6.7 Artisan Sub-sector. It is not possible to calculate the returns to individual producers from the project, since the cost of the training and technical assistance provided is not borne by the brickmakers. However, the return to the artisan sub-sector component of the project has been calculated in Annex 16 and the results summarized in Table 6.3. Financial rates of return are satisfactory in all production growth scenarios, with even the pessimistic "no growth" scenario returning 12 percent. More realistic growth scenarios give returns ranging from 20 to 27 percent.

Table 6.3: PROJECT FINANCIAL RATE OF RETURN

Sub-Sector/Scenario	FIRR (%)
Artisan	
No growth in current production	12
10% annual increase in years 6-20	20
20% annual increase in years 6-20	27
Small Scale, Semi-mechanized	
Replacement of 1 kiln	25
Replacement of 5 kilns over 5 years	24
Replacement of 5 kilns over 3 years	24
Replacement of 5 kilns over 2 years	25

Source: Annex 16.

6.8 Small Scale, Semi-mechanized Sub-sector. Returns for replacement of existing inefficient kilns operating at five sites are excellent at 25 percent. As shown in Annex 16 and Table 6.3, this conclusion is robust and holds over various scenarios of diffusion of the recommended multi-fuel downdraft kiln.

Economic Analysis

6.9 The economic analysis attempts to measure project worth from the national planning perspective and substitutes economic scarcity or "shadow" prices for market prices. The economic analysis herein incorporates two principal shadow pricing assumptions. First, local currency amounts are converted to US Dollar sums using a shadow exchange rate of 1.00 US Dollar equal to 85 Ugandan Shillings derived from IMF estimates of purchasing power parity. Secondly, the value of fuelwood has been adjusted per the following rationale.

6.10 Economic Value of Fuelwood. The economic value of fuelwood should be the opportunity cost to the national economy of a unit of fuelwood consumption. This figure can be approximated by estimating the marginal cost of fuelwood production, and then adding economic felling and extraction costs, a wood producer's "normal" profit, and transport costs to point of consumption.

6.11 The marginal cost of production is the most difficult component to estimate, as it depends both on location and mode of wood production. A range of estimates from Bank sources for wood production costs is given in Table 6.4. Consistent with the Uganda Forestry Rehabilitation Appraisal Report, the mission has selected the residual cost of fuelwood production in multi-purpose plantations for use in the economic analysis. The figure is a mid-range value, and there are arguments to use a lower value, such as an estimate of wood production costs in managed natural forest. However, a good case could then be made to incorporate a "locational rent" in the cost of production, so as to reflect the wood resource's locational convenience relative to the brick producers.

Table 6.4: ESTIMATES OF MARGINAL ECONOMIC COST OF FUELWOOD PRODUTION

Estimate	US$/$m^3$ Stacked
Uganda Tobacco Dryer Fuelwood Plantation	4.20
Uganda Multi-Purpose Plantation	2.57
Tanzania Managed Natural Forest	1.14

Source: Energy Efficiency in the Tobacco Curing Industry, UNDP/World Bank, 1985; Uganda Forestry Rehabilitation Appraisal Report, World Bank, 1987; Tanzania Woodfuel/Forestry Project, UNDP/World Bank, 1988.

6.12 The summation of the other cost components making up fuelwood value is shown in Table 6.5, and results in a estimate of US$5.46 per stacked m^3. This figure is about US$2.00/$m^3$ lower than the demonstrated willingness to pay of brickmakers for fuelwood derived from unmanaged "bush" sources, indicating the conservatism of the estimate.

Table 6.5: ECONOMIC VALUE OF FUELWOOD

Component	US$/$m^3$ stacked
Marginal Production Cost	2.57
Entrepreneurial Factor (25%)	0.64
Felling and Extraction a/	0.25
Transport	2.00
	$5.46

a/ Unskilled labor shadow valued at one-half daily wage.
Source: Tables 6.2, 6.4; Mission estimates.

6.13 Artisan Sub-sector. Due to the lower value of fuelwood assumed, returns in the economic analysis shown in Annex 17 and Table 6.6 are lower than those calculated in the financial analysis. Nevertheless, they are favorable for all but the most pessimistic brick production scenario, indicating ample justification for a national research and training/extension program targeted at artisan producers.

Table 6.6: PROJECT ECONOMIC RATE OF RETURN

Sub-Sector/Scenario	EIRR (%)
Artisan	
No growth in current production	7
10% annual increase in years 6-20	15
20% annual increase in years 6-20	22
Small Scale, Semi-mechanized	
Replacement of 1 kiln	21
Replacement of 5 kilns over 5 years	19
Replacement of 5 kilns over 3 years	19
Replacement of 5 kilns over 2 years	20

Source: Annex 17.

6.14 Small Scale, Semi-mechanized Subsector. Results of the economic analysis of the small scale producer component are also shown in Annex 18 and Table 6.6. With returns averaging 20 percent across all kiln dissemination scenarios, the kiln replacement program is similarly well justified.

Project Risks

6.15 The major project risks rest primarily in the artisan sub-sector. As with any national training and extension effort, implementation is subject to delay or failure to reach target populations. Renewed deterioration of the security situation could compound these difficulties. The risk is minized through careful choice of implementing agents and use of a two-phased pilot/wide-scale dissemination approach to project scheduling and oversight.

6.6 The second major risk is failure to obtain anticipated energy savings. Especially in the artisan sub-sector, this could be the result of producers failing to follow technical advice and new techniques. However, purchased fuelwood makes up a substantial portion of brick and tile production costs, so there thus appear to be adequate incentives for adoption. In addition, the training/extension design incorporates in-field, community-level demonstrations in order to illustrate the new techniques under plausible operating conditions.

List of Institutions and Individials Contacted

Ministry of Energy

Mr. S. Bachou	Deputy Minister
Mr. H. S. Opika Opoka	Permanent Secretary
Mr. Ndiwa-Ndikora	Under Secretary
Mr. Kapampara	Senior Assistant Secretary
Mr. Ziad Alahdad	Senior Energy Advisor
Mr. K. Tugume	Energy Officer

Ministry of Plannig and Economic Development

Mr. D. Okullo Ongar	Principal Eccnomist, Industrial Sector
Mr. J. Atria	Economist, Social Service Sector Officer
Mr. K. Kayondho	Economist, Social Service Sector Officer

Ministry of Housing and Urban Development

Mr. E. M. Byaruhanga	Chief Housing Officer
Mr. J. Rucecerwa	Principal Assistant Secretary
Mr. Z. I. Qazi	Principal Housing Economist
Mr. C. Walakira	Engineer, Building Research and Material Development

Ministry of Industry and Technology

Mrs. J. Mumbule	Senior Industrial Officer
Mr. F. Rwahwive	Officer

Ministry of Cooperatives and Marketing

Mr. A. M. Kaliisa	Chief Economist
Mr. W. S. Ssenfuma	Project Officer
Mr. T. Carr	Computer Specialist

Ministry of Environment Protection and Forestry

Mr. E. D. Olet	Ag. Deputy Chief Forest Officer
Mr. L. Ntiru	Forest Officer

Reconstruction Development Corporation

Mr. H. S. Mwaka	Officer
Mr. V. Byabamazima	Liaison Officer

UNDP Resident Mission

Mr. von Mallinckrodt	Resident Representative
Mr. M. Al-Jaff	Deputy Resident Representative
Mr. B. Moro	Program Officer
Mr. A. Disch	Assistant Resident Representative
Mr. N. Kulkarni	Assistant Resident Representative
Mr. P. K. Das	Program Assistant

ILO Project Staff

Mr. A. Bazargan	Chief Technical Advisor, National Manpower Survey
Mr. T. Crudele	Chief Technical Advisor, Intensive Employment Program
Mr. E. Black	Volunteer Forester
Mr. S. Ofori	Civil Engineer

IMF Resident Mission

Mr. Z. Ibrahim-Zadeh	Resident Representative

IBRD Resident Mission

Mr. G. Slade	Resident Representative

The Experiment in International Living (EIL)

Mr. S. Hanson	East Africa Representative

Uganda Development Bank

Mr. P. R. Behl	Head, Project Operations

Kiteredde Construction Institute (Bannakaroli Brothers)

*Brother L. Mutebi	Superior General

*Also met other "Brothers" in charge of the Institute.

Makerere University

Professor B. G. Kirya	Vice-Chancellor
Professor E. Lugujjo	Dean, Faculty of Technology
Mr. C. H. Mukunya	Asst. Prof., Department of Civil Engineering

Private Sector Enterprises

Mr. O. Botti	Consultant to and Previous MD, Uganda Clay
Mr. L. I. Kasule	Production Manager, Universal Clay Works
Mr. M. Olowo-Opoya	Chairman, Century Works, Ltd.

Institute of Teachers Education

Mr. G. Sizoomu	Instructor of Ceramics

STRUCTURE OF THE BRICK AND TILE INDUSTRY

Artisan Brick subsector

1. The bulk of bricks used in Uganda is produced by traditional artisan brickmakers, an estimated 20 million bricks/year. Sites of artisan commercial brick production are along all major roads (up to 3 miles off road) and concentrated within 15-20 miles radius of major Urban Centers. Production sites are close to clay deposits, mainly swamps, with production interrupted only by long rains. In general, artisan brickmaking can be found throughout Uganda, wherever there is a demand. The subsector is independant and not bound to electrical power or external inputs. These producers supply the residential, agricultural and commercial sectors in rural, small as well as large towns. To some extent, people also produce bricks in their "backyards" for their personal use. Bricks are hand-made and are fired in various sizes of fuelwood-fired clamp kilns. The bricks are of low quality, weather proof and load bearing for single story structures. The subsector is highly labor intensive. Energy consumption of these producers is estimated at 0.5 m^3 fuelwood stacked per ton of fired products (about 114 solid weatherproof bricks).

Small-scale, Semi-mechanized Subsector

2. Butendi Brick Works - A small-scale, semi-mechanized brick plant with an installed capacity of about 6,000 tons/year and operating at about 25% of capacity, is located north of Masaka. The plant is owned and operated by the Catholic Diocese and supplies its products to the diocese and industrial and commercial enterprises. The high quality products is fired in periodic up-draft kilns, without proper draft control, using wood as fuel. Fuel consumption is estimated at 1.8 m^3 stacked wood per ton of fired product (211 standard facing bricks). The plant suffers from usual production, management and financial constraints; i.e., lack of spare parts and adequate transport, management problems, as well as insufficient funds for reconstruction of kilns and maintenance of plant.

3. Kizubi Brick Works - Also a small-scale, semi-mechanized plant with an installed capacity of about 6,000 tons/year, operating at about 25% of capacity, is located on the road from Kampala to Entebbe. The plant is owned and operated by the Kampala Catholic Diocese and supplies the diocese, commercial and industrial projects with bricks and tiles. The products are of high quality and are fired in periodic up-draft kilns without effective draft control. The plant uses a combination of fuelwood and coffee husks as fuel. Fuel consumption is estimated at equivalent of 1.9 m^3 stacked wood per ton of fired products (211 standard facing bricks). The plant suffers from lack of spare parts, interruptions in electrical power, inadequate drying shed and poorly designed, run-down periodic kilns.

4. Kibimba Brick - a small-scale, semi-mechanized plant also with a capacity of about 6,000 tons/year is located on the road between Junja and Tororo. The plant is part of the Kibimba rice scheme, operated by the Chinese, and producing primarily for itself and the Tororo rice scheme consumption and selling the surplus in the surrounding markets. The products are of high quality and are fired in a down-draft kiln without effective draft control, using rice husks and fuelwood as fuel. Fuel consumption is estimated at 1.8 m^3 stacked wood equivalent per ton of fired product (211 standard facing bricks).

5. Matanga Clays Ltd. - A semi-mechanized production plant in the Masaka area, uses a normal clamp kiln fired with wood. The fuel consumption is estimated at 1.3 m^3 stacked wood per ton of fired product. The plant produces solid bricks and blocks which are formed by semi-dry clay dust pressing, using hand-operated leverpress. The clay dust is prepared by successive open-air drying, hand-operated crushing and sieving of the raw material.

6. Pan African Enterprises Ltd. - This is also a small-scale, semi-mechanized brick plant located across from Uganda Clays on the Kampala to Entebbe road. The plant is privately owned. However, due to plant's deteriorated conditions and lack of inputs, it lies dormant and requires complete reconstruction. This plant also has a designed capacity of 6,000 tons/year.

7. Universal Clay Works, Ltd. - A small-scale plant with an installed capacity of about 6,000 tons/year is operating at about 30% of capacity. The plant is locatad 15 miles north of Kampala. The company is privately owned and produces a range of high-quality bricks and blocks. The products are fired in a Hoffmann ring kiln. The kiln should be fired continuously but due to lack of drying capacity, it is fired periodically. Although the kiln is designed to be fired by used motor oil as well as coffee husks, it is using coffee husks only because of high price of used oil. Fuel consumption is about 1.5 m^3 stacked wood equivalent per ton of fired product, whereas the potential fuel consumption in a continuously operated kiln is much lower. The kiln is poorly built. The clay joints in the arch of the kiln are too wide which endangers the durability of the kiln's structure. The production constraints also include transport delays, electrical power disruption, lack of spare parts and a need for kiln repairs.

Medium-scale Brick Subsector

8. Uganda Clay Works, Ltd. - A medium-size plant with a production capacity of about 36,500 tons output/year, is located in the outskirts of Kampala and owned by a private company and the National Housing and Construction Corp. (Parastal). Producing a range of high-quality bricks and tiles, the factory is operating at about 25% of production capacity. Clay products are fired in a Hoffmann Ring Kiln, using coffee husks as fuel. Fuel consumption is estimated at equivalent of 0.2-0.3 m^3 stacked wood per ton of fired products (about 211 standard

facing bricks). Bricks are supplied to the public, commercial and industrial sectors and, to a less extent, to the private residential sector for large housing units. The factory is the major supplier of tiles in Uganda. The plant is presently in dire need of spare parts and suffers from frequent electrical disruptions.

9. In addition to the above-mentioned mechanized/semi-mechanized brick and tile producing plants, there are a number of other plants registered with the Ministry of Industry. Although some of the registrations date back to 1981, to mission's knowledge none of these other factories has been established.

Cement Bonded Bricks and Tiles

10. In comparison to clay buidling products in Uganda, there are also some small production units making cement bonded bricks and tiles. The raw materials mix commonly used, on the volume basis, are:

Laterite (Maram)	75%
Sand	20
Cement	5
Bonded Water	added as necessary

The bricks are shaped with a hydraulically or mechanically operated presses at a pressure of 600 Bar (60 N/mm^2). The hardening of the bricks takes place in sheds and there is no heat treatment involved. The size of the currently produced bricks is 290x140x100 mm, weighing 8.0 kg and having a dry compressive strength of 8.5 N/mm^2. The preparation and shaping of the raw materials mix takes 5 persons/press. The press has a capacity of 40 bricks/hour which, in conjunction with shortage of cements and other technical problems, restricts the significance of this production method. There are also firms making concrete tiles with wooden hand-made moulds. The production capacity, however, is dependent on the number of moulds avaiable, which in case of one manufacturer visited by the mission (in Tororo) was about 200 tiles/day.

11. Sisal cement tiles are also being produced on a very small scale in Uganda. The raw materials for these tiles are cement, sand and sisal, with the cement sand ratio of 1 to 3 by volume. The cement and sisal consumption amount to 450 kg and 11 kg per 1,000 tiles, respectively. The tiles are shaped in plastic moulds, and one such unit visited by the mission in Jinja had a capacity of 120 tiles/day. In general, the production of this type of tiles depends on imported materials sisal, cement (at present), machines and extruded forms, in addition to limited production possibilties.

ESTIMATION OF BRICK AND TILE DEMAND

A. Estimation of Demand for Bricks a/

1. Estimated Brick Needs for Various Residential Prototypes

1.1 Building "Type A" - $30m^2$ - 1 Room
Building "Type B" - $60m^2$ - 2 Rooms
Building "Type C" - $90m^2$ - 3 Rooms
Building "Type D" - $120m^2$ - 4 Rooms
Building "Type E" - $150m^2$ - 5 Rooms
Building "Type F" - $180m^2$ - +5 Rooms

(Rooms include bedrooms, living rooms, dining and other habital space.)

Assume: Plate height of 2.5 meters or 24 courses, increase to 30 courses to include gable ends.
Typical brick/block 300mm x 150mm x 100mm

1.2 Building "Type A": 5m x 6m = 22 lm. = 74 stretchers x 1.25 (interior walls) = 92.5 bricks x 30 courses = 2,775 bricks

Building "Type B": 6m x 10m = 32 lm. = 106 stretchers x 1.5 (interior walls) = 159 x 30 = 4,770 bricks

Building "Type C": 9m x 10m = 38 lm. = 126 stretchers x 1.75 (interior walls) = 220 x 30 = 6,600 bricks

Building "Type D": 10m x 12m = 44 lm. = 146 stretchers x 2.0 (interior walls) = 292 x 30 = 8,760 bricks

Building "Type E": 10m x 15m = 50 lm. = 166 stretchers x 2.25 (interior walls) = 373 x 30 = 11,190 bricks

Building "Type F": 12m x 15m = 54 lm. = 180 stretchers x 2.5 (interior walls) = 450 x 30 = 13,500 bricks

2. Housing Demand and Composition Opposed to Population Projections.

2.1 Current backlog as of 1982 140k units (See section 3.0 backlog)
- Urban growth 3.8% plus demolition, renovation and maintenance
- Unit demand by 2000 estimate 300k units = 20k units/year

a/ Mission estimates.

2.2 Existing housing stock (Urban) = 120k units

2.3 Percentage of housing stock in permanent construction type (assume +30 year material life - bricks, iron sheets, concrete, tile...):

Jinja	61.6
Tororo	25.5
Mbale	20.0
Soroti	25.7
Lira	24.7
Gulu	45.0
Lugazi	34.6
Kabale	30.5
Kasese	45.4
Kabarole	4.3

2.4 Number of rooms (includes bedrooms, dining, living room and other habital space):

Number of Rooms* Percent Permanent	1 10%	2 20%	3 40%	4 80%	5 100%	+5 100%
Jinja	4.1	3.4	6.9	8.6	4.6	6.4
Tororo	2.1	3.6	6.6	15.8	8.2	15.9
Mbale	4.2	2.6	4.5	11.4	11.5	8.1
Soroti	4.0	2.6	5.6	11.2	7.4	11.0
Lira	3.4	3.3	6.6	15.4	6.8	6.8
Gulu	3.4	4.9	5.8	13.4	3.8	6.9
Lugazi	4.8	3.5	7.4	8.6	1.5	3.1
Kabale	1.1	2.8	7.4	19.6	9.5	23.0
Kasese	3.0	5.7	7.7	8.0	3.7	8.5
Kabarole	.05	4.5	8.6	18.5	11.2	16.9

* Number of rooms assumes all 5 and +5 room houses of a quality and status to be all or 100% brick whereas this percentage decreases to assuem that only 10% of the polled 1 room houses would be built of permanent materials.

2.5 Average household size:

Jinja	5.4
Tororo	5.8
Mbale	5.4
Soroti	5.2
Lira	6.5
Gulu	6.5
Lugazi	4.3
Kabale	5.7
Kasese	5.4
Kabarole	5.9
Average	5.6

2.6 Population growth: assuming 5% urban, 4% Kampala, 3.2% national:

	1980	1985	1990	1995	2000
Kampala	458.5K	557.5K	678.6K	825.3K	1.0M
Entebbe	21.2	27.0	34.3	43.8	56.2
Masaka	29.1	37.1	47.1	60.2	77.2
Mbarara	23.3	29.7	37.7	48.2	61.8
Jinja	45.1	57.5	73.0	93.3	119.6
Tororo	16.7	21.3	27.0	34.5	44.3
Mbale	28.0	35.7	45.4	57.9	74.2
Soroti	15.0	19.1	24.3	31.0	39.8
Lira	9.1	11.6	14.7	18.8	24.1
Gulu	15.0	19.1	24.3	31.0	39.8
Lugazi	10.4	13.3	16.8	21.5	27.6
Kabale	31.5	27.4	34.8	44.5	57.0
Kasese	9.9	12.6	16.0	20.5	26.2
Kabarole	26.8	34.2	43.4	55.5	71.1
Minor Towns	370.4K	472.6K	600.0K	766.7K	982.3K
Total Urban	1.1M	1.4M	1.78M	2.27M	2.9M
Rural	11.5M	13.3M	15.5M	17.9M	20.7M
Total	12.6M	14.7M	17.3M	20.2M	23.6M

2.7 Number of new households since 1980 (average 5.6 people/household):

	Household Size	1985	1990	1995	2000
Kampala	5.6	17.7K	21.6K	26.2K	32.0K
Entebbe	5.6	1.03	1.3	1.7	2.2
Masaka	5.6	1.43	1.78	2.34	3.04
Mbarara	5.6	1.14	1.43	1.87	2.43
Jinja	5.4	2.3	2.87	3.76	4.87
Tororo	5.8	.8	1.0	1.29	1.69
Mbale	5.4	1.4	1.8	2.3	3.0
Soroti	5.2	.8	1.0	1.3	1.7
Lira	6.5	.38	.48	.63	.81
Gulu	6.5	.63	.8	1.03	1.35
Lugazi	4.3	.67	.81	1.09	1.42
Kabale	5.7	1.03	1.3	1.7	2.19
Kasese	5.4	.5	.63	.83	1.05
Kabarole	5.9	1.25	1.56	2.05	2.64
Minor Towns	5.6	18.25K	22.75K	29.77K	38.5K
Rural	5.6	321.4K	392.8K	428.6K	500.K

2.8 Number of new houses of brick:

	Percent Brick Houses	1985	1990	1995	2000
Kampala	61.6	10.9K	13.3K	16.1K	19.7K
Entebbe	61.6	.6	.8	1.0	1.3
Masaka	61.6	.88	1.1	1.44	1.87
Mbarara	61.6	.7	.88	1.15	1.5
Jinja	61.6	1.42	1.77	2.3	3.0
Tororo	25.5	.2	.26	.33	.43
Mbale	20.0	.28	.36	.46	.6
Soroti	25.7	.21	.26	.33	.44
Lira	24.7	.094	.118	.156	.20
Gulu	4.5	.028	.036	.046	.061
Lugazi	34.6	.23	.28	.38	.49
Kabale	30.5	.31	.39	.52	.67
Kasese	45.4	.23	.29	.38	.48
Kabarole	4.3	.054	.067	.088	.113
Minor Towns	25.0	4.56K	5.69K	7.44K	9.63K
Rural	5.0	13.4 K	16.1 K	17.8 K	19.5 K

2.9.1 Number of "Type A" houses (30 m^2 - 1 room - brick):

	Percent of Brick "Type A's"	1985	1990	1995	2000
Kampala	4.1	.72K	.88K	1.07K	1.31K
Entebbe	4.1	.04	.05	.07	.09
Masaka	4.1	.04	.05	.06	.08
Mbarara	4.1	.03	.04	.05	.06
Jinja	4.1	.09	.12	.15	.20
Tororo	2.1	.04	.005	.007	.009
Mbale	4.2	.012	.015	.019	.025
Soroti	4.0	.008	.010	.13	.017
Lira	3.4	.003	.004	.005	.006
Gulu	3.4	.001	.001	.002	.002
Lugazi	4.8	.011	.013	.018	.023
Kabale	1.1	.003	.004	.005	.007
Kasese	3.0	.007	.009	.011	.014
Kabarole	.05	-	-	-	-
Minor Towns (average)	3.3	.15K	.187K	.245K	.317K
Rural	-	13.4 K	16.1 K	17.8 K	19.5 K

2.9.2 Number of "Type B" houses (60 m^2 - 2 rooms - brick):

	Percent Brick "Type B's"	1985	1990	1995	2000
Kampala	3.9	.70K	.84K	1.02K	1.25K
Entebbe	3.9	.04	.05	.06	.08
Masaka	3.9	.03	.04	.06	.07
Mbarara	3.9	.03	.04	.05	.06
Jinja	3.9	.09	.11	.15	.19
Tororo	3.6	.007	.009	.012	.015
Mbale	2.6	.007	.009	.012	.015
Soroti	2.6	.005	.006	.008	.011
Lira	3.3	.003	.004	.005	.006
Gulu	4.9	.001	.001	.002	.002
Lugazi	3.5	.008	.010	.013	.017
Kabale	2.8	.009	.010	.014	.019
Kasese	5.7	.013	.016	.022	.027
Kabarole	4.5	.002	.003	.004	.005
Minor Towns (average)	3.8	.173K	.216K	.283K	.366

