

GREENHOUSE GASES DIAGNOSTIC REPORT

Industry GHG Reduction to Support the Implementation of Thailand's Climate Change Master Plan

Supported by:

On behalf of

Programmbüro
**Internationale
KlimaschutzInitiative**



Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany

Contents

1. Introduction	1
Project Background and Objectives	1
Report Objectives	2
Specific Terms	2
Reporting Structure	2
2. Overview of Thai Manufacturing Sector	4
Overview	4
Key Sub-Sectors and Industries	5
Manufacturing Sector Characterization	6
National Development Agenda and Sector Policies	9
3. Greenhouse Gas Emissions from Manufacturing Sector	12
GHG Situation in Thailand	12
GHG Emissions from Manufacturing Sector	15
Completeness, Accuracy and Quality Control of Industry Emissions	22
4. Preliminary Sub-Sector Selection Analysis	24
Perspective and Issues related to GHG Mitigation Action in the Country	24
Preliminary Analysis: Precondition and Selection Criteria	26
Scoring, Weighting and Performance Matrix	31
Result from Preliminary Analysis	33
5. Proposed Sub-Sectors and Chosen Specific Industries	35
Metal Products, Machinery and Equipment	35
Textiles and Wearing Apparel	36
Food, Beverages and Tobacco	36
Non-metallic Mineral Products	39
Conclusions	40
6. Recommendations	42
Readiness, Consistency and Completeness of Data	42
Supplement and Integration with Other Sectors	42
Stakeholder Engagement	43
General Policy Advice	44
Reference	45
Annex 1: Relevant Sub-Categories Contributing to GHG emissions in Manufacturing Industrial Sector	48
Annex 2: Scoring Details of the MCA	50

1. Introduction

Project Background and Objectives

Over the past decade, climate change has quickly become an issue of importance in Thailand. The country has produced a number of high level plans that address climate change mitigation, including a *Strategic Plan on Climate Change* and more recently *Thailand Climate Change Master Plan 2014-2050* (ONEP, 2014). The ultimate goal of the Master Plan is to reduce greenhouse gas (GHG) emissions and to become a low carbon society by 2050.

The Master Plan outlined a number of short-term actions including: “to identify GHG emissions reduction targets and capacity of each sector by 2020”. However, one of the key crosscutting issues for implementation outlined in the Master Plan is the need for a robust database of sectoral GHG emissions and mitigation measures to facilitate scenario development and mitigation planning. In addition, an economic impact analysis for the reduction targets – assessing its potential effect on sectoral growth – is imperative for setting a reduction target that balances GHG mitigation and economic development.

This project entitled ***Industry GHG reduction to support the implementation of Thailand’s Climate Change Master Plan*** (referred as ‘the Project’), managed and implemented by the Global Green Growth Institute (GGGI), aims to assist the implementation of the Climate Change Master Plan by developing clear roadmaps for GHG reduction, in selected three manufacturing industrial sub-sectors of the Thai economy.

In supporting the Office of Natural Resources and Environment Policy and Planning (ONEP), Ministry of Natural Resources and Environment (MNRE), in implementing the Climate Change Master Plan, the GGGI’s Thailand project, with strong support from the German Government, plans to **develop GHG reduction roadmaps**, which shall be underpinned by:

1. An updated and improved GHG inventory for the selected sub-sectors which conforms to international standards for accurate emissions reporting;
2. Credible historical and projected emissions, abatement technologies, mitigation potential, policy measures, and economic impact analysis for the selected sub-sectors. This will be accompanied by the identification and prioritization of comprehensive emissions mitigation policies, which have the support of businesses and government;
3. An enhanced capacity for coordination and technical and economic analysis within the Royal Thai Government (RTG) and the private sector in relation to GHG inventories, emission projections, mitigation opportunities, and economic impact assessment of mitigation measures on the selected sub-sectors.

The Project has three major components as follows:

Component 1: Sector Diagnostic

Component 2: GHG Reduction Roadmap

Component 3: Project Governance, Stakeholder Engagement and Capacity Building

Report Objectives

This Diagnostic Report is the outcome of Component 1, which aims to carry out a diagnostic assessment of industrial GHG emissions to transparently and systematically identify and confirm the most appropriate three sub-sectors to engage with.

