intermediate technology consultants

Mechanisms to Improve Energy Efficiency in Small Industries

Synthesis

Front Cover

Picture showing pollution from Khurja DD kilns

or

"How ESI are ESCOs?"

By:

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Acknowledgements

Include credit for front cover photo

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(to be completed)

SEC	Specific energy consumption – this is the amount of energy consumed to produce a unit of output
PCRA	
CGCRI	
Energy Foundation	
KITE	
PRI	
ESCO	
ESI	
IEAC	
DfID	
GTMO	
FPIB	
CERAM	
KaR	
ETSU	
DETR?	
SDC	
TERI	

Glossary

Kiln furniture

Stochiometric – a mixture of fuel and air that will burn leaving neither unburned fuel nor uncombined O_2.Excess air – air supplied in addition to that required for the stochiometric combustion of a fuel

Contravec or air curtain – this is a system for blowing air into a tunnel kiln to counteract the effects of convection currents

3 *Introduction*

3.1 Brief overview of project

This was an 18 month project, funded by DfID KaR. Started in September 1999, and completed at the end of March 2001. This aim of the project was to explore mechanisms, both technical as well as policy and institutional, for improving the efficiency of energy use in small industries in Ghana and India. The small industries chosen were sawmills in Ghana, and ceramics firms in India. This project was different to many previous studies in that it set out to look not just at the technical options, but to explore the barriers around the adoption of those options, measures to reduce those barriers.

An important element of the work was to explore the policy framework needed for Energy Service Companies (ESCOs) to flourish. Another central element was to try to quantify the impact of improvements in energy efficiency on the stakeholders, especially the workforce – i.e. to help answer the question “how does improving industrial energy efficiency help the poor?”.

In India, after an initial overview of pottery clusters throughout the country, the project focussed on the Khurja ceramics cluster, about 100 km east of Delhi, in the state of Uttar Pradesh. Khurja is the largest ceramics cluster in India, with about 491 active firms. The project worked in detailed with 12 firms, who all signed up to participate in the project. The primary focus of the final work was on improving the performance of diesel fired shuttle and tunnel kilns.

In Ghana the project began with an overview of sawmill clusters throughout the country, and surveys were carried out in a total of 56 firms. Later in the project, the project focussed on sawmills in the Kumasi area of Ghana in the Ashante region.

3.2 Reasons for the high priority of this research

Improving the economic efficiency of energy production and end-use has the potential to allow developing countries to meet their economic growth and improved living standard needs with their own economic, financial, operational and environmental resources. This is a classic “win-win” option in which the economic needs of developing countries would be matched with their environmental needs and also the global need to reduce carbon emissions.

For all countries, and especially for developing countries, energy and economic development are closely linked; their economic growth, the primary method for eliminating poverty, requires a growth in energy services.

Very often measures to increase energy efficiency per unit of output in industrial production activities are highly correlated with an over all increase in production efficiency. Therefore increases in energy efficiency are likely to be accompanied by lower inputs of other materials, lower wastes, and reduced pollution loads. Besides the issues specific to energy production and use, there is a concern that unless the impacts of economic and production activities are reduced, they will increasingly generate environmental constraints which will further limit the scope for economic development besides their negative impacts on the health of human and other living things (World Commission, 1987). More efficient and cleaner technologies are those designed to reduce the throughputs and waste streams of energy, water, materials and by products and these provide developing countries, the choice, often termed “leap-frogging,” to follow less polluting options rather than using outdated technology.

Furthermore, this project offers a potential for improving the technology services provided to small and medium industries. SMEs, which provide the maximum amount of employment in all countries and are seen as a major element of any employment generating developmental path. At the same time, small and medium size businesses tend to be less efficient and more polluting (per unit of production) than many larger units and do not have the in-house capacity to resolve their technical problems.

The issues of efficient and effective intermediation to provide efficiency services are currently among the most exciting research and public policy issues relevant to increased efficiency for SME units, for promotion of cleaner production, and possibly for other development issues.

3.3 Aim of this report

There are separate final reports available from each country, as well as several other reports that were produced during the project (see appendix for list of related reports). This report aims to present the key findings and recommendations from each country in a succinct and accessible way. This document also aims draw out any generic points emerging from the research that would be applicable to other industries, and other countries, as this is a primary aim of the DfID KaR programme. It also seeks to compare and contrast the findings from the two countries.

As such this document is aimed at the following people: DfID, and other donors; other researchers in the field of energy efficiency and SMEs.

3.4 Report structure

The structure of the report reflects the structure of the research. It begins with an overview of the methodology that was followed in each country (section 4). It then goes on to present what was learnt from a review of previous literature and research in this field, and how those lessons shaped the direction of the project (section 5). Section 6 gives an overview of each of the two industries, to place them in context for the reader, and to give a feel for the types of technology and processes used, and the nature of energy consumption. Section 7 briefly summarises the scope for energy efficiency improvement in each of the two industries, and outlines the key technical mechanisms for delivering these savings. Section 8 presents the barriers that were discovered to firms adopting more energy efficient technologies and practices, be they technological, institutional, policy, or financial. Section 9 discusses what the project found about linkages between energy efficiency improvements in SMEs amd poverty reduction – both at a micro level, for the workforce and local population, and at a macro level. Sections 10 and 11 present a summary of the key findings, and recommendations, respectively.

3.5 Description of Study Team

The team consisted of:

- Dr Abeeku Brew-Hammond, and Sefa Bonsu-Atakora of the Kumasi Institute of Technology (KITE) in Ghana
- Dr Amitav Rath, Policy Research International (PRI), Canada
- Industrial Development Services (IDS), Delhi, India
- Stephen Ward, ITC, overall project manager

In addition, the following experts were brought in during the project to provide additional expertise:

- Carl Shenton, CERAM, UK – kiln expert
- Dr Mike Hornsby – quality control, production engineer

- Mr Nketiah, Forest Research Institute of Ghana (FORIG)
- Mr Viswanathan, local India kiln expert

3.6 Overview of project purpose and outputs

The overall purpose of the project (see also appendix for copy of original logframe) was to:

(1) To develop technical, institutional and market mechanisms that will increase the adoption of energy efficient technologies and practices for small scale industries in India and Ghana

(2) To monitor effects of these technologies on the workforce and local population against a number of indicators including employment levels, working conditions, local pollution, etc.

The specific outputs that the project sought to achieve were:

- To gain a comprehensive understanding of research and work that has been carried out into improving energy efficiency in the selected industries
- To understand the effects of such energy efficiency technologies on the workforce and local population
- To gain an initial knowledge of the scope for energy efficiency improvements in the selected industries
- To gain a comprehensive understanding of the opportunities and constraints for energy efficiency improvements in the selected industries including social, legal and environmental issues
- To identify the key policy issues necessary to create an enabling environment for the energy efficiency improvements in the industries (i.e. national and local government regulations, guidelines and fiscal policies)
- Successfully overcome barriers to enable interventions in firms
- Convince stakeholders of the advantages of energy efficiency technology

4 Methodology and Research Activities

The bulk of the work undertaken during this research project has in fact been at the micro-level, while keeping a larger macro policy perspective that takes into account the broader goals of poverty reduction and environmental improvements. In keeping with the findings of earlier research, the project has focused on working in partnerships with meso level institutions (that can be governmental, or industrial associations, or NGOs) that are mandated to provide services to the enterprises.

The broad overall methodology for the project was to focus on a series of studies to examine:

- first, whether there is in fact a large gap in energy efficiency, between actual practice and what could be economically achieved, in the two sectors in the two countries.
- second, given that large gaps in fact exist, what are the causes of these gaps, that is, what are the specific barriers to technology adoption of more efficient practices and processes?
- third, to what extent can these potentials for economic and environmental gains be attained and what is the role of the present institutions in realising these gains?
- fourth, what lessons emerge from the experience of attempting to improve the economic and environmental performance?

4.1 India

Originally, this project was to examine the energy efficiency opportunities in the small foundry and glass sectors in India. However, in both these cases it did not seem the best time to look at these sectors.

In the case of the glass bangles they were under threat of closure because they are in the area around Agra (the "Agra Trapezium") from which all polluting industries have been banished, and there was a lot of uncertainty about whether or when all of these industries would be re-located.

In the case of the foundries, the improved cupola furnace has been demonstrated at Howrah, Calcutta, showing greatly improved efficiency and reduced pollution. However, the Swiss and TERI, their Indian partner, were as yet unable to show that the change in working patterns, which are considerable, could be readily adopted, and in any case SDC was planning a programme to disseminate the technology. Both Dr Veena Joshi, and Ariane Waldvogel of SDC were happy for us to contribute to this programme, but the timing was wrong for our project. So, on the advice of TERI we changed to another labour- energy-intensive small industry, that of pottery.

The first part of the effort was to increase our own knowledge about the sector. We collected background studies that have been undertaken, both in India and outside, on the pottery sector. The work in India included information on the economic side, such as the size of the sector, the geographical location of clusters, types of products, sales, employment and so on and any assessment of the sector (see appendix for list of related reports). It also looked at the technological issues relevant to the sector, the problems which had been identified and the solutions proposed. We identified the key institutions and agencies, involved with the small scale and with pottery in India, both at the national and the state level.

1. Initial survey from existing reports on the Pottery sector in India. September 1999
2. Survey of the literature on Poverty and Energy Efficiency
3. Survey of the literature on Technical support to SMMES
4. Survey of the literature on Pottery units, technical problems and Energy Efficiency
5. First draft of the issues December 1999.

Based on this preliminary work and taking into account several facts about Khurja, that CGCRI had an extension office there; the large size of the cluster, the long history of pottery development at Khurja; and, its closeness to Delhi, we made a preliminary selection of Khurja as the site for our pilot work. Between December 1999 and January 2000, we established preliminary communications with all stakeholders in Khurja, visited and discussed the plan of work with them and then developed a preliminary questionnaire.

6. Selection of Khurja as the area of study
7. Meetings with manufacturers and support institutions in Khurja to explain the project and its purpose
8. Preliminary informal data collection and interviews

The questionnaire was field tested in a few units in February 2000 after which we took a team of 8 people to Khurja in March and interviewed owners and workers in around 25 units and collected detailed information on the units, their problems, and their and our perception of solutions that could be most useful and cost effective in the first instance.

9. Preparation of instruments for study of firms in Khurja
10. Field Survey of 25 firms, March 2000
11. Analysis of first survey and identification of key problems
12. Meetings with additional support institutions for the pottery sector and co-operation agreements for continued work in partnership, namely:

    - Ministry of Small Scale Industry, Government of India
    - Petroleum Conservation Research Association, (PCRA)
    - Central Glass and Ceramic Research Institute, (CG&CRI)
    - Khurja Pottery Manufacturers Association (KPMA)

13. Selection of Pottery and Kiln expert from CERAM, UK and from the USA
14. Agreements signed with 12 firms who volunteered to participate in the firm level study of technological improvements and to implement the measures
15. Field work with the CERAM expert form the UK (October 2000)
16. Workshop with all partners on the findings
17. Modified further plans as the US expert was not able to make the trip
18. Continued collection of information from the firms, small improvements implemented
19. Collection of data on costs and availability of materials and instruments required to improve performance (December 2000 to February 2001)
20. Final analysis of recommendations incorporating estimates of costs and benefits
21. Feed back to the participants and partners

During the course of the work in India, several key choices had to made regarding areas of focus. These are summarised below:

- The choice of kilns - there are three types of kilns which predominate in Khurja. Down draft coal fired kilns, diesel fired shuttle kilns and tunnel kilns. There was also one gas fired tunnel kiln in Khurja. The first survey of the units and a review of the solutions suggested that most coal fired kilns in Khurja were operating at low capacity utilisation, they were highly energy inefficient, they were also the most polluting. The range of options available to improve their technical performance was not very high and even if their performance was improved they will be less attractive than liquid and gas fired kilns. Also, the discussions with the manufacturers showed that they were keen to move away from coal fired kilns, there was a rapid growth in diesel fuel kilns and so it was decided to concentrate on these as any technical improvements would have a larger scope for application.

- The question has been raised as to why we chose to focus on the diesel fired kilns, which is still a fossil fuel, and not examine the use of more renewable fuels, such as biomass, or cleaner fuels, such as gas. The reason for this is that we chose to start from where the firms already were, and to build on what they had, and their existing level of knowledge. In fact, there are plans for a gas supply to be made available to the firms, but it is not currently in place.

- In fact, the recommendations made to the firms on oil/diesel fired kilns are still valid if the kilns switched to being run off gas – a switch to gas does not require major modifications to the current kilns. It will require a change in burners. Given the higher calorific value of gas per unit cost it should result in lowering the energy cost of the units that make the switch. It will also further reduce the emissions from the kilns. These benefits combined with the possibility of making a higher value product, should make this a priority for the industry, and policy makers.

- Focus on energy use (fuel) in kilns rather than on electricity use. It was found from the first Khurja field survey that 80% of the energy used by the firms was in their kilns – the energy cost in kilns was far larger than electricity (22 to 35% of sales value of production). However, some data on electricity consumption was collected, and other reports or Khurja cover this aspect in more depth (see related reports).

- Stages of the production process - as with any production process, the raw materials selected, their composition, the process of forming the products, and the firing process all interact with one another, to provide the final and resultant quality of the output, the rejection rates and the specific energy consumption.

  The project intended to look at the entire process. But due to the lack of availability of an additional pottery expert at the last minute, the project was unable to examine this part of the process in sufficient depth. But some of the recommendations from CGCRI and other experts involved in the project has been provided. Therefore, the main focus of the work presented here is on the firing process (again, see related reports for recommendations on non-firing aspects of process).

4.2 Ghana

The approach adopted for the project was basically to first carry out a desktop research on general energy efficiency practices and to also carry out preliminary field studies of sawmills in the country.

To this end, both foreign and local literature on energy efficiency practices in the industry were reviewed. Visits to a total of 56 firms, about a third of the total number of sawmills in the country, located in different parts of the country, were undertaken to gather first hand information. The preliminary energy audits that were carried out at this stage focussed primarily on electricity use. Some of the information collected includes the location of firms, type and output of products, type of fuel in use in the firms, environmental impacts and institutional matters. A strategy document detailing the results was prepared, at the end of 1999, which listed some key recommendations for the second phase of the project.