2.9.3 Number of "Type C" houses (90 m^2 - 3 rooms - brick):

	Percent Brick "Type C"	1985	1990	1995	2000
Kampala	6.9	1.22K	1.50K	1.8K	2.2K
Entebbe	6.9	.07	.09	.12	.15
Masaka	6.9	.06	.07	.10	.13
Mbarara	6.9	.05	.07	.08	.10
Jinja	6.9	.16	.19	.26	.33
Tororo	6.6	.013	.017	.022	.028
Mbale	4.5	.013	.016	.020	.027
Soroti	5.6	.012	.015	.018	.025
Lira	6.6	.006	.008	.010	.013
Gulu	5.8	.002	.002	.003	.004
Lugazi	7.4	.017	.020	.028	.036
Kabale	7.4	.023	.029	.038	.050
Kasese	7.7	.017	.022	.030	.037
Kabarole	8.6	.005	.006	.007	.010
Minor Towns (average)	6.7	.30K	.38K	.49K	.64K

2.9.4 Number of "Type D" houses (120 m^2 - 4 rooms - brick):

	Percent Brick "Type D"	1985	1990	1995	2000
Kampala	8.6	1.52K	1.85K	2.25K	2.75K
Entebbe	8.6	.08	.11	.15	.19
Masaka	8.6	.07	.09	.12	.16
Mbarara	8.6	.06	.07	.10	.13
Jinja	8.6	.19	.25	.32	.42
Tororo	15.8	.03	.04	.05	.07
Mbale	11.4	.03	.04	.05	.07
Soroti	11.2	.02	.03	.04	.05
Lira	15.4	.014	.018	.024	.031
Gulu	13.4	.004	.005	.006	.008
Lugazi	8.6	.020	.024	.033	.042
Kabale	19.6	.061	.076	.102	.131
Kasese	8.0	.018	.023	.030	.038
Kabarole	18.5	.010	.012	.016	.021
Minor Towns (average)	11.8	.54K	.67K	.88K	1.14K

2.9.5 Number of "Type E" houses (150 m^2 - 5 rooms - brick):

	Percent Brick "Type E"	1985	1990	1995	2000
Kampala	4.6	.81K	.99K	1.2K	1.47K
Entebbe	4.6	.04	.06	.08	.10
Masaka	4.6	.04	.05	.07	.09
Mbarara	4.6	.03	.04	.05	.06
Jinja	4.6	.10	.13	.17	.22
Tororo	8.2	.016	.021	.027	.055
Mbale	11.5	.032	.041	.053	.070
Soroti	7.4	.015	.019	.024	.033
Lira	6.8	.006	.008	.011	.014
Gulu	3.8	.001	.001	.002	.002
Lugazi	1.5	.003	.004	.006	.007
Kabale	9.5	.030	.037	.050	.064
Kasese	3.7	.008	.011	.014	.018
Kabarole	11.2	.006	.007	.009	.013
Minor Towns (average)	6.2	.28K	.35K	.46K	.60K

2.9.6 Number of "Type F" houses (180 m^2 - 5 plus rooms - brick):

	Percent Brick "Type F"	1985	1990	1995	2000
Kampala	6.4	1.1K	1.4K	1.7K	2.0K
Entebbe	6.4	.06	.08	.1	.14
Masaka	6.4	.06	.07	.09	.12
Mbarara	6.4	.04	.06	.07	.09
Jinja	6.4	.14	.18	.24	.31
Tororo	15.9	.03	.04	.05	.07
Mbale	8.1	.023	.029	.037	.049
Soroti	11.0	.023	.029	.037	.049
Lira	6.8	.006	.008	.011	.014
Gulu	6.9	.002	.003	.003	.004
Lugazi	3.1	.007	.009	.012	.015
Kabale	23.0	.071	.089	.119	.154
Kasese	8.5	.019	.025	.032	.041
Kabarole	16.9	.009	.011	.015	.019
Minor Towns Average	9.4	.43K	.53K	.70K	.90K

2.10 Demand for bricks for various cities by type of housing through year 2000:

	Housing Type						
	A	B	C	D	E	F	Subtotal
Kampala							
1985	2.00M	2.22M	8.05M	13.31M	9.06M	14.85M	49.49M
1990	2.44	2.67	9.90	16.21	11.08	18.90	61.20
1995	2.97	3.24	11.88	19.71	13.43	22.95	74.18
2000	3.63	3.97	14.52	24.09	16.45	27.00	89.66
Entebbe							
1985	.11	.13	.46	.70	.45	.81	2.66
1990	.14	.16	.59	.96	.67	.95	3.60
1995	.19	.19	.79	1.31	.89	1.21	4.72
2000	.25	.25	.99	1.66	1.12	1.62	6.16
Masaka							
1985	.11	.09	.40	.61	.45	.81	2.47
1990	.14	.13	.46	.79	.56	.95	3.03
1995	.17	.19	.66	1.05	.78	1.21	4.06
2000	.22	.22	.86	1.40	1.01	1.62	5.33
Mbarara							
1985	.08	.09	.33	.52	.33	.54	1.89
1990	.11	.13	.46	.61	.45	.81	2.05
1995	.14	.16	.53	.87	.56	.94	3.20
2000	.16	.19	.66	1.14	.67	1.21	4.03

	Housing Type						
	A	B	C	D	E	F	Subtotal
Jinja							
1985	.25M	.29M	1.05M	1.66M	1.12M	1.89M	6.26M
1990	.33	.35	1.25	2.14	1.45	2.43	8.00
1995	.42	.48	1.72	2.80	1.90	3.24	10.56
2000	.55	.60	2.18	3.68	2.46	4.18	13.65
Tororo							
1985	.01	.02	.08	.26	.18	.40	.95
1990	.01	.03	.11	.35	.23	.54	1.27
1995	.02	.04	.14	.44	.30	.67	1.61
2000	.02	.05	.18	.61	.39	.94	2.19
Mbale							
1985	.03	.02	.08	.20	.36	.31	1.06
1990	.05	.03	.11	.35	.46	.39	1.39
1995	.06	.04	.13	.44	.59	.50	1.76
2000	.07	.05	.18	.61	.78	.66	2.35
Soroti							
1985	.02	.01	.08	.17	.17	.31	.76
1990	.03	.02	.10	.26	.21	.39	1.01
1995	.04	.02	.12	.35	.27	.50	1.30
2000	.05	.03	.16	.46	.37	.66	1.71
Lira							
1985	.01	.01	.04	.12	.07	.08	.33
1990	.01	.01	.05	.16	.09	.11	.43
1995	.01	.02	.07	.21	.12	.15	.58
2000	.02	.02	.09	.27	.16	.19	.75
Gulu							
1985	.01	.01	.01	.03	.01	.03	.10
1990	.01	.01	.01	.04	.01	.04	.12
1995	.01	.01	.02	.05	.02	.04	.15
2000	.01	.01	.03	.07	.02	.05	.19
Lugazi							
1985	.03	.02	.11	.17	.03	.09	.45
1990	.04	.03	.13	.21	.04	.12	.57
1995	.01	.04	.18	.29	.07	.16	.79
2000	.06	.05	.24	.37	.08	.20	1.00
Kabale							
1985	.01	.03	.15	.53	.33	.96	2.01
1990	.01	.03	.19	.66	.41	1.20	2.50
1995	.01	.04	.25	.89	.56	1.61	3.36
2000	.02	.06	.33	1.15	.72	2.08	4.36

	Housing Type						
	A	B	C	D	E	F	Subtotal
Kasese							
1985	.02M	.04M	.11M	.16M	.09M	.26M	.68M
1990	.02	.05	.14	.20	.12	.34	.87
1995	.03	.07	.20	.26	.16	.43	1.15
2000	.04	.09	.24	.33	.20	.55	1.45
Kabarole							
1985	.01	.01	.03	.04	.07	.12	.33
1990	.01	.01	.04	.11	.08	.15	.40
1995	.01	.01	.05	.14	.10	.20	.51
2000	.01	.01	.06	.18	.14	.26	.66
Minor Towns							
1985	.42	.55	1.98	4.73	3.13	5.80	16.61
1990	.52	.687	2.51	5.87	3.92	7.15	20.66
1995	.68	.900	3.23	7.71	5.15	9.45	27.12
2000	.88	1.16	4.22	9.99	6.71	12.15	35.11
Rural							
1985	37.19	-	-	-	-	-	37.19
1990	44.68	-	-	-	-	-	44.68
1995	49.40	-	-	-	-	-	49.40
2000	54.11	-	-	-	-	-	54.11

2.11 Summary of brick demand estimate based on population growth:

	1985	1990	1995	2000
14 Major Towns	69.44	86.44	107.93	133.49
Minor Towns	16.61	20.66	27.12	35.11
Rural	37.19	44.68	49.40	54.11
Total	123.24M	151.78M	184.45M	222.71M

3. **Number of bricks demand due to backlog in national housing stock:**

3.1 **Backlog Estimate, 1983-85:**

	Urban	Rural	Total
1983	72K	88K	160K
1984	83	101	184 a/
1985	95	117	212 a/

---

a/ Assuming 15% annual increase.

3.2.1 Scenario A

212K Units x Assumed 25% Brick Construction = 53K Brick Units
53K Units x 7,932 Bricks (Average Brick House) = 420 Million Bricks

Number of Bricks, 1985	420 Million

3.2.2 Scenario B

95K Urban Units x 7,932 Bricks (Average Brick House) = 753.5 Million
117K Rural Units x 2775 Bricks ("Type A" House) = 324.6 Million

Number of Bricks, 1985	1,078.1 Million

4.0 Estimate Scenarios (Order of Magnitude):

Optimistic Case 1985:

Residential Demand - Population Generated (see Section 2.11)	123.24M
Residential Demand - Backlog (see Section 3.2.2 Scenario B)	1,078.1 M
Subtotal	1,201.34M

Assumption: Industrial, commercial, clerical and public new construction, reconstruction and maintenance 10 - 30 percent residential demand.

Assumption: Optimistic Economic Climate
$1.3 \times 1{,}201.34 =$ 1,561.7M Bricks 1985

Demand for Brick, Optimistic Case, 1987

Estimated demand for 1985	1,561M
Annual increase since 1985	
1986: 8% p.a.	125
1987: 8% p.a.	135
Total Optimistic Case	1,821M

Low Case 1985:

Residential Demand - Population Generated (see Sec. 2.11)	123.24M
Residential Demand - Backlog - Assume 20% annual absorption of backlog over 5 year period. Use average of Backlog scenarios A and B. $\frac{1{,}078.1 + 420 \times 20\%}{2}$	149.81
Subtotal	273.05M

Assumption: poor economic climate for non-residential new construction, reconstruction and maintenance

1 x 1.1 x 273.05 =	300.35 Bricks 1985

Demand for Brick, Low Case, 1987

Estimated demand for 1985	300M
Annual increase since 1985	
1986: 8% p.a.	24
1987: 8% p.a.	26
Total Low Case	350M

B. Estimation of Demand for Tiles

5.0 Estimated Tile Needs For Various Residential Prototypes
(See Section 1.0, Estimation of Demand for Bricks for the size of the building type and the number of room in each).

5.1 Assume: Simple pitched roof with continuous .5m overhang and 1/2 slope with long axis excluding ridge cap.

Building "Type A": 5m x 6m = 46.9m^2 x 16 Tiles/m^2 = 750 Tiles

Building "Type B": 6m x 10m = 86.m^2 x 16 Tiles/m^2 = 1,376 Tiles

Building "Type C": 9m x 10m = 123m^2 x 16 Tiles/m^2 = 1,968 Tiles

Building "Type D": 10m x 12m = 160m^2 x 16 Tiles/m^2 = 2,558 Tiles

Building "Type E": 10m x 15m = 197m^2 x 16 Tiles/m^2 = 3,148 Tiles

Building "Type F": 12m x 15m = 212m^2 x 16 Tiles/m^2 = 3,400 Tiles

6.0 Housing Demand & Composition are Based on Population Demand
(See Section 2.0 - 2.9.6: Housing Demand & Composition)

6.1 Demand for tiles through year 2000 for various cities (in millions):

	Housing Type						
	A	B	C	D	E	F	Subtotal
KAMPALA							
1985	.54m	.96m	2.40m	3.89m	2.55m	3.74m	14.08m
1990	.66	1.16	2.95	4.73	3.12	4.76	17.38
1995	.80	1.40	3.54	5.75	3.78	5.78	21.05
2000	.98	1.72	4.33	7.03	4.63	6.80	25.49
ENTEBBE							
1985	.03	.05	.14	.20	.12	.20	.74
1990	.04	.07	.18	.28	.19	.27	1.03
1995	.05	.08	.24	.38	.25	.34	1.34
2000	.07	.11	.29	.49	.31	.47	1.74
MASAKA							
1985	.03	.04	.12	.18	.12	.20	.69
1990	.04	.05	.14	.23	.16	.24	.86
1995	.04	.08	.19	.31	.22	.31	1.15
2000	.06	.10	.25	.41	.28	.41	1.51
MBARARA							
1985	.02	.04	.10	.15	.09	.14	.54
1990	.03	.05	.14	.18	.12	.20	.72
1995	.04	.07	.16	.26	.16	.24	.93
2000	.04	.08	.20	.33	.19	.31	1.15
JINJA							
1985	.07	.12	.31	.48	.31	.48	1.77
1990	.09	.15	.37	.64	.41	.61	2.27
1995	.11	.21	.51	.82	.53	.82	3.00
2000	1.15	.26	.65	1.07	.69	1.05	3.87
TORORO							
1985	----	----	.02	.08	.05	.10	.25
1990	----	.01	.03	.10	.06	.14	.34
1995	----	.02	.04	.13	.08	.17	.44
2000	----	.02	.05	.18	.11	.24	.60
MBALE							
1985	----	----	.02	.08	.10	.08	.28
1990	.01	.01	.03	.10	.13	.10	.38
1995	.01	.02	.04	.13	.17	.12	.49
2000	.02	.02	.05	.18	.22	.17	.66
SOROTI							
1985	----	----	.02	.05	.05	.08	.20
1990	.01	----	.03	.08	.06	.10	.28
1995	.01	----	.03	.10	.07	.12	.33
2000	.01	.01	.05	.13	.10	.17	.47

	Housing Type						
	A	B	C	D	E	F	Subtotal
LIRA							
1985	----	----	.01	.03	.02	.02	.08
1990	----	----	.01	.05	.02	.03	.11
1995	----	----	.02	.06	.03	.04	.15
2000	----	----	.02	.08	.04	.05	.19
GULU							
1985	----	----	----	.01	----	.01	.02
1990	----	----	----	.01	----	.01	.02
1995	----	----	----	.01	----	.01	.02
2000	----	----	.01	.02	----	.01	.04
LUGAZI							
1985	.01	.01	.03	.05	.01	.02	.13
1990	.01	.01	.04	.06	.01	.03	.16
1995	.01	.02	.05	.08	.02	.04	.22
2000	.02	.02	.07	.11	.02	.05	.29
KABALE							
1985	----	.01	.04	.15	.09	.24	.53
1990	----	.01	.06	.19	.12	.30	.68
1995	----	.02	.07	.26	.16	.40	.91
2000	----	.03	.10	.33	.20	.52	1.18
KASESE							
1985	----	.02	.03	.04	.02	.06	.17
1990	.01	.02	.04	.06	.03	.08	.24
1995	.01	.03	.06	.08	.04	.11	.33
2000	.01	.04	.07	.10	.06	.14	.42
KABAROLE							
1985	----	----	.01	.02	.02	.03	.08
1990	----	----	.01	.03	.02	.04	.10
1995	----	----	.02	.04	.03	.05	.14
2000	----	----	.02	.05	.04	.06	.17
MINOR TOWNS							
1985	.11	.23	.59	1.38	.88	1.46	4.65
1990	.14	.30	.75	1.71	1.10	1.80	5.80
1995	.18	.39	.96	2.25	1.45	2.38	7.61
2000	.24	.50	1.26	2.92	1.89	3.06	9.87
RURAL							
1985	10.05	----	----	----	----	----	10.05
1990	12.07	----	----	----	----	----	12.07
1995	13.35	----	----	----	----	----	13.35
2000	14.62	----	----	----	----	----	14.62

6.2 Summary of Tile Demand Based on Population Growth

	1985	1990	1995	2000
14 Major Towns	19.56	24.57	30.5	37.78
Minor Towns	4.65	5.80	7.61	9.87
Rural	10.05	12.07	13.35	14.62
TOTAL	34.26	42.44	51.46	62.27

7.0 Demand for Tiles Due to Backlog in National Housing Stock

(See Sec. 3.1, Backlog Estimate).

7.1 Scenario A

212 Units x Assumed 25% Brick Construction = 53K Brick Units
53K Units x 2200 Tiles (average tiled roof) = 116.60M Tiles 1985
Demand for Tiles, 1985 116.60M Tiles

Scenario B

95K Urban Units x 2200 Tiles (average tiled roof) = 209.00M Tiles
117K Rural Units x 750 Tiles (Type 'A' House) = 87.75M Tiles
Demand for Tiles, 1985 296.75M Tiles

8.0 Estimate Scenarios (Order of Magnitude):

8.1 Optimistic Case - 1985

Residential Demand - Population Generated (see Sec 6.2)	34.26M
Residential Demand - Backlog (see Sec. 7.1, Scenario B)	296.75M
SUBTOTAL	331.01M

Assume: Industrial, Commercial, Clerical & Public New Construction, Reconstruction and Maintenance 10-30% Residential Deand

Assume: Optimistic Economic Climate: 30% x 331.01 99.30M

Optimistic Case - 1985 430.31M Tiles

Demand for Tiles, Optimistic Case, 1987

Estimated demand for 1985	430.M
Annual increase since 1985	
1986: 8% p.a.	34
1987: 8% p.a.	37
Total Optimistic Case	501M

8.2 Low Case - 1985

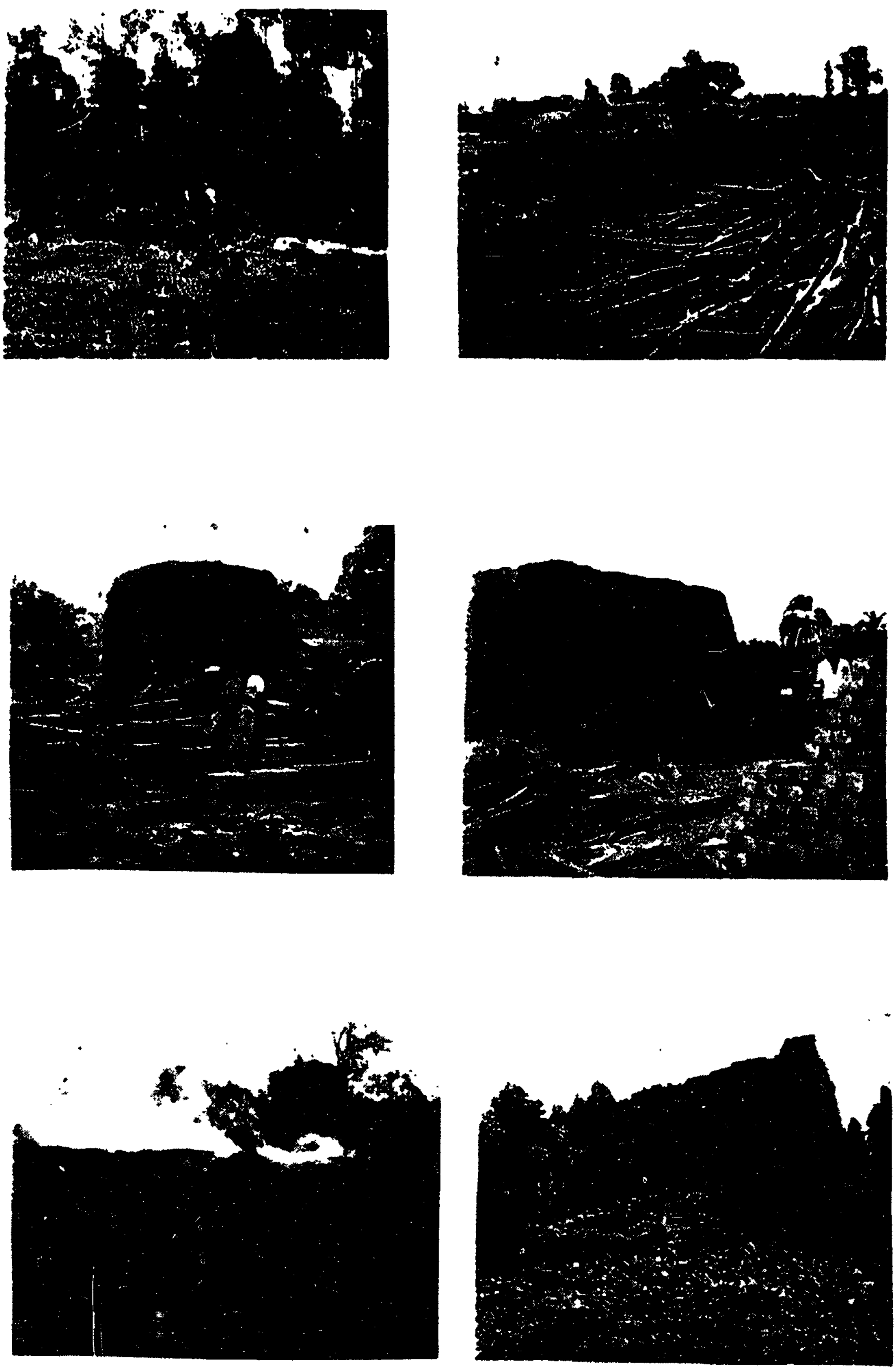
-Residential Demand-Population Generated (Ref. Sect. 6.2)	34.26m
-Residential Demand-Backlog - Assume 20% Annual Absorption of Backlog Over 5 Year Period Use Average of Backlog Scheme A&B $\frac{116.6 + 296.75}{2}$ x 20% -	41.33m
Assume poor economic Climate For Non-Residential New Construction, Reconstruction & Maintenance 10% x 75.59M	7.56
Low Case - 1985	83.15M Tile

Demand for Tiles, Low Case, 1987

Estimated demand for 1985	83M
Annual increase since 1985	
1986: 8% p.a.	7
1987: 8% p.a.	7
Total Low Case	97M

Partial List of Referenced Materials and Documents:

MHUD	Report Survey - 10 Major Urban Centers	1984
MHUD	Entebbe Housing Study - UNIDO Mission	1980
UN/HABITAT	Pre-Investment Appraisal Mission for Uganda National Housing Development Programmes	1982
UNDP	Building Construction Material Appraisal Mission for Masaka and Mbarara	1981
USAID	Housing Policy Review in Uganda - Padco Mission	1984
IBRD	Urban Study GRAMM	



