การศึกษาผลกระทบที่มีต่อการยกเลิกการใช้ไครโซไทล์ในประเทศไทย:

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Economic Impact of the Proposed Ban on Chrysotile in Thailand:

Case of Chrysotile Roofing Tiles

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Abstract

Chrysotile is a major ingredient used in the production of high-density cement products such as corrugated sheets, cement flat sheets, vinyl floor tiles, cement pipes and friable materials like thermal insulation. In Thailand, chrysotile is used mainly in the production of high density roofing materials and has been in use for more than 50 years. The use of this type of roofing had been widespread particularly in rural and provincial areas where users have identified the product as cheap, durable, and suitable for utilization in agricultural and industrial purposes, given the peculiarities of Thailand's climate.

On April 12, 2011, the Government of Thailand adopted a proposal to ban the import of chrysotile and the production of chrysotile containing products in Thailand to be substituted with non-chrysotile based alternatives. Although the regulation has not yet been implemented, some producers in Thailand have begun production of substitute, non-chrysotile containing roofing products, despite of ambiguity in the quality and durability of these substitutes as compared to chrysotile containing roofing materials.

This paper studies the potential effects of the proposed ban on chrysotile containing products in the Thai economy with an emphasis on the high density roofing tile sector. Selection of this specific sector was based on its dominance in the range of products currently using chrysotile in Thailand. Specifically, this study estimates the costs of using substitute products as well as replacement costs and durability of non-chrysotile products in the Thai roofing tile industry.

The study found evidence that non-chrysotile roofing tiles have lower quality and durability than chrysotile roofing tiles, and tend to have shorter product life spans, requiring replacement approximately every 2 – 8 years. This difference implies that the cost of substitute materials could be up to ten times higher than chrysotile containing roofing tiles, assuming comparative utilization after 20 years.

In addition, it was found that the proposed ban on chrysotile in this sector would generate a direct impact on manufacturers, employees and consumers (i.e. costs incurred on households, the business sector and the government sector). Indirect impact was found to be minimal. Finally, the induced impact of the proposed ban is significant and reflects replacement costs for substitute products, governmental costs to implement the ban, and possible litigation and compensation costs that could result in the long run.

The study found that the estimated cost to consumers would be approximately 464 billion baht.

The study recommends that it is important for the Thai Government to consider the economic impact from the proposed ban on chrysotile carefully before proceeding, as any ban could lead to large costs to the economy both in the short run and long run. Furthermore, there is a need for the Thai Government to investigate possible evidence of any health dangers as a result of the use of chrysotile in high density roofing material in Thailand and to clarify whether a ban on chrysotile or a safe-use policy is necessary. Finally, in the event that a ban is implemented, there is a need for the Thai Government to support the development of substitute products that are comparable in quality and durability to chrysotile containing roofing tiles so that future economic costs could be minimized.

I. Introduction

Chrysotile is a form of asbestos that is widely utilized as an input into the production of various industrial products. In Thailand, around 90% of chrysotile imports are used in the construction industry as an ingredient in the production of high density cement corrugated sheets (which are well- known for Romantile, Mini Sheets, or fibre cement tiles), cement flat sheets, cement pipes, and other construction products.[1] Chrysotile containing roofing tiles had been widely used in Thailand for more than 50 years, particularly in rural and provincial areas where users have identified the product as cheap, durable, and suitable for utilization in agricultural and industrial purposes (Roofing and Accessories Club, 2011).

Bio-chemically, there are several types of asbestos utilized in industrial production which include the amphibole and serpentine families. According to IARC (1998), the production and utilization of all forms of asbestos has been banned in several countries including New Zealand, Australia and the EU. However, chrysotile, which belongs to the serpentine family, is currently not banned for use in the United States, Canada, Brazil, Russia, India, and many other countries.

In Thailand, the issue of chrysotile import and usage was considered by the Thai Cabinet on April 12, 2011, when the Cabinet approved a proposal to ban chrysotile containing products that can be replaced by substitutes. The proposal to ban the use of chrysotile was put forward by the National Health Commission Office Thailand (NHC, 2011; Prachachart Thurakit, 2011). To date, the regulation has not been implemented in pending for a product by product substitutability review; nevertheless some manufacturers have begun producing substitutes for chrysotile containing roof tiles.

Scientifically, the impact of chrysotile on human health is a matter of controversy and open discussion, both domestically and internationally. Adding to this ambiguity is the fact that no studies have been conducted in Thailand on the potential health hazards associated with the usage of or exposure to chrysotile in high density roof tiles industry for workers or consumers.

Unlike chrysotile, amphibole varieties have been universally confirmed as a dangerous human carcinogen, resulting in its near universal banning. Roof tiles that contain chrysotile (non-amphibole) have been widely used in Thailand for more than five decades, specifically in consumer housing, manufacturing industries, agricultural industries, government installations and buildings such as hospitals, schools, police stations, and public bus stands. To date, there are no indications from national surveillance schemes or employee claims associated with any ill health effects from exposure to or use of chrysotile in this industry.

If a ban on chrysotile is implemented, the use of substitute products (which would be referred to as non-chrysotile containing substitutes) needs to be considered carefully. This is due to the questionability of the quality and durability of non-chrysotile products when compared to those containing chrysotile.

In the roof tile industry, the Thailand Industrial Institute (TIS) has carried out a series of tests comparing high density cement tiles that contain chrysotile with those which do not. According to the strength tested conducted by TIS non-chrysotile roofing tiles (TIS 1407-2540) have significantly less strength than chrysotile containing roofing tiles (TIS 79-2529). TISI (1986) employed the regulated standards for Asbestos Cement Assymentrical Section Corrugated Sheets to have strength not less than 4,250 Newton/meters of sheet with a thickness of 50 ± 3.0 millimeters. However, for non-chrysotile fibre-cement sheets, the strength is not less than 1,500 Newton/ meter for sheets with a thickness of 20-55 millimeters. (TISI, 1997) Thus, it is quite apparent that the strength of non-chrysotile roofing tiles is not comparable to chrysotile containing roofing tiles.

[1] Around 6-8% of Chrysotile is used in the automotive industry as ingredients for producing brakes and clutches, and another 2% in the production of gasket, heat insulation materials, and fire protection clothing. (Chrysotile Information Center, 2011)

In addition, the use of cellulose or pulp material in non-chrysotile products to replace chrysotile could generate long term impact on the durability of the product due to the greater possibility for water absorption which can reduce the product life cycles to last approximately 2-8 years. Moreover, research on the potential dangers associated with other materials and substances that are used with cellulose in the production of non-chrysotile roofing tiles such as Polyethylene, Polyvinyl Chloride (PVC) and Polyvinyl Alcohol (PVA) are still insufficient to identify problems that could result from their use, including possibilities in causing human carcinogen.

Based on the range of ambiguities and questionability that substitute products can in fact adequately replace chrysotile containing products, the proposed ban could create a large impact on the economy in the long run. Thus, it is essential for this study to evaluate the economic impact of the proposed ban on chrysotile in Thailand focusing on the Thai roofing tile industry in order to lend support to the government in implementing an appropriate policy on the use of chrysotile in the future.

Objectives of the study

The research aims to achieve three objectives:

1. To study the social and economic impact that could result from the banning of chrysotile containing high density cement roof tiles on all stakeholders, including manufacturers, employees, consumers, related industries, suppliers, retailers, and other stakeholders;
2. To evaluate the overall economic impact and cost, focusing on the post ban environment for chrysotile containing high density cement roof tiles; and
3. To provide recommendations to all stakeholders in order to assist in implementing effective policies with respect to the future use of chrysotile in Thailand.

Scope of the Study

This study analyzes the impact of a proposed ban on chrysotile in Thailand focusing on the high density cement roofing tile industry that uses chrysotile in its manufacturing process. The analysis incorporates interviews with domestic producers and different groups of consumers of chrysotile containing roofing tiles, along with analysis of secondary data such as price, total sales, and other data. Data on price, total sales, and other secondary data on roofing tiles are provided from the Chrysotile Information Center, the Department of Internal Trade, the Ministry of Commerce, the National Health Commission, the Ministry of Education and other related government sources.