In June 2000, a second round of surveys was carried out in 10 Kumasi sawmills, involving members from the whole team of PRI, ITC, KITE and FORIG. These surveys, as well as looking at energy use, also dealt with broader issues relating to the economics of the firm, information on the workforce, and linkages to information and service provider, and financial institutions. The questionnaire was based on the one that had been used in Khurja in march 2000.

At the end of the surveys, a workshop was held with the project team to decide on the strategy for the next phase of work. It was agreed the scope of work, away from just looking at improving the efficiency of electricity use, because:

a) a question mark hung over how significant electricity use is as a share of firms production costs, and that there may be greater scope for energy savings and benefits to firm in other forms of energy use
b) to provide more scope for examining linkages of energy interventions to poverty alleviation – it was felt that only looking at electricity use provided minimal opportunities for exploring direct impacts on workforce and local population

The project team agreed to broaden the emphasis of the work in the following ways:

- conduct a sub-sector analysis, to obtain a better understanding of the upstream and downstream linkages, wood flows, sales and value addition. This will further the understanding of linkages to poverty alleviation
- following this, come up with a strategy for intervention to support higher value addition (this is linked to improved energy use, as it reduces waste, and maximises recovery of the log)

A *sub-sector analysis* is a systemic approach which involves looking at:

- the legal and regulatory environment within which enterprises operate
- the market channels / value chains within which enterprises operate including their relationships (backward & forward linkages) to others involved in procuring, producing, processing and distributing information, goods and services

Firms in a subsector are linked by a common raw material, which in the Ghana case, was timber. A key point about the sub-sector analysis is that it doesn't look just at the target firms – the sawmills – but looks at other trade groups in the sub-sector that may well have a significant influence on the target group. The aim of the analysis is to identify opportunities for leveraged interventions to support the target group – but these interventions may not necessarily be aimed directly at the target group themselves, but may remove some bottleneck elsewhere in the sub-sector.

More general literature on the industry was reviewed and further visits to a number of small-scale sawmills were undertaken. An attempt was also made to get more in-depth information on the processes and cost distribution of these firms.

This phase was characterized by many meetings with various stakeholders in an effort to gain more knowledge of the industry. A general trend of sawmills integrating forward to process tertiary products was identified and the study was further widened to investigate the scope of savings that could be achieved through value addition/waste minimization. The culmination of this was a subsector analysis workshop that was held in March 2001, in which key informants from the timber industry participated. The output of the workshop was a subsector map for the timber industry, and recommendations on possible leveraged interventions for enterprise development support to sawmills, and smaller tertiary processers. (see section 6 for the map).

4.3 Dealing with the poverty aspect

In order to explore the impact of energy efficiency improvements on the workforce and local population, the team decided to deal with the issue in two ways:

- To develop a conceptual framework, based on a review of the literature on energy, poverty and SME's, which would show the variety of linkages between improving energy efficiency and poverty reduction

- To explore and estimate the possible benefits for the workers and local population of improved efficiency, in terms of reduced exposure to pollution and toxins, and levels of employment

The possible direct benefits to the workforce were explored through collecting data on wage levels, and numbers of employees during the surveys of firms. Also, in Khurja, where the impact of air pollution was more obvious, interviews were held with health workers, and a review of secondary data relating to pollution levels in the cluster was carried out. For India, this enabled some estimates and analysis of the impacts of energy efficiency improvements on employment and air pollution to be carried out, and these are presented in section 9.

5 Review of previous research and literature

5.1 Introduction

As part of the project, a separate review of relevant literature and previous research, relating to the two industries, were carried out by each of the country teams, and is not presented in detail here. For this see the related reports (in appendix).

As part of the conceptual framework to explore linkages between energy efficiency in SMEs and poverty reduction, an overview of relevant literature and research is presented separately in the review produced by PRI (see list of related reports, in appendix 2).

This section discusses more the key research and literature that was identified from the UK, by the UK project manager, and how that shaped and influenced the subsequent research.

Although the literature and research review was broad, covering over 50 documents, there were some key documents and research, namely:

- The previous DfID KaR research (R7222) carried out by Nandini Dasgupta, of NRI, looking at Energy efficiency and poverty alleviation, which had focussed on India
- The various DETR guides, prepared by ETSU, as part of the UK Energy efficiency best practice programme
- The work carried out in India by SDC and TERI on improving energy efficiency in energy intensive small industries, and on developing a Vertical Shaft Brick Kiln (VSBK)

Presented below are some of the key findings from these, and, where relevant, and indication of how the findings shaped the research of this project:

5.1.1 ETA-TERI work on energy audits in India

- Between 40% and 70% of the identified *economic* energy cost reduction potential are "better housekeeping" measures that require very little investment, since energy inefficiency caused by mismanagement, bad investment decision-making and lack of process control is rampant. [An example of a better housekeeping measure, from this project, is better maintenance of the seals on kiln cars in tunnel kilns, to stop heat leaking out].

5.1.2 Review of ETSU best practice reports on UK ceramics industry

- It is clear from the UK experience that *quality management and process control are as, if not more important mechanisms for achieving energy efficiency improvements than any specific technology*. After all, the greatest inefficiency of all is to fire a product and then have to throw it away! Therefore, the project should also try to ascertain the proportion of product that is being scrapped by manufacturers, and identify ways of reducing this. (However, I suspected that this information may be rather hard to come by, and be particularly sensitive - my discussions with CERAM in the UK supported this view.)

- In addition to quality management, maximising throughput and product fill of dryers can lead to significant reductions in the SEC. Therefore, the project should include possible rationalisation of production within its scope.

- Similarly, the fundamental first step in improving energy efficiency is to implement a programme of energy monitoring and management (know as Monitoring and Targeting , M&T). Someone in the organisation has to be responsible for this task and to champion it - it is inevitable that at times the energy manager will get a rough ride from colleagues who see his work merely as an inconvenience and meddling. This has implications for an assessment of training and capacity building needs to be addressed as part of the project.

- The above points to the fact that to maximise the success of any programme of energy efficiency improvement within a firm *cannot just deal with one particular process or technology in isolation. Instead, the aim of improving efficiency needs to be built into the overall management structure of the firm.*

- It is important to try to ascertain the proportion of a firm's production costs that are due to energy consumption, as this will have a major impact on the attractiveness of any investment. For example, in the UK bone china sector, energy accounts for only 3% of the total production cost, due to the high cost of raw materials. In brick manufacture, on the other hand, energy accounts for as much as 27% of the manufacturing cost. Therefore, before focussing on a particular sub-sector, the project should try to get an idea of this relative cost for each of the subsectors, namely: sanitary wares, tablewares (split into bone china, earthenware, stoneware, porcelain, etc. if separate firms) and tiles (split into wall and floor, if separate firms).

- To calculate SEC, data on the quantity of raw material used will be required in addition to energy consumption data.

5.1.3 From NRI study of Energy efficiency and poverty alleviation

- *A participatory approach, a la the NPC Waste Minimisation Circles, may lead to greatest success* - a participatory approach to the problem appears to have a higher success rate than a top-down, technology-led approach

- ND makes the case for *an energy-led, broad based approach to process interventions, in order to maximise the benefits to workforce, entrepreneur and environment.* If the focus is only on combustion-related technologies (i.e. technology-led) then there is a danger that will not produce environmental benefits. This suggest that a more holistic *"energy-led"* approach is required to lead to improvements in ambient and workplace pollution. This means looking at energy and waste consumption for the entire process.

- Pollution control and energy efficiency cannot be expected to follow from trying to super-impose successful models from larger scale industry onto small-scale industries – (this has implications for the Ghana side of the project). Also, this implies that we need to use the UK experience carefully.

- It is important to develop "win-win" (or win-win-win!, if we include poverty benefits) strategies. In order to counter negative perceptions and attract attention, crucial to inform industry of the benefits of improved technology and processes, in terms of:

  - Reduced fuel cost
  - Higher material recovery
  - Lower waste generation

i.e. we must sell the idea to entrepreneurs in terms of increased profits, and not with an environmental or poverty reduction agenda.

5.1.4 From experience with SDC VSBK project

- The action research approach proved very successful in this instance – could this be appropriate for our project? Would DfID give us this degree of flexibility? Action research means "learning-while-doing" and retaining enough flexibility within the project so that outputs can be changed, depending on what is learnt during the course of the project, and to meet the requirements of the different stakeholders.

- In its initial stages, the project focussed quite rightly on building a *technical reputation* and gaining the trust of partners and beneficiaries. The social or livelihood issues are difficult, and can lead to conflicts between entrepreneurs and workers. *It would have been difficult to address them in a major way early on in the project, before the various parties involved got to know and respect each other.* The implication of this is that the agenda of looking at benefits to the workforce, must, in the early stages of the project, be handled very discreetly.

- Partners need to monitor the *Total Quality chain* – brick quality at some of the kilns is still disappointing, which could affect the VSBK reputation. The bulk of the project focussed on getting the kiln right – recently a ceramics expert has been brought in to address this quality issue.

6 Overview of selected small industries

The aim of this section is to give the reader a brief overview of the two industries – ceramics in India, and sawmills in Ghana. The aim is to place them in context, and give an overview of key defining characteristics, such as: numbers of firms, levels of employment, production figures, types of products, technology and processes used, markets, as well as the nature of energy use in each of the industries. The information presented here is only a small part of the more comprehensive information that was collected, and this is given in the separate country reports (see appendix 2 for list of related reports)

6.1 Ghana

The timber resource is a key foreign exchange earner for the country. Until recently when it was overtaken by tourism, it was the third highest-ranking foreign exchange earner. It earned DM 354 million for exports in 1994, which is 18% of total export income. The earnings for 1999 amounted to DM 311 million (from a volume of 433,125 cubic metres) accounting for 11% of the nation's foreign exchange earnings. The timber trade also accounts for 6% of the Gross Domestic Product (GDP) having fallen from 12% in the early 70s'. (Source: National Statistical Office)

The timber sub-sector is reported to employ over 100,000 people, but also provides a livelihood for about 2 million Ghanaians. In addition to these, the economic benefits from fuelwood, charcoal and other non-timber forest products could raise the sector's GDP contribution to 8%. (Forestry Commission, 1999; Ofosu-Asiedu, 1995).

Firms in the wood industry of Ghana may be put into three classes on the basis of degree of value-addition/processing as follows:

- The primary operators/enterprises (i.e. Loggers);
- The secondary enterprises (sawmillers, veneer – and plywood producers as well as particleboard manufacturers); and
- The tertiary and down-stream processing enterprise (i.e. Furniture, mouldings, flooring and toy manufacturers).

Wood-processing firms in Ghana may also be classified according to size – small, medium and large – as shown in Table 1.

Table 1: Ghana sawmills size distribution

Mill category	Input capacity	Total No. of Mills	% of Total
Large scale	10,000 cubic metres and above	33	27.5
Medium scale	5,000 – 10,000	32	26.7
Small-scale	Below 5,000	55	45.8
TOTAL		**120**	**100**

There are no reliable figures on the number of sawmills throughout the whole of Ghana and how many of such firms are also involved in logging activities. Nevertheless, between the Forest Products Inspection Division (formerly Forest Products Inspection Bureau) and the Ghana Timber Association, it is possible to construct a table – as shown in Table 2 – which gives the total numbers of wood-processing and logging firms and their distribution across the country. This table gives the total numbers of wood-processing and logging firms at 153 and 374, respectively.