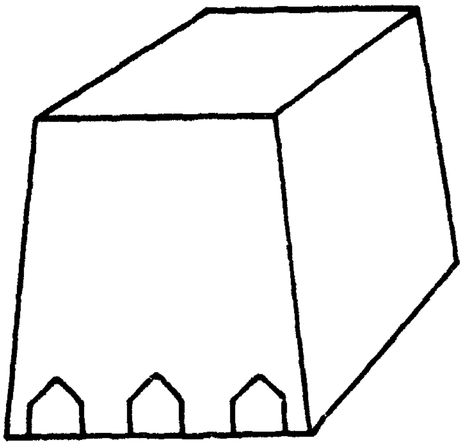
Brick making in Uganda

Clamp kilns fired with Wood

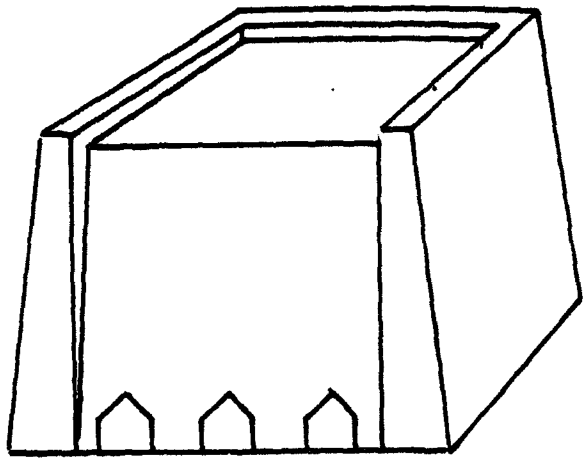
The World Bank

Washington, D.C., USA

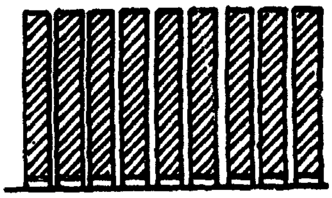
A SAMPLE OF PERIODIC KILNS



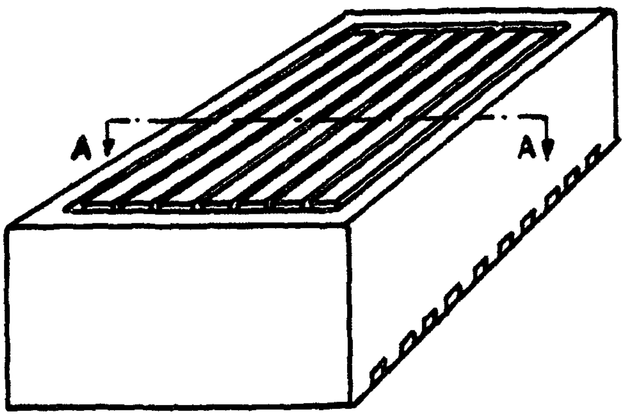
Clamp Kiln



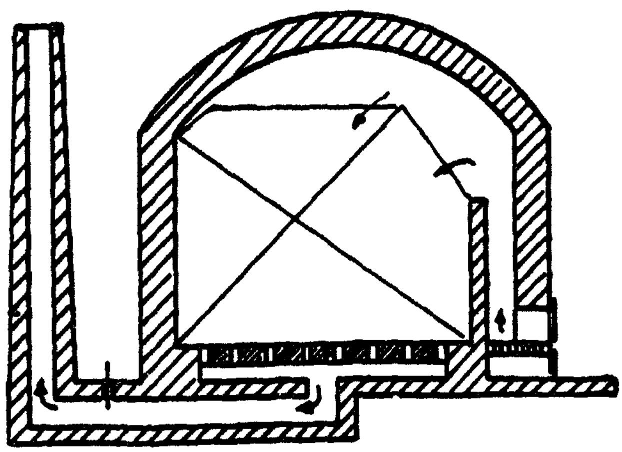
3-Wall Updraft Kiln



Cross Section A A



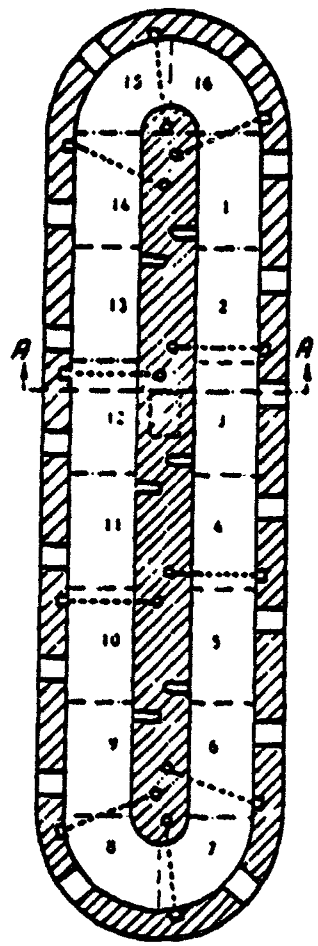
Rice-Husks Fired Clamp
With Blade Setting of Bricks



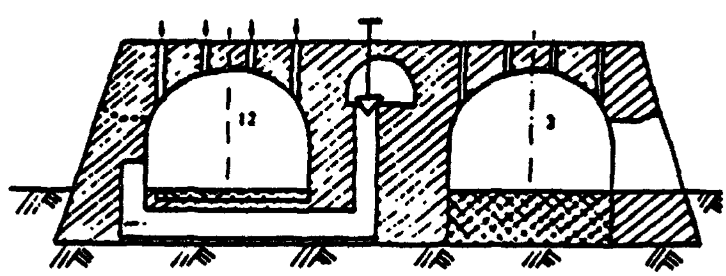
Vertical Cross Section of
a Periodic Downdraft Kiln

HORIZONTAL AND VERTICAL CROSS SECTIONS OF A HOFFMANN RING KILN

Annex 6

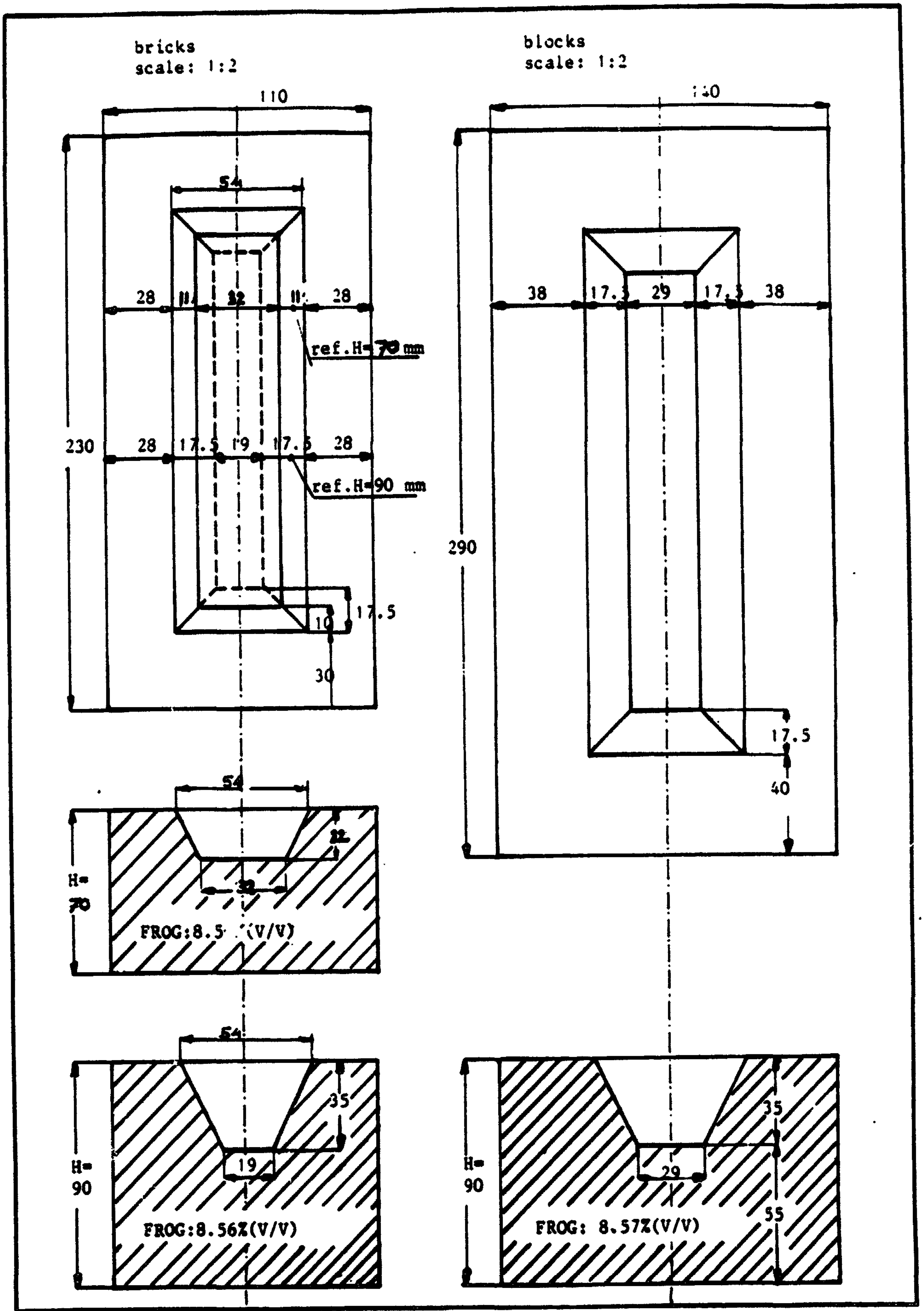


Horizontal Cross Section
of a Hoffmann Ring Kiln

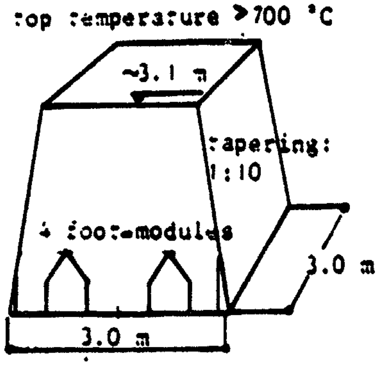


Vertical Cross Section "A-A" Of A Hoffmann Ring Kiln

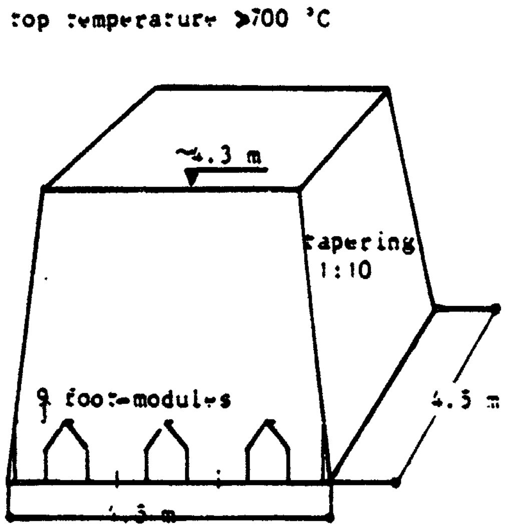
BRICK AND BLOCK WITH FROG
(Average Reduction in Weight: 8.5%)



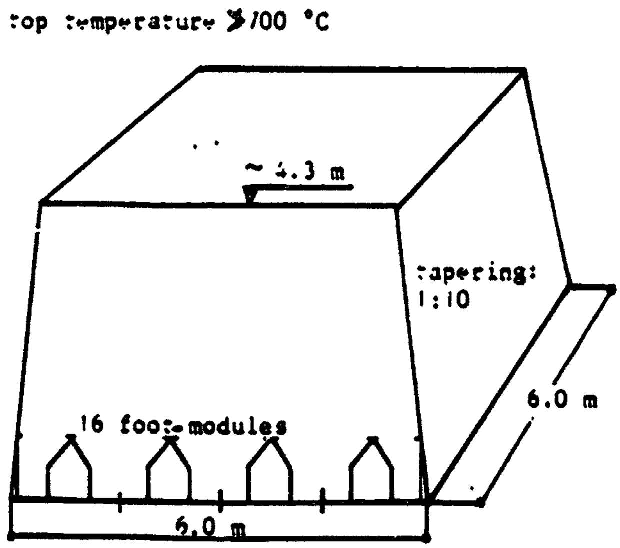
RELATIONSHIP OF OUTPUT OF CLAMP KILN TO KILN SIZE 1/
(Brick Dimension: 290 x 140 x 90 mm; Weight 5.85 kg)



Number of Layers	6 + 16 = 22
Number of Bricks	5300
Mass of Bricks	31.0 ton
Well Fired 2/	54%
Under Fired 3/	46%



Number of Layers	6 + 25 = 31
Number of Bricks	16860
Mass of Bricks	98.6 ton
Well Fired 2/	69%
Under Fired 3/	31%



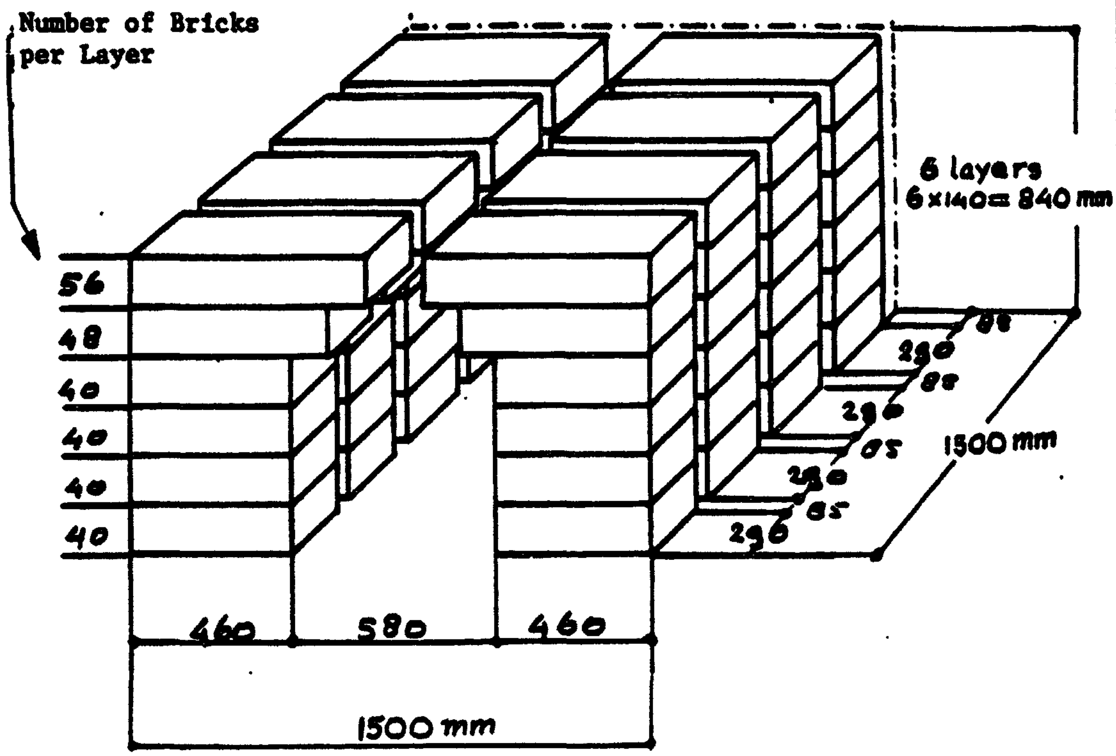
Number of Layers	6 + 25 = 31
Number of Bricks	30840
Mass of Bricks	180.4 ton
Well Fired 2/	76%
Under Fired 3/	24%

1/ Occupied area in horizontal cross sections of clamp body: 85% of clamp shall (0.3m): 90%.

2/ Firing breakage included.

3/ Damaged, Plastered bricks included.

FOOT MODULE OF A CLAMP KILN
(Firehole Area: 0.40 m^2)



Brick Dimensions: 290 x 140 x 90 mm
Number of Bricks per Module: 264
Extra Bricks for Filling Gaps: 24 Bricks per Side
Extra Bricks for Blocking Firehole: 30 Bricks per Hole

Kiteredde Construction Institute

Background

1. The Kiteredde Construction Institute (KCI) was established in 1980 by The Experiment in International Living (EIL), a private voluntary organization, and the Bannakaroli Brothers, an African Catholic order with headquarters in Kiteredde in the Rakai District of Uganda. The Center was specifically designed to train young men and adults in construction skills using locally available materials.

2. Initial funding support was provided by the U.S. Agency for International Development (USAID) (1979-1981). Additional support was provided by the Canadian International Development Agency (CIDA), the Australian High Commission, Catholic Relief Services, and EIL. Land, work space and start-up facilities were provided by the Bannakaroli Brothers.

3. Training specialists from EIL worked side-by-side with the technical and construction personnel of the Bannakaroli order in all phases of planning and implementation of the project, i.e. from the design of the curriculum to the actual construction of classrooms, dormitories and work spaces. From the beginning, the emphasis of the program was on practical skills development, learning by doing, the preparation of trainees for jobs in the construction industry and in public works departments, and the placement of each student in wage-earning employment immediately upon graduation.

4. The Bannakaroli Brothers have utilized the excellent clays and other materials available in southern Uganda for the construction of their own buildings, as well as carrying out construction assignments for others. This knowledge of brick, tile, block and clay moulding; of efficient kilns and appropriate firing techniques; of masonry and carpentry; of tropical building design; of the use of local materials to make mortar, paints, plasters and other necessary elements of construction, in the absence of manufactured and imported materials, form the basic components of the training program at the KCI.

Extension Activities

5. In January, 1985 EIL, in cooperation with the KCI, began the implementation of a three-year Extension Training Project, to provide training seminars and workshops in the development of the use of local materials for various groups and institutions in Uganda. During the six month pre-implementation period (June-December, 1984), KCI conducted several local materials development workshops for primary school teachers, Boy Scout leaders and Girl Guide leaders. The 250 participants from schools and groups in Rakai District received instruction in:

(a) identifying clays and soils for brick-making;
(b) clay preparation;

(c) brick moulding;
(d) drying, stacking, curing of bricks;
(e) kiln construction and kiln fuels;
(f) kiln firing, operation and management;
(g) solar drying, air-drying of bricks; and
(h) basic practical instruction in the construction of foundations and walls for houses, classroom buildings and other structures.

6. The initial phase of construction of a Local Materials Demonstration Site and Resource Centre has been undertaken on the grounds of the KCI. This demonstration site is currently being utilized to train Ugandans in the use of local materials, and in basic building techniques.

7. The KCI is also providing technical assistance to the Busoga Multi-Sectoral Rural Development Program in eastern Uganda, which carries out development activities in 41 villages, parishes and project locales. KCI, as part of its extension program, has assisted many Busoga villages in the construction of seepage wells and protected springs, and has provided training in the repair and maintenance of clean water sources and supplies.

8. The current KCI/EIL Extension Training Project at the KCI responds to numerous requests from educational and development-related institutions, contractors and builders, farmers and local citizens, for KCI to "extend" its knowledge to a wider constituency in the fields of: production of local building materials, clays, bricks, blocks, tiles, local cements, local paints, roofing materials, and in basic construction techniques using local materials.

9. In response to these requests, KCI, in cooperation with EIL, is expanding their extension, technical assistance and training services to cover up to 13 districts in Uganda. Graduates of KCI known as "Old Boys", have been hired by KCI to form a team of extension field work specialists to assist KCI in providing training and technical services to rural areas, to local institutions, to schools and to farmers.

Extension Training Project Objectives and Goals

10. The objectives of the Extension Training Projects at the KCI are as follows:

(a) continue to strengthen KCI's extension training capacity by constructing demonstration and resource centers that will aid in the dissemination of information on building techniques, and the uses and applications of local building materials;

(b) conduct an ongoing needs assessment through community surveys to assess the problems in rural areas and to identify places where KCI can contribute skills training activities;

(c) organize a cadre of KCI "Old Boys", prepared to serve as skilled training team, to design and carry out technical assistance, training and outreach activities by applying practically oriented skills, for the benefit of schools, institutions, groups and individuals;

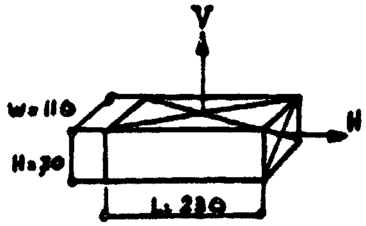
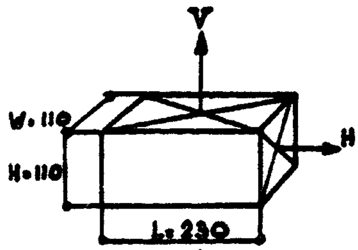
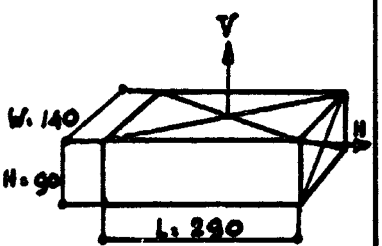
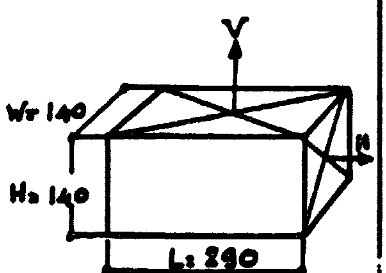
(d) more effective use of local materials for low-cost housing, and for the construction and repair of schools, public and commercial buildings, private homes, food storage and farm buildings, and other agricultural and livestock facilities;

(e) upgrade and standardize materials for clay moulding, bricks, blocks and tiles; appropriate kiln construction and management; the use of supplementary kiln fuels; management of lumber supply; and the proper preparation, drying and seasoning of lumber; and

(f) finally, improvement and protection of water sources and supplies; the construction and maintenance of wells, water catchment and water storage facilities.

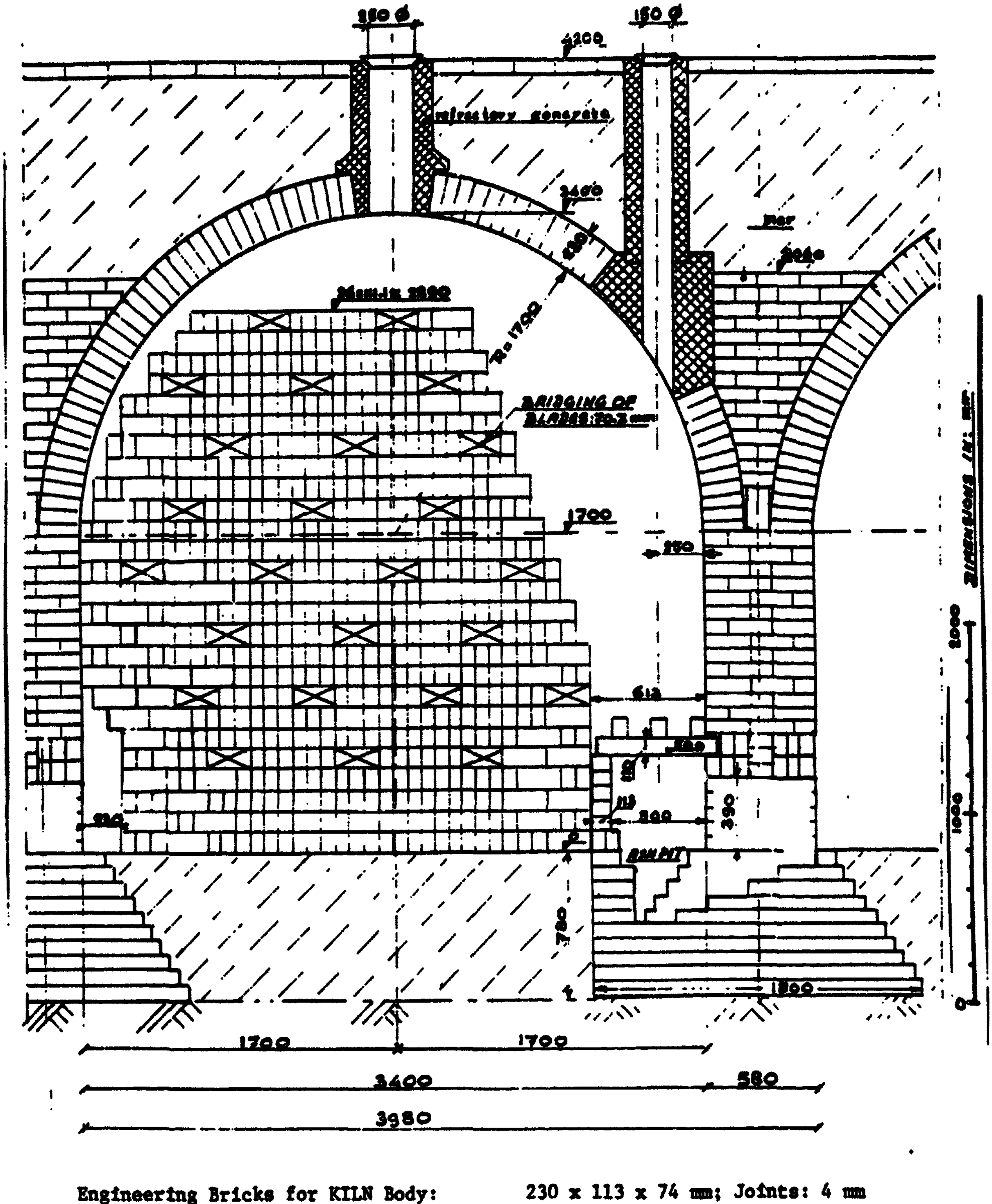
PROPOSED DIMENSIONS Fo STANDARD BRICKS AND BLOCKS[1/]

Annex 10

Number of Units per m^2 Strecher Wall; joints: 10 mm		Unit Weight of Bricks and Blocks in kg						
		Handmade Density = 1600 kg/m^3		Extruded Density = 1850 kg/m^3				
					Perforation			
					Vertical: V			Horizontal: H
Dimensions of Units in mm	No	Solid	Cavity V 85%	Solid	10%	20%	30%	60%
 standard bricks 230x 110 x70	52 (433/m^3)	2.83	2.59	3.28	2.95	2.62	-	-
 standard blocks 230x 110x 110	34 (283/m^3)	4.45	4.07	-	4.63	4.12	-	2.06
 ISO- blocks 290x 140 x 90	33 (222/m^3)	5.85	5.35	-	-	-	4.73	2.70
 ISO- blocks 290 x 140x 140	22 (148/m^3)	-	-	-	-	-	7.36	4.21

1/ The standards are designed based on the national traditions and recommendations of the International Organization for Standards (ISO).