The analysis of the economic impact from a proposed ban on chrysotile incorporates both qualitative analysis from in-depth interviews and quantitative analysis from secondary data collected from different organization and government sources. For qualitative analysis, in-depth interviews were conducted with leading stakeholders identifying their perceptions and viewpoints given the expected policy implications for the industry.

Interviewees are divided into three groups and include roofing tile manufacturers, employees and consumers. Consumers are further divided into households, industries that use chrysotile containing roofing materials such as the swine industry, construction contractors, and other industries that use chrysotile roofing tiles. Additional secondary data includes data for cost estimation in the form of data for different substitute products such as fibre cement and metal sheets, the cost of demolition, the cost of replacement materials, and the cost of installation.

II. Literature Review

Weinstein (2010) and Oxford Economics (2007) have conducted economic impact analyses based on three impact categories. These include direct impact, indirect impact, and induced impact. Direct impact factors include those that are directly affected as a result of a ban, such as manufacturers that use chrysotile, and employees and consumers in the chrysotile roofing tile industry. Indirect impact would include activity supported further down the supply chain in core industries, including suppliers, wholesalers and retail businesses. Dewees & Daniels (1986) and Harrington, Morgenstern, & Nelson, Spring (2000) identified the use of comparative analysis between ex ante estimates and ex post assessment of regulation to identify the overall economic impact of regulation and implementation of suitable compensation to those that are affected. The perception is compiled in the induced impacts analysis which includes activities that could result from the implementation of a ban on chrysotile including abatement costs, litigation costs and other social and economic costs.

III. Methodology

In analyzing the economic impact of the proposed ban on chrysotile in Thailand, information was collected from different stakeholders according to the framework in Weinstein (2010) and Oxford Economics (2007). Stakeholders were defined as:

3.1 Manufacturers, officers and employees in chrysotile roofing tile companies.

- In-depth interviews were held with current company managers at Oran Vanich Co. Ltd. and Diamond Roofing Tile Public Co. Ltd.
- In-depth interviews were conducted with 10 officers and employees that are working in factory environments.

The objectives of the interviews were:

- To collect information about the products, including marketing, substitute materials, production processes, production costs for chrysotile and non-chrysotile roofing tiles, production planning, and management of employees in the event that chrysotile is banned.
- To collect information on the health of officers and employees that could have been exposed to chrysotile and;
- To collect perceptions toward the Thai government's proposal to ban chrysotile's use in the high density cement roof tile industry.

3.2 Consumers and other stakeholders.

- In-depth interviews were conducted with owners and managers of wholesale and retail construction materials in Bangkok, the vicinity, and other provinces (a total of 10 interviews were conducted).
- In-depth interviews were conducted with industries that use chrysotile roofing tiles in their industry
    - Owners and managers of swine farms (5 mega farms and SMEs).
    - Owners and managers of poultry farms (5 mega farms and SMEs).
    - Construction contractors (5 interviews).
    - Producers or managers of housing estates (5 interviews).
    - Owners and managers of other industries that use chrysotile roofing tiles (5 interviews).
    - Households that use chrysotile roofing tiles (5 interviews).

The objectives of the interviews were to collect data on the usage and quality of chrysotile and non-chrysotile containing roofing tiles from the above mentioned stakeholders in order to collect information and record perceptions about the proposed ban on chrysotile, as well as to collect information about substitute products, prices, installation costs, the quality of substitute products and plans for using chrysotile and/or non-chrysotile containing roofing tiles in the future.

3.3 Government and State Enterprises

- In-depth interviews were conducted with government officials related to the design, purchasing, recruitment and construction of public organizations and buildings.
- In-depth interviews were conducted with officers of the National Housing Authority.

The objectives of the interviews was to collect information on the present uses of chrysotile and non-chrysotile containing roofing tiles and plans for using chrysotile and/or non-chrysotile containing roofing tiles in the future.

In addition, the study analyzed the costs for consumers to change to substitute products, including the additional cost of demolition of old roofing, the cost of materials for new roofing, and the cost of reconstruction of roofing by conducting cost estimates based on the assumption that substitute products have a durability and product life cycle of approximately 2-8 years.

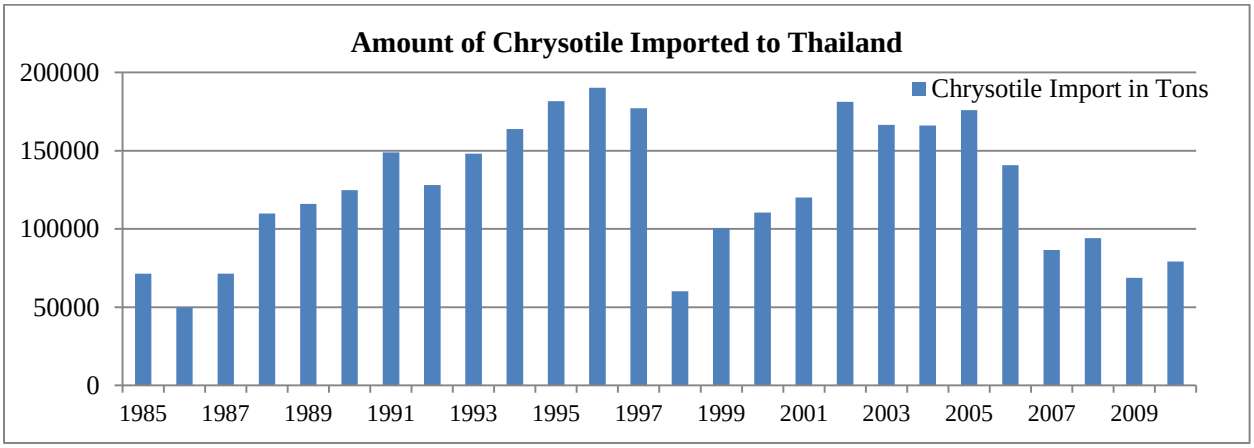
IV. Research Outline

In order to identify the expected impact of the ban, an overview of the chrysotile roofing tile industry, its market perspective, and the production and usage during the past decade has been analyzed. The analysis on direct, indirect, and induced impacts is contained in sections 4.2, 4.3, and 4.4.

4.1 Overview of the Chrysotile Containing Roofing Industry in Thailand

Considering the total market size, the amount of the chrysotile imported into Thailand over the past 25 years is just over 3.2 million tons, covering the period from 1985 to 2010 (Figure 1). From this, 90% of the chrysotile imported has been used in the production of chrysotile containing high density cement by the roof tile industry. This amount represents the production of over 2.3 billion square meters of chrysotile roofing tiles.[2]

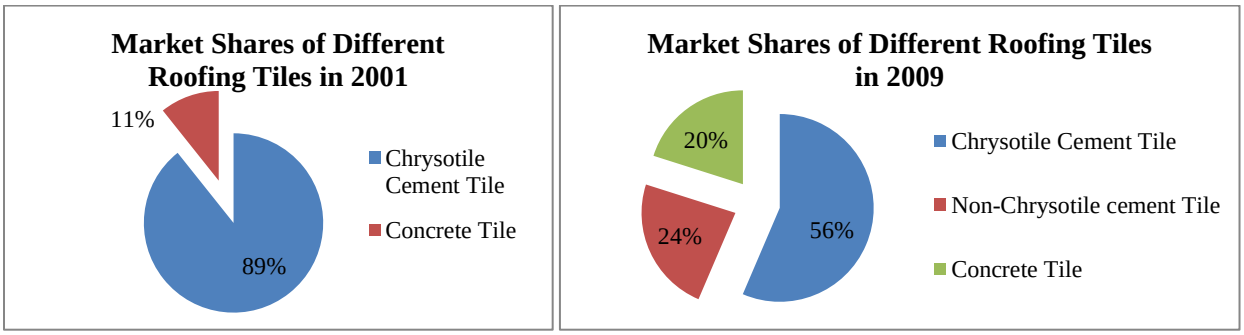
Figure 1 Amount of Chrysotile Import to Thailand from 1985 to 2010



Source: Thai Customs Departments, Import and Export Statistics; Virta (2006)

The high density cement chrysotile containing roof tile industry has existed in Thailand for more than 50 years with a total market value in 2010 of over 10.4 billion baht or around 0.2% of GDP[3]. As compared to the production of other roofing materials, this represents over 50% of the market share in the roofing tile industry as seen in Figure 2.[4]