Fig 1: Sub-sector map for Ghana timber sub-sector

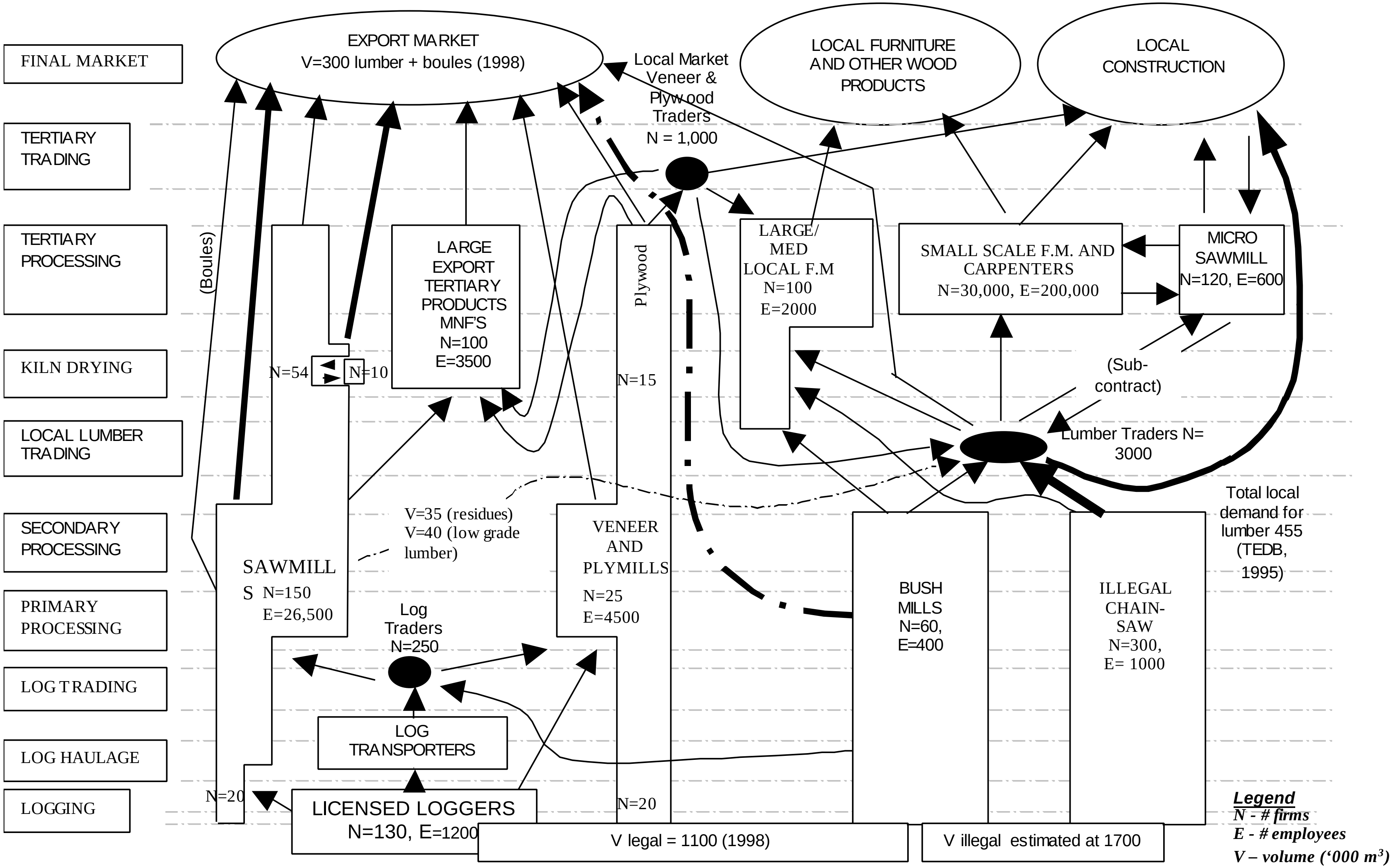


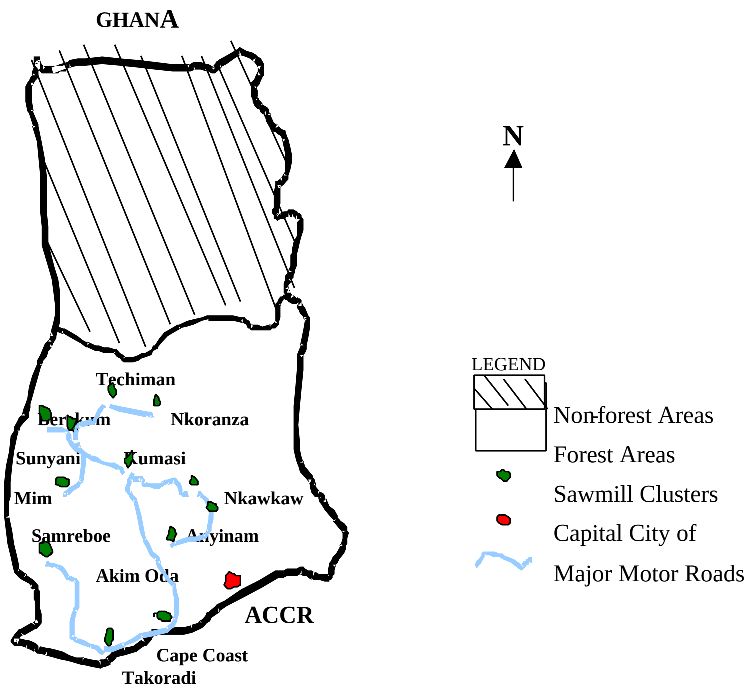
Table 2: Numbers of sawmills and logging firms in Ghana by region

Region	**Timber Processing Firms***		**Logging companies/ concessionaires***	
	Number	%	Number	%
Ashanti	85	56	115	31
Western	24	16	58	16
Eastern	18	12	69	18
Brong-Ahafo	15	10	79	21
Central	8	5	53	14
Others	3	2	-	-
Total	**153**	**100**	**374**	**100**

* Source: Forest Products Inspection Bureau Reports, (1999). The figure is for all types of wood processing, but does not include small-scale carpenters and wood-workers.

** Source: Ghana Timber Association (GTA) office in Kumasi, 1999.

Fig: 2 Map showing location of sawmill clusters in Ghana



The wood-processing industry in Ghana is one industry where energy consumption in the forms of electricity and heat are very significant. The government policy to develop value-added wood products before export[1] has mandated the drying of most of the processed lumber produced in the country. The drying of lumber in the industry is largely met through the use of wood-processing residues (biomass). With the exception of one or two plants that are remotely located, all timber companies meet their electricity demand through the grid.

6.2 India

An initial survey (IDS) found information on 100 pottery manufacturing clusters in India. Many of these are small clusters and the data available on them was not very detailed. More detailed information was available on 24 clusters from fourteen different state. The geographical distribution of the clusters is shown in figure 3.

Fig. 3: Map showing location of ceramics clusters in India

[1] There is a high penalty for exporting untreated/green products

The Indian ceramic industry can be broadly divided into two major groups, whiteware pottery and red clay pottery (including terracotta), which are both produced in India. The products of each of these groups are listed below.

Red Clay

- Building Bricks
- Roofing tiles
- Utility articles such as kulhar, saucers, surahi, matka sets

Whitewares

- Cups, saucers, mugs, tea-sets
- Stoneware kundis, jars
- Pressed porcelain insulators and other LT and HT insulators
- Chemical porcelain items
- Decorative pottery items such as flower vases, toys, ash-trays
- Fire bricks, saggars and other heat resisting items.

The 24 clusters identified in the survey, including the cluster in Khurja, produce predominantly whiteware, although also some small amounts of terracotta are also produced. Terracotta tiles are popular in Southern India, while utility items made from red clay are ubiquitous in the country and tend to be made by the smallest and also more rural units. There is a new demand for high fired terracotta ware in the export markets which is being met by some larger units in Khurja. This is actually a non-traditional product in the sense the clay composition is different and the ware is fired at a much higher temperature. There by this product has a higher lustre and lower porosity.

Beyond the 100 clusters identified and the 24 clusters for which data is available, there are thousands of pottery units scattered across India which have not been cited nor surveyed as part of this project. Many villages and towns have small traditional pottery units making low fired utility items. None of these have been studied here.

In the 24 clusters for which more information was available, the data shows that there were 2,191 individual pottery units with estimated sales per month of 445 million Rupees or annual sales of almost 6000 million Rupees (US$150 million using an exchange rate of US$1 = 40 Rupees). The smallest cluster identified, Chinat in Uttar Pradesh, had only 6 units and estimated per monthly sales of 1.6 million Rupees. The largest cluster identified was Khurja (in Uttar Pradesh) with 491 units and annual sales of almost 2500 million Rupees. Clearly Khurja is the single most important pottery cluster in India composed of small scale units. Of the sample of 24 clusters, it is estimated that the Khurja cluster alone accounts for 25% of the manufacturing units and over 40% of the production.

The industry is labour intensive. Almost 95,000 people are estimated to be employed by the 24 clusters surveyed (this is likely to be an under estimate for reasons discussed later). The above data suggests that the output to labour ratio is 60,000 Rupees (US$1,500) in the 24 clusters. The industry is also energy intensive.

The firing of the clay in kilns and dryers account for most of the energy consumption. Fuel used to power the kilns includes gas, electricity, diesel oil, kerosene, coal, wood and cow dung. Of these wood and cow dung are used in smaller and rural kilns, while coal is probably the most common fuel used by the largest number of units. Electricity is rarely used because of high costs and erratic supplies due to shortages in the country. The fuel of choice is diesel oil or kerosene in the newer oil fired kilns. Gas is not common again due to supply constraints in India. But it is very likely that the availability of gas and its use will increase slowly as more natural gas pipelines are being built.

Environmental problems arising from the ceramics industry in India include air pollution from combustion, coal ash disposal, effluents from the clays and possible impact on deforestation where wood is predominant.

Ceramic ware is produced both for the domestic market and for export. But over all export markets are unlikely to be more than 10-15% of total production. There is increased imports of ceramics in the higher price range and the smaller units face competition from large scale manufacturers also.

7 Technical Mechanisms: the scope for energy efficiency improvement

7.1 India

As the work in Khurja focussed primarily on the firing stage, given below is a brief overview of the 3 types of kiln in use in Khurja – coal fired down draft, oil (or diesel) fired shuttle kiln, and oil fired tunnel kiln. The overview covers the range of energy consumption and efficiency of each. As explained earlier in this report, the project focussed on improving the efficiency of the diesel/ oil rather than the coal fired kilns, as the latter were becoming defunct. Therefore, this section presents only key measures for improving the performance of the former.

7.1.1 Coal-fired Downdraft Kilns

(schematic/picture to be included for all 3 kiln types)

The downdraft kilns used in Khurja are a typical example of coal-fired kilns of European design. The kiln makes use of natural draft and as such does not require any blowers or fans for its operation. The hot gasses from the fireboxes circulate to the top of the kiln chamber, and are then pulled down through the setting and leave through flue gas holes in the floor. These flue gas channels combine to one main gas flue path under the floor which is then connected to the chimney of the kiln.

Downdraft kilns are batch kilns with greenwares placed in saggars and then in the kiln for firing. A typical operation cycle from cool to cool takes approximately 5-7 days. The required temperature gradient over time and its uniformity cannot be maintained in the downdraft kiln which contributes to a high rejection rate of between 15-30%. There is little monitoring and control capability and the ware is tested by removing a sample from the kiln through a hole.

Downdraft kilns using coal have been used in the Khurja pottery cluster for over fifty years. During this time the technology has undergone no modification or improvement. And until early 1990s all production was carried out using these kilns and there are around 200 coal fired down draft kilns in Khurja. The advantages of this kiln are that its construction is well known to the local people and the cost of a unit is in the order of Rupees 500,000. While the newer oil fired kilns cost at least two times more and up to four times as much, depending on the size and quality of construction.

Their energy efficiency is extremely low at only between 3-6%. Pottery units using coal-based downdraft kilns can expect 33-35% and sometimes 40% of their production costs to be spent on energy. No new coal-based downdraft kilns are known to have been installed in Khurja in the past decade.

7.1.2 Shuttle Kilns

Shuttle kilns are also batch kilns and are particularly suited to the firing of specialized items like bonechina and stoneware decorative items and crockery. Combined with loading and unloading shuttle kilns have a total cycle time of 2-3 days, compared to 5-7 days for coal fired downdraft kilns. Firing and cooling cycles take approximately 12 hours each. Shuttle kilns have an energy efficiency of 25%; they are more energy efficient than coal-based downdraft kilns but not as efficient as tunnel kilns. Compared to tunnel kilns however, shuttle kilns require less space and a smaller capital investment. Also, as they are a batch kiln, they are suited t a lower throughput.

The sample of shuttle kilns examined in Khurja, ranged in size from 4 to 20 cubic metres, and a firing of between 0.7 to 5 tons per day. This translates to an annual capacity, with around 120-150 firings per year, of 100 to 600 tonnes of product. The cost of the shuttle kilns naturally will depend on the size and the quality of materials and insulation, but in general in Khurja ranges from Rupees 700,000 to 1,200,000. Shuttle and tunnel kilns were first introduced into the Khurja pottery cluster in 1993 - 1994.

7.1.3 Tunnel Kilns

Tunnel kilns are steady state continuous kilns; on average about 22 to 23 trolleys travel through the kiln in 24 hours. Tunnel kilns have an energy efficiency of 30% and the rejection rate of finished products is 2-3%. This translates into significant savings as compared to coal-based downdraft kilns. Although tunnel kilns do however do require a significant capital outlay and also more land space than either shuttle or downdraft kilns. In the late 1990s as employment of tunnel kilns became more widespread, TERI has found that production costs of Khurja units which have installed tunnel kilns have fallen by about 10-15% as compared to units using coal-based down draft kilns (TERI 2001). This in turn has resulted in a lowering in prices of finished products in the cluster (TERI 2001). The cost of tunnel kilns in Khurja range from Rupees 1,200,000 to 2,000,000.

The data on the 3 types of kilns is summarised in table 3 below:

Table 3: Summary of data on kiln types

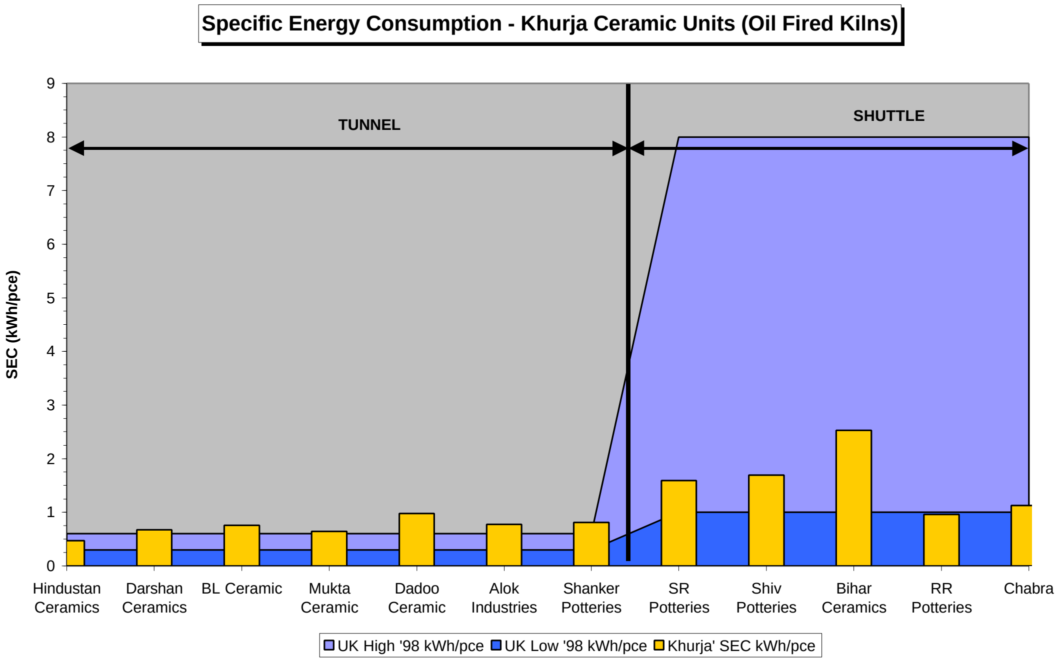
Kiln	Cost (INR)	Cost ($)	Output per year tonnes	Energy Use Kcal/kg
Coal DD	500,000 750,000	12,500 19,000	200 500	7,000-12,000
Shuttle Oil Local	700,000 1,200,000	18,000 30,000	100 600	3,000-5,000
Tunnel Oil Local	1,200,000 2,000,000	30,000 50,000	500 1200	1,400-2,500
Shuttle (Imported[2])	4,200,000	105,000	300	Low 660 Average 2040 High 3300
Tunnel (Imported[2])	19,200,000	480,000	900	

7.1.4 Scope for improving efficiency of shuttle and tunnel kilns

The graph in figure 4 shows the measured SEC for each of the 12 participating firms in Khurja, and compares this with UK benchmarks obtained from CERAM. Two levels of UK benchmark are shown – a low SEC, which is for a product quality roughly comparable to that in Khurja, and high SEC which is for a high quality product. This shows that there is significant scope to improve the energy efficiency in tunnel kilns in Khurja, by roughly 50%, based on the lower quality UK figure.