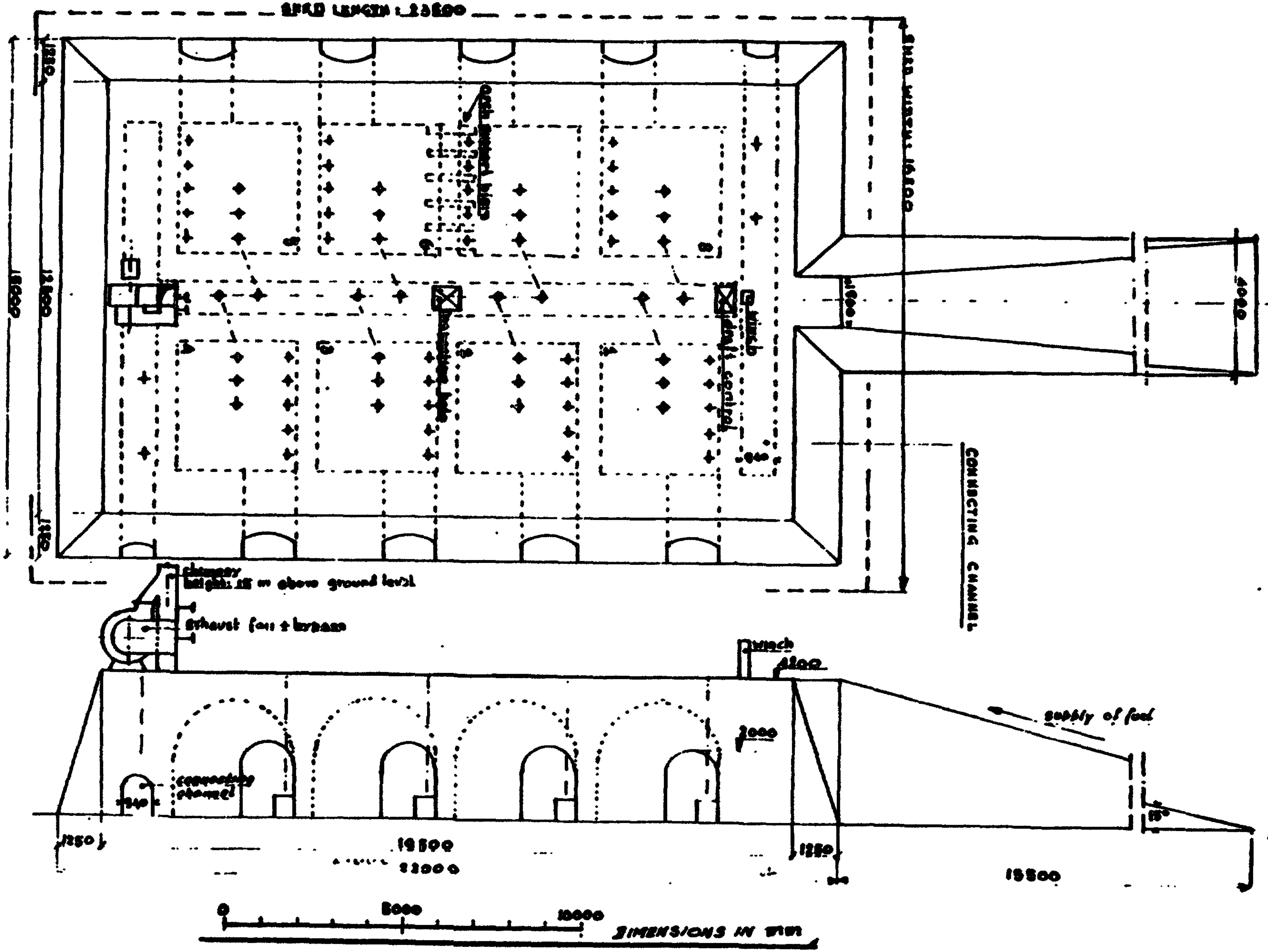
VERTICAL CROSS SECTION A A OF A CHAMBER OF A MULTI-FUEL DOWNDRAFT KILN FOR CONTINUOUS OR PERIODIC OPERATION WITH A SETTING OF BRICKS, 230x110x70 mm



Engineering Bricks for KILN Body: 230 x 113 x 74 mm; Joints: 4 mm
Arch Brichs, 78 Bricks per Row: 230 x 113 x 74/65; Joints: 3.5 - 4 mm

Load of KILN Chamber: 9960 Standard facing Bricks, 230 x 110 x 70 mm, PERF: 20%
Number of Birck Blades per Chamber: 12; Number of Bricks per Blade: 830
Dimensions of Dried Green Bricks: 232,3 x 111.1 x 70.7 mm; Weight Fired: 2.62kg
Load Per Chamber: 26.1 ton

TOP VIEW OF A MULTI-FUEL DOWNDRAFT KILN FOR CONTINUOUS OR PERIODIC OPERATION WITH EIGHT CHAMBERS



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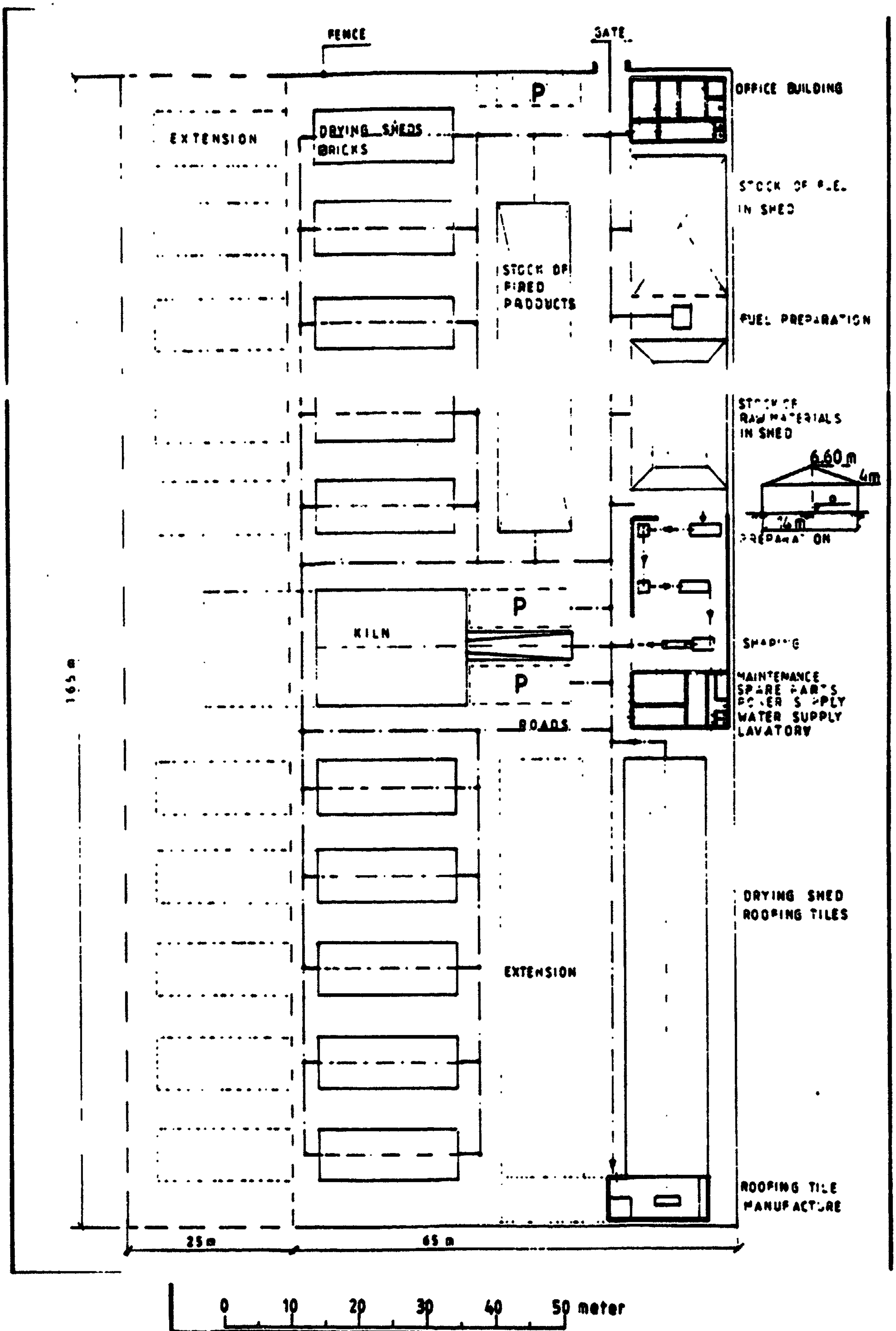
LAYOUT OF A BRICK AND TILE FACTORY

CAPACITY: 2.1 MILLION BRICKS (230x110x70mm) +0.3 MILLION ROOFING TI S/YEAR)



MODEL SMALL-SCALE, SEMI MECHANIZED BRICK AND TILE PRODUCTION UNIT

TABLE OF CONTENTS

SUMMARY

1. One of the technical options available for improving the efficiency of entry use and the productivity in the small-scale, semi-mechanized brick and tile production units in Uganda is the substitution of existing worn out manufacturing equipment, particularly kilns, with more efficient means of production.

2. The design of the proposed small-scale, semi-mechanized brick and tile production unit presented in this Annex, provides the technical information necessary to prepare the final feasibility studies. The estimate of the cost is to help attract and negotiate with interested investors. It also provides the basis for procurement operation and construction planning. Considering the main production problems of this category of producers, much attention is paid to the selection and design of the kiln. Special features of the proposed eight - or ten - chamber downdraft kiln are its suitability for relatively small production capacities - an annual capacity for production of 2.1 million standard bricks (230mm x 110mm x 70mm), and 0.3 million roofing tiles (20 tiles/m^2); its flexibility to use different types of fuels; and its potential for efficient use of energy.

I. INTRODUCTION

1.1 The design of the following small-scale, semi-mechanized brick and tile production unit is a basis for the final feasibility studies, negotiation with interested investors, procurement operations and construction planning.

II. PROPOSED PLANT

Products

2.1 The plant will produce solid and perforated extruded standard quality clay bricks and blocks with several sizes, as well as clay roofing tiles. The design of the plant is based on the production of a standard brick with 20% perforations by volume, a length of 230mm, a width of 110mm, a thickness of 70mm and a weight of about 2.6 kg per piece. As such, one square meter of a stretcher wall will need 52 standard size bricks. For roofing tiles the provisional size selected has been 310mm x 240mm (gross), or 250mm x 200mm (net), requiring 20 tiles per square meter roof, with the weight of about 2.0 kg per piece. Thus, a packed row of tiles with a length of one meter will contain 34 tiles.

Output

2.2 Based on information provided by brick makers in the existing small-scale, semi-mechanized, clay brick industry of Uganda, the output of the designed plant has been selected at 130 tons of fired ware per week. Depending on the actual range of products made, the output of the brick and tile production unit will vary from 120 to 130 tons of fired ware per week, of which about 12 tons per week will be roofing tiles. These figures correspond with a yearly output of 2.1 million standard bricks (230mm x 110mm x 70mm) and 300,000 roofing tiles (20 tiles/m^2). However, the designed lay-out of the factory allows for a possible doubling of the output in the future.

Plant Location

2.3 It is assumed that the plant will be located near ample and suitable raw material deposits with adequate source of process water. It is further assumed that the site area is flat, well above water table and well drained. The area must have stable subsoil with acceptable load bearing properties as well as necessary infra-structure, i.e. electricity, man-power and roads for the transportation of the ware to brick and tile market.

Raw Materials

2.4 A process design must be based primarily on the technological behavior of a specified raw materials mixture. Therefore, it is assumed that the test results of the raw material prove the suitability for the manufacture of perforated bricks and tiles. The following data can be used for technical calculations:

Bulk Densities:

Clay deposit, undisturbed	1950 kg/m^3
Clay lumps, loosely dumped	1100 kg/m^3
Clay in a 3 meter high stockpile	1600 kg/m^3

Firing Shrinkage: 1%

Total Shrinkage: 7%

Weights of a Standard Size Brick (230mm x 110mm x 70mm):

Just shaped, wet	3.5 kg
Air dried	2.9 kg
Fired	2.6 kg

Process Design

2.5 Mining and Storage of Raw Material, Claybody Preparation and Shaping. It is assumed that mining and storage of raw material, claybody preparation and shaping are mechanized; mining and storage of raw materials are preferably done in the dry season and the raw materials are stored in a spacious shed at the plant site.

2.6 Preparation and shaping are scheduled for one shift, 8 hours per day (including one hour lunch break), for 5 working days per week, and 49 weeks per year. The clay clots for the weekly roofing tile production are extruded each Monday morning and transported to the tile manufacturing unit where they are stored and used for the tile making during the week. The rest of the week, the extruder is used for brick making.

2.7 Handling of Raw Materials and In-Plant Transportation. The handling of raw materials and in-plant transportation of wet, dried and fired ware is done by hand, using simple means of transportation like trolleys with solid tires and wheelbarrows. Therefore, good condition for the plant's internal roads is a prerequisite for an efficient brick and tile production.

2.8 Drying of Bricks and Tiles. The bricks and tiles are dried in drying sheds. For the initial drying and stiffening of the bricks, they are placed in racks. This period covers 3 working days. The bricks and blocks are then stacked in open settings. It is assumed that the total drying process will take a period of 15 working days.

2.9 For the initial drying of the roofing tiles, the tiles are placed on wooden supports and subsequently are set in racks for a period of 3 working days. Then the tiles are set by juxtaposition in rows on the floor of the shed. As far as weather conditions permit, the final drying of the tiles can be improved by exposing them to direct sun radiation in the open areas in between the drying sheds for bricks. It is assumed that the total drying process of the tiles will also take a period of 15 working days.

2.10 For the transport and handling in relation to the natural drying of bricks and tiles, the working hours are in accordance with those for the shaping of the ware.

2.11 Firing of the Ware. The air dried bricks and tiles are fired in a downdraft chamber kiln, having eight chambers, each with a capacity of 10,000 standard size bricks. A special feature of the recommended kiln is the possibility to fire the kiln with all types of fuel; i.e., split wood logs, coffee husks, rice husks, papyrus, peat, coal, oil and gas. Another important feature is that the kiln can be operated continuously as well as periodically, depending on the actual supply of dried green ware. As such, from full capacity down to half of the capacity, the kiln can be operated continuously by diminishing the number of bricks and tiles fired per chamber. Below 50% of capacity, the kiln chambers can be operated periodically.

2.12 The energy consumption of the kiln with continuous operation will be slightly higher than the energy consumption of a normal Hoffmann ring kiln, the latter also being very efficient in terms of energy use, but not having some of the special features mentioned above. A Hoffmann ring kiln is, for instance, less suitable for the use of fuel wood. The main reasons for the selection of the proposed type of downdraft kiln are the rather low production level and the desirable flexibility of small-scale, semi-mechanized production units as envisaged in this Annex, as well as its low fuel consumption per ton of ware. Figure 2 illustrates the firing schedule for a continuous operation of the eight-chamber kiln. The planned production is five-chamber loads per week.

2.13 The waste gases are exhausted by a centrifugal fan. In case of interruptions of power supply, an electric generator with a capacity sufficient for the fan and the illumination of the top floor of the kiln can be used. For bridging short periods of power interruption, the fan can also be bypassed.

2.14 The size of the kiln is based on the assumption that the ware presents a normal firing behavior. If, for instance, very thick raw materials are to be used however, it is recommended to erect a ten-chamber kiln, instead of an eight-chamber kiln. The two extra chambers can be used for final drying of the ware utilizing the hot air extracted from the cooling zone. The design of the kiln offers the possibility to install hot air ducts for this purpose. The steel ducts can be buried alongside the main chimney channel. In addition, a ten-chamber kiln has to be considered also if the ware is sensible on cooling. In this case, the two extra chambers can be used to lengthen the cooling zone. The firing of the kiln is a continuous operation, i.e. three shifts per day, 7 days each week.

2.15 Filling and Emptying of the Kiln Chambers. Hand operated trolleys are used to transport the dried green ware to the kiln. The setting of the ware in the kiln and the emptying of the kiln chambers is done by hand.

2.16 In consequence of the restricted setting and de-hacking front in kilns, the filling of one chamber per day and the emptying of one chamber per day, during 5 working days per week, have to be a continuous operation during about 10 hours per day. It is recommended to work with two teams, for transport and handling, in two shifts, supplemented during resting periods of the teams by workers who also have other duties. The setting patterns of bricks, blocks and roofing tiles in the kiln are specified in Figures 4,5,6 and 7.

2.17 Fuel Supply. Fuel transport to the kiln occurs from a central fuel stock at the plant site. Here, the fuel is prepared for feeding the firing zone of the kiln (thick and long wood logs have to be sawn and split to logs measuring about 330mm x 100mm x 100mm; rice husks and coffee husks have to be packed in jute sacks; papyrus stalks have to be cut to 1 meter length. The prepared fuel is transported to the top of the kiln, with hand operated trolleys, using a simple winch to facilitate the haulage of the trolleys up to the kiln top. The fuel is stored alongside of the kiln top floor where it is ready for use by the stokers.

III. LAY-OUT OF THE PLANT

Plant Areas

3.1 The lay-out of the brick and tile factory is illustrated in Figure 1. The plant area has a length of 165m and a width of 65m. In case of a possible future doubling of the production, the width has to be extended to 90m. The plant roads are indicated with center-lines. The whole area is well drained and bordered by a fence.

Structures and Buildings

3.2 The following structures and buildings can be distinguished:

(a) an office building, 126 m^2;
(b) a roofed shelter for fuel storage and fuel preparation, 350m^2;
(c) a roofed shelter for a 3 meter high stock pile of raw materials, sufficient for a production period of 7 to 8 weeks;

(d) a partially enclosed structure for claybody preparation and shaping, 315m^2;
(e) a totally enclosed structure for maintenance, spare parts, power supply, water supply and lavatories, 112m^2;
(f) a drying shed, with thatched roof for roofing tiles, 60m x 12m, constructed as illustrated in the Figures 10 and 12;
(g) a partially enclosed structure for the manufacture of roofing tiles, 100m^2;
(h) ten drying sheds with thatched roofs for bricks and blocks (20m x 7.5m), constructed as illustrated in the Figures 10 and 11; and
(i) a roofed shelter for an eight-chamber down-draft kiln, 23.5m x 16.5m as illustrated in the Figures 3 and 8.

Stock Area for Fired Products

3.3 The area for storing fired products is about 500m^2. By stacking bricks to a height of about 1.5 m, the area can store about 400,000 bricks (230mm x 110mm x 70mm), corresponding to 8 weeks of production.

IV. KILN CONSTRUCTION

4.1 The main components of the structure of the proposed eight-chamber down-draft kiln are illustrated in the Figures 3, 4, 5, 8 and 9. The kiln body can be erected from solid homemade engineering bricks and homemade mortar. Refractory concrete however, has to be used for the walling of the various holes in the kiln body. The kiln must be built on a stable subsoil, well above the water table.

4.2 The thickness of the joints in the brickwork should not exceed 5mm. Therefore, the bricks must be dimensionally consistent and have well coordinated dimensions. As such, these bricks are slightly different from those used for brickwork in houses. The proposed dimensions are 230mm x 113mm x 74mm, giving 4mm joints. The bricks can be handmade or extruded. It is recommended to use professional advice in finding the best possible raw materials mix for the manufacture of bricks and mortar. Resistance to deformation under load at high temperatures and spalling resistance are important properties in this respect.

4.3 The bricks could be fired in existing kilns or clamps and sorted out into three quality classes (prime, select and common), for distinct applications in the kiln structure. The building materials needed for the construction of an eight-chamber downdraft kiln are estimated as follows:

Part of kiln body	Type and Size (mm)	Quality... class....Amount
- Chamber walls and arch	bricks: 230 x 113 x 74	prime.....78,000
	wedges: 230 x 113 x 74/65	prime.....20,000
- Connecting channels	bricks: 230 x 113 x 74	prime..... 3,000
	wedges: 230 x 113 x 112/74	prime..... 4,500
- Chimney channel	bricks: 230 x 113 x 74	prime..... 4,000
	wedges: 230 x 113 x 112/74	prime..... 3,000
- Chamber gates	bricks: 230 x 113 x 74	select.... 4,500
	wedges: 230 x 113 x 74/55	select.... 5,500
- Support structures	bricks: 230 x 113 x 74	select....60,000
- Outer walls and ascent	bricks: 230 x 113 x 74	select....40,000
- Foundations	bricks: 230 x 113 x 74	common....80,000
- Casings arch holes	refractory concrete	prime..... 15 m^3
-Brickwork joints	clay mortar	- ..... $70m^3$
- Filler in structure	mix of sand and clay	- ..... $300m^3$

4.4 The estimated total number of bricks required (230mm x 113mm x 74mm), are 270,000 and the total number of special shapes are 33,000.

4.5 Other components required for the kiln construction are:

- 104 refractory grate bars (650mm x 230mm x 110mm);
- 44 firehole covers (150mm Ø);
- 24 gas outlet covers (250mm Ø);
- 8 gas inlet covers (400mm Ø);
- 2 sets of bipartite manifolds (see Figure 9):
- 1 draft control damper (960 x 500mm);
- 1 man hole cover (960 x 500mm);
- 1 set of steel ducting with bypass and 2 dampers;
- 1 steel exhaust pipe (470mm Ø, length = 10m);
- a centrifugal fan, capacity $7000m^3/h$, total pressure 1000 Pa, maximum temperature 200 °C, electric motor = 3 kW;
- a generator (5 tot 10 kW), to guarantee power supply to the fan in case of power interruptions; and
- 10 oil lamps for emergency illumination.

4.6 The feeding of the fireholes with fuel is done by hand, using a simple hook for lifting the firehole covers. Visual process control is supported by movable instruments indicating the temperature (range 0-500 °C, probe length 2500mm) and the draught (range 0-250 Pa) in the pre-heating zone and by an instrument indicating the temperature of the exhaust gases (range 0-500 °C, probe length 250mm).

V. MAIN MANUFACTURING EQUIPMENT

5.1 The Main equipment required for manufacturing at various stages of production are as follows:

5.2 Mining and Storage of Raw Materials:

(a) one excavator;
(b) one all purpose truck; and
(c) spades.

5.3 Feeding, Clay Body Preparation and Shaping

(a) one box feeder, with a clay compartment, a smaller filler compartment and a rotating scraper;
(b) one double roll crusher;
(c) one set of smooth rolls;
(d) one double shaft mixer;
(e) one deairing extruder, 350mm ø complete (capacity at least 25 perforated bricks of 3.5 kg each per minute);
(f) five dies for 5 product types;
(g) one harp cutter and take-off conveyer;
(h) one roofing tile sliding frame screw press (capacity at least 3 tiles of 2.7 kg each per minute);
(i) four conveyors;
(j) steel structures for machinery;
(k) electric motors and control systems;
(l) equipment for water supply;
(m) 4000 wooden supports for roofing tiles; and
(n) concrete foundations for machinery.

5.4 Transport and Handling of Ware and Fuel:

(a) 25 trolleys with solid tires, each capable of transporting 150 standardized size bricks 230mm x 110mm x 70mm in wet, dried or fired condition;
(b) 10 wheelbarrows; and
(c) one winch.

