

Assessing environmental impact of small and medium ceramic tile manufacturing enterprises in Thailand



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ABSTRACT

Manufacturing processes employed by small and medium ceramic tile production enterprises in Thailand consume substantial amounts of energy. This study reveals that a small plant uses twice as much energy to produce one square meter of tile than does a medium plant. With the exception of global warming effects, the environmental impacts of a small plant are also larger than those of a medium plant, specifically with respect to ozone depletion, acidification and eutrophication. In addition, the environmental management perspective of the medium plant is based on cost reduction and social necessity. In contrast, the small plant has a negative attitude toward environmental management measures, taking the view that these are not appropriate concerns for small plants. These differing impacts and viewpoints suggest that environmental management in the small and medium plants should apply different approaches. On the one hand, the medium plant should emphasize the accelerated transfer of environmental knowledge to its personnel, while on the other, the owners of the small plant should be made to recognize the environmental impacts of their production activity and products. Additionally, potential benefits that might accrue to the plant owner from environmental impact mitigation should be highlighted.

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1. Introduction

In the current global economy, business organizations are asked to consider their social responsibility to mitigate the environmental impacts of their activities [1–3]. This is especially true for those industries that produce worldwide environmental impacts. The ability to manage the environment also depends on factors external to an organization, such as resource availability, strategic attitude, sector and geographic location, and especially, a company's size [4–6]. Most previous studies on environmental management in the production sector have focused broadly on the industry as a whole or on large enterprises. The environmental management of small enterprises has been rarely studied [7]. A number of important differences, including differences in technology, level of understanding, size and resources [6], make it difficult if not impossible to apply environmental management guidelines derived from the study of large enterprise study to small enterprises [8,9]. These fundamental differences between large and small operations necessitate a clearer understanding of the actual environmental management context of small and medium plants.

In Thailand, 99.5% of all businesses can be classified as small or medium enterprises (SMEs) [10] on the basis of the international standards [11]. These businesses account for 38.9% of the nation

GDP [10], making them major contributors to business growth and national development. Of these small- and medium-sized business, 29.6% are in the production sector, which accounts for most environmental impacts. The production of ceramic products in Thailand is a particularly important contributor, consuming the greatest quantity of energy and fuel relative to the global standard energy consumption of 17.51 GJ per ton of ceramics produced [12]. Based on the studies of Shular and Nicoletti, ceramic production was also found to produce the greatest environmental impact [13–15]. Several countries have attempted to quantify these environmental impacts and design solutions to reduce them through technological development, new regulations, and dissemination of literature promoting environmentally friendly ceramic production methods [13,16].

Most of the ceramic producers in Thailand are small and medium enterprises, and there is a lack of studying environmental impact arising from this industry. This research focuses on studying environmental impact from the small and medium ceramic tile production businesses so as to compare degrees of environmental impact and serve as a guideline for reduction of environmental impact from the said businesses.

2. Manufacturing process

2.1. The medium plant

The medium plant mixes soil powder on-site, purchasing raw materials from its production sources that it then crushes and sends

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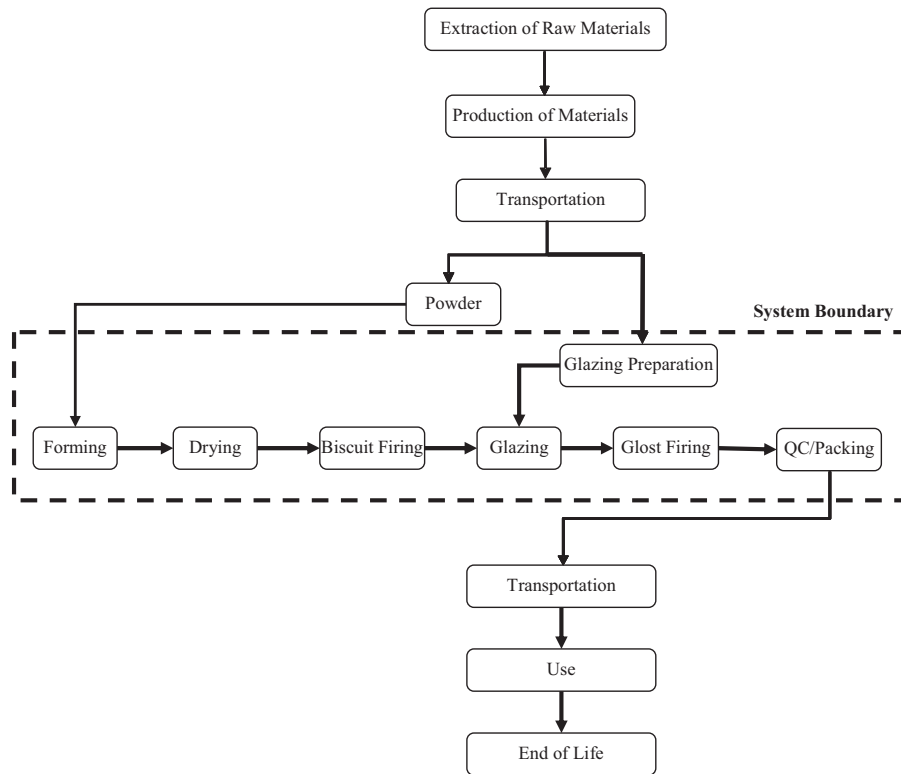