[2] The numbers provided above for UK are for one specific kiln of that size, while the SEC numbers provided for UK are for the sanitary ware sector as a whole. It should be noted that these ranges do not *only* represent the kiln efficiency. Larger kilns, heavier pieces, inherently provide higher output to energy use than smaller kilns loaded with small and lighter pieces. Second, more complex pieces and higher quality products need more heat work to be performed and so will show a lower output to energy than simpler pieces and those of lower quality.

Fig. 4: Comparison between SEC of ceramics firms in Khurja and those in UK



The team found that one of the major areas of improvement that could be related to the pattern of air flow within the tunnel kilns in Khurja. Although the basic layout is similar to designs found in Europe or USA there are some fundamental differences.

In a conventional tunnel kiln the air movement is from exit to entrance, a fan in the exhaust stack is used to pull the gases down the kiln. With ware moving against the airflow the kiln is effectively operating as a counter flow heat exchanger. This means that the exhaust gases from the firing zone are used to preheat the ware before they exit through the exhaust stack.

The kilns in Khurja have been built and set up with the belief that the majority of the gases from combustion should be kept in the firing zone, the preheat air curtain is used to restrict the flow of hot gases to the front of the kiln. The cooling curtain is used to provide some cooling, it would appear that a quantity of cooling air is going into the firing zone. There is some flow of gases through the preheat but this is due to pressure from the cooling curtains and velocity from the burners.

The lack of exhaust fan means that exhaust gases are not drawn down through the load and there will be a less efficient use of exhaust gases. An observation that drew attention to the lack of hot gases being pulled through the preheat is the exhaust gas temperature, most of the kilns had exhaust flue around ambient temperature, some were around 50-60^{o}C in a more conventional kiln it would be usual to see this temperature well in excess of 100^{o}C.

Figures 5 and 6 below show the typical layout of tunnel kilns in Khurja, and the final layout as recommended by CERAM.

Fig. 5: Typical layout of tunnel kiln in Khurja

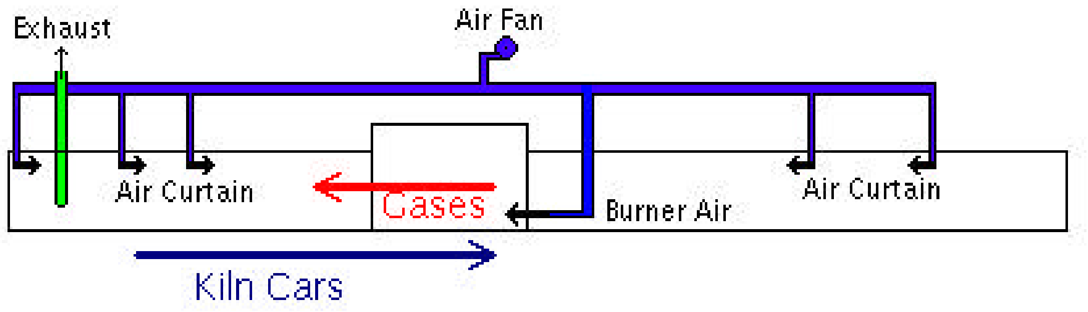


Fig. 6: Final recommended layout of tunnel kilns in Khurja

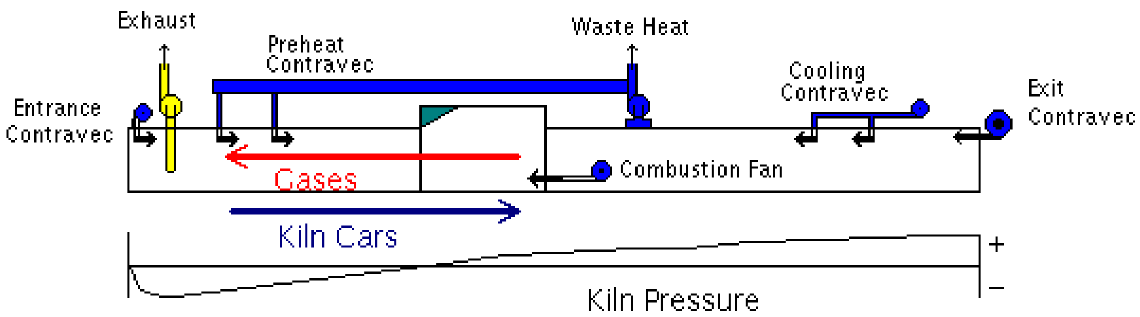


Fig. 6 shows how the pressure profile has been altered, through the use of fans to ensure a negative pressure in the pre-heat region, to pull hot gases back from the firing zone through the unfired load.

In all, the team came up with 19 recommendations regarding energy used in firing, and these are summarised below in two tables.

All the These follow after the implementations listed in the benchmarking section in Tables 1 and 2. Below in Table 7 we list some of the simpler changes that will not require the presence of a kiln expert to implement. Then in Table 8 we list those improvements which are a little more complicated and will require the availability of a kiln expert to provide adequate support. Ideally, beginning an implementation program will require careful design and continued support at the local level in Khurja at the level at which it was provided during the diagnostic phase of this work.

Table 4: Key measures for improving energy efficiency in Khurja tunnel and shuttle kilns - low or no capital cost, that firms can do with current level of expertise available to cluster

No.	Description	Rough estimate of possible contribution to fuel saving/ product quality
1.	Improve burner efficiency	0 to 2%
2.	Fit air and oil filters	Improve product quality
3.	Fit air and fuel flow meters for each burner	This is necessary to be able to carry out measure 6. Also, will allow fuel use over time to be recorded.
4.	Separate the air supply to the burners from that to the air curtains – so install small blower for burner air supply	This is necessary to be able to carry out measure 5.
5.	Calibrate burners, using meters installed in measure 3., so that air:fuel mix is at stochiometric. This will also enable equalisation of burner energy output, by using air and fuel meters – so that oppositely placed burners produce same thermal output	0 to 5% Improved product
6.	Minimise excess air level – once burners have been set to stochiometric, then all excess air must be coming in through air curtains. Trial and error will determine the minimum amount of excess air required for required quality of surface finish on product	0 to 10%
7.	Lower peak temperature in steps down to 1200^{o}C, and increase the “soak” time of the ware in the firing zone – this will ensure the same amount of heat work is done	5-10%
8.	Increase drying time of “green” ware, and reduce moisture below 2%	Reduce cracks, rejects, some fuel saving
9.	Under car seals – check and fix, to stop hot air leaks	0-5%
10.	Sand seals - Correct and use river sand instead of grog	0-5%
11.	Light burners on low oil, high air settings (shuttle kilns only)	Reduction in rejects
12.	Reduce kiln pressure (shuttle kiln) need 2-3 mm positive pressure, to eliminate cold air infiltration.	Increase life of fibre lining.

These measures will give savings in SEC of 5-25%.

Table 4b - medium or high capital cost that firms can do with current level of expertise available in cluster

13.	Explore with one or a few redesigned kiln cars, with lower mass	10%
14.	Explore with lower weight kiln furniture, purchased from market	10%

These measures will give additional savings of 20% in SEC.

Table 4c – measures that firms can take that will require expertise currently not available in cluster

15.	Fit pitot tubes (tunnel kilns) to obtain readings of pressure profile	Necessary to set up 16.
16.	Install exhaust fan (tunnel kilns)	Maintain better temperature and pressure profile; 5 to 10% gains
17.	Reshape combustion chamber (tunnel kilns) at time of renovations, to ensure smooth transition into firing zone	Not possible to estimate
18.	Calculate optimal insulation on kiln - at renovation and for new tunnels	Depends on current level of insulation, and what is cost effective
19.	Recirculate cooling air to burner air supply and/or air curtains (tunnel and shuttle kilns)	10%

These measures will give an additional saving in SEC of 15 to 20%. So overall, the total reductions in SEC that can realistically be achieved are in the order of 40 to 65%.

7.2 Ghana

7.2.1 Summary of measures for reducing energy (electricity) consumption

The main options for ensuring efficient electricity consumption in sawmills are concerned with lighting, electric motors (including power factor correction), and machinery. The most popular measure amongst the sawmills surveyed in the early part of this study, was power factor correction; 19 of the 56 firms surveyed (or 34%) were found to have power factor values equal to or greater than 0.9 even though close to 50% of the firms surveyed had installed capacitor banks. Implementation of other electrical energy efficient practices were found to be rare, although a few firms had energy efficient lights and some also used cogged V-belts.

With respect to energy for extracting trees from the forest and transporting them to the sawmill, and energy for transporting processed wood from the sawmill to the port, most of the extracting equipment and trucks used by sawmills are old, inefficient and not well maintained even by Ghanaian standards. During interviews, sawmill managers often complained of increasing fuel costs but there is little information available on the quantities of diesel fuel used for transportation and there is no evidence of actions by sawmillers to improve the efficiency of energy use in this area of activity.

Ideally the kind of product a timber company deals in should have an effect on the energy or electricity consumed and an attempt was made in this study to capture the pattern of consumption of energy by the type of product. Many wood companies deal in more than one product and it is difficult to assess the energy requirement for one product type amongst the rest. The available information summarized in Table 5 is 5 inconsistent.

Company IEAC/006/99 that produces only lumber utilises 114 units of electricity per m^3 of product as against 36 units used by company IEAC/004/99 that processes lumber further down stream into T&G and panel boards. The information suggests that either the former, which is using about four times as much electricity per m^3 as the latter, is highly inefficient or there is some under reporting on the volume of products. Analysis for the veneer stream of production is similar (see companies IEAC/005/99 and IEAC/008/99).

Table 5: Electricity consumption by product type in Ghana sawmills

Company Name	**Type of Products**	**Product Output, m^3**	**Electricity Consumed/ Product Output, kWh/m^3**
IEAC/002/99	Lumber, Veneer, Mouldings	35,088	146
IEAC/004/99	Lumber, Tongue and Grooves, Panel Boards	11,520	36
IEAC/005/99	Veneer and Ply Boards	8,640 – 14,400	30
IEAC/006/99	Lumber	4,800	114
IEAC/008/99	Veneer and Plywood Products	4,800	114

Table 6: Key measures for improving energy efficiency in Ghana sawmills

Key EE Options	**Installation Cost**			**Range of Simple Payback (Months)**
	No/Low Cost	**Medium Cost**	**High Cost**	
EE Lamps Installation		✔		4 - 23
Skylight Installation		✔		14 - 73
Power factor Correction		✔		1.5 - 41
Switching Off Idle Machinery	✔			Immediate
Energy Efficient Motor		✔		11 - 26
Cogged V-belts Drives	✔			Immediate
Use of Synthetic Lubricants	✔			Immediate
Repair air Leaks	✔			9
Insulation of steam pipes	✔			3 - 7

7.2.2 Summary of Technical Measures for Value Addition/Waste Minimisation

An overview of the key technical measures for added value/residue utilisation to maximise recovery and their financial implications is presented in Table 7 below.

Many of the options considered have been found to have relatively short payback period. The prospect of increase in recoveries and better utilization of residues is also very encouraging since this has implications for the financial bottom line as far as practically all sawmills are concerned. The profitability of these identified measures for improvement in value added/waste recovery is very site specific (;each option would be specific to particular wood processing companies and the necessary assessment would have to be made before investment in any of the measures is undertaken.

Specific processes used in adding value, increasing wood recovery and residues utilization include the following:

- optimal log positioning
- kiln drying
- finger jointing
- moulding
- ply milling
- thin blade technology
- circular saw tensioning
- residual cores utilization
- particle board manufacture
- sawdust briquetting
- residues utilization for heat and power

Table 7: Key Technical Measures for improving log recovery, minimising waste and adding value in Ghana sawmills

Description	**Scope for savings**	**Capital Cost**[3]	**Payback Time**[4]
1. Moulding machine 2. Finger Jointing machine 3. Kiln dryer	These 3 together get approx. 20% extra useful product from log (from STP)	1. $10,000 - $60,000 2. $10,000 - $40,000 3. $	6-12 years
Morticing machine (for furniture, doors, windows)	Mainly for small scale processors – doesn't save wood – saves labour	$ 700 - $ 40,000 depending on the complexity of the equipment	4 – 10 years
Training on better log positioning	2-5%	$100 - $2000	1 – 4 years
Use of appropriate saws (e.g. use of thinner blade saws)	1-5% max.	$1,000 - $2,000	1 – 2 years
Use of Woodmizer (to process branch wood, smaller diameter logs, residues)	Can make use of branch wood, equivalent to about 5-7.5% of log	$1,200 - $13,000	1-3 years
Sawdust burners for kiln dryers	2-3% on waste that could be finger-jointed	$160,000 - $ 400,000	5-8 years
Briquetting and particleboard	10-15% of log ends up as sawdust	For small-scale briquetting machine, $4,000 - $20,000 for 100kg/hr	2 – 7 years

A lot of material that comes out of the wood processing industries as 'waste' finds use in the local and regional market usually as carpentry and construction material or as wood fuel in either the raw or processed forms. Solid waste comprising of off-cuts, edgings, barks, and slabs are the type of waste that are suitable for the uses mentioned as well as for possible down stream processing. Wood processing waste in the form of shavings and sawdust usually have a negative value and their disposal often poses problems for the wood industry. In an effort to minimize the problems caused by these wastes some companies in the country have acquired boilers with furnaces that are fed on sawdust and shavings. Other areas where these kinds of waste could be put to use include particleboard manufacture, briquetting and cogeneration.

[3] Quotations here are mainly for reconditioned machines on the international market. One primary source has been Electro Motion UK (Export) Ltd.
[4] Payback depends on a lot of other factors such as other machinery and only approximate figures are given here.