5.5 Drying
See paragraph 3.2, items f and h.

5.6 Firing
See section IV

5.7 Ancillary Equipment

(a) equipment for maintenance and repairs;
(b) an ample set of spare parts;
(c) a power supply unit;
(d) equipment for fuel preparation (sawing and splitting equipment, bags);
(e) office inventory; and
(f) sanitary installations.

VI. PRODUCTION PERSONNEL

6.1 The number and duties of the personnel required for the production function are as follows:

Task	Number of Persons	Function
- Managing the production	1	manager
- Excavation	2	drivers
	2	laborers
- Preparation and shaping bricks	2	laborers
- Loading trolleys with bricks	1	laborers
- Transport of bricks to dryer	3	laborers
- Handling of bricks in dryer	3	laborers
- Shaping of tiles	3	laborers
- Transport of tiles to dryer	2	laborers
- Handling of tiles in dryer	1	laborers
- Transport of bricks and tiles to the kiln	6	laborers
- Kiln loading	6	laborers
- Kiln service	2	laborers
- Kiln firing	4	strokers
- Fuel preparation and supply	3	laborers
- Unloading kiln	6	laborers
- Brick and tile storage	4	laborers
- Maintenance and repairs	2	mechanics
- Area and road maintenance	1	laborers
- Administration	1	administration
Total number for production personnel	55	persons

VII. FUEL CONSUMPTION AND POTENTIAL FUEL SAVINGS

7.1 It is estimated that the heat consumption of an eight-chamber downdraft kiln as specified in this proposal will amount to 3,000 MJ per ton of well fired ware when operated continuously at full capacity and to 6,500 MJ per ton of ware when the kiln is operated periodically. The heat consumptions correspond with fuelwood consumptions of 0.4 m^3 and 0.85 m^3 per ton of fired ware, respectively. In comparison to proposed kiln, the present small-scale, semi-mechanized brick and tile production industry in Uganda is using periodically operated updraft or downdraft kilns without effective draft control, fired with fuelwood, coffee husks or rice husks. The equivalent fuelwood consumption of these kilns, based on four inspected units, are estimated at 1.8 m^3 fuelwood ($\pm$ 20%) per ton of fired ware. Therefore, the potential fuelwood savings, by substitution of existing worn out periodic kilns with an eight-chamber downdraft kiln as specified in this proposal, will amount to [illegible]-60% when the kiln is operated periodically, and to 70-80% when the kiln is operated continuously at full capacity.

VIII. INVESTMENT REQUIREMENTS

8.1 The mission estimates of the investment cost of the recommended brick and tile units, i.e. the cost of investment for a new, small-scale, semi-mechanized brick and tile production unit with the output of 130 tons of fired ware per week, as US$ 1.25 million, which in broad catagories, are indicated in the following table.

ESTIMATED COST OF THE RECOMMENDED BRICK AND TILE PLANT
(US$)

Description	Foreign	Local	Total
Foreign Exchange Components			
Machinery for excavation and storage of raw materials including excavator and truck	70,000	-	70,000
Machinery for preparation, extrusion and cutting	470,000	-	470,000
Imported component cost of a multi-fuel, downdraft eight-chamber kiln	40,000	-	40,000
Spare parts	100,000	-	100,000
Ancilliary equipment	25,000	-	25,000
Transportation to Kampala including insurance	150,000	-	150,000
Supervision of installation and commissioning	100,000	-	100,000
Contingencies	45,000	-	45,000
Subtotal	1,000,000	-	1,000,000
Local Cost Components			
Land and site preparation	-	20,000	20,000
Kiln construction	-	15,000	15,000
Shed for kiln and drying of the bricks and tiles	-	22,000	22,000
Clay preparation building	-	15,000	15,000
Office building	-	10,000	10,000
Electricity and telephone connection	-	9,000	9,000
Water supply and pumps	-	2,500	2,500
Machinery and electrical installation	-	35,000	35,000
Office furniture	-	2,000	2,000
Other local materials including bricks	-	25,000	25,000
Pre-operation expenditure	-	50,000	50,000
Contingencies	-	44,500	44,500
Subtotal	-	250,000	250,000
Total	1,000,000	250,000	1,250,000

Source: Mission estimates.

Figure 1

LAYOUT OF A BRICK AND TILE FACTORY

CAPACITY: 2.1 MILLION BRICKS (230x110x70mm) +0.3 MILLION ROOFING TILES/YEAR)

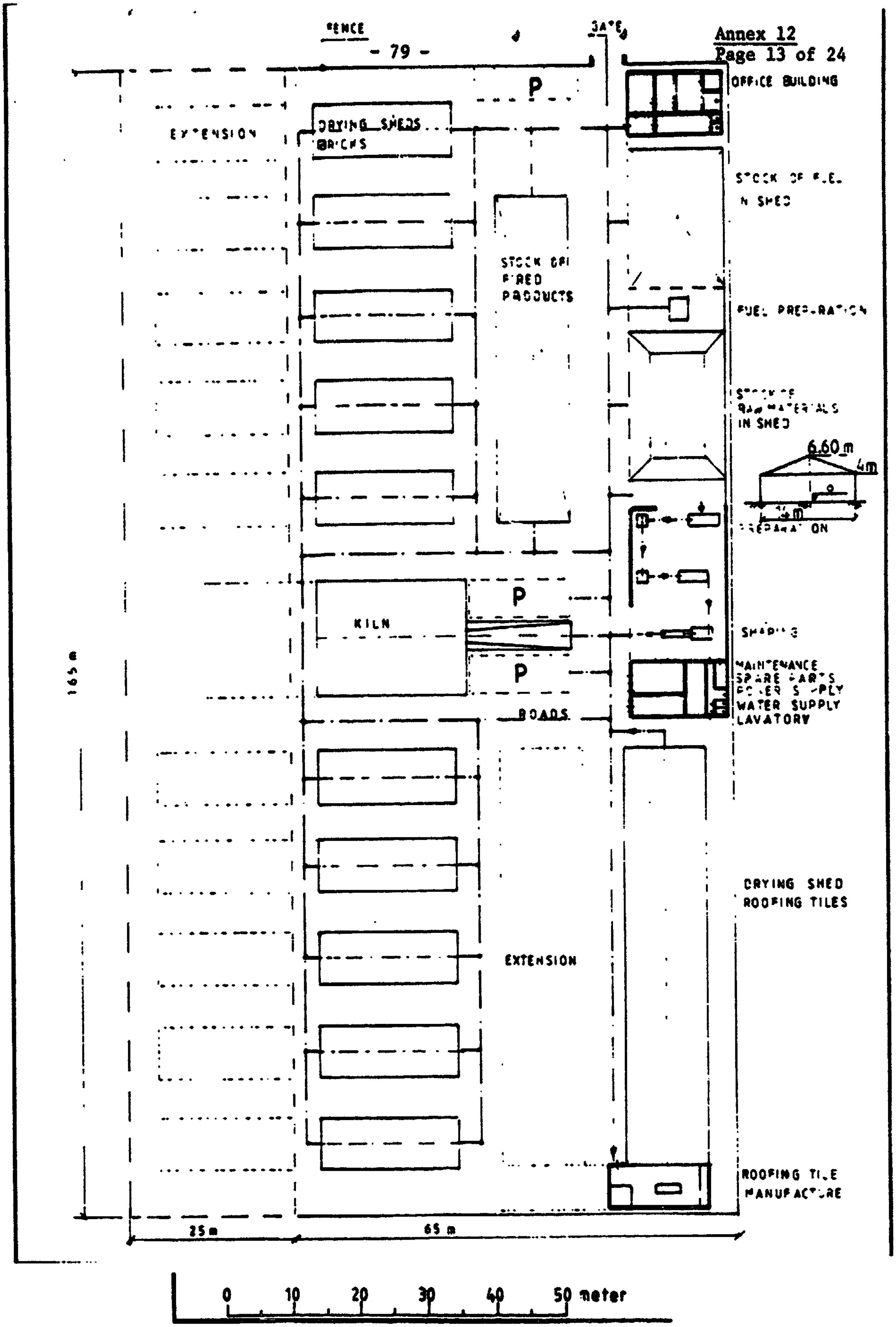
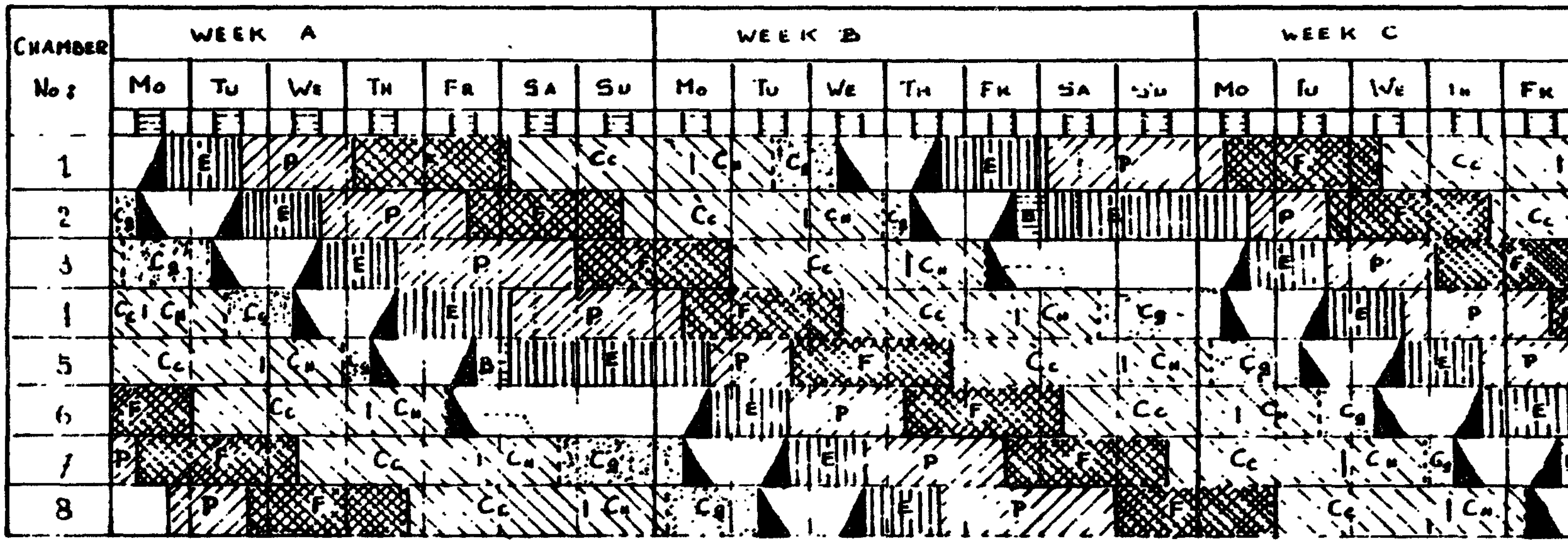


Figure 2

PRODUCTION SCHEME OF AN EIGHT-CHAMBER DOWNDRAFT KILN WITH 50,000 BRICK EQUIVALENTS PRODUCTION/WEEK



filling chamber, bricking up door

buffering ware

exhausting waste gases, preheating slowly

preheating ware by combustion gases

firing, fuel supply

cooling, (cooling holes in top of chamber closed)

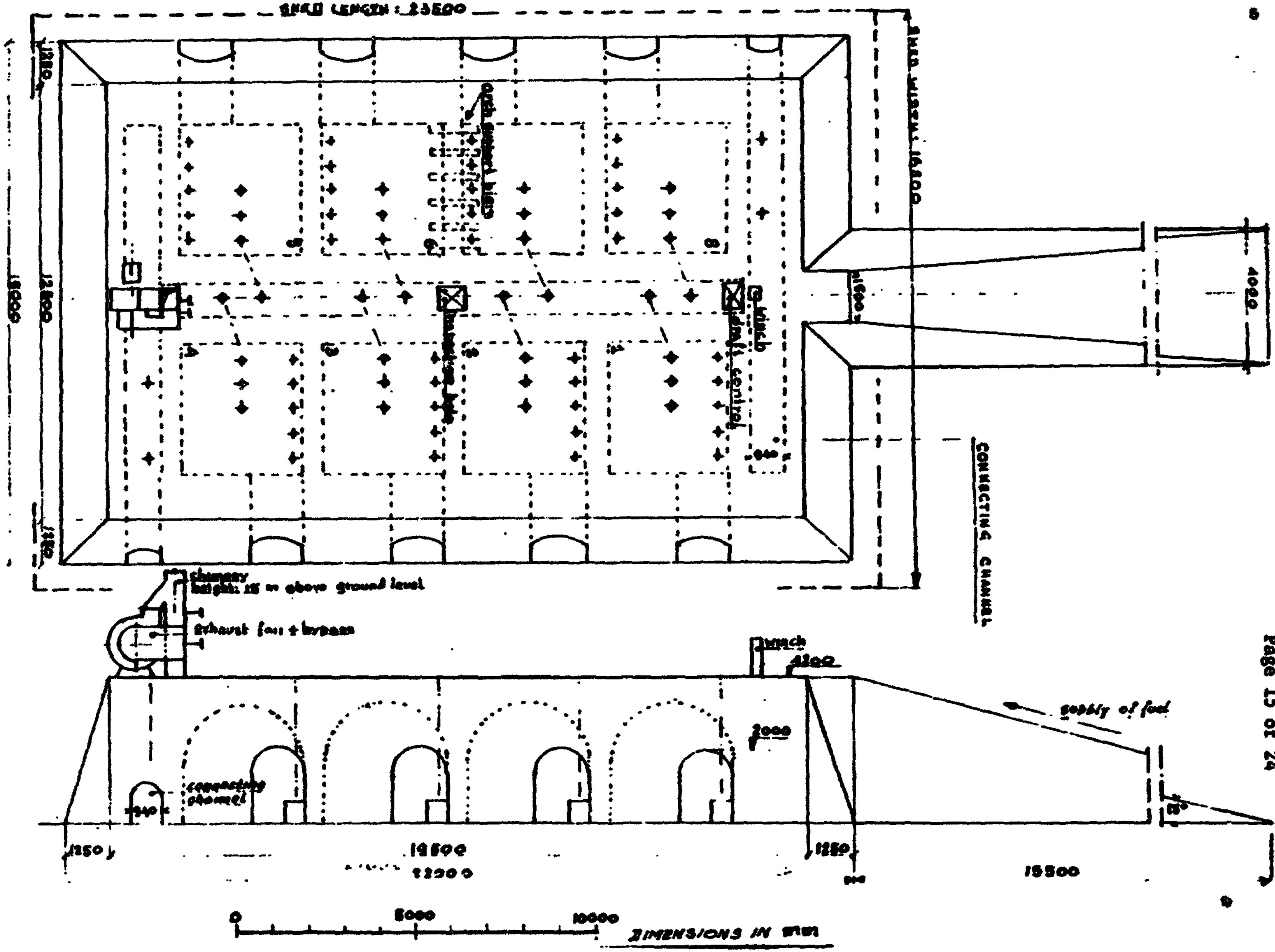
cooling, (cooling holes open)

end colloing, opening door, removing door

emptying, cleaning, sealing chamber, removing ash from ash pit next chamber

Figure 3

TOP VIEW OF A MULTI-FUEL DOWNDRAFT KILN FOR CONTINUOUS OR PERIODIC OPERATION WITH EIGHT CHAMBERS



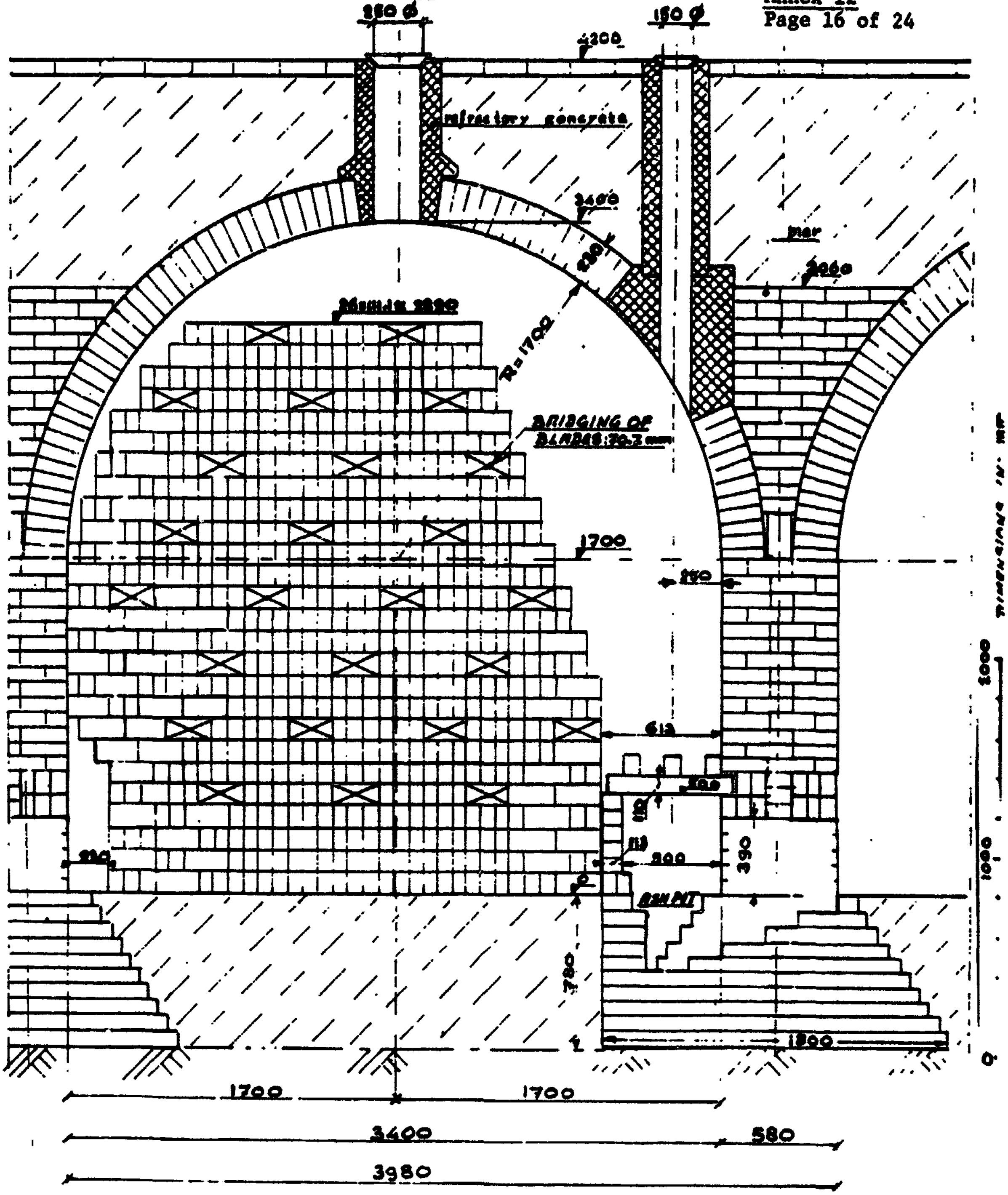


Figure 4
VERTICAL CROSS SECTION A A OF A CHAMBER OF A MULTI-FUEL DOWNDRAFT KILN FOR CONTINUOUS OR PERIODIC OPERATION WITH A SETTING OF BRICKS, 230x110x70 mm

Engineering Bricks for KILN Body: 230 x 113 x 74 mm; Joints: 4 mm
Arch Brichs, 78 Bricks per Row: 230 x 113 x 74/65; Joints: 3.5 - 4 mm

Load of KILN Chamber: 9960 Standard facing Bricks, 230 x 110 x 70 mm, PERF: 20%
Number of Birck Blades per Chamber: 12; Number of Bricks per Blade: 830
Dimensions of Dried Green Bricks: 232,3 x 111.1 x 70.7 mm; Weight Fired: 2.62kg
Load Per Chamber: 26.1 ton

HORIZONTAL CROSS-SECTION BB OF A CHAMBER OF A MULTI-FUEL DOWNDRAFT KILN FOR CONTINUOUS OR PERIODIC OPERATION

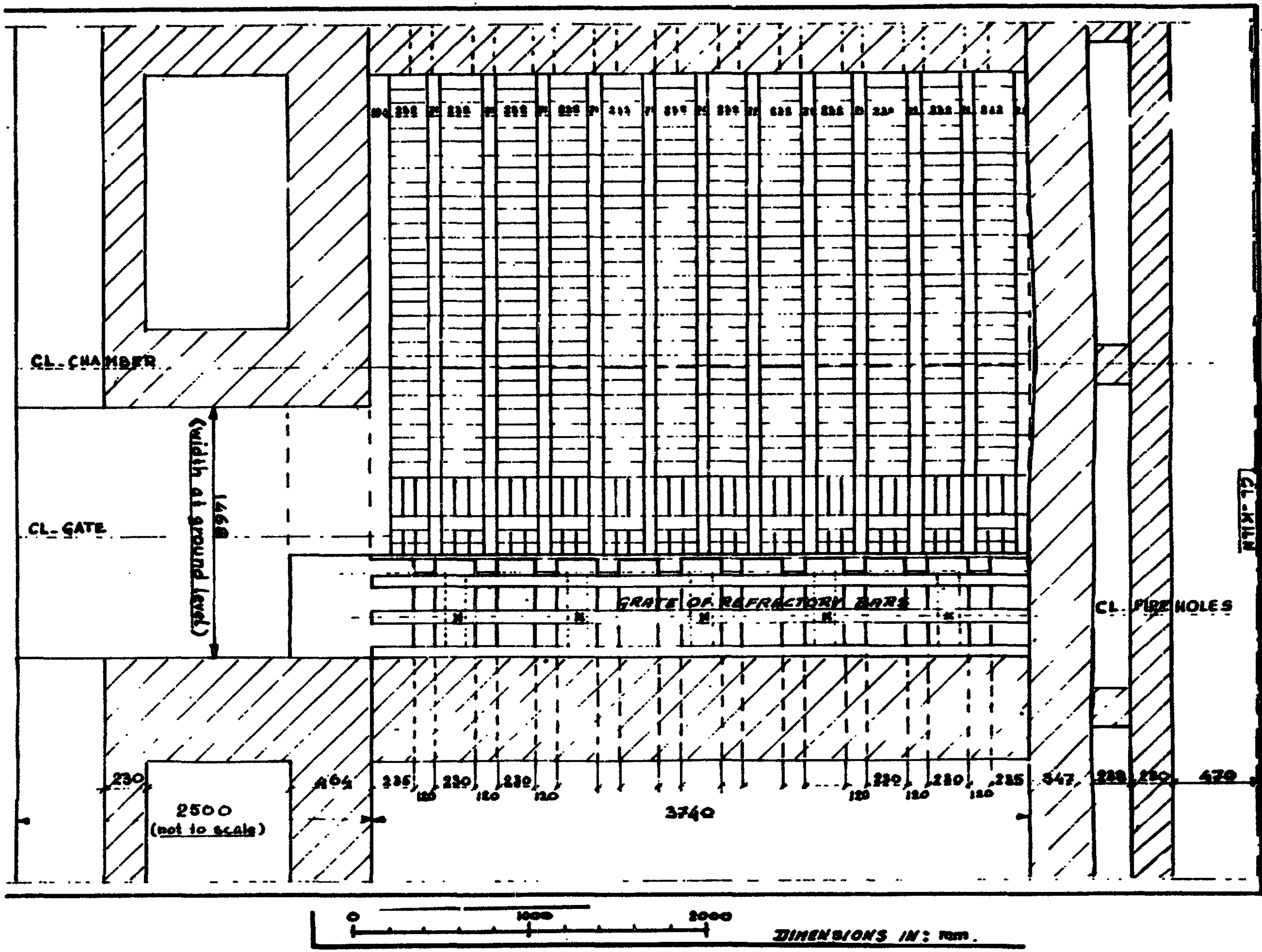
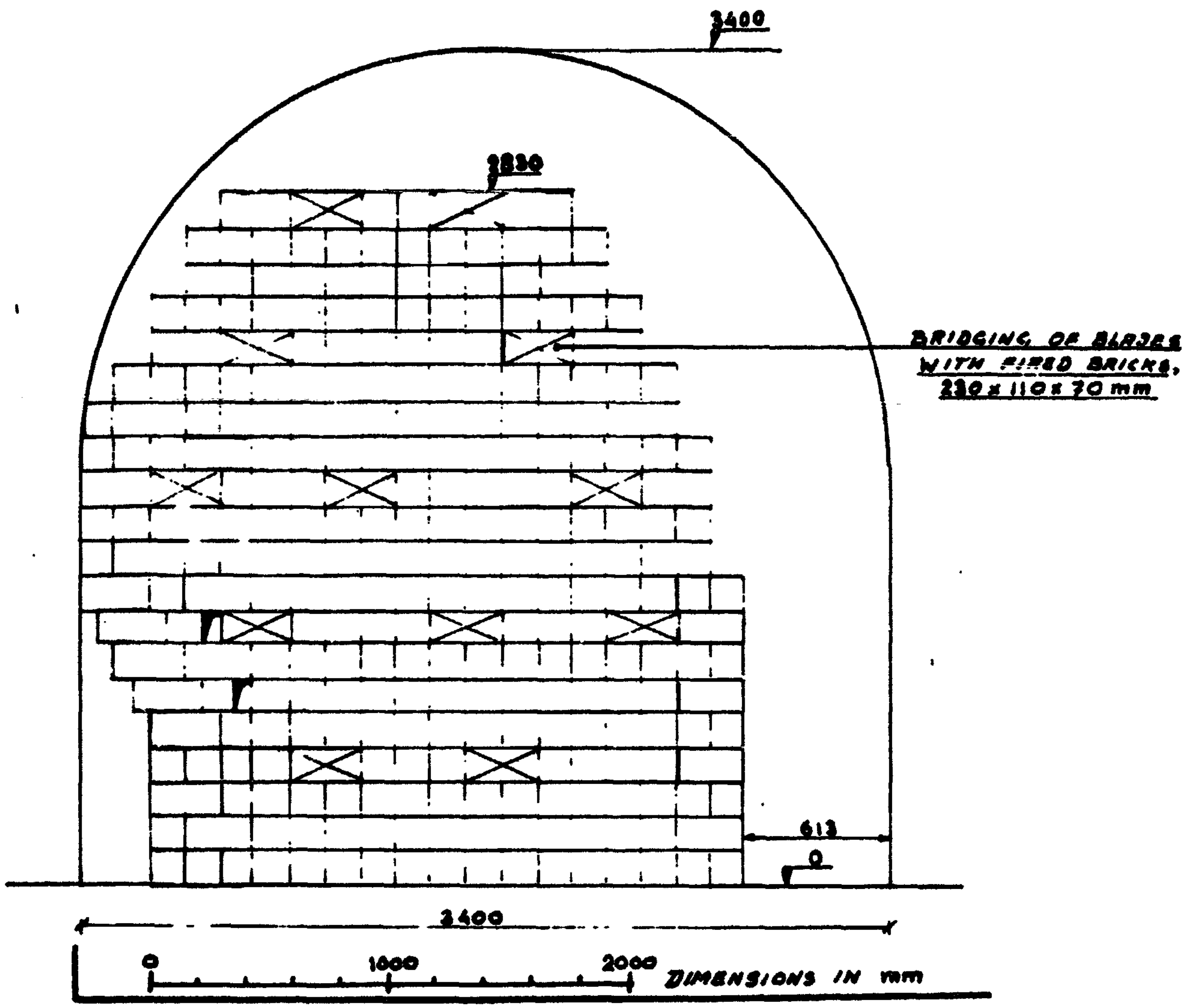