Specific Terms

In order to ensure mutual understanding on background, method applied, analysis and the report output, it is needed to define some terms which would be used throughout the report. These terms include:

‘Manufacturing (Industrial) Sector’ refers to the physical or chemical transformation of materials, substances or components into new products. Substantial alteration, renovation or reconstruction of goods is generally considered to be manufacturing.

‘Sub-Sector’ is a subdivision of the entire spectrum of any particular sector. In this study, the ‘sub-sector’ generally refers to the subdivision of ‘manufacturing sector’ following the Thailand Standard Industrial Classification developed in 1972 (TSIC-1972).

‘Industry’ refers to a particular economic activity concerned with the processing of raw materials and manufacture of goods.

Reporting Structure

The report includes the following chapters:

Chapter 2: Overview of Thai Manufacturing Sector, identifying relevant manufacturing industrial sectors and sub-sectors; economic characterization of sub-sectors and key national policies relevant to the sector.

Chapter 3: Greenhouse Gas Emissions from Manufacturing Sector, assessing Thailand’s existing GHG inventory, particularly that of manufacturing industrial sectors, in relation to completeness and accuracy of industry emissions.

Chapter 4: Preliminary Sub-Sector Selection Analysis, outlining the approach applied to the study and the result of the analysis.

Chapter 5: Proposed Sub-Sectors and Chosen Specific Industries, providing the final judgment on the agreed selected sub-sectors and the chosen industry within each of three sub-sectors.

Chapter 6: Recommendations, providing recommendations to future development of the GHG reduction roadmaps and identifying key stakeholders to the implementation of measures in the future.

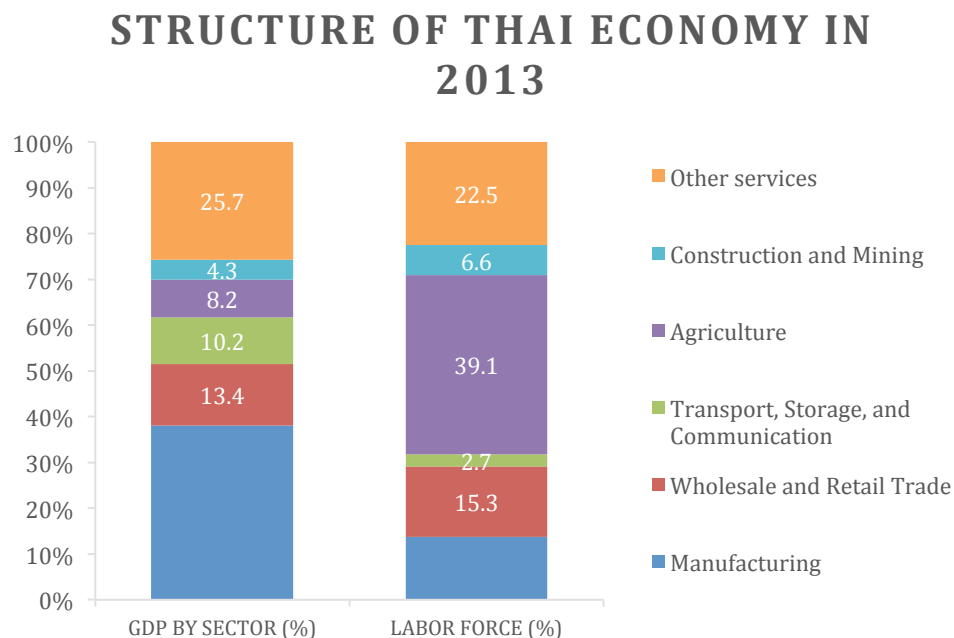
The results of this component will provide a solid foundation for Component 2 and Component 3 of the Project.

2. Overview of Thai Manufacturing Sector

Overview

Thai manufacturing sector plays a crucial role in advancing the country's economy. In 2013, the sector accounts for 38 percent of Gross Domestic Product (GDP) as presented in *Figure 1* below, while employing only around 14 percent of the total workforce. As a result, the industrial sector is the largest economic driver of the country and its economic output per unit of labour force is much greater than other sectors.