8 Barriers to improving energy efficiency and mechanisms to overcome them

8.1 Introduction

The previous section has shown that the efficiency gap between actual practice, and what could be economically achieved is real. So what are the possible explanations for this? The project set out to explore what barriers exist to the adoption of energy efficient technologies and practices in the two countries, be they technological, institutional, policy or financial. This section presents the barriers discovered by the project, for each country. The section also presents and discusses the strategy used during the project to overcome some of these barriers, and to what extent this was achieved.

8.2 India

The specific barriers that were found to affect the applications of efficiency solutions in Khurja and in India were found to be:

- overly complex and yet poorly applied regulations – for example, the original requirement for pollution control equipment in Khurja
- difficulties in obtaining finance for efficiency investments
- poor information flows and awareness by firms
- poor formulation of solutions by service providers
- high risk perceptions
- high transaction costs
- unevenly distributed technical capacity

The first observation was that many of the owners, managers and workers are not formally trained in the technical issues relating to the ceramics or combustion processes, though many appeared to be very knowledgeable about existing operating principles and parameters from their experience. In fact among our sample of around 25 managers and owners, only one person has been trained formally in ceramics technology.

We also found that the owners were very sceptical that there would be much advantage that can be gained from technological changes. This attitude stemmed from a belief that either they already did the best under the circumstances in which they worked, or sometimes, that while they had heard about, or seen improved machinery and procedures, these were not relevant to their own operations.

They felt that any improved machinery and process would cost too much for them to implement in a cost effective manner. They also felt that any improved procedures will not be followed by the work force. And finally, given the poor market conditions, none of these were of much value anyway, as they could not get better price realisation from their efforts.

This is only to be expected, as all human beings possess inherent abilities and keenness to learn about the processes they are involved in. So it is a mistake to assume a priori that any differences and shortcomings in the operations that were observed are all due to a lack of knowledge. Some of the so called “deficiencies” or gaps are due to the firms being smaller and their having to operate at scale and with capital intensity that is considerably smaller than what “best practices” require.

For instance, over the past ten years at least, there is increasing and possible universal knowledge, that oil fired kilns are more energy efficient and provide better output and lower rejects than coal fired kilns. But, the barrier for many is not the lack of knowledge, but the fact that all oil fired kilns cost more so require a higher capital investment. And also, in the case of tunnel kilns, they have a higher throughput per kiln than the coal fired kilns, thus again there is more capital required for materials, labour, inventory, moulds and so on. Finally, for a shift to tunnel kilns, it is not only the increase the capital and scale of operations that they require, the change also requires the owner to have sufficient confidence in the market for the sales of the higher outputs.

In arriving at the recommendations all support institutions must carefully distinguish the exact barrier that prevents the take up of the solutions offered. These include size and scale issues, capital required, risks of various kinds and finally, knowledge and information.

Box 1 - kiln technology upgradation in Khurja

From the 1960’s to the early 90’s, the kiln technology in used in Khurja was the coal-fired down draft (DD) kiln.This type of kiln is highly polluting, inefficient, and produces a relatively poor quality product.

In interviews with the firms, there was general agreement that the Khurja cluster faced many difficulties in the late 1980s and the early 1990s. The interviewees suggested that many firms either stopped production or had to reduce their production because of insufficient supply of coal and its poor quality; the lack of government support and the decline in the common facilities provided earlier; and, increased competition from manufacturers from other regions.

In one version of the story, a group of entrepreneurs from Khurja, in the early 1990’s, took the initiative to visit the Thangad pottery cluster (near Ahmedabad, Gujarat), which had been operating tunnel kilns for about ten years earlier and which had a reputation for greater efficiency and productivity. In the other version, this visit did take place but was organised by one of the support agencies of the government to allow the owners from Khurja to learn from Thangad.

Immediately after this visit, several owners, decided to invest in shuttle and tunnel kilns. The adoption of shuttle and tunnel kilns was motivated by competitive pressure from other pottery clusters in India and also fears of globalization. In the 1990s the Khurja pottery cluster was finding it increasingly difficult to match its (domestic) competitors in price and quality.

The original design for the tunnel kilns in Thangad had come from the UK. After the first UK-designed tunnel kiln had been commissioned, technicians in Thangad began constructing the kilns locally. The first tunnel kiln was subsequently built in Khurja in 1992. However, few pottery units followed this example until the late 1990s. In 1997 two pottery units were issued with notifications to close their operations by the UP SPCB. This motivated Khurja entrepreneurs to hire technicians from Thangad to construct tunnel kilns in Khurja.

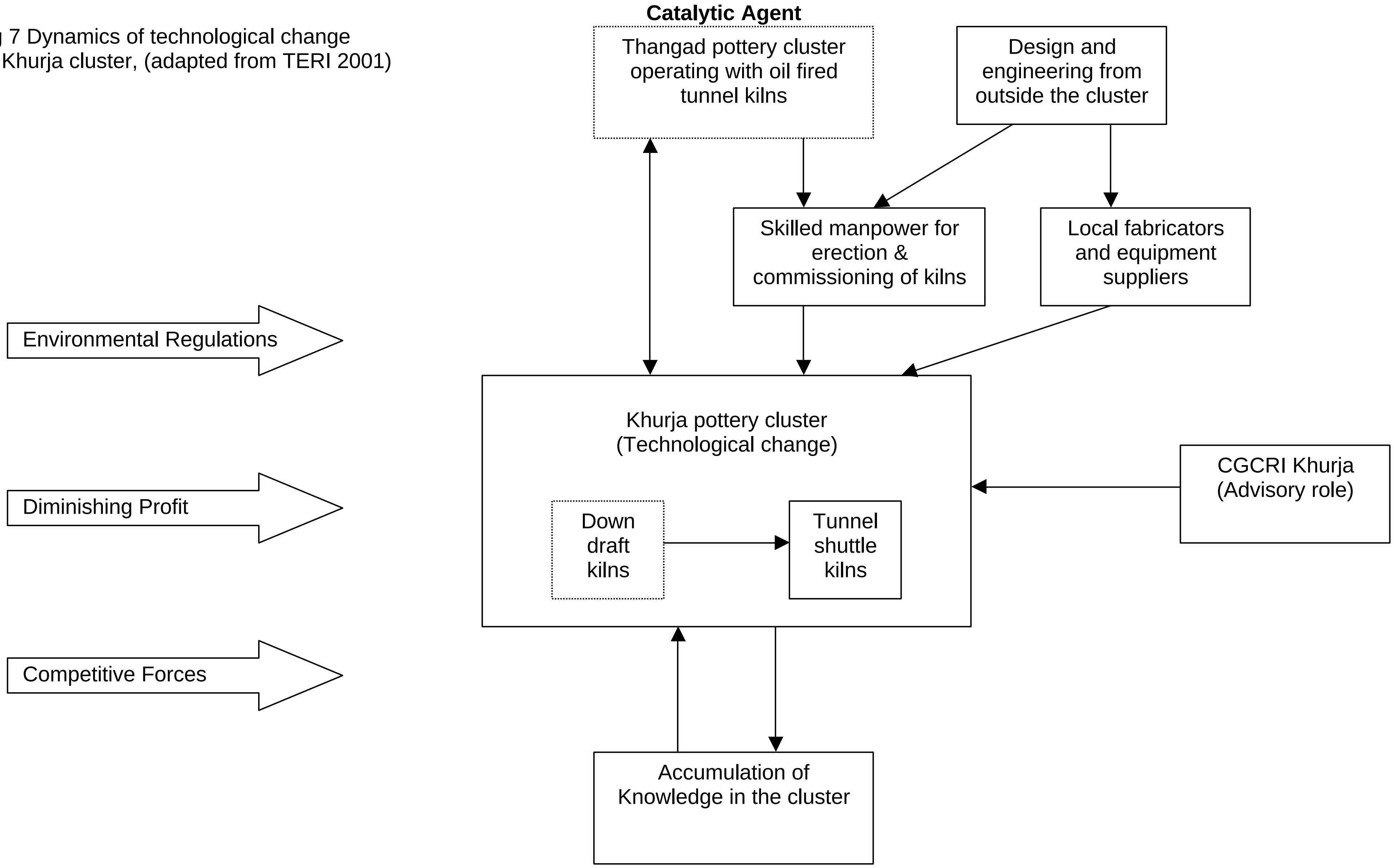
Adoption of tunnel kilns has been rapid since this time.To date, 130 firms in Khurja have now invested in either diesel fired tunnel (60) or shuttle kilns (70). The coal DD kiln is only 3-6% efficient, while the diesel tunnel kiln is 30% efficient. As a result of the switch, firms have reported savings in production costs of 10-15%. This demonstrates a classic “win-win” situation - environmental benefits, coupled with financial and productivity benefits for firms.

A summary of the lessons that can be drawn from this experience are as follows:

- Win-win scenarios have been demonstrated in Khurja - firms can gain significant benefits from “clean production”
- Drivers have to be in place for firms to adopt energy efficient technology – either, or both economic, and regulatory
- Demonstration and removal of risk, both for firms and financing institutions, is a key area – the demonstration of the technology in Thangad gave a high level of confidence to firms
- The Thangad cluster provided demonstration in this case, but there is a key role for support institutions to do this
- The Khurja CGCRI played a key support role throughout - educating users and suppliers, and documenting savings

A schematic summary of the dynamics of the technology change in Khurja is shown on the next page.

Fig 7 Dynamics of technological change in Khurja cluster, (adapted from TERI 2001)



8.3 Ghana

8.3.1 Barriers at Policy and Macroeconomic Level

There have been many positive development at the level of institutions and programmes for energy efficiency improvement. However there are still a number of areas within the broader energy policy environment in Ghana where several barriers hinder the adoption of energy efficiency measures. The primary barriers at the policy level are:

- Low electricity tariffs;
- Poor co-operation and coordination among some key stakeholders (firms, ESCOs, utilities);
- Lack of codes, standards and guides on EE and EE equipment such that firms generally have very little information and there is no guidance on what to buy.
- Inadequacy of existing framework of financial arrangements to support energy efficiency investments;
- Limited number of suppliers for some specialized EE equipment like Variable Speed Drives and high efficiency motors; and small number and size of local Energy Service Companies.

From a macroeconomic perspective, Ghana's high inflation rates result in high cost of capital. Thus the range of EE options that are financially attractive is smaller than it may otherwise have been. The opportunities available are too small to interest local EE equipment and service providers, leading to a scarcity of well-equipped and experienced ESCOs[5]. The few well-equipped and experienced ESCOs therefore prefer to operate in the capital city (Accra) where there is a relatively larger market and, as much as possible, bundle many projects together in order to reduce transaction costs and attain better returns on their investment.

[5] Brew-Hammond et. al., 1998.

Box 2: The story of emerging ESCOs in Ghana – the role of the Energy Foundation

The general growth of the private sector in the country has had a similar influence on the energy efficiency market. There is in general a growing number of ESCOs *resulting mainly from donor funded training of existing and prospective entrepreneurs in the energy efficiency business.* An association of Ghana Energy Services Companies (GHAESCO) was launched recently. GHAESCO has a large membership comprising of researchers, EE equipment suppliers and other industrialists who are in general concerned with the environment.

Prior to the establishment of the IEAC, a study tour was organized for a number of Ghanaian energy efficiency experts in March 1996 to institutions in the USA to acquaint them with the operations of the US DOE Industrial Assessment Program. The study tour enabled the consultants to acquaint themselves with best-practice technologies in America and to develop their management capabilities. Some of these experts together with the dozens of people trained in the 1980s and 90s are involved in the activities of the few energy service companies (ESCOs) now present in Ghana.

From a macroeconomic perspective, Ghana's high inflation rates result in high cost of capital. Thus the range of EE options that are financially attractive is smaller than it may otherwise have been. The opportunities available are too small to interest local EE equipment and service providers, leading to a scarcity of well-equipped and experienced ESCOs[6]. *The few well-equipped and experienced ESCOs, therefore, prefer to operate in the capital city (Accra) where there is a relatively larger market and, as much as possible, bundle many projects together in order to reduce transaction costs and attain better returns on their investment.*

The **Energy Foundation** has been quite instrumental in fostering the right environment for ESCOs, and has the full backing of the government and the private sector. The Energy Foundation (EF) is a non-governmental organization established in November 1997 and inaugurated in August 1998. The EF is the brainchild of the Private Enterprise Foundation (PEF)[7]. The then Ministry of Mines and Energy endorsed the idea and collaborated with PEF to establish the EF.

The EF's strategy is to create a machinery that supplies public information and awareness through campaigns using advertisements in the press and other medium of mass communication, as well as educational programs and seminars, to sensitize all categories of energy consumers about the potential benefits associated with energy efficiency and conservation. This strategy is being implemented vigorously through some powerful TV adverts, very active elementary school eco-clubs, colourful calendars, etc.

Energy efficiency today is very much on the lips of the general public, thanks in part to the EF's public awareness campaign but it is clear that more will have to be done in order to see significant increases in the actual implementation of energy efficiency measures. Indeed, the EF is addressing this implementation challenge by organizing a series of programmes to build capacity among ESCOs in Ghana. The EF is also carrying out case studies of successful practices and going on to disseminate the information among key stakeholders.

[6] Brew-Hammond et. al., 1998.

[7] PEF brings together the major energy consumer groups including the Association of Ghana Industries, the Ghana Chamber of Mines, Ghana Chamber of Commerce, Ghana Employers Association, Federation of Associations of Ghanaian Exporters, etc.