Figure 6

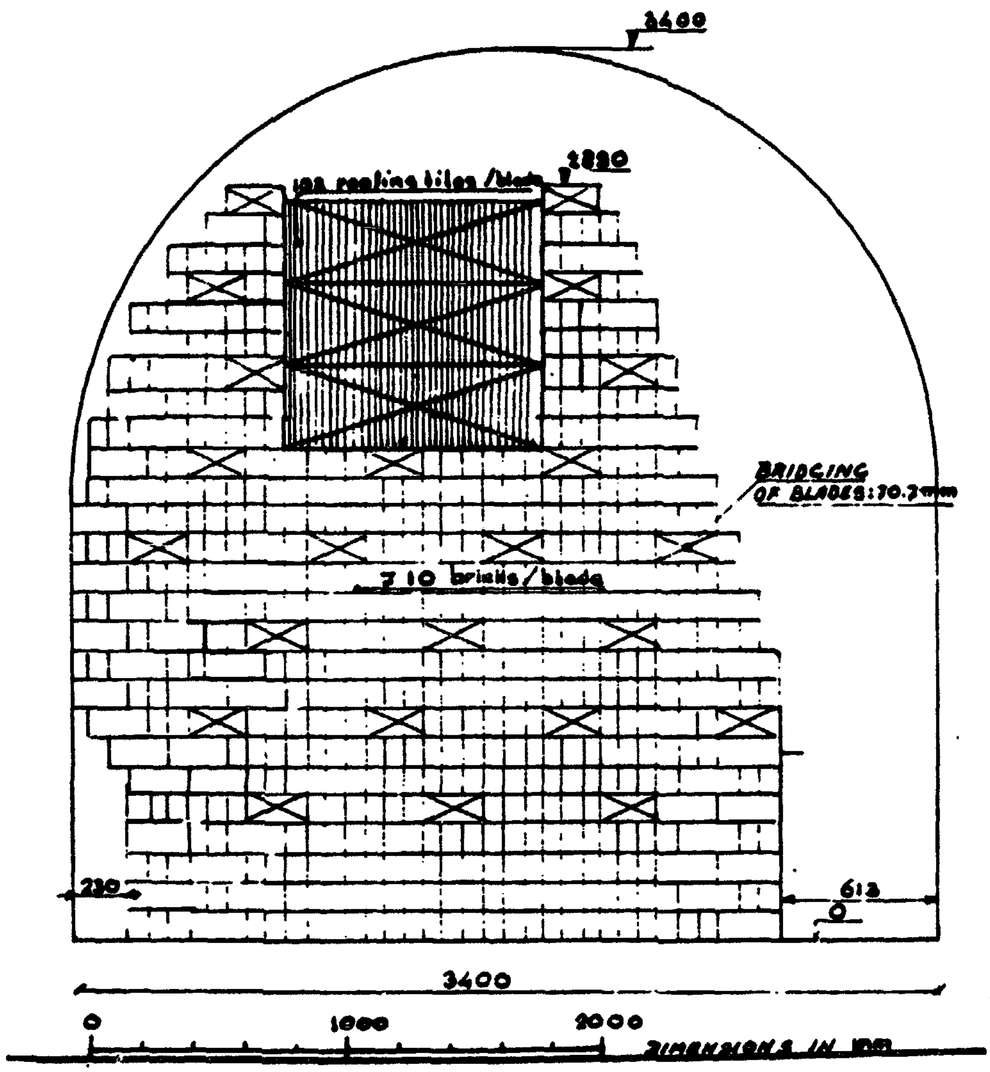
SETTING OF BLOCKS, 290 x 140 x 140 mm, IN A KILN CHAMBER



ALTERNATIVE LOAD OF KILN CHAMBER: 3240 BLOCKS 290 x 140 x 140 mm, PERF: 30%
NUMBER OF BLADES PER CHAMBER: 10, GAP BETWEEN BLADES: 70 mm
NUMBER OF BLOCKS PER BLADE: 324
DIMENSIONS OF DRIED GREEN BLOCKS: 292.9 x 141.4 x 14.1 mm, WEIGHT FIRED: 7.36 kg
LOAD PER CHAMBER: 23.8 TON

Figure 7

COMBINED SETTING OF BRICKS AND ROOFING TILES
IN A KILN CHAMBER



ALTERNATIVE LOAD OF KILN CHAMBER:
12 Blades, Each Consisting of: 710 Bricks, 230 x 110 x 70 mm
Plus: 102 Roofing Tiles, 310 x 240 mm (20 tiles per m^2 Roof)
(Setting Density: 34 Tiles per meter)

LOAD PER CHAMBER:

12 x 710 = 8520 Bricks = 8520 x 2.62 kg=		22.3 ton
12 x 102 = 1224 Tiles = 1224 x 2.00kg=		2.4 ton
	TOTAL LOAD	24.7 ton

KILN PRODUCTION: 5 CHAMBERS PER WEEK = 42600 BRICKS (230 x 110 x 70 mm)
Plus: 6120 Roofing Tiles (20 tiles/m^2)

ANNUAL KILN CAPACITY (49 WEEKS, LOSSES LEFT OUT OF ACCOUNT) =
2.1 Million Bricks (230 x 110 x 70 mm) Plus 0.3 Million Roofing Tiles(20 tiles/m

Figure 8

VERTICAL CROSS SECTION OF A MULTI-FUEL DOWNDRAFT CHAMBER KILN FOR CONTINUOUS OF PERIODIC OPERATION

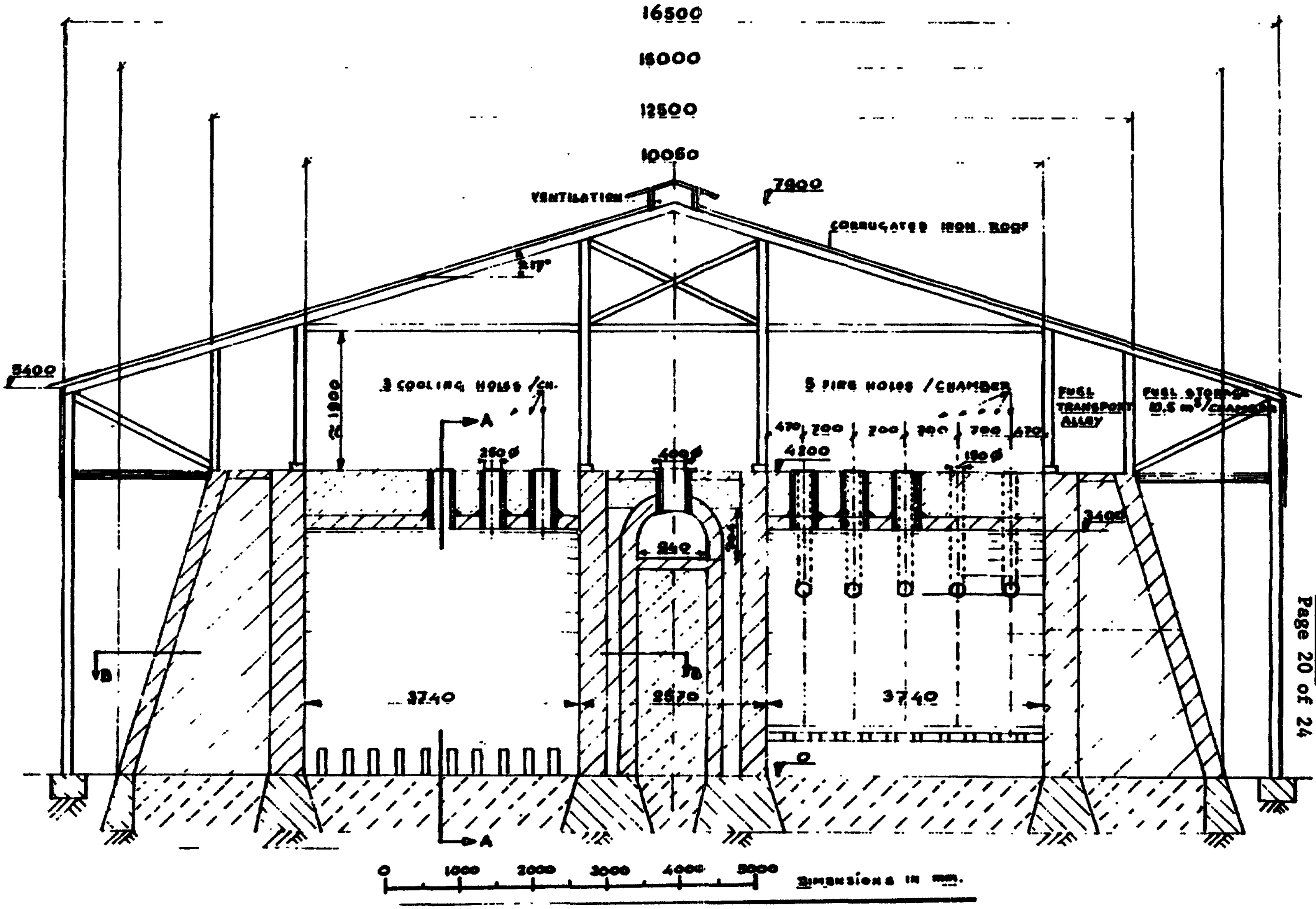


Figure 9

BIPARTITE TRANSPORTABLE MANIFOLD FOR EXTRACTING WASTE GASES FROM THE KILN

MATERIAL: St 37/2mm

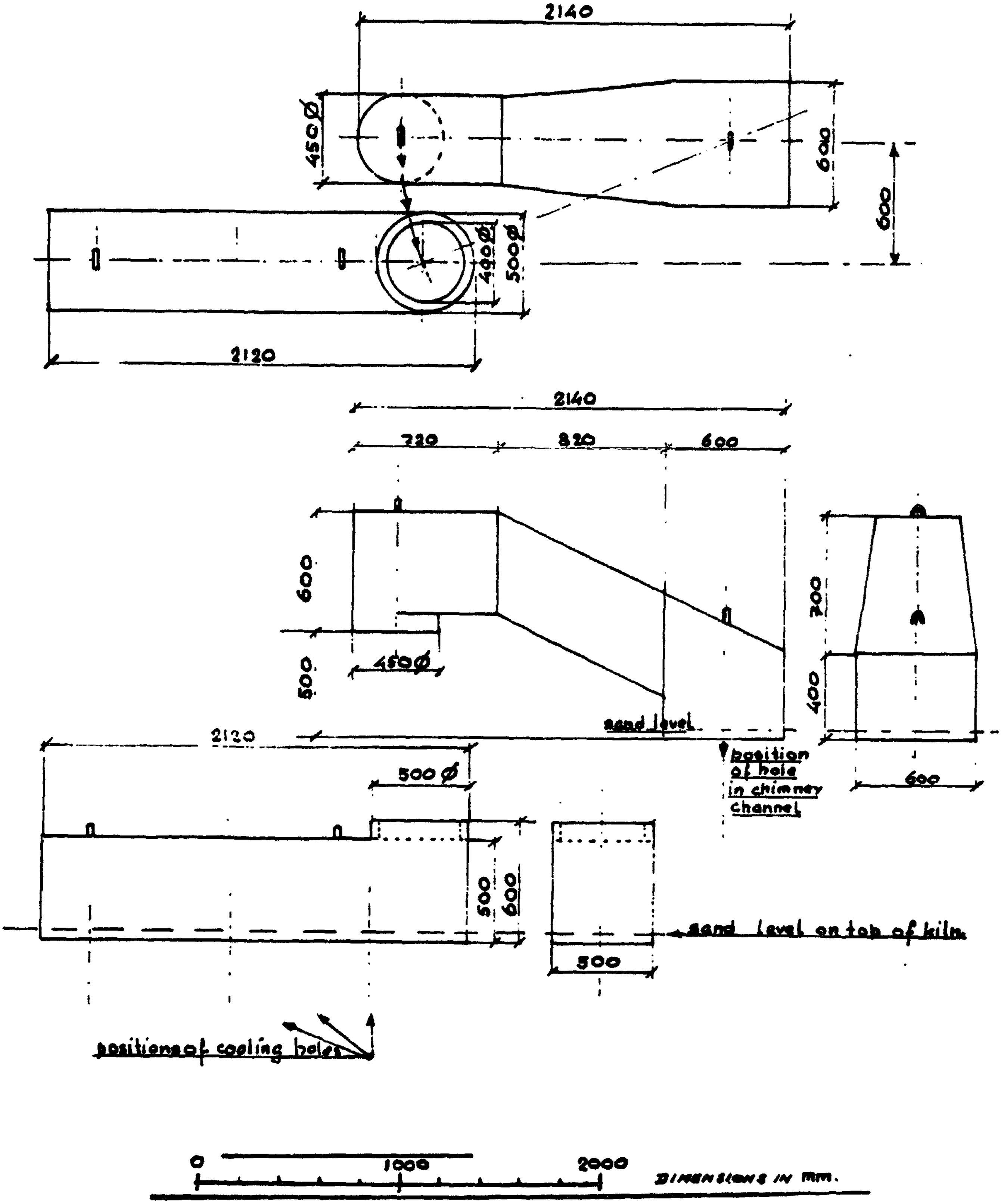
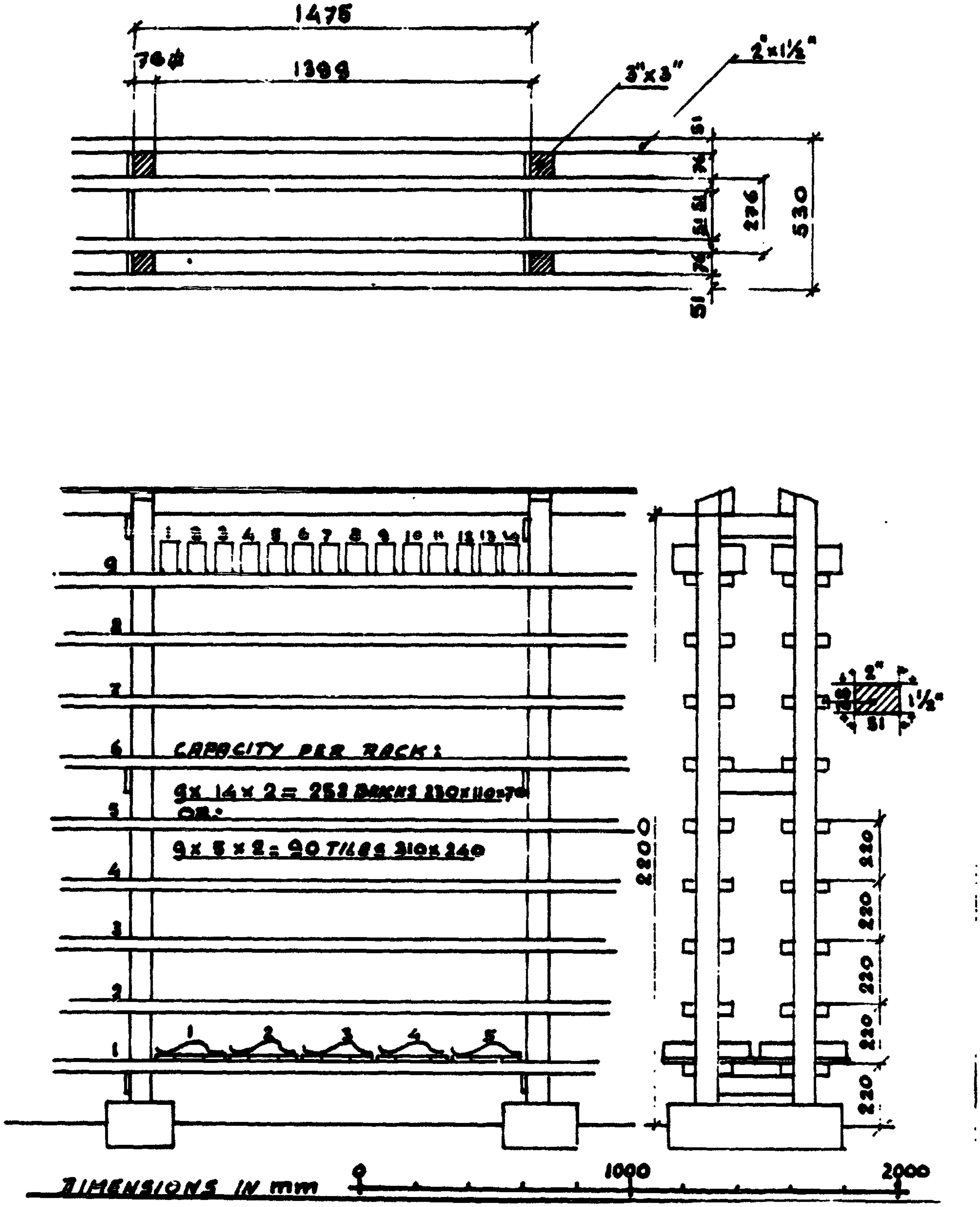


Figure 10

PRE-DRYING OF FRESH BRICKS AND FRESH ROOFING TILES IN RACKS DURING THE FIRST THREE WORKING DAYS



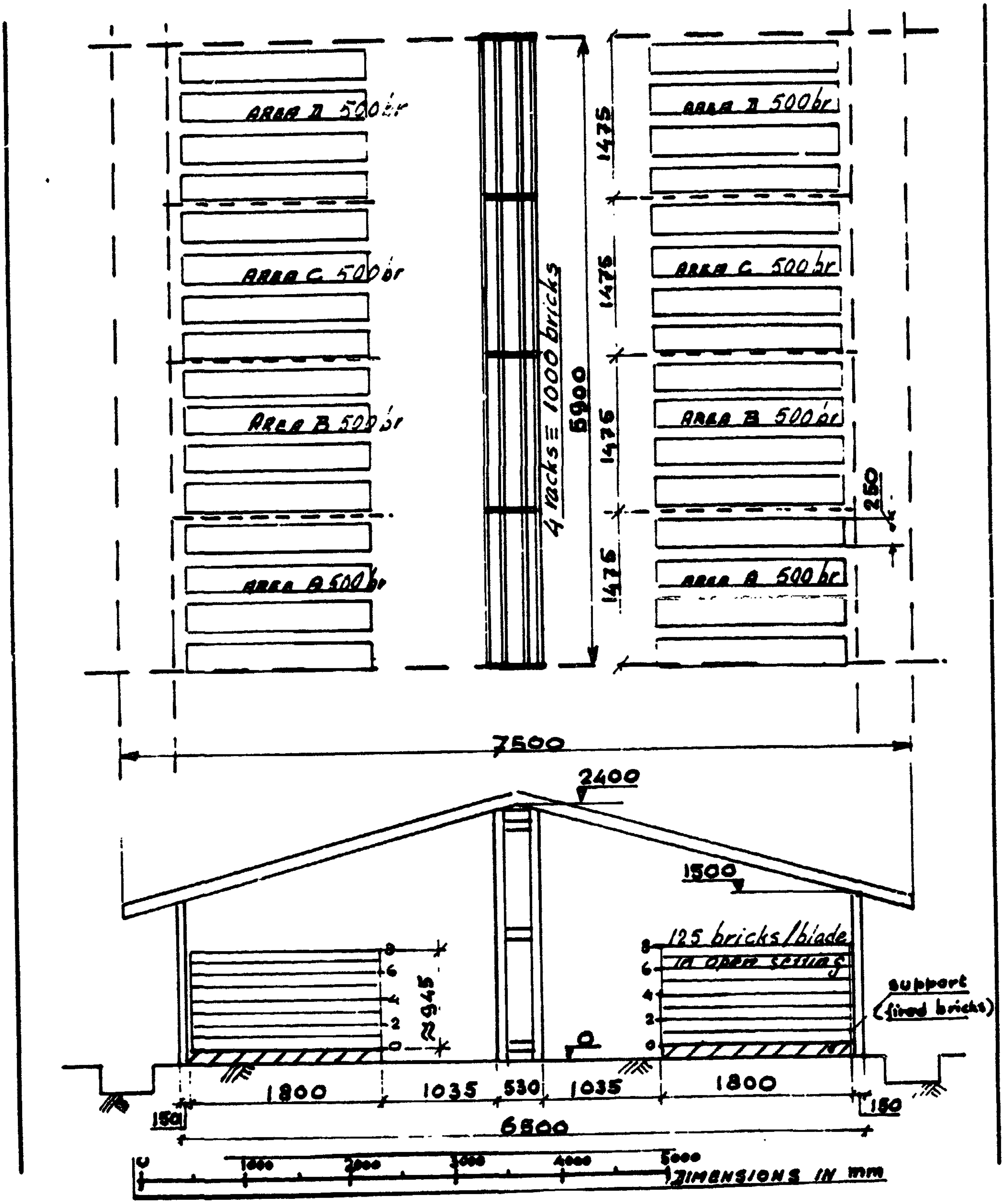
NUMBER OF RACKS FOR PRE-DRYING OF BRICKS: 120