Figure 2 Market Shares of Different Types of Roofing Tiles in 2001 and 2009



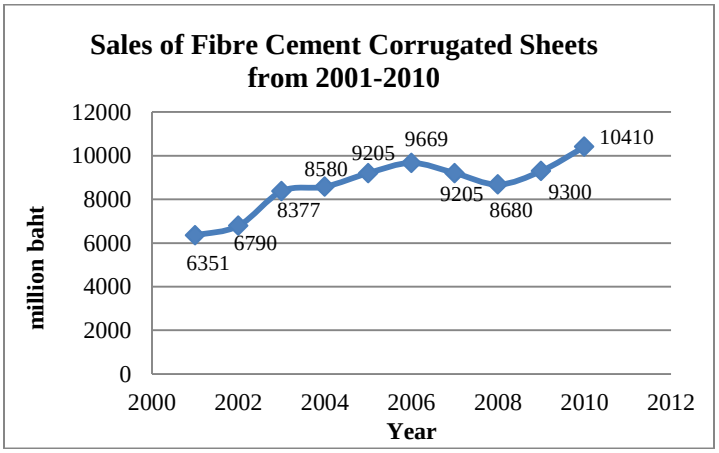
Source: Chrysotile Information Center, 2011

[2] Total chrysotile roofing tiles from 1985-2010 is calculated by taking 90% of total import of chrysotile and converting that into the total number of square meters whereby 1.2276 kilogram of chrysotile is used to produce one square meter of roofing tiles.

[3] The Ministry of Industry of Thailand termed the product, Asbestos Cement Assymentrical Section Corrugated Sheets. Calculated from total sales of Chrysotile Cement Tiles from Chrysotile Information Center in 2010 and GDP from Bank of Thailand.

[4] Information for 2001 and 2009 are provided to show changes in the demand of roofing tiles market where in 2007, Non-Chrysotile Cement tiles were first introduced into the market. Data of 2010 are estimated figures so data of 2009 is used instead.

Figure 3 Sales Value of Roofing Tile Industry in Thailand

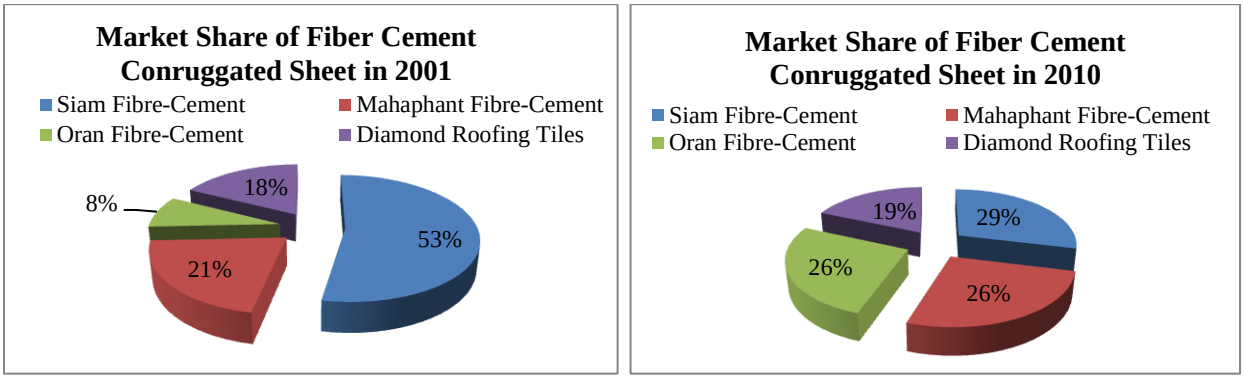


Note: Includes only sales of Chrysotile and Non-chrysotile Roofing
Data of 2010 are estimated sales.
Source: Adapted from data of Chrysotile Information Center, 2011

Chrysotile and non-chrysotile cement sheets are known as high density fibre cement corrugated sheets which have similar features and usage. Sales of fibre cement corrugated sheets have been increasing steadily with an annual growth rate of approximately 5-6% per year. Figure 3 provides an overview of sales during the past 10 years from 2001-2010.

The fibre cement corrugated sheet industry at present is dominated by four major companies and includes, Siam Cement Public Co., Ltd (SCG), Mahaphant Fibre-Cement Co., Ltd. (MFC), Oran Vanich Co. Ltd, and Diamond Building Products Public Co., Ltd.

Figure 4 Market Share of Fibre Cement Corrugated Sheet in 2001 and 2010



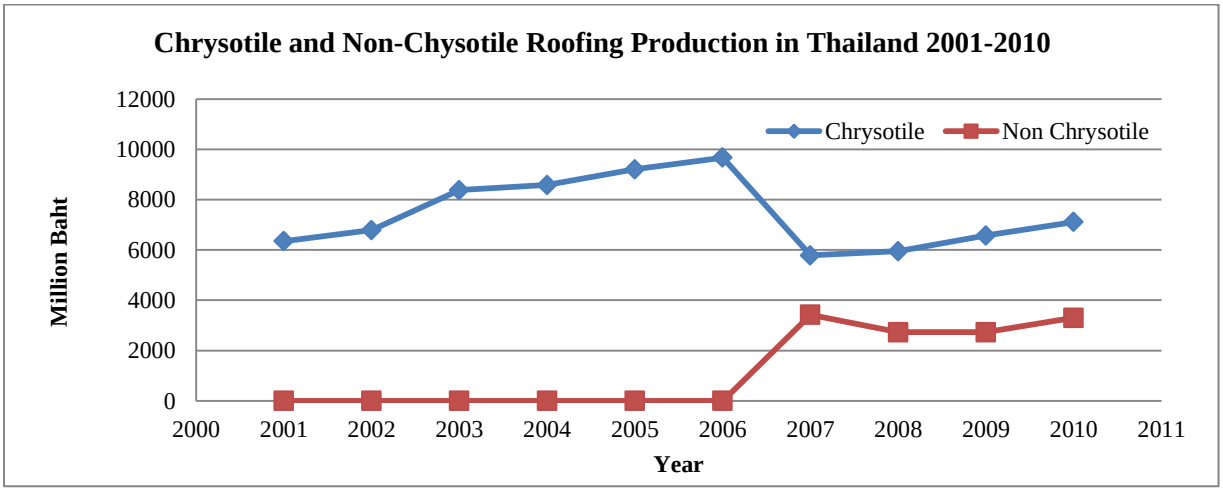
Source: Adapted from data of Chrysotile Information Center

Within the industry, Siam Fiber-Cement (SCG) used to hold the largest market share with over 50%. However, SCG's market share has recently been taken over by other producers and today represents around 30% of the market. Figure 4 provides a pie chart of the producer's market share in 2001 and 2010 respectively.

In 2001, all sales of high density fibre cement roofing tiles products were made using chrysotile. Beginning in 2007 some producers started to produce non-chrysotile containing products. By 2010, the production of chrysotile products in Thailand reduced significantly due principally to the shift away in production by two producers to non-chrysotile containing products. Figure 5 shows the trend of chrysotile and non-chrysotile roofing tile sales from 2001 to 2010.

As most housing structures in the past were made from wood, the most suitable roofing material for that structure needs to be light such as chrysotile containing roofing tiles. Moreover, construction work with this type of product is not complicated. This makes it popular among construction workers. Chrysotile containing roof products are known to withstand heat and be strong when combined with cement, light in weight but large in size, rendering the product particularly attractive to middle to low income consumers to utilize it in their work building, houses and among other industries.