8.3.2 Barriers at Firm Management Level

There are a number of barriers to the adoption of energy efficient measures that have been found to exist at the management level within firms throughout Ghana. These are:

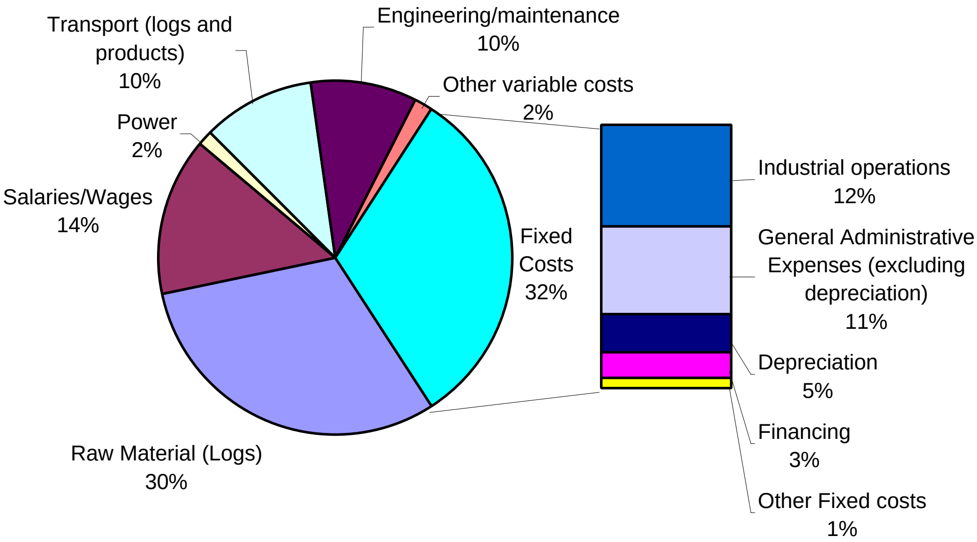
- Low level of awareness and capacity on the part of plant owners, managers and technical personnel about specific options to improve energy efficiency
- Lack of sufficient financial incentive when EE investments are considered in terms of their impact on company profit margins
- inappropriate or complete absence of electricity consumption records

8.3.3 Barriers Specific to Sawmills

The following barriers were identified throughout the course of this study and are known to specifically (though not exclusively) affect sawmills. Some of these barriers overlap with those mentioned above; and may be summarized as follows:

- electricity costs represent only a small percentage, of wood processing cost insignificant when compared to other expenses leading to low priority allocated to energy costs and associated energy efficiency by sawmill management (see fig. 8 below). The data in figure 8 is taken from that collected by the DfID Wood Industry Study in Ghana, and is for 1999. It shows that power costs represent only 2% of the total.

Fig. 8: Pie chart showing breakdown of production costs of small sawmills in Ghana



- sawmill management are reluctant to invest in EE equipment and technologies that are yet to be "proven locally" (many managers actually stated they would only trust innovations that they know to have been successful in other competing mills);
- sawmillers expect high rates of return over short time periods;
- shortage of in-house technical resources to implement efficiency improvement recommendations;
- there is a general lack of knowledge in sawmills, about EE options;
- there is a general unwillingness to give medium term financing to sawmills (banks are usually more rigid when it comes to timber companies because of their traditional inclination to default on loans);
- There is great concern about the security or longevity of the industry and many mill owners complain about the dwindling timber resource.

Table 8: Ghana - table of barriers and opportunities for improving (electricity) energy efficiency

Category	Constraints	Opportunities
Market Development	• Low market leading to high transaction costs to ESCOs for small firms' EE programmes • Low level of Awareness of EE Options in firms • Demonstration effect: wanting to see EE Option in implemented in another wood firm • Lack of standards and codes • EE not financially attractive enough to firms	• Growing number of ESCOs : The driving force has been donor funded training • Possible increase in electricity tariffs • Indexation of exchange rate
Training, Skills and Management	• Low/Lack of in-house-skills/knowledge on EE/management • Lack of training for firm level • Poor Records of energy use • ESCO's - lack of capacity to overcome market barriers	• More Training now available for potential ESCOs and ESCO staff (Energy Foundation, Industrial Energy Assessment Centre)
Technology	• Lack of Availability of some technologies (e.g. Variable Speed Drives)	• Emergence of new suppliers (due to general growth of the private sector)
Policy Environment	• Low Electricity Tariffs • Inertia in introducing new policy instruments (e.g. lobby for time of day tariffs, tax breaks)	
Finance	• Firms tend to expect quick returns (<1 year) • Banks unwilling to provide longer term finance	
Legal & Institution Environment	• Performance Contracting • Weak Contractual arrangements • Lack of co-ordination between utilities – especially distributing companies • Uncertainty over the future of the industry which is a disincentive to investment • Existing EE intermediaries are biased towards large firms	• Energy Foundation now has the full backing of the government and the private sector

9 Energy efficiency improvements in SMEs and impact on poverty

9.1 General Findings

The conceptual framework that was developed by PRI, explored the linkages between energy efficiency in SME's and poverty reduction. This conceptual framework took the following logical progression:

- To define what is meant by poverty. Taking a consensus view from a research of the literature, and ADB dialogues, of the indicators of the multi-dimensional nature of poverty, 15 indicators, the inadequacy of which signifies poverty, were selected.

- Having defined what is meant by poverty, to explore the linkages between energy and these 15 indicators (note, this work was carried out before the team were aware of DfID's Sustainable Livelihoods Framework – instead of using these 15 indicators, the same analysis could equally well have been carried out using the SLF).

- The argument was then extended to show that energy efficiency has the same linkages to poverty reduction as, without the drawbacks of increased pollution that arise from increased use of fossil-fuelled energy. This is summarised in the table below, against the 15 indicators:

Table 9: Rating of contribution of energy efficiency to poverty reduction against indicators

	Indicators	***Increasing Energy Inputs***		***Improving Energy Efficiency***	
		For the Poor	***In the Economy***	***In uses by the poor***	***In the Productive Sector***
1	**Food**	Improves	Improves	Improves	Improves
2	***Nutrition***	Improves	Improves	Improves	Improves
3	***Health*** *(coal&pollution)*	Worsens	Worsens	Improves	Improves
4	***Water / sanitation***	-	Improves	Improves	Improves
5	***Clothing***	-	Improves	-	Improves
6	***Shelter***	-	Improves	-	Improves
7	***Security***	Environmental security worsens	Environmental security worsens, job security improves	Environmental security improves	Environmental and job security improves
8	***Income***	-	Improves	-	Improves
9	***Employment***	-	Improves	-	Improves
10	***Education***	-		-	Improves
11	***Skills***	-	-	-	Improves
12	***Participation***	-	-	-	Improves
13	***Family***	-	-	-	-
14	***Psycho-social needs***	-	-	-	-
15	***Equity & distribution***	-	Tends to improve/ Associated with improvements	-	Possible

The linkages were then analysed to see which applied specifically to SME's. These are described below, and summarised in the schematic.

9.1.1 Consumption/income

Energy efficiency improvements generate savings and improvements in the production process through lower energy costs, reduction of waste, increased productivity etc. By reducing resource use, energy efficiency improvements will increase the industry's overall efficiency. This increased efficiency will inevitably lead to increased profits. These higher profits can benefit the poor in various ways:

1. If the enterprise is of the micro size, then the workers and owners of the enterprise are often the same. Thus reduced costs translate immediately into increased earnings by the poor potter families.

2. Where the units use hired labour there the chain of effects become more indirect. Profits can be utilised in several ways and normally some or all of the effects below should take place. Some of the increased profits may be redistributed through the industry as increased wages to employees;

Or, the increased profits can be used for additional investments and production, purchases of inputs and services, creating spin-offs in input providing and output using industries and so promote economic growth. Economic growth has a positive effect on employment and poverty reduction as discussed earlier.

Or, the increased savings may be passed on to the user of the output in lower sale prices. If the users are low-income groups then it improves their incomes. In all cases the increased competitiveness of the sector should lead to higher production and employment.

Or even in the worst case, where the profits are only accrued by the owner, who may not be poor, it will lead to higher profitability for the sector, which in turn will lead to expansion of production by others.

9.1.2 Health

As the pottery industry is clustered, the emissions from its factories, stemming from large quantities of fossil fuel burning, tend to have large negative local environmental effects. Small plants, in general, are more pollution-intensive per employee, and presumably per unit of output (Dasgupta et al. 1998). By reducing energy requirements through the introduction of energy efficient technology and conservation practices, lower levels of pollutants such as NOx, SO2 and airborne suspended particulates will be present in the area (in addition to the global benefit of reduced CO2 emissions). This benefit will be of greater importance to the poor, as they generally live in the proximity of these polluting factories. Pollution-intensive industries have a tendency to locate in low-wage areas (Dasgupta et al. 1998) for various reasons. Firstly, pollution regulation in often weaker or absent in poorer regions (Pargal and Wheeler, 1996; Wang and Wheeler, 1996; Dasgupta et al. 1996). This may be due to the lower relative value assigned to environmental quality by the poor, and/or because low-income communities may be less informed and/or less organised to regulate pollution effectively (Dasgupta et al. 1998).

9.1.3 Education and skills

Any improvement in energy efficiency will require higher skills of the workers. It is assumed that important training and education benefits can accrue to the workers on energy efficiency and conservation.

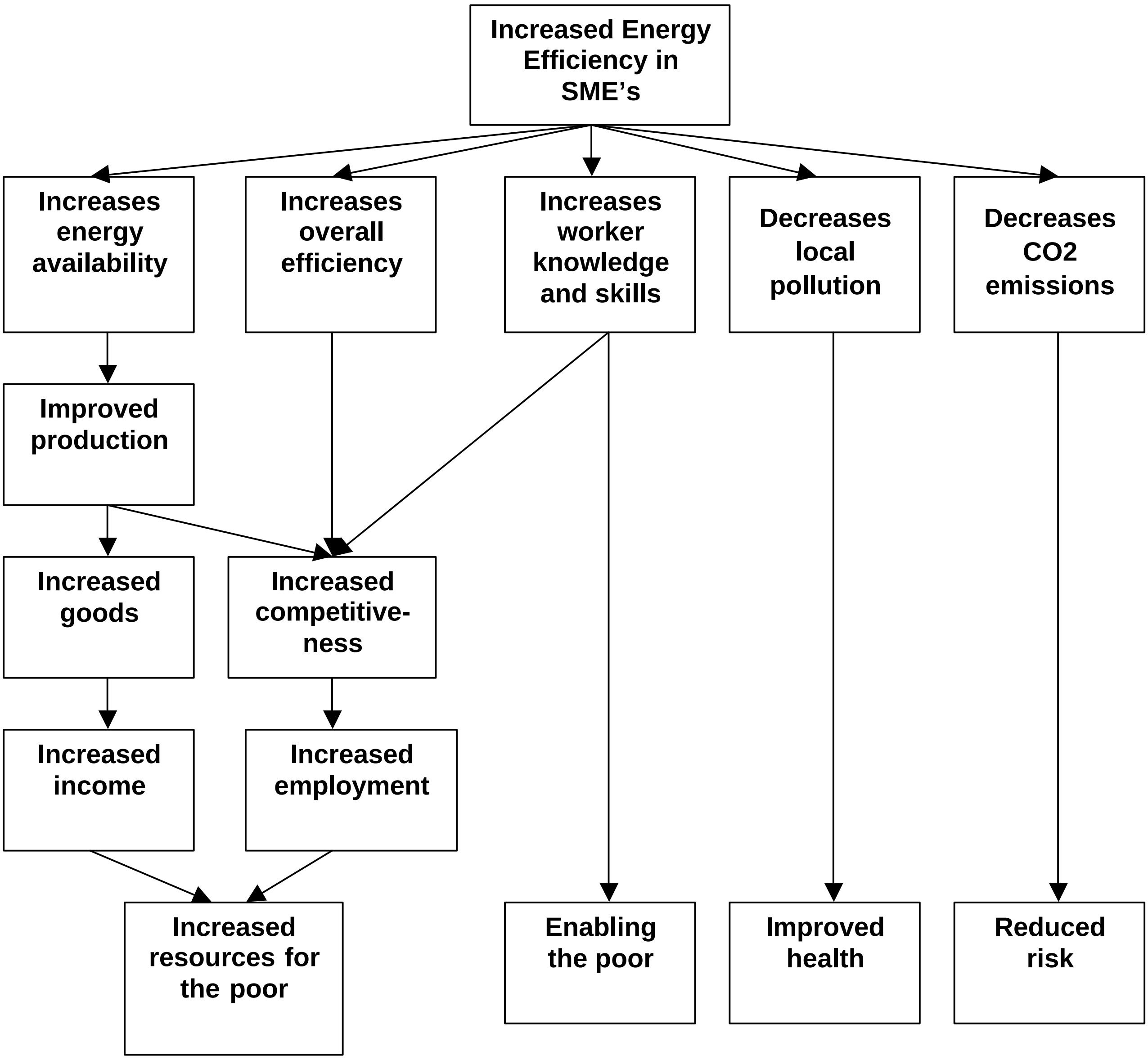
9.1.4 Access to decision making

A key aspect of the project is the participatory process to be used and the discussions with pottery industry workers.

9.1.5 Risk and vulnerability

The problem of risk, as Kanbur and Squire (1999) identify, is that it keeps the poor in low-risk, low-return activities and it endangers what they already have. One of the greatest barriers to investment in new (higher-risk, higher-return) technology is access to capital and this problem is even more acute in poorer industries. By providing both the information and energy efficient technology, the project reduces the risk level for pottery entrepreneurs. This gives them access to a high-return activity with a reduced corresponding risk. It also reduces of the owners and workers to future risks of not meeting higher environmental standards and risk of not being competitive with other sectors for domestic and export markets.
Following Bruno et al.'s (1995) conclusions, then by allowing the poor to make productive investments through either lowered credit constraints or by increasing the available information about new technologies, this leads to a higher and more equitable growth process.

Fig. 9: Linkages between increased energy efficiency in SMEs and poverty reduction



9.2 India

During the course of the research one member firm of the KPMA changed over from a coal fired down draft kiln to diesel fired tunnel kiln. During the course of our first field survey conducted during the first quarter of 2000, this unit was still running on downdraft coal fired kiln. By the end of the project, in March 2001, the firm had successfully installed and was operating the new diesel fired kiln. As a KPMA member firm, and one building a new tunnel kiln, the firm that was keen to utilize any technological improvements that could be suggested by the research team. The team was able to view the progress of this construction and had detailed discussions with the Kiln “mistry” or builder and also the manager and owner of the firm.