NUMBER OF RACKS FOR PRE-DRYING OF TILES : 40

Figure 11

SHEDS FOR DRYING OF BRICKS

DRYING SCHEDULE FOR BRICKS

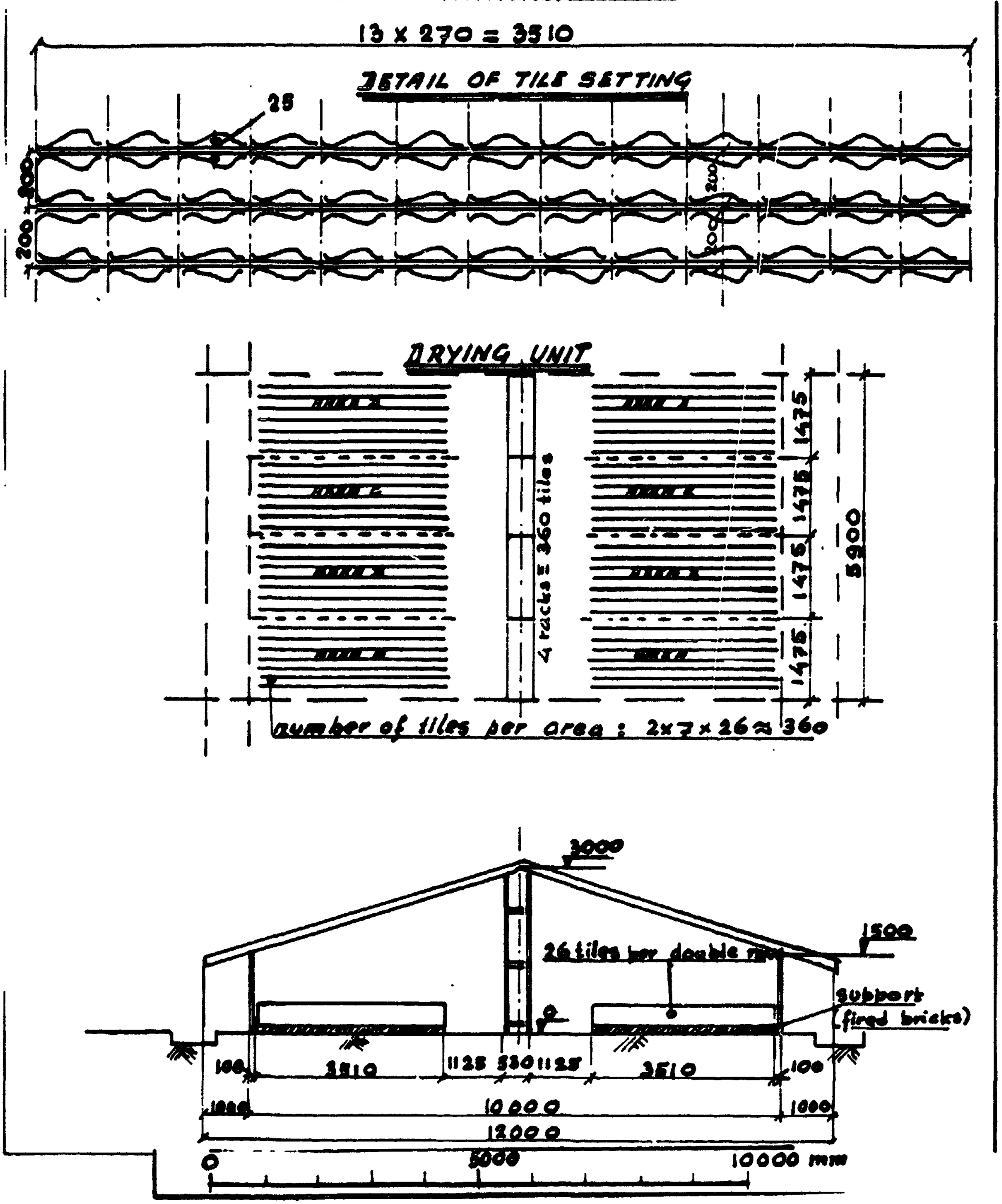


One drying unit consists of 4 racks (1000 bricks).
The bricks in a drying unit are to be stacked in the areas A,B,C,D successively with intervals of three working days.
Each shed covers 3 drying units = 17.7m.
Number of brick-drying sheds: 10.

Figure 12

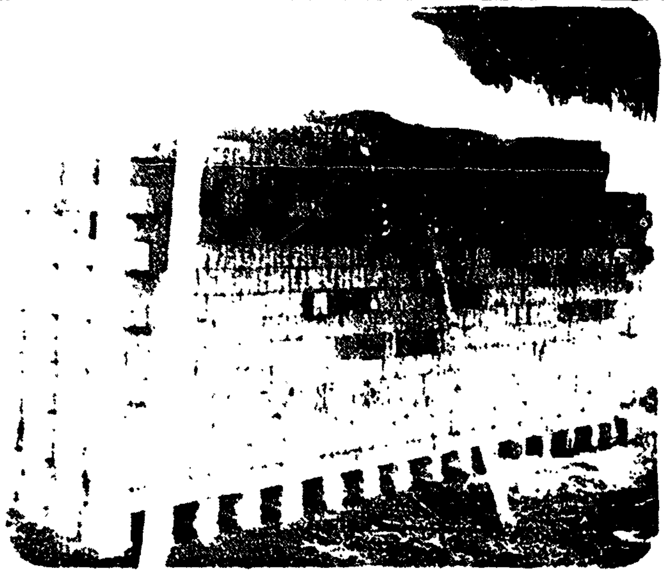
SHED FOR DRYING OF ROOFING TILES

DRYING SCHEDULE FOR ROOFING TILES



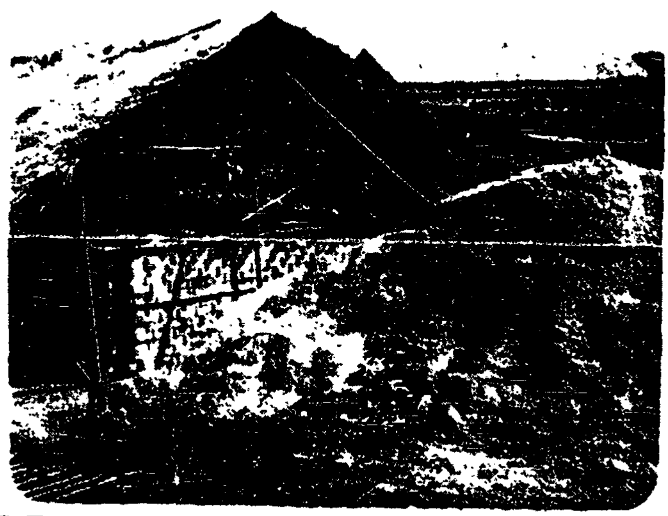
One drying unit consists of 4 racks (360 tiles).
The roofing tiles in a drying unit are to be set in the areas A,B,C,D successively, with intervals of three working days. One drying shed covers 10 drying units = 59m.
Number of tile-drying sheds: 1

Annex 13



setting pattern of clay bricks in a clamp kiln fired with rice husks. The gaps between the blades of bricks are filled with rice husks.

firing with smouldering rice husks in the gaps takes appr. 7 days. The ashes are removed at clamp base. During firing the gaps are replenished with rice husks on top of the clamp.



interview with a brickmaker, sitting on the rice husks ashes next to her clamp kiln.

Clamp Kilns with Blade-setting in Indonesia	The World Bank Washington, D.C. USA

Estimated costs of Efficiency Improvement
Measures in Artisan subsector
(US$)

Annex 14

Description	Phase I			Phase II			Project Total		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Construction Cost									
Test/Demonstration Shed	3,400	30,600	34,000	-	-	-	3400	30,600	34,000
Office	900	8,100	9,000	-	-	-	900	8,100	9,000
Storage	700	6,300	7,000	-	-	-	700	6,300	7,000
Molding Pads	1,500	13,500	15,000	-	-	-	1,500	13,500	15,000
Electrification Distribution	8,500	8,500	17,000	-	-	-	8,500	9,500	17,000
Road Repair	1,650	9,350	11,000	-	-	-	1,650	9,350	11,000
Toilet	500	4,500	5,000	-	-	-	500	4,500	5,000
Dormitory	2,300	20,700	23,000	-	-	-	23,000	20,700	23,000
Bath House	400	3,600	4,000	-	-	-	400	3,600	4,000
Permanent Kiln	400	3,600	4,000	-	-	-	400	3,600	4,000
Maintenance									
(5% construction cost/year)	-	-	-	2,300	20,700	23,000	2,300	20,700	23,000
Subtotal	20,250	108,750	129,000	2,300	20,700	23,000	22,550	129,450	152,000
Transport									
Landcruiser/Pick-up									
(4 x $16,000)	64,000	-	64,000	-	-	-	64,000	-	64,000
Personal Van									
(1 x $18,000)	-	-	-	18,000	-	18,000	18,000	-	19,000
Tripper (1 x $30,000)	30,000	-	30,000	-	-	-	30,000	-	30,000
Motor Cycles (8 x 1,500)	12,000	-	12,000	-	-	-	12,000	-	12,000
Bicycles (12 x $120)	1,440	-	1,440	-	-	-	1,440	-	1,440
Parts	20,000	-	20,000	26,000	-	26,000	46,000	-	46,000
Fuel and Lubricants	31,000	-	31,000	150,000	-	150,000	181,000	-	181,000
Subtotal	158,440	-	158,440	194,000		194,000	352,440		352,440
Start-Up and Testing Equipment									
Scale	190	-	190	-	-	-	190	-	190
Chainsaw (3 x $180)	480	-	480	960	-	960	1,440	-	1,440
Water Handpump	200	-	200	-	-	-	200	-	200
PVC pipe (200 lm x $2)	400	-	400	-	-	-	400	-	400
Wheelbarrows (5 x $40)	200	-	200	-	-	-	200	-	200
Spades (20 x $10)	200	-	200	-	-	-	200	-	200
Axes (20 x $20)	400	-	400	-	-	-	400	-	400
Hoe (10 x $6)	60	-	60	-	-	-	60	-	60
Pick - Axes (40 x $12)	480	-	480	-	-	-	480	-	480
Ranges (40 x $4)	160	-	160	-	-	-	160	-	160
Jerrycans (20 x $5)	100	-	100	-	-	-	100	-	100
Paints	400	-	400	-	-	-	400	-	400
Miscellaneous Tools	2,000	-	2,000	-	-	-	2,000	-	2,000
Miscellaneous Materials	2,000	2,000	4,000				2,000	2,000	4,000
Subtotal	7,270	2,000	9,270	960	-	960	8,230	2,000	10,230
Office and Demonstration Equipment									
File Cabinets (6 x $150)	300	600	900	-	-	-	300	600	900
Typewriter (2 x $200)	400	-	400	-	-	-	400	-	400
Desk & Chairs	200	800	1,000	-	-	-	200	800	1,000
Stationary	1,500	500	2,000	-	-	-	1,500	500	2,000
Drafting Equipment	600	-	600	-	-	-	600	-	600
Small Equipment	1,500	-	1,500	-	-	-	1,500	-	1,500
Audio-Visual Equipment	2,000	-	2,000	-	-	-	2,000	-	2,000
Camera/Film (b & w)	700	-	700	-	-	-	700	-	700
Duplicating Machine	1,500	-	1,500	-	-	-	1,500	-	1,500
Bonuses/Incentive -									
Production Dump	-	-	-	-	12,000	12,000	-	12,000	12,000
Operational: Food, Health,									
Misc.	-	5,000	5,000	-	40,000	40,000	-	45,000	45,000
Subtotal	8,700	6,900	15,600	-	52,000	52,000	8,700	58,900	67,600
National Staff									
Center and Field									
Supervisors (2)	-	6,000	6,000	-	24,000	24,000	-	30,000	30,000
Center Foreman (2)	-	3,600	3,600	-	14,400	14,400	-	18,000	18,000
Field Foreman (6)	-	10,800	10,800	-	43,200	43,200	-	54,000	54,000
Day Labourers (10)	-	4,800	4,800	-	19,200	19,200	-	24,000	24,000
Center Admin. Asst. (1)	-	1,800	1,800	-	7,200	7,200	-	9,000	9,000
Driver/Mechanic (2)	-	3,600	3,600	-	14,400	14,400	-	18,000	18,000
Subtotal	-	30,600	30,600	-	122,400	122,400	-	153,000	153,000
Expatriate Staff									
Brick and Tile expert (1)	70,000	-	70,000	300,000	-	300,000	370,000	-	370,000
Extension Trainer (1)	55,000	-	55,000	240,000	-	240,000	295,000	-	295,000
Subtotal	125,000	-	125,000	540,000	-	540,000	665,000	-	665,000
Total	319,660	148,250	467,910	737,260	195,100	932,360	1,056,920	343,350	1,400,270
Contingencies (7.12%)	22,760	10,555	33,315	52,493	13,891	66,384	75,253	24,447	99,700
Grand Total	342,420	158,805	501,225	789,753	208,991	998,744	1,132,173	367,797	1,499,970

Source: Mission Estimates

Annex 15

COST OF AN EIGHT CHAMBER DOWN DRAFT KILN
(US$)

	Foreign	Local	Total
Foreign Exchange Component			
Kiln Component:			
Drawings and bill of quantity	10,000	-	10,000
104 Refractory grates bars	12,000	-	12,000
44 Firehole covers			
24 Gas outlet covers			
8 Gas inlet covers			
2 Sets of bipartite manifolds			
1 Draft control damper			
1 Man hole cover	7,000	-	7,000
1 Set of steel ducting with bypass and 2 dumpers	5,000	-	5,000
1 Steel exhaust pipe	5,000	-	5,000
1 Centrifugal fan	5,000	-	5,000
1 Generator	15,000	-	15,000
Refractory Concretes	3,000	-	3,000
10 oil lamps, hooks, etc.	1,000	-	1,000
1 Winch	3,000	-	3,000
Subtotal	56,000	-	56,000
Spare Parts (18% of $56,000)	10,000	-	10,000
Transport to Kampala and site (25% of $56,000)	14,000	-	14,000
Supervision of construction and commissioning: (125 days/$320 day)	40,000	-	40,000
Auxiliary Equipment:			
Sawing equipment	3,000	-	3,000
10 trollys for transport	10,000	-	10,000
Subtotal	143,000	-	143,000
Contingencies	7,000	-	7,000
Subtotal	150,000	-	150,000
Local Cost Component			
Bricks a/: (270,000 x USh3 = 810,000 USh)	-	13,500	13,500
Special Shapes a/: 33,000 x 6 USh = 198,000)	-	3,300	3,300
Extra fuel, transport and sorting (1,008,000 USh x 30%)	-	5,200	5,200
Site preparation and construction			
Technician: (125 days/100 USh day)	-	230	230
Truck and tractor driver: (125 day/80 USh day)	-	170	170
Mason: (10 x 125 day/60 USh day)	-	1,250	1,250
Unskilled labor: (30 x 125 days/40 USh day)	-	2,500	2,500
Shed (material, labor, etc): (390 m^2 x $65 m^2)	-	25,350	25,350
Fuel Shed: (370 m^2 x $50 m^2	-	18,500	18,500
Auxiliary equipment	-	5,000	5,000
Electrical installation	-	10,000	10,000
Subtotal	-	85,000	85,000
Contingencies	-	15,000	15,000
Subtotal	-	100,000	100,000
Total Cost	150,000	100,000	250,000

a/ Bricks are assumed to be made on site.

Source: Mission Estimates.

ARTISAN PRODUCERS
CALCULATION OF FINANCIAL RATE OF RETURN
SCENARIO A 1/

Artisan Producers

Year	Amount of Investment	Percentage of Savings	Amount of Savings	Net Cash Flow
	(US$)	(%)	(US$)	(US$)
1	501,225	10%	20,596	(480,629)
2	249,686	30%	61,789	(187,897)
3	249,686	50%	102,982	(146,705)
4	249,686	70%	144,174	(105,512)
5	249,686	100%	205,963	(43,723)
6		100%	205,963	205,963
7		100%	205,963	205,963
8		100%	205,963	205,963
9		100%	205,963	205,963
10		100%	205,963	205,963
11		100%	205,963	205,963
12		100%	205,963	205,963
13		100%	205,963	205,963
14		100%	205,963	205,963
15		100%	205,963	205,963
16		100%	205,963	205,963
17		100%	205,963	205,963
18		100%	205,963	205,963
19		100%	205,963	205,963
20		100%	205,963	205,963
@ D.R. =	10%		NPV =	171,059
			IRR =	12.3%

1/ Assume no growth in current production in years 6-20.

ARTISAN PRODUCERS
CALCULATION OF FINANCIAL RATE OF RETURN
SCENARIO B 1/

Artisan Producers

Year	Amount of Investment	Percentage of Savings	Amount of Savings	Net Cash Flow
	(US$)	(%)	(US$)	(US$)
1	501,225	10%	20,596	(480,629)
2	249,686	30%	61,789	(187,897)
3	249,686	50%	102,982	(146,705)
4	249,686	70%	144,174	(105,512)
5	249,686	100%	205,963	(43,723)
6		10%	226,559	226,559
7		10%	249,215	249,215
8		10%	274,137	274,137
9		10%	301,550	301,550
10		10%	331,705	331,705
11		10%	364,876	364,876
12		10%	401,364	401,364
13		10%	441,500	441,500
14		10%	485,650	485,650
15		10%	534,215	534,215
16		10%	587,636	587,636
17		10%	646,400	646,400
18		10%	711,040	711,040
19		10%	782,144	782,144
20		10%	860,359	860,359
@ D.R. =	10%		NPV =	1,116,644
			IRR =	19.6%

1/ Assume annual increase in current production of 10% in years 6-20.

ARTISAN PRODUCERS
CALCULATION OF FINANCIAL RATE OF RETURN
SCENARIO C 1/

Artisan Producers

Year	Amount of Investment	Percentage of Savings	Amount of Savings	Net Cash Flow
	(US$)	(%)	(US$)	(US$)
	501,225	10%	20,596	(480,629)
2	249,686	30%	61,789	(187,897)
3	249,686	50%	102,982	(146,705)
4	249,686	70%	144,174	(105,512)
5	249,686	100%	205,963	(43,723)
6		20%	247,156	247,156
7		20%	296,587	296,587
8		20%	355,904	355,904
9		20%	427,085	427,085
10		20%	512,502	512,502
11		20%	615,002	615,002
12		20%	738,003	738,003
13		20%	885,603	885,603
14		20%	1,062,724	1,062,724
15		20%	1,275,269	1,275,269
16		20%	1,530,322	1,530,322
17		20%	1,836,387	1,836,387
18		20%	2,203,664	2,203,664
19		20%	2,644,397	2,644,397
20		20%	3,173,276	3,173,276
@ D.R. =	10%		NPV =	3,323,948
			IRR =	26.8%

1/ Assume annual increase in current production of 20% in years 6-20.

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF FINANCIAL RATE OF RETURN
REPLACEMENT OF ONE KILN

Small Scale, Semi-Mechanized Producers

Year	Amount of Investment (US$)	No. of Kilns in Production	Amount of Savings (US$)	Net Cash Flow (US$)
1	270,000	0	0	(270,000)
2		1	68,526	68,526
3		1	68,526	68,526
4		1	68,526	68,526
5		1	68,526	68,526
6		1	68,526	68,526
7		1	68,526	68,526
8		1	68,526	68,526
9		1	68,526	68,526
10		1	68,526	68,526
11		1	68,526	68,526
12		1	68,526	68,526
13		1	68,526	68,526
14		1	68,526	68,526
15		1	68,526	68,526
16		1	68,526	68,526
17		1	68,526	68,526
18		1	68,526	68,526
19		1	68,526	68,526
20		1	68,526	68,526
@ D.R. =	10.0%		NPV =	275,650
			IRR =	25.0%

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF FINANCIAL RATE OF RETURN
REPLACEMENT OF FIVE KILNS
ALTERNATIVE A

Small Scale, Semi-Mechanized Producers

Year	Amount of Investment	No. of Kilns in Production	Amount of Savings	Net Cash Flow
	(US$)		(US$)	(US$)
1	350,000	0	0	(350,000)
2	250,000	1	68,526	(181,474)
3	250,000	2	137,052	(112,948)
4	250,000	3	205,578	(44,422)
5	250,000	4	274,104	24,104
6		5	342,630	342,630
7		5	342,630	342,630
8		5	342,630	342,630
9		5	342,630	342,630
10		5	342,630	342,630
11		5	342,630	342,630
12		5	342,630	342,630
13		5	342,630	342,630
14		5	342,630	342,630
15		5	342,630	342,630
16		5	342,630	342,630
17		5	342,630	342,630
18		5	342,630	342,630
19		5	342,630	342,630
20		5	342,630	342,630
@ D.R. =	10.0%		NPV =	1,049,771
			IRR =	23.9%

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF FINANCIAL RATE OF RETURN
REPLACEMENT OF FIVE KILNS
ALTERNATIVE B

Small Scale, Semi-Mechanized Producers

Year	Amount of Investment (US$)	No. of Kilns in Production	Amount of Savings (US$)	Net Cash Flow (US$)
1	350,000	0	0	(350,000)
2	500,000	1	68,526	(431,474)
3	500,000	3	205,578	(294,422)
4		5	342,630	342,630
5		5	342,630	342,630
6		5	342,630	342,630
7		5	342,630	342,630
8		5	342,630	342,630
9		5	342,630	342,630
10		5	342,630	342,630
11		5	342,630	342,630
12		5	342,630	342,630
13		5	342,630	342,630
14		5	342,630	342,630
15		5	342,630	342,630
16		5	342,630	342,630
17		5	342,630	342,630
18		5	342,630	342,630
19		5	342,630	342,630
20		5	342,630	342,630
@ D.R. =	10.0%		NPV =	1,168,957
			IRR =	24.4%

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF FINANCIAL RATE OF RETURN
REPLACEMENT OF FIVE KILNS
ALTERNATIVE C

	Small Scale, Semi-Mechanized Producers			
Year	Amount of Investment	No. of Kilns in Production	Amount of Savings	Net Cash Flow
	(US$)		(US$)	(US$)
1	350,000	0	0	(350,000)
2	1,000,000	1	68,526	(931,474)
3		5	342,630	342,630
4		5	342,630	342,630
5		5	342,630	342,630
6		5	342,630	342,630
7		5	342,630	342,630
8		5	342,630	342,630
9		5	342,630	342,630
10		5	342,630	342,630
11		5	342,630	342,630
12		5	342,630	342,630
13		5	342,630	342,630
14		5	342,630	342,630
15		5	342,630	342,630
16		5	342,630	342,630
17		5	342,630	342,630
18		5	342,630	342,630
19		5	342,630	342,630
20		5	342,630	342,630
@ D.R. =	10.0%		NPV =	1,234,360
			IRR =	24.6%

ARTISAN PRODUCERS
CALCULATION OF ECONOMIC RATE OF RETURN
SCENARIO A 1/

Artisan Producers

Year	Amount of Investment			Fuelwood Savings			Cost of Coffee Husk	Percentage of Savings	Amount of Savings	Net Cash Flow
	Local	Foreign	Total 2/	Quantity	Unit Value	Total				
	(US$)	(US$)	(US$)	(m3 stack)	(US$/m3)	(US$)	(US$)	(%)	(US$)	(US$)
1	158,805	342,420	454,518	32,833	5.46	179,268	37,986	10%	14,128	(440,389)
2	52,248	197,438	234,319	32,833	5.46	179,268	37,986	30%	42,385	(191,934)
3	52,248	197,438	234,319	32,833	5.46	179,268	37,986	50%	70,641	(163,678)
4	52,248	197,438	234,319	32,833	5.46	179,268	37,986	70%	98,898	(135,421)
5	52,248	197,438	234,319	32,833	5.46	179,268	37,986	100%	141,282	(93,037)
6				32,833	5.46	179,268	37,986	100%	141,282	141,282
7				32,833	5.46	179,268	37,986	100%	141,282	141,282
8				32,833	5.46	179,268	37,986	100%	141,282	141,282
9				32,833	5.46	179,268	37,986	100%	141,282	141,282
10				32,833	5.46	179,268	37,986	100%	141,282	141,282
11				32,833	5.46	179,268	37,986	100%	141,282	141,282
12				32,833	5.46	179,268	37,986	100%	141,282	141,282
13				32,833	5.46	179,268	37,986	100%	141,282	141,282
14				32,833	5.46	179,268	37,986	100%	141,282	141,282
15				32,833	5.46	179,268	37,986	100%	141,282	141,282
16				32,833	5.46	179,268	37,986	100%	141,282	141,282
17				32,833	5.46	179,268	37,986	100%	141,282	141,282
18				32,833	5.46	179,268	37,986	100%	141,282	141,282
19				32,833	5.46	179,268	37,986	100%	141,282	141,282
20				32,833	5.46	179,268	37,986	100%	141,282	141,282
@ D.R. =	10%								NPV =	(164,970)
									IRR =	7.4%

1/ Assume no growth in current production in years 6-20.