Figure 5 Sales Value of Chrysotile and Non-chrysotile Roofing in Thailand 2001-2010



Source: Adapted from data of Chrysotile Information Center

Chrysotile containing roofing tiles are produced from Portland cement combined with chrysotile fiber. The production process used to make chrysotile roofing tile products makes use of the wet and closed process. The most important part of the production process is the mixture of ingredients that serve to strengthen the bonding of the cement in the roofing materials, making the final product strong, safe, and locking in the chrysotile fibers, such that their dispersion into the atmosphere when utilizing the product is minimal. This conclusion was supported by findings of the United States-Environmental Protection Agency. (FTI, 2007)

The Department of Civil Engineering (2011), Faculty of Engineering, Kasetsart University has recently performed a test on chrysotile and non-chrysotile containing roof tiles and compared the differences in the quality between the two products. Test results showed that:

1) *Non-chrysotile roofing materials have lower breakage resistance than chrysotile roofing products by a factor of three times.*
2) *Non-chrysotile roofing tiles, over time showed leakage at the bottom surface while chrysotile containing products exhibited no leakage.*
3) *The durability to heat and rain of chrysotile containing roofing tiles is higher than non-chrysotile roofing tiles. When exposed to heat and rain at the same time, non-chrysotile roofing tiles generate several cracks at random points while chrysotile containing roofing tiles showed no cracks.*

Among the differences found between non-chrysotile and chrysotile roofing tiles is the relatively low quality and durability of non-chrysotile tiles. Additionally, because non-chrysotile roofing tiles are made from cellulose fibre, they have the added quality of absorbing and withholding water which leads to questions about product durability when faced with heavy rain. Although non-chrysotile roofing tiles are widely used in European countries, the utilization of this product in tropical and humid regions like Thailand, especially in the southern areas with frequent rain and high humidity, implies that the lifetime usage of non-chrysotile roofing tiles could be only 2-8 years.

Moreover, from interviews conducted with construction contractors, some commented that the replacement of non-chrysotile roofing tiles is also difficult as worn-out tiles make re-construction work complicated and dangerous. As a result, construction workers might reject the work for future replacement or altering of such roofing materials.

At present, it was found that some producers utilize color coating to coat the top surface of the sheets to prolong the lifetime of the product. Still, this would make the product's life time dependent on the durability of the color coating. Apart from the non-chrysotile product, Kitikarnjonruk & Juntakhet (2010) analyzed the difference in pricing and features of different materials in terms of roofing products including metal sheets, concrete tiles, and chrysotile roofing tiles. These are other types of roofing materials that could be used as substitutes; however, the prices of these materials are much higher, especially for metal sheets. Table 1 provides the details of the differences between different types of roofing materials.

Table 1 Comparative Price and Unit Use of different Roofing Material

	Metal Sheet Color Coated	**Concrete Tile Monier**	**Chrysotile Tile**
Utilization per sq. m.	0.79 pieces	10.7 pieces	2.2 pieces
Weight	6.3 kilogram	44.94 kilogram	13.64 kilogram
Color	Standard Color (Red)	Standard Color (Red)	Cement Color
Price per unit	490	11	48
Price per sq. m. (baht)	387.10	117.70	105.6

Source: Kitikarnjonruk & Juntakhet (2010)

Thus, a ban on chrysotile that includes chrysotile containing high density roof tiles might not be implementable immediately as there is a need for the government and/ the private sector to develop a comparable substitute that has equivalent quality and price characteristics.

4.2 Direct Impacts from a Ban on Chrysotile

The analysis of the direct impacts from the proposed ban on chrysotile is divided into three parts which include the impact on manufacturers in the roofing tile industry, the impact on employees in the roofing tile industry, and the impact on consumers including households, business sectors, and government sectors.

4.2.1 Impact on Manufacturers of Chrysotile Containing Roofing Tiles

Based on interviews with several producers, conversion to non-chrysotile production would require an additional investment of 30 million baht per line of newly installed production. Among the existing producers, each producer has several lines of production ranging in the capacity from 5 to 10 lines of production per product type. Nevertheless, most producers expressed their willingness to stop current production and change to non-chrysotile production even though it would require a large capital investment. However, some producers were not sure of the quality of substitute products, particularly the quality and durability when compared to chrysotile containing products. In addition, the higher cost of production for substitute products could cause the price of the non-chrysotile roofing tiles to be higher. All these factors affect manufacturers in their decision to adopt and adapt to the production of a non-chrysotile product line. These factors are further compounded by the fact that after a certain period of time, if substitute products wear out, producers might be responsible for compensation costs to replace inferior material as well as the loss of consumer loyalties that could result from problems with the non-chrysotile roofing tiles.

The banning of chrysotile containing roofing products would generate a direct impact for manufacturers based on the large sunk costs and substantial incremental cost. Sunk costs arise from the fixed cost such as machines and equipment dedicated solely to the use of chrysotile containing roofing tile production lines. Incremental costs represent additional costs necessary to purchase new technology and equipment in order to produce non-

chrysotile roofing tiles. To consider the possible sunk cost, the value of the opportunity cost for using the capital equipment in the future periods would be calculated as the sunk cost instead.[5]

For incremental costs, twenty-five existing productions lines[6] of chrysotile roofing tiles would be replaced by non-chrysotile lines, requiring a total investment of approximately 750 million baht. Prachachart Thurakit (2011) noted that one of the manufacturers, Mahaphant Fibre-Cement Co., Ltd. (MFC), has already invested 100 million baht to change their chrysotile production to non-chrysotile production. An up-front investment in new machinery does not mean that manufacturers could produce a substitute product that has equal or higher quality than chrysotile containing products.

Moreover, this cost does not include possible hidden costs from research and development in creating substitutes that would have equal or better quality, durability, life time, and prices that are comparable to chrysotile containing roofing tiles. Table 2 provides cost estimates for new machinery to transform chrysotile lines into non-chrysotile containing production facilities.

Table 2 Cost Estimation of New Capital Investment

No. of New Production Lines	Cost of Capital and Technology/Line	Total Cost for Whole Industry
25	30,000,000	750,000,000

Source: Author's estimation with respect to interviews conducted with manufacturers.

In addition to the cost of machinery and equipment, producers need to also consider the cost of training staff and labor, including the knowledge and ability to operate new machinery in producing non-chrysotile containing roof tiles. This includes the need to recruit additional technicians and train staff for problems emerging from the use of new machinery. Thus, the cost of training staff and labor would become an incremental cost which would contribute to higher production costs for manufacturers during the early transitioning phase to non-chrysotile production.

The incremental cost from the machinery and labor training will influence the overall production cost to be higher in the short run after banning chrysotile. At present, there are some producers of non-chrysotile containing roof tiles that set the price of non-chrysotile roof tile close to chrysotile roof tiles due to marketing reasons which the pricing does not reflect the real cost of the non-chrysotile roof tiles. This is only possible in the short run and prices of non-chrysotile roof tiles would gradually increase in the near future to reflect the real cost from production.

4.2.2 Impact on Staff and Labor Working in Chrysotile Roofing Tile Companies

Based on interviews with staff and labor, different perception was found from different manufacturers about how each company would deal with their employees if the Thai government implements the ban on chrysotile in high density fibre cement roof tile manufacture. According to the interviews, some manufactures indicated they would close down the entire chrysotile production line and would not produce non-chrysotile containing roof tiles because they felt that substitute products are not comparable. These manufacturers claim they would therefore be liable with respect to the inferior performance of substitute products.

[5] In the analysis of sunk cost, by considering the cost of machinery and equipment together with the condition of the machinery at present (after over 20 years of utilization in many manufacturers), the depreciation cost could be zero.

[6] From interviews with producers of chrysotilecontaining roofing tiles, it could be approximated that there are around 25 production lines operating in 2010.

Reviewing the results from different manufacturers, some part of the labor force might be transferred to the production of other types of roofing tile products in the company, while others might have to be laid off. Among these, approximately 4,000-5,000 workers that are presently employed in the production of chrysotile roofing tiles could be laid off. Based on interviews with staff and labor employed at high density cement chrysotile roof tile factories, it was found that all employees have annual health checks with a specific focus on respiratory and lung tests which are in accordance with regulations from the National Health Commission. Results found that in one of the manufacturers' factory, most of the staff and labor had been working in the company for more than 10 years[7]. None of the laborers reported any health problems with respect to respiratory and lung diseases which has traditionally been the claims against the production and/or usage of asbestos containing products, including those containing only chrysotile.

When asked about employee perception on the issue of potentially banning the use of chrysotile, all employees interviewed were aware of the issue. However, all said that the production process that utilizes chrysotile in making roofing tiles incorporated the use of the wet process, which is safe and should not generate any impact. From interviews with two companies, both utilize waste water treatment and water recycling systems which minimize the opportunity for chrysotile and other waste materials to be exposed in the external environment.