As a result of the change, the company’s capacity and actual production has increased from an average of 2 tonnes per day for around 200 firings earlier to almost 5 tonnes per day for over 300 working days now (or from 400t/year to 1000t/year). The products manufactured by the company are LT & HT insulators. The company has been able to increase their production capacity by almost 2.5 times with little additional capital investment beyond that required for the kiln. The cost of the kiln is around Rupees 1,600,000 (or $40,000). The company did not need any additional investments in other equipment or in other sections, such as ball mills, body preparation, glazing and the like. The increased turn over of the firm is now around Rupees 1,300,000 from the earlier estimated value of around Rupees 500,000.

Discussions with the owners suggest that the labour inputs have increased by over 40 per cent for the increase in production of 250%. This has been achieved through the workers taking on additional shifts, so the total number of workers employed has not changed, but the number of hours worked, (for additional wages) has. Originally there were approximately 14,000 person days of labour used and now it is approximately 20,500 workdays. This suggests an increase in outputs to labour by almost 100% and the incremental labour to capital ratio of 1 person year per investment of 80,000 rupees.

We have already remarked that the major difference in pollution between the coal fired and the diesel units is in the amount of particulates emitted to the air. In the coal fired kilns the range of flue gas flow rate is 9,000 to 15,000 M^3/hour (or 4,000 to 11,000 Nm3/hour, where Nm^3 refers to cubic metres of Nitrogen) . The particulates in the flue gas range from 1,200 to 9,500 mg/N m^3.(Source: Ceramic Industry, Central Pollution Control Board, New Delhi, January, 1995, page 69).

For a typical firing of a 10 tonne batch of ware in a DD kiln, the amount of particulates generated (taking a middle number of 5,000 Nm^3/hour x 5,000 mg/Nm^3) is 25,000,000 mg per hour. This for a typical firing cycle of 30 hours amounts to 750,000,000 mg or 750 kg. In 20 firings per year this would amount to 15,000 kg of particulates, per kiln.

In contrast the particulate load generated in diesel and kerosene fired tunnel kilns was found (ibid, page 72) to be in the range of 0.036 kg per hour to 0.5 kg/hour. For the same 10 tonne output, a typical 3 tonne tunnel kiln needs 67 days of 24 hours, or 1608 hours. Therefore the particulate emissions will range from a low of 58 kg to a maximum of 804 kg. Thus even if this tunnel is in the worst emissions range it will produce 5% of the particulates as a DD kiln.

9.3 Ghana

The subsector analysis showed that the raft of policies and regulations that have and continue to be put in place to re-structure the Ghanaian timber industry will not only affect the sawmills, but will have a considerable impact on downstream firms, particularly small scale carpenters, who sell into the local market. The impact on small scale carpenters is likely to be negative in two ways:

i) The policies and regulations to bring about more sustainable timber and forestry practices will inevitably lead to an increase in the price of the raw material – lumber, or logs. The ban on the sale of roughsawn chainsaw lumber has already had an impact on small scale carpenters. This ultimately is likely to push up the price of lumber and timber products on the local market, and will lead to some reduction in demand.

ii) The incentives for greater added value processing in sawmills will mean that firms will use more of their own residues and offcuts on site – either to be burnt in kiln driers, or to go into tertiary processing. The result will mean a reduction, and hence a price increase, in the residues and offcuts used by carpenters.

This is a classic example of “winners” and “losers” in a development intervention. Furthermore, it is an example of where there can sometimes be a contradiction between impacts of “efficiency” interventions at a micro level and at a macro level.

It would seem to be surely a good thing that the more sustainable forestry and timber practices being promoted by DfID should take place. There will be benefits for the local forest communities, who will see a greater return for the logs harvested. There will be benefits for the local and national government, as they will receive a greater share of the revenues. There will be benefits for the industry as a whole, as it will promote increased efficiency, productivity and higher skills through the adoption of latest technologies for maximising recovery and adding value.

However, it appears that unless the small scale carpentry micro-enterprises can be supported to shift into use of alternative materials for furniture products, coupled with promotion of lesser used timber species for the local market, then their livelihoods will suffer.

10 Summary of key findings of project

10.1 Introduction

This section presents an overview of the key findings of the project. It begins by presenting the findings relating to the scope for energy efficiency improvements in each of the industries. The key question to be answered here is whether or not there is in fact a large efficiency gap between actual practice and that which would be economically efficient. The emphatic answer here, from both countries, is definitely *yes*.

Having established this fact, the next question to be answered is – "if this efficiency gap is real, why haven't firms in each industry acted to close it, as it would be financially attractive for them to do so?". This section goes on to present the barriers to adopting the more efficient technologies and processes that were found in each country.

Next to be presented are possible policy and institutional mechanisms for overcoming these barriers. The key finding here is the need for Energy Service Institutions (ESIs). The section then moves on to show the key findings relating to the impact of energy efficiency improvements on poverty reduction – in terms of impact on the local workforce and population, but also at a more macro level.

Finally, we present reflections and lessons from the methodology that was followed during the project.

Where points are felt to be country specific, then they have been placed under the heading of either "India" or "Ghana". Where points are more general, and applicable to both countries, and are more generic points, then they are placed under the heading of "general". This heading also covers contrasts and comparisons between the two countries.

10.2 Technical Mechanisms – the scope for energy efficiency improvements

10.2.1 India

- Generally, there are a large number of improvements that can be made to the operations of the ceramic units. The units suffer from low quality products, high energy use per unit of output, relatively high rejection rates, and often low prices for their output.

- The project has found that there is a considerable scope for improving SEC in diesel-fired tunnel kilns, as they are used in Khurja. Compared to UK kilns, at a comparable level of quality, there is scope for reducing SEC by about 50%. 10 to 40% of this can be achieved at little to no cost, through improved set-up and optimisation of the kiln. Additional savings can come from firms investing in lower thermal mass kiln furniture, and trolleys.

- The team found that calculating energy efficiency savings, and, indeed, agreeing on a set of recommendations to ceramics firms was a complex business. This is because the ceramics firing process is itself a complex one. The optimum performance of a tunnel kiln, which is an open system, with air coming in from outside, depends on the correct flow of hot gases inside the kiln, and the temperature and pressure profile.

  It was found that many of the estimated savings suggested by other energy efficiency service providers, did not take this complexity into account, and so over-estimated the possible savings. Examples of this are in calculating the savings from reducing the mass of kiln cars, which is difficult to model because the cars give up heat back to the kiln after they leave the firing zone, as well as absorbing heat on the approach to the firing zone.

- Many of the recommendations can be carried out by the firms with the support and skills available locally. However, it is clear that some of the recommendations made for modifying the tunnel kilns cannot be made by the firms without additional support. This is because the modifications require a number of measurements to be made (for example, level of excess air, pressure profile), and for those measurements to be interpreted. The level of knowledge to do this does not currently exist among the owners of the firms. Some of the more complicated and longer term solutions will require a concerted effort with the help of agencies such as CGCRI and PCRA. These intermediary agencies themselves will require additional capacity building in order to provide such support.

- India research has shown that issues around improving energy efficiency, and waste and reject minimisation (the greatest waste of energy of all is to throw away reject product at the post-firing stage) are closely related to those of improving product quality. Both require careful monitoring and optimisation of raw materials, clay body moisture content, optimisation of kiln performance and control, accurate record keeping and good housekeeping.

- Further, the India work has shown that there can actually be a trade off between product quality and increasing fuel efficiency in tunnel kilns. It may be that firms will choose to increase their product quality, to enter new export markets, for example, rather than reduce fuel consumption. The result of this could be that firms, as a result of this project, could produce a higher quality of product for the same level of fuel consumption as they have now.

  The experience in the UK ceramics sector, is that firms produce a higher quality of tableware, have a higher level of SEC. For the ceramics industry, at least, this points to the fact that development benefits from improved efficiency should not just be framed in terms of reduced environmental impacts, but that the increased growth and productivity of SME's resulting from technical assistance is also a very important factor.

10.2.2 Ghana

- Although there exists a broad scope to improve energy efficiency in the timber industry, activity in this area has rather been on the low side. Many sawmills (about 50% of those located in the cities) have made a go at power factor improvement through installation of capacitor banks but very little has happened with respect to other (primarily electricity) efficiency improvement options. This is despite the fact that the key measures identified have attractive payback times of less than one year.

- This can be explained by the very small contribution that changes in electricity consumption would make to profit margins. The research team was eventually able to establish that power represented only 2% of total production costs. Further, the data shows that, for small sawmills, total power costs represent only 5% of the profit margin on the lowest revenue lumber product (Wawa), so the savings would be only in the order of 1% of profit margin, as a maximum.

- In contrast, however, it seems that several investments have taken place in the area of more added value – in the form of kiln dryers, and tertiary processing equipment. This has been stimulated by the rising price of raw material, information provision, and government policies, such as levies on the export of non-kiln dried lumber. The cost of the log is the largest single production cost item per unit of output. There are clearly wider energy efficiency benefits in maximising log recovery, due to the energy expended in extracting the log from the forest and transporting it to the sawmill.

- However, it is an interesting fact that despite the lack of financial attractiveness for sawmills to improve electricity energy efficiency, half of the firms surveyed had installed capacitor banks to correct power factor. The dates of these installations appear to have co-incided with the last government increase in electricity tariffs in 1998. It is notable that all of these firms are based in cities.

- Whilst in general energy efficiency measures were not widely practiced, they were more commonly found amongst sawmills in the Ashanti and Western regions. This is likely to be due to the high concentration of timber firms in these areas. For example, equipment suppliers or institutions promoting energy efficiency would be likely to focus their activities in these areas due to the access to a large number of firms. The high concentration of firms would also facilitate greater information flows between the firms, and perhaps a more keenly felt competitive pressure, as compared to those firms spread across more rural and dispersed locations

10.2.3 General

1. There is an important issue over how energy efficiency improvements in energy intensive SMEs are to be measured. In the case of ceramics, the measure used is specific energy consumption (SEC) – this is the energy used to fire a given amount of product. Implementing the key measures for improving tunnel kilns, as outlined in section 5, will certainly enable firms to reduce their SEC, but will not, in the medium term, necessarily lead to a reduction in the absolute levels of fuel consumption. This is because firms may use the savings in production costs, or capabilities presented by the new technology to expand production. The same point is just as applicable to the Ghana SMEs. This fits with the “clean development” model – i.e. where SMEs in developing countries are able to grow, without necessarily *increasing* energy consumption, or the attendant environmental and health impacts.

2. **The need for a holistic approach to energy efficiency**
   In both countries, the project has found that the greatest scope for energy efficiency improvement, and that which is most financially attractive to firms, does not relate to improving the efficiency of electricity use, although this is by no means negligible. Rather, it relates to broader improvements in the production process, involving aspects of maximising recovery of raw material, in the case of sawmills, and quality control in the pre-firing stage, as well as kiln optimisation for ceramics firms. This suggests that if the “win-win” is to be maximised, then energy efficiency interventions need to look at the entire production process, and consider aspects such waste minimisation, and quality, and not just focus narrowly on electricity consumption, for example.

3. Win-win solutions to do exist

The work in India has shown that win-win solutions do exist – cover story of upgrade from coal to diesel; scope for improving energy efficiency of tunnel kilns that are attractive to firms. Our findings in Khurja add to the global evidence and confirm the earlier findings that such opportunities are quite large and significant in Khurja.

10.3 Barriers to energy efficiency

10.3.1 General

1. **Generic solutions do not lead to action**
   There had been a number of previous energy efficiency studies carried out at Khurja. A major problem of the studies that we have reviewed is that there is an assumption inherent in them that there is one state of the art technology for the firms *and all the advice tends to be generic*. As a result, the recommendations did not lead to action plans. Our finding is that any real strategy for change will have to build on the current conditions, knowledge and capacity of the industry, the managers and owners and the work force, and also the existing situation of support services available to the industry in Khurja. This also points to the need for (Again, this points to the need for ESIs.)

   Linking macro to micro – the need for Energy Service Institutions (ESIs)

1. The principal hypothesis of this study is that there is an important need for further institutional innovations, in particular the development and strengthening of intermediary institutions, which can mediate between the available solutions and the needs of the users and which can recover the costs of the intervention and investments from the benefit stream accrued by the user. We refer to these as Energy Service Institutions (ESIs).

   ESCO or ESI? The need for a broader definition
   We have chosen to use the term Energy Service Institution (ESI) rather than ESCO, as this is a broader, more inclusive definition that does not lock us into to one model of service provider. The ESI set includes ESCO but not the other way around. An ESI can be either a public institution, or a private service provider, or a mix. It can be an industry association (e.g. PCRA, CERAM), or an NGO (e.g. TERI), or a private company. It can just be a simple information provider, or it can take on additional features of finance bundling, common services, performance contracting, and so on.

2. The need for these ESIs is shown by this project as well as previous studies. In Khurja, the CGCRI played a key role during the shift from coal fired kilns to diesel, and meso level support is essential if the firms in Khurja are to implement many of the recommendations.

   This is supported also by the findings from Ghana. There, the IEAC has so far conducted energy audits of 18 facilities altogether, including 11 timber firms. In more than 50% of the cases, the energy audit reports had not been delivered to the companies mainly because IEAC was waiting for an implementing agency to come forward in order to ensure that when the reports were submitted, the recommendations would be implemented. The absence of such an implementing agency (or agencies) constitutes a major bottleneck with respect to achieving the more fundamental objective of realising concrete energy efficiency improvements in firms (including sawmills) and elsewhere throughout the country.

10.3.2 Ghana

It is interesting to note that the KITE team, and previous energy audits carried out by IEAC in Ghana, had, (justifiably as that was their remit) focussed only the technical issues around more efficient energy use, identifying key measures, capital costs and payback times. These previous studies had not attempted to look at issues around firms production costs, and expenditure on energy as a proportion of production costs or margins. The team, and previous studies, had identified several measures that had attarctive payback times, but the rate of uptake had been relatively low.

It was only when this project broadened the analysis to look at firm economics that the reasons for this became apparent. Whilst it is clearly a good thing to continue to build capacity in the energy efficiency industry, there is a lesson for policy makers here. This lesson is that unless there are economic, and perhaps regulatory pressures on firms to adopt energy efficiency measures, the rate of uptake will be low. This suggests that energy efficiency support should be targeted at SMEs where these pressures and drivers are apparent.

It is important to note that, in terms of whether firms will find energy efficiency measures financially attractive, it is not necessarily the cost of energy as a proportion of production costs that is the key. It is rather the cost of energy as a proportion of profit margins that counts.