2/ Local amounts converted at 1.00 US$ = 85 USh shadow exchange rate.

ARTISAN PRODUCERS
CALCULATION OF ECONOMIC RATE OF RETURN
SCENARIO B 1/

Artisan Producers

Year	Amount of Investment			Fuelwood Savings			Cost of Coffee Husk	Percentage of Savings	Amount of Savings	Net Cash Flow
	Local	Foreign	Total 2/	Quantity	Unit Value	Total				
	(US$)	(US$)	(US$)	(m3 stack)	(US$/m3)	(US$)	(US$)	(%)	(US$)	(US$)
1	158,805	342,420	454,518	32,833	5.46	179,268	37,986	10%	14,128	(440,389)
2	52,248	197,438	234,319	32,833	5.46	179,268	37,986	30%	42,385	(191,934)
3	52,248	197,438	234,319	32,833	5.46	179,268	37,986	50%	70,641	(163,678)
4	52,248	197,438	234,319	32,833	5.46	179,268	37,986	70%	98,898	(135,421)
5	52,248	197,438	234,319	32,833	5.46	179,268	37,986	100%	141,282	(93,037)
6				32,833	5.46	179,268	37,986	10%	155,410	155,410
7				32,833	5.46	179,268	37,986	10%	170,951	170,951
8				32,833	5.46	179,268	37,986	10%	188,047	188,047
9				32,833	5.46	179,268	37,986	10%	206,851	206,851
10				32,833	5.46	179,268	37,986	10%	227,536	227,536
11				32,833	5.46	179,268	37,986	10%	250,290	250,290
12				32,833	5.46	179,268	37,986	10%	275,319	275,319
13				32,833	5.46	179,268	37,986	10%	302,851	302,851
14				32,833	5.46	179,268	37,986	10%	333,136	333,136
15				32,833	5.46	179,268	37,986	10%	366,450	366,450
16				32,833	5.46	179,268	37,986	10%	403,095	403,095
17				32,833	5.46	179,268	37,986	10%	443,404	443,404
18				32,833	5.46	179,268	37,986	10%	487,744	487,744
19				32,833	5.46	179,268	37,986	10%	536,519	536,519
20				32,833	5.46	179,268	37,986	10%	590,171	590,171
@ D.R. =	10%								NPV =	483,663
									IRR =	14.9%

1/ Assume annual increase in current production of 10% in years 6-20.

2/ Local amounts converted at 1.00 US$ = 85 USh shadow exchange rate.

ARTISAN PRODUCERS
CALCULATION OF ECONOMIC RATE OF RETURN
SCENARIO C 1/

Artisan Producers

Year	Amount of Investment			Fuelwood Savings			Cost of Coffee Husk	Percentage of Savings	Amount of Savings	Net Cash Flow
	Local	Foreign	Total 2/	Quantity	Unit Value	Total				
	(US$)	(US$)	(US$)	(m3 stack)	(US$/m3)	(US$)	(US$)	(%)	(US$)	(US$)
1	158,805	342,420	454,518	32,833	5.46	179,268	37,986	10%	14,128	(440,389)
2	52,248	197,438	234,319	32,833	5.46	179,268	37,986	30%	42,385	(191,934)
3	52,248	197,438	234,319	32,833	5.46	179,268	37,986	50%	70,641	(163,678)
4	52,248	197,438	234,319	32,833	5.46	179,268	37,986	70%	98,898	(135,421)
5	52,248	197,438	234,319	32,833	5.46	179,268	37,986	100%	141,282	(93,037)
6				32,833	5.46	179,268	37,986	20%	169,539	169,539
7				32,833	5.46	179,268	37,986	20%	203,446	203,446
8				32,833	5.46	179,268	37,986	20%	244,136	244,136
9				32,833	5.46	179,268	37,986	20%	292,963	292,963
10				32,833	5.46	179,268	37,986	20%	351,555	351,555
11				32,833	5.46	179,268	37,986	20%	421,866	421,866
12				32,833	5.46	179,268	37,986	20%	506,240	506,240
13				32,833	5.46	179,268	37,986	20%	607,488	607,488
14				32,833	5.46	179,268	37,986	20%	728,985	728,985
15				32,833	5.46	179,268	37,986	20%	874,782	874,782
16				32,833	5.46	179,268	37,986	20%	1,049,738	1,049,738
17				32,833	5.46	179,268	37,986	20%	1,259,686	1,259,686
18				32,833	5.46	179,268	37,986	20%	1,511,623	1,511,623
19				32,833	5.46	179,268	37,986	20%	1,813,948	1,813,948
20				32,833	5.46	179,268	37,986	20%	2,176,738	2,176,738
@ D.R. =	10%								NPV =	1,997,783
									IRR =	22.2%

1/ Assume annual increase in current production of 20% in years 6-20.

2/ Local amounts converted at 1.00 US$ = 85 USh shadow exchange rate.

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF ECONOMIC RATE OF RETURN
REPLACEMENT OF ONE KILN

Small Scale, Semi-mechanized Producers

Year	Amount of Investment			Fuelwood Savings			Cost of Coffee Husk	Percentage of Savings	Amount of Savings	Net Cash Flow
	Local	Foreign	Total	Quantity	Unit Value	Total				
	(US$)	(US$)	(US$)	(m3 stack)	(US$/m3)	(US$)	(US$)	(%)	(US$)	(US$)
1	100,000	150,000	220,588	9,616	5.46	52,503	2,921	0%	0	(220,588)
2				9,616	5.46	52,503	2,921	100%	49,582	49,582
3				9,616	5.46	52,503	2,921	100%	49,582	49,582
4				9,616	5.46	52,503	2,921	100%	49,582	49,582
5				9,616	5.46	52,503	2,921	100%	49,582	49,582
6				9,616	5.46	52,503	2,921	100%	49,582	49,582
7				9,616	5.46	52,503	2,921	100%	49,582	49,582
8				9,616	5.46	52,503	2,921	100%	49,582	49,582
9				9,616	5.46	52,503	2,921	100%	49,582	49,582
10				9,616	5.46	52,503	2,921	100%	49,582	49,582
11				9,616	5.46	52,503	2,921	100%	49,582	49,582
12				9,616	5.46	52,503	2,921	100%	49,582	49,582
13				9,616	5.46	52,503	2,921	100%	49,582	49,582
14				9,616	5.46	52,503	2,921	100%	49,582	49,582
15				9,616	5.46	52,503	2,921	100%	49,582	49,582
16				9,616	5.46	52,503	2,921	100%	49,582	49,582
17				9,616	5.46	52,503	2,921	100%	49,582	49,582
18				9,616	5.46	52,503	2,921	100%	49,582	49,582
19				9,616	5.46	52,503	2,921	100%	49,582	49,582
20				9,616	5.46	52,503	2,921	100%	49,582	49,582

@ D.R. = 10%

NPV = 131,518

IRR = 20.9%

1/ Local amounts converted at 1.00 US$ = 85 USh shadow exchange rate.

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF ECONOMIC RATE OF RETURN
REPLACEMENT OF FIVE KILNS
ALTERNATIVE A

Small Scale, Semi-mechanized Producers

Year	Amount of Investment			Fuelwood Savings			Cost of Coffee Husk	Number of Kilns in Production	Amount of Savings	Net Cash Flow
	Local	Foreign	Total	Quantity	Unit Value	Total				
	(US$)	(US$)	(US$)	(m3 stack)	(US$/m3)	(US$)	(US$)		(US$)	(US$)
1	100,000	250,000	320,588	9,616	5.46	52,503	2,921	0	0	(320,588)
2	100,000	150,000	220,588	9,616	5.46	52,503	2,921	1	49,582	(171,006)
3	100,000	150,000	220,588	9,616	5.46	52,503	2,921	2	99,165	(121,424)
4	100,000	150,000	220,588	9,616	5.46	52,503	2,921	3	148,747	(71,841)
5	100,000	150,000	220,588	9,616	5.46	52,503	2,921	4	198,329	(22,259)
6				9,616	5.46	52,503	2,921	5	247,912	247,912
7				9,616	5.46	52,503	2,921	5	247,912	247,912
8				9,616	5.46	52,503	2,921	5	247,912	247,912
9				9,616	5.46	52,503	2,921	5	247,912	247,912
10				9,616	5.46	52,503	2,921	5	247,912	247,912
11				9,616	5.46	52,503	2,921	5	247,912	247,912
12				9,616	5.46	52,503	2,921	5	247,912	247,912
13				9,616	5.46	52,503	2,921	5	247,912	247,912
14				9,616	5.46	52,503	2,921	5	247,912	247,912
15				9,616	5.46	52,503	2,921	5	247,912	247,912
16				9,616	5.46	52,503	2,921	5	247,912	247,912
17				9,616	5.46	52,503	2,921	5	247,912	247,912
18				9,616	5.46	52,503	2,921	5	247,912	247,912
19				9,616	5.46	52,503	2,921	5	247,912	247,912
20				9,616	5.46	52,503	2,921	5	247,912	247,912
@ D.R. =	10%								NPV =	583,944
									IRR =	19.0%

1/ Local amounts converted at 1.00 US$ = 85 USh shadow exchange rate.

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF ECONOMIC RATE OF RETURN
REPLACEMENT OF FIVE KILNS
ALTERNATIVE B

Small Scale, Semi-mechanized Producers

Year	Amount of Investment			Fuelwood Savings			Cost of Coffee Husk	Number of Kilns in Production	Amount of Savings	Net Cash Flow
	Local	Foreign	Total	Quantity	Unit Value	Total				
	(US$)	(US$)	(US$)	(m3 stack)	(US$/m3)	(US$)	(US$)		(US$)	(US$)
1	100,000	250,000	320,588	9,616	5.46	52,503	2,921	0	0	(320,588)
2	200,000	300,000	441,176	9,616	5.46	52,503	2,921	1	49,582	(391,594)
3	200,000	300,000	441,176	9,616	5.46	52,503	2,921	3	148,747	(292,429)
4				9,616	5.46	52,503	2,921	5	247,912	247,912
5				9,616	5.46	52,503	2,921	5	247,912	247,912
6				9,616	5.46	52,503	2,921	5	247,912	247,912
7				9,616	5.46	52,503	2,921	5	247,912	247,912
8				9,616	5.46	52,503	2,921	5	247,912	247,912
9				9,616	5.46	52,503	2,921	5	247,912	247,912
10				9,616	5.46	52,503	2,921	5	247,912	247,912
11				9,616	5.46	52,503	2,921	5	247,912	247,912
12				9,616	5.46	52,503	2,921	5	247,912	247,912
13				9,616	5.46	52,503	2,921	5	247,912	247,912
14				9,616	5.46	52,503	2,921	5	247,912	247,912
15				9,616	5.46	52,503	2,921	5	247,912	247,912
16				9,616	5.46	52,503	2,921	5	247,912	247,912
17				9,616	5.46	52,503	2,921	5	247,912	247,912
18				9,616	5.46	52,503	2,921	5	247,912	247,912
19				9,616	5.46	52,503	2,921	5	247,912	247,912
20				9,616	5.46	52,503	2,921	5	247,912	247,912
@ D.R. =	10%								NPV =	659,311
									IRR =	19.4%

1/ Local amounts converted at 1.00 US$ = 85 USh shadow exchange rate.

SMALL SCALE, SEMI-MECHANIZED PRODUCERS
CALCULATION OF ECONOMIC RATE OF RETURN
REPLACEMENT OF FIVE KILNS
ALTERNATIVE C

Small Scale, Semi-mechanized Producers

Year	Amount of Investment			Fuelwood Savings			Cost of Coffee Husk	Number of Kilns in Production	Amount of Savings	Net Cash Flow
	Local	Foreign	Total	Quantity	Unit Value	Total				
	(US$)	(US$)	(US$)	(m3 stack)	(US$/m3)	(US$)	(US$)		(US$)	(US$)
1	100,000	250,000	320,588	9,616	5.46	52,503	2,921	0	0	(320,588)
2	400,000	600,000	882,353	9,616	5.46	52,503	2,921	1	49,582	(832,771)
3				9,616	5.46	52,503	2,921	5	247,912	247,912
4				9,616	5.46	52,503	2,921	5	247,912	247,912
5				9,616	5.46	52,503	2,921	5	247,912	247,912
6				9,616	5.46	52,503	2,921	5	247,912	247,912
7				9,616	5.46	52,503	2,921	5	247,912	247,912
8				9,616	5.46	52,503	2,921	5	247,912	247,912
9				9,616	5.46	52,503	2,921	5	247,912	247,912
10				9,616	5.46	52,503	2,921	5	247,912	247,912
11				9,616	5.46	52,503	2,921	5	247,912	247,912
12				9,616	5.46	52,503	2,921	5	247,912	247,912
13				9,616	5.46	52,503	2,921	5	247,912	247,912
14				9,616	5.46	52,503	2,921	5	247,912	247,912
15				9,616	5.46	52,503	2,921	5	247,912	247,912
16				9,616	5.46	52,503	2,921	5	247,912	247,912
17				9,616	5.46	52,503	2,921	5	247,912	247,912
18				9,616	5.46	52,503	2,921	5	247,912	247,912
19				9,616	5.46	52,503	2,921	5	247,912	247,912
20				9,616	5.46	52,503	2,921	5	247,912	247,912
@ D.R. =	10%								NPV =	700,669
									IRR =	19.6%

1/ Local amounts converted at 1.00 US$ = 85 USh shadow exchange rate.

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

Activities Completed

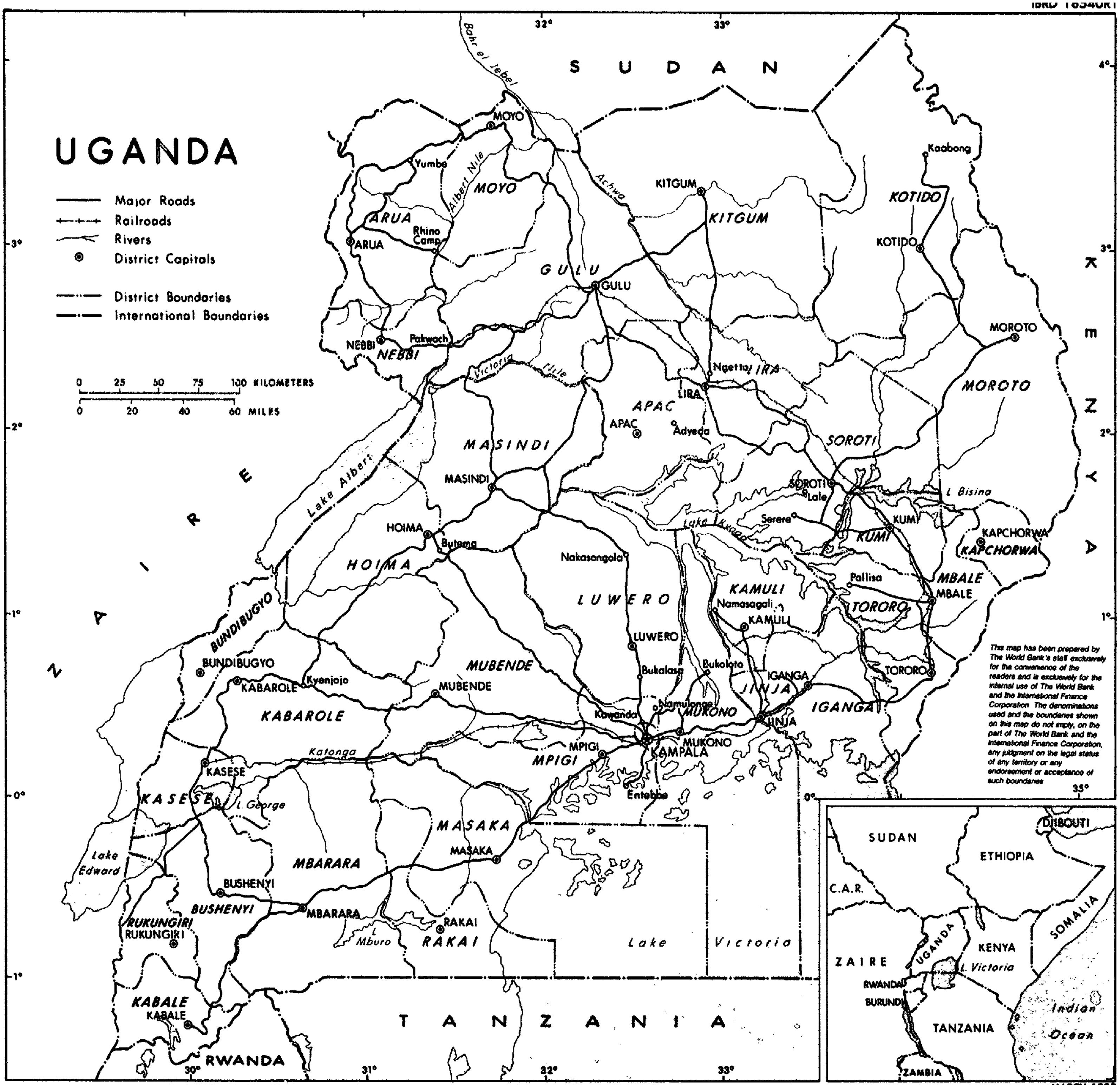
Country	Project	Date	Number
Energy Efficiency and Strategy			
Africa Regional	Participants' Reports - Regional Power Seminar on Reducing Electric System Losses in Africa	8/88	087/88
Bangladesh	Power System Efficiency Study	2/85	031/85
Botswana	Pump Electrification Prefeasibility Study	1/86	047/86
	Review of Electricity Service Connection Policy	7/87	071/87
	Tuli Block Farms Electrification Prefeasibility Study	7/87	072/87
Burkina	Technical Assistance Program	3/86	052/86
Burundi	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987)	5/85	036/85
	Review of Petroleum Import and Distribution Arrangements	1/84	012/84
Costa Rica	Recommended Technical Assistance Projects	11/84	027/84
Ethiopia	Power System Efficiency Study	10/85	045/85
The Gambia	Petroleum Supply Management Assistance	4/85	035/85
Ghana	Energy Rationalization in the Industrial Sector of Ghana	6/88	084/88
Guinea-Bissau	Recommended Technical Assistance Projects in the Electric Power Sector	4/85	033/85
Indonesia	Energy Efficiency Improvement in the Brick, Tile and Lime Industries on Java	4/87	067/87
	Power Generation Efficiency Study	2/86	050/86
	Diesel Generation Efficiency Improvement Study	12/88	095/88
Jamaica	Petroleum Procurement, Refining, and Distribution	11/86	061/86
Kenya	Power System Efficiency Report	3/84	014/84
Liberia	Power System Efficiency Study	12/87	081/87
	Recommended Technical Assistance Projects	6/85	038/85
Madagascar	Power System Efficiency Study	12/87	075/87
Malaysia	Sabah Power System Efficiency Study	3/87	068/87
Mauritius	Power System Efficiency Study	5/87	070/87
Panama	Power System Loss Reduction Study	6/83	004/83
Papua New Guinea	Energy Sector Institutional Review: Proposals for Strengthening the Department of Minerals and Energy	10/84	023/84
	Power Tariff Study	10/84	024/84
Senegal	Assistance Given for Preparation of Documents for Energy Sector Donors' Meeting	4/86	056/86
Seychelles	Electric Power System Efficiency Study	8/84	021/84
Sri Lanka	Power System Loss Reduction Study	7/83	007/83
Syria	Electric Power Efficiency Study	9/88	089/88
Sudan	Power System Efficiency Study	6/84	018/84
	Management Assistance to the Ministry of Energy and Mining	5/83	003/83
Togo	Power System Efficiency Study	12/87	078/87

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

Activities Completed

Country	Project	Date	Number
Energy Efficiency and Strategy (Continued)			
Uganda	Energy Efficiency in Tobacco Curing Industry	2/86	049/86
	Institutional Strengthening in the Energy Sector	1/85	029/85
	Power System Efficiency Study	12/88	092/88
Zambia	Energy Sector Institutional Review	11/86	060/86
	Energy Sector Strategy	12/88	094/88
	Power System Efficiency Study	12/88	093/88
Zimbabwe	Power Sector Management Assistance Project: Background, Objectives, and Work Plan	4/85	034/85
	Power System Loss Reduction Study	6/83	005/83
Household, Rural, and Renewable Energy			
Burundi	Peat Utilization Project	11/85	046/85
	Improved Charcoal Cookstove Strategy	9/85	042/85
Côte d'Ivoire	Improved Biomass Utilization--Pilot Projects Using Agro-Industrial Residues	4/87	069/87
Ethiopia	Agricultural Residue Briquetting: Pilot Project	12/86	062/86
	Bagasse Study	12/86	063/86
The Gambia	Solar Water Heating Retrofit Project	2/85	030/85
	Solar Photovoltaic Applications	3/85	032/85
Global	Proceedings of the ESMAP Eastern & Southern Africa Household Energy Planning Seminar	6/88	085/88
India	Opportunities for Commercialization of Non-Conventional Energy Systems	11/88	091/88
Jamaica	FIDCO Sawmill Residues Utilization Study	9/88	088/88
	Charcoal Production Project	9/88	090/88
Kenya	Solar Water Heating Study	2/87	066/87
	Urban Woodfuel Development	10/87	076/87
Malawi	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry	11/83	009/83
Mauritius	Bagasse Power Potential	10/87	077/87
Niger	Household Energy Conservation and Substitution	12/87	082/87
	Improved Stoves Project	12/87	080/87
Peru	Proposal for a Stove Dissemination Program in the Sierra	2/87	064/87
Rwanda	Improved Charcoal Cookstove Strategy	8/86	059/86
	Improved Charcoal Production Techniques	2/87	065/87
Senegal	Industrial Energy Conservation Project	6/85	037/85
	Urban Household Energy Strategy	2/89	096/89
Sri Lanka	Industrial Energy Conservation: Feasibility Studies for Selected Industries	3/86	054/86
Sudan	Wood Energy/Forestry Project	4/88	073/88
Tanzania	Woodfuel/Forestry Project	8/88	086/88
Thailand	Accelerated Dissemination of Improved Stoves and Charcoal Kilns	9/87	079/87
	Rural Energy Issues and Options	9/85	044/85
	Northeast Region Village Forestry and Woodfuel Pre-Investment Study	2/88	083/88
Togo	Wood Recovery in the Nangbeto Lake	4/86	055/86
Uganda	Fuelwood/Forestry Feasibility Study	3/86	053/86
	Energy Efficiency Improvement in the Brick and Tile Industry	2/89	097/89

MAP SECTION



UGANDA
Major Roads
Railroads
Rivers
District Capitals
District Boundaries
International Boundaries
0 25 50 75 100 KILOMETERS
0 20 40 60 MILES
SUDAN
KENYA
TANZANIA
ZAIRE
RWANDA
Bahr el Jebel
Albert Nile
Achwa
Victoria Nile
Lake Albert
Lake Kyoga
L. Bisina
Katonga
L. George
Lake Edward
L. Mburo
Lake Victoria
MOYO
Yumbe
ARUA
Rhino Camp
NEBBI
Pakwach
GULU
KITGUM
Kaabong
KOTIDO
MOROTO
LIRA
Ngetta
APAC
Adyeda
SOROTI
Lale
Serere
KUMI
KAPCHORWA
MBALE
Pallisa
TORORO
MASINDI
HOIMA
Butema
Nakasongola
LUWERO
Bukalasa
KAMULI
Namasagali
Bukoloto
IGANGA
JINJA
MUKONO
Namulonge
Kawanda
KAMPALA
Entebbe
MPIGI
MUBENDE
Kyenjojo
KABAROLE
BUNDIBUGYO
KASESE
MASAKA
MBARARA
BUSHENYI
RAKAI
RUKUNGIRI
KABALE
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SUDAN
ETHIOPIA
DJIBOUTI
C.A.R.
SOMALIA
ZAIRE
UGANDA
KENYA
L. Victoria
RWANDA
BURUNDI
TANZANIA
Indian Ocean
ZAMBIA

MARCH 1989