4.2.3 Impact on Consumers Using Chrysotile Containing Roof Tiles

For consumers, analysis has been categorized into the impact on different groups of consumers, including households, business sectors and government sectors. The analysis takes into consideration the possible replacement costs and future costs for each group. Considering the overall market size, the total amount of the chrysotile imported over the past 20 years has been reviewed. According to Figure 1, of the total amount of chrysotile imported to Thailand from 1985 to 2010, 90% was used in the production of chrysotile containing roofing tiles. Therefore if chrysotile containing roofs are banned in Thailand, existing chrysotile roofing tiles would need to be replaced. Based on the usage of chrysotile over the last 15 years[8], the total production of chrysotile roofing tiles would cover 1.4 billion square meters, which would cost approximately 365 billion baht for replacement with either chrysotile or non-chrysotile roofing tiles[9].

Table 3 provides different replacement costs for non-chrysotile roofing tiles based on different years of durability. The differences in durability range from 2-8 years as compiled from interviews. For the replacement of 1.4 billion square meters of roofing tiles over the next 15 years[10], the total expense would be approximately 2.741 trillion baht if non-chrysotile roofing tiles last only 2 years. In the case that non-chrysotile roofing tiles last up to 8 years, the cost would be 685 billion baht for replacement over 15 years.

[7] From the interview, some staffs informed that they had been working in the company for more than 15 years and never had any big health problem especially respiratory problems. For those who have some health problems are from other illness with respect to aging which are not related to the cause of lung cancer.

[8] The product life cycle of high density cement hrysotile roofing tiles is approximately 15 to 30 years according to interviews with different group of consumers ie. households, swine industries, construction contractors, wholesale and retail shops. A few mentioned that they had never changed the roofing since they started business.

[9] Calculation of the total amount of chrysotile was compiled from the total import of chrysotile over the past 15 years, where 90% of the imports were utilized to produce high density cement chrysotile containing roofing tiles. In the production of chrysotile roofing tiles, 1 square metere of roofing tiles weighs 13.64 kilogram. Of this approximately 1.22 kilos or 9% is made of chrysotile. The cost of replacement is 260 baht per square meter which includes 60 baht for 2 pieces of roofing tile per square meter and 200 baht of construction cost per square meter. Information on the weight and size are from Kitikarnjonruk & Juntakhet (2010).

[10] Assuming that Chrysotile roofing tiles could last 15 to 30 years, the table provides the different scenarios of durability of Chrysotile from 15-30 years as oppose to the durability of non-chrysotile roofing tiles from 2-8 years. The information on the durability of non-chrysotile roofing tiles was according to the data from interview with past users and retail shops that have experience with non-chrysotile roofing tiles.

Table 3 Cost Scenarios for Replacement of non-chrysotile versus chrysotile containing Roof tiles

		Chrysotile Roofing Cost	Non-Chrysotile Roofing Cost of Different Years of Durability						
			2 years	3 years	4 years	5 years	6 years	7 years	8 years
Chrysotile Roofing Cost of Different Years of Durability	15	365.59	2741.95	1827.96	1370.97	1096.78	913.98	783.41	685.49
	20	365.59	3655.93	2437.29	1827.96	1462.37	1218.64	1044.55	913.98
	25	365.59	4569.91	3046.61	2284.95	1827.96	1523.30	1305.69	1142.48
	30	365.59	5483.89	3655.93	2741.95	2193.56	1827.96	1566.83	1370.97

Note: Values are in billions of baht. The cost of roofing tiles is based upon the total imports of chrysotile from 1996-2010 which could produce 1.4 billion square meters of chrysotile roofing tiles. The cost of replacement is calculated from the price of chrysotile and non-chrysotile roofing tiles at 260 baht per square meter. The replacement cost of 260 baht includes 60 baht for 2 pieces of roofing tile per square meter and 200 baht of construction cost per square meter.
Sources: Authors calculation based on data from the Thai Customs Departments, Import and Export Statistics; Virta (2006)

The following analysis shows the impact on different groups of consumers including households, the business sector (as represented solely by the swine industry), and the government sector (as represented solely by the impact on the schools and hospitals).

1. Households

Based on interviews with households, the study found that chrysotile containing roof tiles are a popular material for middle to low income people especially in simple houses built by provincial contractors, and for roofing of cattle sheds, stables, and farm warehouses. These consumers are highly price sensitive and tend to choose materials that are cheap and durable which optimize expenses. Based on interviews with retailers of construction materials in different provinces, some provided information indicating that more than half of the sales in the roofing tile market are sales of 4 millimeter chrysotile containing roof tiles. Retailers commented that this is because chrysotile containing roof tiles are cheap and their use is not limited among households but includes several small-medium sized farms as well.

An important perception from the household segment regarding the proposed ban of chrysotile products was on the suitability of substitute products. Many households perceived that substitution is only possible if substitute has comparable or better quality and durability, with prices that are not higher than chrysotile containing products. Nevertheless, consumers do not have much information on the differences between the two products especially the quality of substitute products as the use of non-chrysotile products in the market has existed for less than 5 years. Thus, many households perceived that the government should be responsible for providing information and knowledge on the quality differences between chrysotile and non-chrysotile containing roofing tile products.

Table 4 Number of Households in Thailand in 2010

	No. of Households	No. of Provinces
Bangkok	2,400,540	1
Central	5,147,160	22
Eastern	1,896,447	7
Northern	2,279,471	9
Northeastern	5,939,879	19
Southern	2,911,245	14
Western	1,106,893	5
Total	21,681,635	77

Source: Department of Provincial Administration (2011)

The Bureau of Housing Strategy and Information, Department of Housing Development, National Housing Authority has surveyed the number of population and housing throughout Thailand. It was found that in 2010 the total number of households in Thailand is 21,681,635 houses as shown in Table 4 which provides the number of household in each region of Thailand.

Assuming that each household takes an average size of 100 square meters and approximately 80%[11] of total household uses chrysotile contain roofing tiles, the total area of chrysotile containing roof tiles in the market should be approximately 1.73 billion square meters.

With respect to the proposed ban on chrysotile, the cost of replacement for all households including the cost of material replacement, the cost of demolition and reconstruction costs need to be considered. From interviews with retailers of construction material, demolition costs average 100 baht per square meter, the cost of replacement material assuming the same price as chrysotile roofing tile at 60 baht per square meter, while the installation cost is 100 baht per square meter. This would therefore make the replacement cost of substitute products on household to be approximately 450 billion baht. Furthermore, if the material is durable for only 2-8 years, another 450 billion would be needed every 2-8 years. Table 5 provides a summary of the cost estimation for the replacement cost for households.

Table 5 Cost Estimation of the Replacement Cost

No. of Households	Area (Million sq. m.)	Cost of Substitute (Million Baht)	Cost of Replacement After every 2 - 8 years (Million Baht)
17,345,308	1,734.53	450,978.01	450,978.01

Source: Author's calculation based on data of Department of Provincial Administration (2011)

2. Swine Farm Industries

The proposed ban on chrysotile products has a resultant impact on industries that utilize chrysotile containing roof tiles including factories and farms such as swine, poultry, and agricultural product farms. From interviews conducted with different industries, it was found that one of the industries that exhibit a large impact from the proposed ban is the swine industry. In the business sector analysis, the study takes the swine industry as an industry case study in estimating costs from the proposed ban of chrysotile containing high density cement roof tiles.

Commercial swine farming is one of the industries that rely on chrysotile containing roofing products. Since pigs have to live in-doors, there is a need to build enclosed pig pens or swine houses. On average, the size of

[11] 80% of chrysotile containing roof tiles is referred from Figure 2 which provides the market share of chrysotile containing roof tiles in Thailand. On average from 2001 to 2010, chrysotile containing roof tiles represents around 80% of the total roofing tiles sales. (Chrysotile Information Center, 2011)

swine houses is approximately 1,000 square meters, in order to contain 400-500 pigs. Chrysotile containing roof tiles are relied upon in this industry due to their cheap price, durability, and long lifetime usage. Moreover, chrysotile does not react to substances such as methane gases that are an unavoidable bi-product from animal waste.