There is normally a general lack of technical and financial capacity within companies to carry out efficiency improvements. Other barriers to more energy and process efficiency-improvement activity in the sector have been identified to include lack of proper assessment to invest in improved and emerging technologies at the firm level and the high rate of returns that entrepreneurs, especially those in the timber industry, expect from investments. Experience in Ghana shows that serious efforts will be made at addressing these barriers only when entrepreneurs begin to feel the pinch. This points to the need for macro level support.

10.4 9.4 Overcoming barriers – institutional and policy mechanisms

10.4.1 India

The research team found that for the ceramics industry, the export market can be an important additional driver for improving energy efficiency, as it will demand a higher level of quality from firms. This is due to the link between product quality and process efficiency, as explained above. In order to improve quality, firms will need to put in place measures that are closely related to those required for improved energy efficiency, and will improve overall process efficiency. However, as mentioned above, this will be only true up to a point. Above a certain level of quality, firms may trade off quality against fuel efficiency in kilns, although there will still be improvements in energy efficiency in other parts of the production process – quite where the break point is for this is unclear. However, the feeling is that in Khurja, the firms are still some way below it.

10.4.2 General

- **Drivers for improving energy efficiency in SMEs**

  Broader macro-economic policies have an important role to play – for example, the removal of fuel subsidies, and increased competition. This was demonstrated both by the story of kiln technology upgradation in Khurja, and moves towards greater added value processing in Ghana. Setting up appropriate economic policies, of reduced subsidies, increased competition and the greater play of market forces, will ensure that the firms buy the improved technologies or they go out of business.

- Regulation and regulators have a key role to play, in conjunction with these policies, and other actors. However, it is clearly important for regulators, where possible, to try to work with firms, service providers and other key actors, to seek out opportunities for "win-win" approaches, otherwise there is a risk that these opportunities will be missed altogether.

  For example, the environmental regulator had advocated that firms adopt "end-of-pipe" measures for reducing emissions from the coal-fired downdraft kilns. This involved fitting electrically powered scrubbers in chimneys to remove particulates. Clearly, compliance with these measures would have brought no benefits to the firms themselves. Fortunately, the regulator took a sympathetic view, as they were aware of the poor economic state of the firms in Khurja, and had no wish to close them down, and indeed encouraged a win-win situation. They gave an ultimatum whereby they insisted that the firms either fitted the pollution control equipment, or switched from coal fired to diesel-fired kilns.

  To date, no firms have introduced pollution control equipment whereas 130 firms have now invested in diesel-fired kilns. This is a clear example of the clean production paradigm in action. If firms *had* fitted the end-of-pipe measures, then, arguably, they would have had less incentive to move towards diesel-fired kilns.

- However, it is clear from this project, and previous studies, that although it is important to have these drivers in place, there is still a need for technical assistance and support to SMEs to enable them to adopt new technologies. In other words, macro level policies, need to be coupled with support at the micro level. This project, and previous work suggests that the most effective mechanism by which to deliver this micro level support is through *meso* level institutions, and service providers. This is illustrated by the role CGCRI played, and continues to play, during the shift away from coal fired kilns in Khurja. As mentioned above, meso level support is essential if the firms in Khurja are to implement many of the recommendations. This is discussed in more detail below.

- One interesting comparison to be made between Ghana and India, is that in Ghana the barriers to improved energy efficiency appear to be pre-dominantly at the macro, policy level – for example, the low electricity tariffs, and the, until recently, low price of raw material, leading to very low levels of material recovery and added value. In contrast, those in India relate more to technological aspects, in terms of lack of knowledge among firms and service providers relating to tunnel kiln optimisation. This can be attributed to the fact that the ceramics production process is arguably more complex than that for sawmilling, and the optimisation of tunnel kiln performance requires a fairly high level of technological capability.

- **The need for public-private partnership**

  The experience of this project, as well as historical evidence from several reviews of experiences suggests that private actors will not necessarily emerge on their own. *A healthy growth requires partnerships between public and private agents.* The role of public institutions is to:

  - provide the initial demonstrations that there are solutions that work
  - participate in documenting the successes and failures
  - educate potential users and suppliers regarding the approach
  - improve standards, codes of conduct, legal and financial frameworks and arrangements so as to reduce the initial risks of the private actors. As these informational, organisational and institutional barriers are removed, the demand and supply of these services and their uses will expand

This is where the concept of an ESI is useful, as it allows a service provider to embody a public as well as a private role.

10.4.3 Energy efficiency, SMEs and poverty reduction

see section 9

10.4.4 Lessons on methodology

The problem with surveys

1. A major problem that we faced in both countries, and that was also apparent from previous studies, is the fact that for various reasons, largely to do with taxation and legal issues, the firms tend not to report the true details of their operation, i.e. figures for production, number of employees, and profit. This is one reason that the specific energy ratios reported in some of the earlier studies are highly unreliable.

11 Recommendations

11.1 To firms

These are presented in a separate document, to go to the firms, and relevant service providers. The type of recommendations, which vary from firm to firm, are as the key measures given in section 5 of this report.

11.2 To energy efficiency service providers working in each country

- In arriving at recommendations, all support institutions must carefully distinguish the exact barrier that prevents the take up of the solutions offered. These include size and scale issues, capital required, risks of various kinds and finally, knowledge and information.

11.2.1 India

- CGCRI must start to offer a number of new services to the industry. These need to be started initially on a grant or subsidy basis to check that the advice or service in fact works as predicted. After that has been demonstrated to a number of firms, in the range of ten to twenty, then CGCRI should reduce the subsidy element to zero, possibly over a period of one to two years. These can be added to the training services that CGCRI already provides. Over time once the service has proved valuable it should be continued only on the basis of the gains to industry and the industry's willingness to pay.

  Initially candidates for group services arise from the fact that certain tests and measurements are required by the firms in Khurja if they follow the approach outlined. Examples of such services include:

  - Testing moisture content periodically
  - Optimising raw material composition
  - Taking readings and optimising pressure and temperature profile of kilns
  - Measuring levels of excess air in kilns, and advising on minimum level required for desired surface finish
  - Conducting air flow balance following major kiln changes

11.2.2 Ghana

- For the sawmill sector, there is a need for energy efficiency institutions and service providers, such as KITE, to continue to lobby and raise awareness of the benefits of energy efficiency to policy makers. This is to be achieved indirectly through advocating at least economically sustainable levels of electricity tariffs and lobbying for greater attention to forests as well as environmental issues. More sustainable use of the timber resource will inevitably push up the price of the raw material, which will diminish profits of timber processing firms, and make both more efficient use of electricity and of raw material more attractive to firms.

(note, to a certain extent, there is a considerable amount of iteration and interaction between all of these recommendations, and they probably all need to happen in parallel, rather than being a logical sequence of activities)

- At present, although some private sector ESCOs do exist in Ghana, their focus is very much on larger firms, and primarily those in the capital city, Accra. The most active energy efficiency Energy Service Institution in Ghana, the Energy Foundation, has focussed on large scale users, including some of the country's largest sawmills. However, at present there seems to be no-one catering for the needs of energy intensive SMEs, who face the greatest barriers to implementing energy efficiency solutions, through lack of in-house technical capacity, and finance. This suggests that there is a need for the Energy Foundation, or some other intermediary organisation, to "connect up" energy intensive SME's with the Accra based ESCO's. The key barrier for ESCOs to work with SMEs is the high transaction cost. This can be reduced in several ways:

a) the intermediary organisation can act to bundle together smaller projects, to reduce transaction costs to ESCOs (this suggests that fairly generic solutions are possible – but India work suggests this is not the case? – an interesting difference between the 2 countries?)
b) a special fund be set up specifically to support SME's, that ESCOs can apply to

There is still a low level of awareness and technical capability within SME sawmills with regard to improving energy efficiency. There is a chicken and egg situation here. To a certain extent, the technical capacity can be contracted out to an ESCO, assuming the ESCO is interested in providing the service. However, awareness of the benefits of improving energy efficiency, primarily, needs to be raised among firms, before they will approach ESCOs. Again, this awareness raising could be left to ESCOs to carry out, as part of their marketing effort – but this function is perhaps best performed by a service provider/institution within the industry, that can advise on improving all aspects of the production process in the sawmills.

11.3 To DfID, other donors, and national policy institutions

Improved energy efficiency in SMEs does contribute to poverty reduction
Improving energy efficiency within energy intensive small industries does have a clear contribution to make to poverty reduction. This is firstly in the form of health and environmental benefits for local populations, and in some cases for the workforce. Secondly, it is in the form of sustainable development – allowing growth in SMEs, through reductions in production costs, increases in process efficiency, and mitigation of energy supply constraints, but without necessarily a growth in the environmental impact of these firms. This project has provided further evidence that such win-win scenarios are possible. Therefore, DfID and other development agencies should continue to support energy efficiency in energy intensive SMEs in developing countries, as part of a poverty reduction strategy.

Energy efficiency or enterprise development?
Technical assistance for increasing adoption of more energy efficient technologies and practices in energy intensive SMEs is, as we have shown, fundamentally linked with SME development and growth. Therefore, energy efficiency in SMEs can be thought of as a subset of enterprise development. It is interesting that there seems to be a far greater acceptance within the enterprise development community (which includes DfID's work) of the contribution of SME development to poverty reduction. The contribution within that community is more about the best way to provide such support, hence the development of (business development services) BDS guidelines. This work very much supports the approach of the "blue book" BDS guidelines, that support should be focussed on facilitating and creating an enabling environment for appropriate service providers.

Linking macro to micro
Although broader macro level policies to increase industrial efficiency are important drivers, this approach alone *does not concern it self with the livelihoods of a large number of workers in the small scale sector*. For example, many of the existing technologies, such as imported kilns that are more efficient are also very expensive and beyond the capacity of the current manufacturers in Khurja. *It will not be possible for the industry in Khurja to adapt on its own without support*. The approach recommended then is to combine the increased competition with support to upgrade the skill set and increase the application of knowledge and technologies to the current situation in Khurja so that over time the firms can become more efficient and competitive. This approach requires that proposed solutions must be tailored to the current needs and the capacities of the existing units while applying the best technical knowledge that is relevant to the current situation.

Energy Service Institutions
This project, and reviews of previous research, suggest that one of the most sustainable and cost-effective ways for donors to do this is through support for intermediaries, who can interface between available solutions, equipment and service suppliers, and the firms. *Historical evidence from several reviews of experiences, as well as from this project, suggests that private actors will not necessarily emerge on their own, even within a favourable environment. A healthy growth requires partnerships between public and private agents*.

This suggests that donors need to take a broader approach to who these intermediaries should be rather than just thinking in terms of ESCOs, which immediately locks us into a model of private energy efficiency service providers. In place of ESCO, we suggest the term *Energy Service Institution (ESI).* The key distinction between ESIs and ESCOs is that the former is a broader, more inclusive term, which can include the latter, but not the other way around. The concept of ESIs is useful as it can embody public functions such as demonstrations, information provision, and best practice, as well as private service provider functions.

This need for a broader definition of service provider, has been highlighted in this project by the fact that for many energy intensive SMEs, the adoption of more energy efficient practices and processes has little to do with the standard ESCO technology packages of CFLs, capacitor banks, CHP, etc. Instead, the type of service and expertise that is required relates to the entirety of an SME's production process, and therefore, a degree of expertise and knowledge relevant to that industry is required from the energy efficiency service provider. In fact, such a service provider, or ESI, may not see it's primary role as being to increase energy efficiency, but rather to increase productivity, and product quality (c.f. CERAM in the UK).

Performance Contracting
In the longer term, these ESIs can offer services on a cost recovery basis, by charging fees to firms. An alternative model is for these ESIs to be paid out of the energy savings, i.e. an energy performance contracting approach. However, there are still very few examples of this model being used in developing countries, and as far as we are aware there are no examples yet in either India or Ghana. The benefits of performance contracting are twofold: firstly, it is a mechanism for overcoming barriers of risk, and uncertainty for firms; secondly, if larger capital investments are involved, it overcomes financial barriers that smaller firms may face. There is a need for donor funds to provide support to projects to demonstrate this approach to provision of energy efficiency services to SMEs.

Export market as a driver for increased efficiency

For the ceramics firms, and perhaps other sectors, the export market can be an important driver for improved product quality. As described above, this is also closely related to the technological and process changes required for improved energy efficiency. This suggests a role for donor support, or from national governments, in providing support for “joined-up” technical assistance packages that combine marketing, and business linkage support with support on product quality and energy efficiency. This would also provide an example of globalisation providing an opportunity for “pro-poor” growth.

12 References

Energy efficiency and poverty alleviation, Final report, project number R7222, Nandini Dasgupta, NRI
Ceramic Industry, Central Pollution Control Board, New Delhi, January, 1995
ETSU publications on energy efficiency in ceramics industry
Energy sector study, phase 1 – TERI, for SDC, Nov 1995
Energy conservation in small and micro enterprises: an action research plan, SDC, TERI, 1998

ETA/TERI website?

Give a list of relevant website addresses?

Energy Consumption Guide 61 – Energy consumption in the ceramics industry
Good Practice Guide 164 – Energy efficiency operation of kilns in the ceramic industries
Good Practice Guide 244 – The use of low thermal mass materials and systems in the ceramic industries

(Forestry Commission, 1999; Ofosu-Asiedu, 1995) – p.18

SDC/TERI reports – on VSBK, and on overview of India energy intensive industries

Appendices

Original logframe?
List of related reports, also coming out of the project
Questionnaire used for firms in Khurja

Appendix 2 – list of related reports

Below is a list of reports formed outputs during the project.

UK literature review by Martin Hird?

- MSc student report, Edinburgh University
- Ghana Phase 1 report, Energy efficiency in sawmills, October 1999
- India – Poverty and Energy efficiency in small industries – a review of issues
- CERAM report
- Ghana sawmill energy efficiency study – final report
- Study on energy conservation opportunities in ceramic industries, Khurja, oct. 2000
- Survey of the pottery industries in india – desk study report, aug. 1999, IDS
- Energy efficiency survey of sawmills in Ghana, KITE, November 1999