Fig. 1. System boundary.

to the spray dryer where they are converted into soil powder. Soil powder is then shaped into ceramic tiles using a hydraulic machine and conveyed to the dryer for humidity reduction. The tunnel kiln used for this process has the same characteristics as biscuit and glazing kilns, from which it obtains its thermal energy, but has an internal temperature of approximately 100 °C. The residence time in the drying kiln is approximately 28 h, by which time the humidity content of tiles can be reduced to less than 1% percent. Thereafter, tiles are conveyed to the biscuit kiln where they are fired for approximately 38 h at a temperature of 1120 °C. This step further dehydrates the tiles to enhance their ability to absorb glazing. The thermal energy for the biscuit kiln is provided by combustion of liquid propane gas (LPG).

Preparation for the color glazing process begins with the purchase of raw materials from their production sources. The essential materials of glazing are feldspar, color stain, zirconium, certain chemicals and frit, which are mixed in the ball mill in the specified proportions. After biscuit firing, ceramic tiles are transferred via the glazing conveyor to the englobes facility for base glazing, which prevents pinholes from developing on the surface. From here, tiles are conveyed to a second glazing facility, which applies a thicker glaze, and then to a glazing kiln. In this kiln, glazed tiles are fired at 990 °C for approximately 29 h. After completing the firing process, tiles are separated on the basis of quality and size. Ceramic tiles that meet the specified standards are designated Grade A or Grade B and packed in 1 m² paper boxes for distribution to dealers. The remaining tiles are considered damaged products.

2.2. The small plant

Because of size limitations and cost considerations, the small plant does not prepare its own soil powder; instead it purchases finished soil powder from a soil powder production company. After forming the soil powder using a hydraulic machine, tiles are conveyed directly to the biscuit kiln and fired without glazing at a

temperature ranging from 750 to 800 °C. The thermal energy for the biscuit kiln is provided by the combustion of LPG, delivered through a spray valve. A tunnel kiln is used in this kind of plant.

Subsequently, tiles are glazed by englobes and real color, and conveyed to the biscuit kiln for glost firing at 1200 °C. Finished tiles are then inspected by quality control officers. Those tiles that meet the standards are put in 0.5 m² packages, glued without a plastic cover, and then transferred to pallets for transportation to dealers.

3. Goal and scope

To quantify the environmental impact due to ceramic tile production by small and medium enterprises (SMEs) in Thailand with respect to global warming, acidification, eutrophication and ozone depletion. The study was conducted based on the production of glazed ceramic floor pavement tiles to cover 1 m².

Since the production processes of small and medium plants are different, the research excludes the production of powder and focuses on those production processes that are within the scope of small plants to ensure a clear comparison between enterprises. Thus, the scope of this study is limited to a consideration of the stages from forming to packing, as shown in Fig. 1.

4. Methodology

As a case study, two plants located in Bangkok and its surrounding province, one small and one medium, were selected as representative small and medium enterprises. Due to the fact that LCA requires a lot of data, the selection of cases in this research is made based on the capacity of ceramic tile production, ability to provide data, completion of data given by the study sites. In addition, other companies in the ceramic tile industry are also taken into account. The selection of local facilities, which provide convenient access, was dictated by the need for factual, detailed and highly accurate information. Collecting measurements, conducting deep

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