Based on the data surveyed by the Bureau of Livestock Standards and Certification in March 2011, there are a total of approximately 5 million pigs with approximately 10,185 swine houses for all types of pigs in farms countrywide. Details on the current amount of swine products are shown in Table 6. Swine farms can be categorized into four sizes; small (less than 50 pigs), medium (50-500 pigs), large (501-5,000 pigs), and mega farms (more than 5,000 pigs). Although chrysotile containing roof tiles are utilized in most swine houses, different producers seem to have different policies for future plans on building swine houses.

Table 6: Current Amount of Swine Products

Region	Area	Farms (Units)	Swine					Swine Housing (Units)
			Female Breeder	Male Breeder	Fattening Pigs	Piglets	Total	
1	Central Region	404	67,346	2,632	599,127	93,113	761,714	1,523
2	Eastern	594	109,986	3,419	550,693	9,780	808,332	1,617
3	North-Eastern	410	52,323	1,130	351,887	23,727	465,891	932
4	North-Eastern 2	543	28,881	4,603	255,266	10,658	298,073	596
5	Northern 1	463	45,719	1,750	607,117	237,750	815,005	1630
6	Northern 2	342	30,721	1,395	232,417	2,650	295,173	590
7	Central-South	301	142,333	9,817	791,974	95,587	1,271,911	2,544
8	South 1	361	25,904	669	190,181	17,455	2,378,46	476
9	South 2	122	15,983	910	116,301	3,496	138,393	277
	Total	3540	519,196	26,325	3,694,963	494,216	5,092,338	10,185

Source: Bureau of Livestock Standards and Certification, March 2011

Based on interviews with swine farm owners, most of them, especially small, medium and large farms, are satisfied with the use of chrysotile containing roof tiles in terms of functionality, durability, and especially cost. As a result, these producers tend not to consider other types of roofing materials. In contrast, the mega-size farms are currently searching for other appropriate substitute products. As the size of investment is larger, roofing costs for mega farms represent only a small portion of their total cost when compared to smaller size farms. Thus, several mega farms have shifted to metal sheets with foam-foil installation instead of chrysotile containing roof tiles. Even though the total cost is more expensive, metal sheet roofing is preferred by mega farms in terms of its flexible shape which could be pressed into large sheets that do not generate leakage between pieces and most importantly to make the image of the mega farm more modern.

Although metal sheets are more expensive than chrysotile and non-chrysotile containing roof products, the cost of the structure is less, making the overall price between metal sheet and chrysotile containing roof tiles to be comparable when large farms are build. In addition, it was found that construction contractors tend to charge a higher price for metal sheets for SME farms than the price of chrysotile and non-chrysotile containing roof tiles due to smaller purchase amounts. Nevertheless, the use of metal sheets could also generate very loud noise when it rains and be quite hot during the day. Thus, most producers need to install foam-foil beneath the roofing which would create additional cost of 70-100 baht per square meter but could reduce the noise, heat and possibility of leakage.

Apart from the differences in the quality between the metal sheets and chrysotile containing roof tiles, the durability of metal sheets is questionable. Although the normal product life cycle of metal sheets could be more than 10 years, use in the swine farm industry where exposure to methane gas from swine manure is typical, may generate reactions which cause durability and lifetime of the metal sheet to be reduced. Still, as the metal sheet has been used in this industry for less than 3-4 years, it is hard to identify whether metal sheets are better than chrysotile containing roof tiles. Assuming the durability of metal sheet roofs is approximately 5 - 10 years, the replacement cost incurred on the producer could increase which could affect farm owners to re-consider the use of the chrysotile containing roof tiles.

In the analysis of the cost incurred on producers, the analysis could consider the scenario whereby producers are expecting to expand their business by building new swine houses. Additional consideration is also needed therefore for the removal of chrysotile containing roof tiles and replacement with non-chrysotile containing roof tiles if chrysotile is banned. The cost analysis scenario would consider the situation in the swine industry where mega firms would adopt metal sheet for roofing and SME's would adopt non-chrysotile roofing tiles.[12]

The Swine Manufacturing and Processing for Export Association (2000) studied that the amount of pigs produced by large farms is approximately 60% of the pork market where the NESDB in 2000 had studied that the rate of growth of the swine industry has increased on average 2.5% per year. With respect to the amount of swine houses in 2010 which is approximately 10,185 units and the growth rate of the industrythere should be an increase of approximately 205 new swine houses in 2011.

Considering that 60% are large farms, it was found that there should be around 123 new swine houses from Mega farm expansion that would utilize metal sheets while the other 82 farms within SME farms would be expected to use either chrysotile or non-chrysotile containing roof tiles. Thus, if there is a ban on chrysotile, the economic impact on the cost of company expansion and replacement cost would total over 355 million baht in 10 years' time or an increase of 252 million baht if substitute products are used for replacement.

From the cost estimation in Table 7, the cost of utilizing substitute products to replace chrysotile roofing tiles in both Mega farms and SME's total approximately 252 million baht considering 10 years of utilization, and replacement of the material every 5 years. The cost of utilizing substitute products has been estimated to be approximately 3 times higher than that of the cost of chrysotile. Moreover, there is the cost of removing the chrysotile roofing tiles and replacement with non-chrysotile roofing tiles. As the existing farms that use chrysotile containing roofing tiles could use the same structure of the roofing for the non-chrysotile roofing, both large and SME farms would change to non-chrysotile roofing to reduce additional cost on the structure.

[12] From the interviews, it was found that most SME farms are willing to use any type of substitute i.e. chrysotile or non-chrysotile if chrysotile is banned from Thailand. On the other hand, mega farms have a higher tendency to change to metal sheet roofing.

Table 7: Estimated Cost Comparison between Chrysotile and Metal Sheet Farms in 2012

New swine houses			Cost of		Replacement cost after		Discrepancy (In 10 years period)
Farms	Units	Area (sq.m)	Chrysotile roof	Substitute roof	5 years	10 years	
Mega*	123	123,000	61,500,000	107,010,000	82,410,000	82,410,000	210,330,000
SMEs**	82	82,000	41,000,000	41,000,000	21,320,000	21,320,000	42,640,000
				148,010,000	207,460,000		
Total			102,500,000	355,470,000			252,970,000

* Metal sheet

** Non-chrysotile tiles

** Metal sheet@.35mm =200 Baht/sq.m (Sheet only); Foam-foil=100 Baht/sq.m ; installation=300 Baht/sq.m; structure=300 Baht/sq.m Total= 870 Baht/sq.m; Replacement cost=570 Baht/sq.m (Cost of structure is excluded);

*** Chrysotile & Non Chrysotile Roofing Tile@4.5mm =60 Baht/sq.m; installation = 100 Baht/sq.m; structure = 340 Baht/sq.m; Replacement cost = 260 Baht/ sq.m (Cost of structure is excluded)

Source: Author's calculation based on data from interview with Swine Industries

In this study, the cost to the swine industry considers only the change to non-chrysotile roofing. In this case, the cost of removal and replacement of existing chrysotile containing roofing tiles for the swine industry would total approximately 2.6 billion baht as shown the Table 8.

Table 8 Cost in Removal and Replacement of Non-Chrysotile Roofing Tiles in the Swine Industry

Number of Swine Houses	Area (sq. m.)	Removal and Replacement Cost
10,185	10,185,000	2,648,100,000

Note: Cost in removal and replacement of material is calculated to be 260 baht / sq.m.

3. Schools

The Government sector exhibits a direct resultant impact from the proposed ban on chrysotile and non-chrysotile containing roof products in Thailand. This includes schools, hospitals, and houses constructed by the National Housing Authority that are currently and/or previously using chrysotile containing roof tiles. The proposed ban on chrysotile would affect the government's choice of substitute products especially the change from chrysotile containing roof tiles to using other substitute products. Thus, it is the responsibility of the government to make arrangement for the removal and replacement of substitute products for all the public offices which requires a large amount of budgetary funds in order to undertake demolition, deconstruction and renovation of buildings that have chrysotile containing roof materials (public offices i.e. government office buildings, public institutions, schools, public utilities, bus stops, and etc.).

Table 9 Estimated Replacement Cost of Chrysotile Roofing Tiles for Schools in Thailand

No. of Students	No. of Schools		Total	buildings	No. of Buildings	Roofing Area
	Central	BKK	(Units)	(Classroom: Area)		(sq m.)
1-120	12,600		12,600	8 : 669	1	8,429,400
121 – 200	7,397		7,397	8 : 669	1	4,948,593
201 – 300	4,600		4,600	8 : 669	1	3,077,400
301 – 499	3,959	109	4,068	16/18: 703	1	2,859,804
500 – 1,499	2,755	151	2,906	16/18: 703	2	6,128,754
1,500 – 2,499	441	173	614	16/18: 703	5	2,158,210
2,500 – 15,000	255		255	16/18: 703	8	1,434,120
Total roofing area						29,036,281
Replacement cost (260 baht/m^2)						7,549,433,060

Source: Office of the Basic Education Commission Department Operation Center
Bangkok Metropolitan Administration

Note: Categorization of the size of the school is different between the two organizations. For the Bangkok Metropolitan Administration, the schools are categorized into 3 sizes; less than 400, 401-800 and more than 800 students

For public schools, chrysotile containing roof tiles is a material selected as the standard specification under the official designs of most public school building types.[13] Computations of the replacement costs in the schools are based on the average area of all building designs while the numbers of buildings in each school are estimated from the number of students with respect to information from the Ministry of Education. This study covers analysis of the schools under the supervision of the Office of Basic Education Commission (OBEC), the Ministry of Education and those under Bangkok Metropolitan Administration only. Private schools and other school types are not included in this study due to information limitations. With respect to this, the cost of removal has not been included in the calculation due to the differences in the style of the building as shown in Table 9. Thus, the cost of changing chrysotile containing roofing tiles into non-chrysotile roofing tiles would be a total of more than 7.5 billion baht.

4. Public Hospitals

Replacement estimation for hospital roofing is more complicated than schools since many buildings and operating units are required for one hospital such as OPD, IPD, ER, pharmaceutical units, kitchen, laundry, and other service areas. Moreover, unlike schools, there are no standard designs for hospital buildings. The working and roofing area of each hospital is therefore different. In addition, hospitals under the supervision of the Ministry of Public Health could be categorized based on the number of in-patient cases that could be admitted per night. Hence, hospitals could be categorized into regional hospitals, general hospitals, and community hospitals with 10, 30, 60, 90 and 150 beds. The area of the hospitals varies from at least 1,500 to 50,000 square meters. In addition, there are more than 9,000 health centers and community health centers

[13] There are a couple of official designs of school building such as Design 108 for eight classrooms, Design 318/30 (three stories) for eighteen classrooms, Design 216-2529 for sixteen classrooms, Design 318l/30 (Four stories) for eighteen classrooms, 324l (Four stories) for twenty-fours classrooms and so on. The roofing areas of all designs are slightly different as they vary from 598.5 sq m. to 832 sq. m (ie. 669, 589.5, 832, 589.5, and 667 sq m., respectively).

located countrywide. Since chrysotile containing roofing tiles is specified by the government as a standard material to build government buildings, and if chrysotile is banned, the Thai Government would need to allocate a large amount of budgetary funds to replace the roofing materials for all hospitals.

The approximate cost of the replacement is estimated based on the lowest possible cost. For health centers and community health centers, the minimum area requirement is set at 150 square meters while the functional area of a community hospital is different depending on the size of the hospital which can range from 1,500 to 9,000 square meters. This study uses small-sized hospitals or 60 bed-hospitals with an area of 5,266 square meters. According to the study of the Design and Construction Division under the Ministry of Public Health (2007), most hospitals are large, having several buildings and operational units whereby size ranges from 50,000 square meters for general hospital to 100,000 square meters for regional hospitals. From the cost calculation, the Thai government would have to allocate a total of more than 2.9 billion baht to pay for the replacement of the chrysotile containing roof materials for hospitals of different sizes country wide. Table 10 shows the estimation of replacement cost for different hospitals by type.

As the durability of substitute products i.e. non-chrysotile roofing tiles is limited, the replacement cost for both schools and hospitals must be paid periodically every 5 to 10 years depending on the durability of the substitute product. On the other hand, the replacement cost would be higher if other substitute products (i.e. metal sheets) are selected.

Table 10 Estimated Replacement Cost of Roofing Tiles for Hospitals in Thailand

Type of Hospital	Number	Approximated area (sq m.)		Replacement cost (Baht)
		Per hospital	Total	
Regional Hospital	25	100,000	2,500,000	650,000,000
General Hospital	70	50,000	3,500,000	910,000,000
Community Hospital	723	5,266	3,807,318	989,902,680
Health Center	9,758	150	1,463,700	380,562,000
Community Health Center	105	150	15,750	4,095,000
Total				2,934,559,680

Source: Office of Permanent Secretary, Ministry of Public Health
Design and Construction Division, Ministry of Public Health

Note: Cost in removal and replacement of the Non-chrysotile Roofing Tiles is 260 baht/sq.m.

4.3 Indirect Impact from the Ban of Chrysotile

The proposed ban on chrysotile results in an indirect impact on suppliers, wholesalers, and retailers of chrysotile containing products and is analyzed as follows.

4.3.1 Suppliers of Inputs to Chrysotile Containing Roof Tiles Manufacturers

Chrysotile containing roof tiles have two main ingredients: cement which represents 90% of the input, and chrysotile fiber which represents approximately 10%. All chrysotile used in Thailand is imported. All producers in the cement industry are domestic. If chrysotile is banned and consumers are forced to switch to non-chrysotile roofing tiles, there will not be much impact on cement consumption. Therefore, cement producers who supply inputs to chrysotile containing roof tiles industries would not be affected from the ban. However, if non-chrysotile containing roof tiles are of low quality and have short lifetime usage, this could result in lower demand for non-chrysotile containing roof tiles and eventually, lower demand for cement in this industry. Still, the ban on chrysotile would only generate a minimal indirect impact on suppliers.

4.3.2 Wholesalers and retailers of Construction Materials

At present, wholesalers and retailers of construction material are uncertain about the impact from the potential ban on chrysotile. This is because of uncertainty on the policy and non-chrysotile products which have entered the market in a relatively short period of time. In addition, most of their customers do not have knowledge and information about the policy on the proposed ban on chrysotile. From interviews with retailers, many are not worried about the policy to potentially ban chrysotile as they see that there are substitute products in the market despite of the ambiguity of their quality and durability.

Based on interviews with several medium sized retailers of construction materials in provincial areas, many commented that there might be marketing problem if the production of 4 mm. chrysotile containing roof tiles is banned, as the product represents over 50% of sales in the total roofing tile market in Thailand. Moreover, this product is used primarily by consumers who have low income and/or are price sensitive. Thus, if producers still have limitations in producing a qualified substitute for the 4 mm. chrysotile containing roof tiles, this could hamper consumers in building and expanding houses as well as expansion of SME's due to higher costs of construction. Other retailers think consumers will not be affected by the proposed ban on chrysotile because in most cases people who use chrysotile containing roof tiles are construction contractors. However, in the future, if the sales and use of non-chrysotile containing roof tiles is more widespread and the quality of substitutes are improved, this could become a factor that influences consumer and construction contractor's decision over the choice of roofing materials. If quality, durability, and lifelong usage of non-chrysotile roofing tiles remains low, this could generate discontent from consumers after utilization for about 2-8 years, as the product becomes worn out and consumers have to be responsible for the damage and replacement costs of new roofing materials.

4.4 Induced Impacts from the Ban of Chrysotile

The banning of chrysotile containing roof tiles in Thailand could lead to other problems and costs to society and government which are referred to as induced impacts. The induced impact ranges from the government's action in taking responsibility for the replacement of chrysotile containing roofing tiles with non-chrysotile roofing tiles, the provision of public announcements and services on information and knowledge provision to people on the banned products, to possible costs of litigation in the event of damage and claims from consumers who might be affected by the use of chrysotile containing products.

According to the proposal by the National Health Commission (2011) on 25th February 2011, the 2007 National Health Act under the Prime Minister's supervision on the impact of reducing or eliminating chrysotile in Thailand has identified several sectors to be responsible for responding to the implementation of the policy as shown below:

1) Ministry of Industry to control the use of chrysotile to be a level 4 dangerous substance within 2011 which would prohibit the production, importation, exportation or possession of the substance and set a standard for the use of the substitute product.
2) Ministry of Public Health to be the main organization responsible for implementation and coordination with relevant organization such as Ministry of Labor, Ministry of Industry, Ministry of Finance, Ministry of Commerce, Ministry of Science and Technology, Ministry of Interior, Ministry of Natural Resources and Environment, educational institutions, and other relevant organizations to implement the strategy with respect to the "Making Thai Society Asbestos-Free".
3) The Ministry of Interior as the core organization together with the relevant organizations in developing measurement to control demolition, deconstruction, renovation and extension of buildings or material that use chrysotile as part of the ingredient and chrysotile waste disposal measures, particularly in the construction and installation services.
4) The Ministry of Commerce to control the importation of products with chrysotile as ingredient.
5) The Office of the Consumer Protection Board to monitor and issue the list of chrysotile containing products to provide knowledge to society and implement prohibition in the sales of chrysotile products as well as regulations or laws that govern the types of products that contain chrysotile especially products with high risk.
6) The Ministry of Finance to raise import tariffs of chrysotile and reduced import tariffs to replacement substances that are not harmful to health by regulating it as a special conditions which would not affect the taxation of other substances in the same code.
7) The Prime Minister to raise the threshold in the original regulations on the construction of government building by prohibiting the use of materials containing chrysotile as a component in the construction, renovation or repair of new buildings.

Related organizations mentioned above will have to complete the implementation within 2 years or by 2012. (NHC, 2011) These measurements would incur large sums from government budgets in order to be completed. Although government implementation is in process, it is necessary for the government to consider the issue in depth especially given the future impacts.

The impact from the proposed ban of chrysotile could lead to unexpected litigation costs and insurance costs for the government and business sectors. The impacts of the regulation on different industrial sectors result in the government's responsibility in taking over the problems in several countries. In foreign countries where asbestos has been banned, litigation cases demanding compensation from manufacturers and the government are on-going issues which led to high costs for all parties.[14]

In several countries, litigation cases and claim defendants are mainly manufacturers, producers of asbestos and government sector for hospitalization and compensation to claimers. As reported in the RAND report of Carroll et al. (2002) which studied the different types of asbestos claims in the US, there are evidence of numerous asbestos claims resulting in large compensation and bankruptcies of defendant firms. Table 11 provides a summary of the litigation expenses in US, Japan, and UK.

[14] Studies in foreign countries found linkage of lung cancer and mesothelioma cases diagnosed to be affected by the exposures to asbestos an incident referred as Kubota Shock. (Kazan-Allen, 2009) However, the types of the asbestos that generate impact on the human respiratory system are those made of amphibole and crocidolite asbestos. These types of asbestos had long been banned in Thai manufacturing leaving only the use of Chrysotile asbestos in the production of roofing tiles, brake, and cement pipes.

Table 11 Litigation Expenses in US, Japan, and UK

	Claims	Litigation Expenses	Expected Future Litigation Cost*
United States (2002)	730,000	$54 billion	$200-265 billion
Japan (2004)	44,198	$12.6 billion	2.8 trillion yen
United Kingdom (2002)	n.a.	$7.57 billion	$17.7 billion

Source: US - Carroll, et al. (2002); Japan - Ikeya (2005); UK - Saiontz & Kirk, P.A. (2010)

Note: In US, a total of 8400 companies had become defendants leading to 73 bankruptcies by 2002.

* For US, this is the estimates of the expected total costs of all claims to date. For Japan and UK, this is the estimates of total cost expected by 2050.

The impact from expected future litigation expenses was several time more than the litigation expense at present. In many cases, litigation costs do not affected only manufacturers of asbestos products but other industries in a wide range leading to an impact on the whole economy.[15] Thus, the ban on chrysotile might generate unexpected costs and claims on the Thai government and manufacturers. It is therefore important for the Thai Government to take into consideration these experiences from other countries to prevent possible similar problems in the future.

[15] Carroll et al. (2002) identified that impact of the litigation cases on other industries could result in bankruptcies leading to increased unemployment and lower economic growth.

V. Conclusions and Recommendations

This study investigates the expected economic impact of a proposed ban on chrysotile containing products in Thailand, with a specific focus on the high density cement roof industry that utilizes chrysotile in the production process. The roof tile industry was chosen because it accounts for approximately 90% of the chrysotile used in Thailand. The study analyzes the implications of the new regulatory measures on different economic sectors focusing on three dimensions (direct, indirect, and induced impacts).

The study found that the proposed ban on chrysotile generates a direct and significant impact for manufacturers, employees and consumers of chrysotile containing products. Consumer impacts include new costs incurred by households, the business sector and the government sector. While indirect impact for suppliers, wholesalers and retailers were found to be minimal, the induced impact was substantial. Induced impact is defined as the cost of replacement of chrysotile roofing tiles with substitute products, i.e. the government's cost in implementing the ban on chrysotile, and possible litigation and compensation costs that could result after chrysotile is banned.

Table 12 shows the estimated costs for different stakeholders from the proposed ban on chrysotile as summarized from the analysis. The total impact for manufacturers and consumers is 464 billion baht in value for replacing existing chrysotile containing roof tiles with non-chrysotile containing roof tiles.

Table 12 Summary of Cost Estimation on Different Stakeholders

Costs estimates on:	Amount in Baht
Manufactures:	750,000,000
Consumers:	464,110,102,740
- Household	450,978,010,000
- Swine Industry	2,648,100,000
- Schools	7,549,433,060
- Hospitals	2,934,559,680

Source: Author's compilation

As mentioned previously, the argument for the use of non-chrysotile containing roof tiles to replace chrysotile containing roof tiles remains an important issue for the government to clarify. The lower quality and durability of non-chrysotile containing roof tiles demonstrates that a ban on chrysotile can bring unwanted results. Since the use of non-chrysotile containing roof tiles would imply the installation of substitute products with a life cycle of approximately 2 – 8 years, this could make the cost of substitute materials much higher than chrysotile containing roof tiles making the cost 10 times higher over a comparison of 20 years. Moreover, ambiguity about the real hazards of the use of chrysotile remains, which makes the decision on the ban costly if government decides to ban without further investigation and clarification.

Recommendations

This paper seeks to identify important considerations with regard to the proposed ban on chrysotile in Thailand and provide analysis of the possible economic impact for different stakeholders in the chrysotile containing roof tile industry. Based on the study, it is apparent that the Thai Government should consider carefully the economic impact from the proposed ban of chrysotile as it could lead to large costs to the economy both in the short run and the long run.

This can start with an investigation on the evidence of dangers from the use of chrysotile in Thailand and whether a clarification on the safe use of chrysotile in the industrial sector could be a policy choice that the government can undertake, instead of a total ban on the substance.

In addition, there is a need for the government to focus on the development of substitute products that are more comparable in quality and durability. If consumers and producers foresee that substitute products are better in terms of quality, durability and price, the banning of chrysotile containing roof tiles would not generate a large impact on different stakeholders and the adoption of substitute products would be more imminent from both producers and consumers. Finally, careful strategic planning and analysis regarding the future impact of regulatory measures is important to ensure the long run sustainability of policy regulation. The different issues of litigation in foreign countries need to be carefully studied by the government in order to identify all possible events of claims over the issue of chrysotile prohibition and develop regulations that could reduce the unexpected cost on the public and industrial sector in the long run.

Limitations and Further studies

As the paper focuses solely on the chrysotile containing roof tile industry, a ban on chrysotile could also have an impact on other related industries such as chrysotile cement pipes, the automotive industry, and fire protection devices. The Thai government should conduct additional research on the economic impact of these industries and how long term management of product substitution could be made. Another important ambiguity that needs to be further studied and clarified is regarding the material utilized in the production of non-chrysotile roofing tiles which include Polyethylene, Polyvinyl Chloride (PVC) and Polyvinyl Alcohol (PVA). There have not been any tests or researches reviewing the safety in consumption and utilization of these products in the short run and long run. Thus, it would be beneficial for the Thai government to conduct an investigation into the economic impact from the ban of chrysotile before fully implementing the restriction.

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