Figure 1- Structure of Thai Economy in 2013

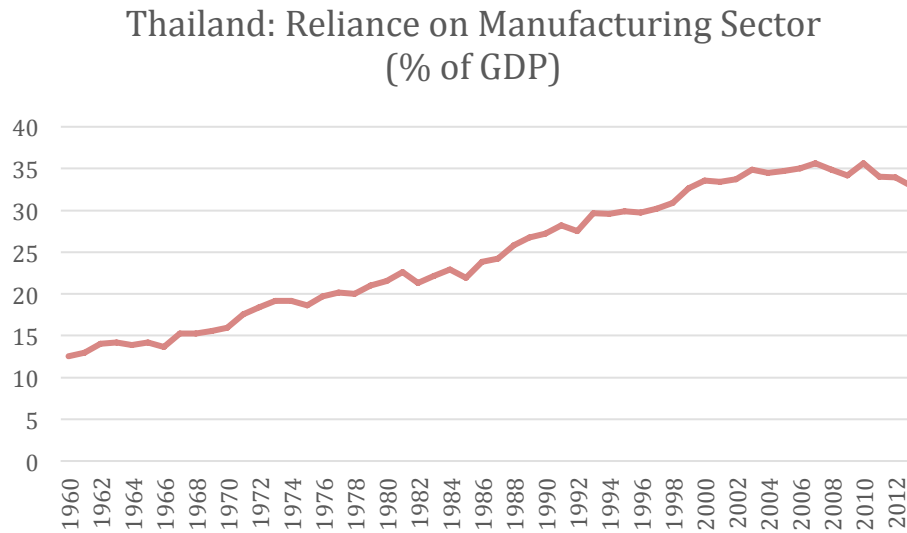


Source: Bank of Thailand (BOT), 2014

Note: Other services include financial sector, education, hotels and restaurants, and etc.

As the country developed, there was a clear trend of increasing reliance on the manufacturing sector. *Figure 2* below shows the reliance on the sector as a percentage of GDP. In 1960, the sector accounted for only 12.5 percent of the total GDP. However, with policies to promote industrial development during the 1970s and the 1980s, its share increased significantly to more than 35 percent in 2010. This level of reliance is expected to be maintained, or even increased, according to the *National Industrial Development Master Plan 2012-2031* (OIE, 2011) that aims to promote the Thai industry to be a major manufacturer in the region, especially under the ASEAN Economic Community (AEC).

Figure 2- Thailand Reliance on Manufacturing Sector



Source: World Development Indicators, World Bank, 2014

Key Sub-Sectors and Industries

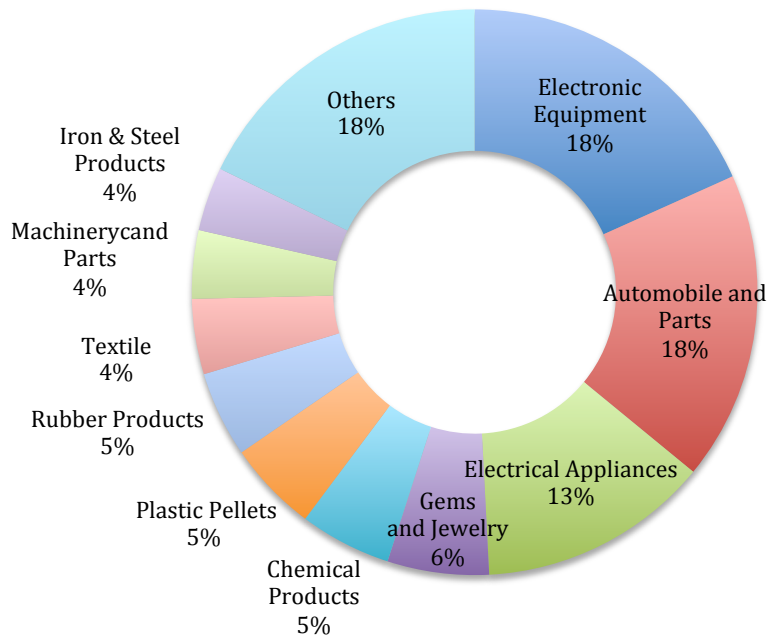
Thailand is an export-dependent economy. The country exported a total of US\$228.5 billion worth of goods in 2013, accounting for 59 percent of its GDP (US\$327.3 billion). China, Japan and the United States together accounted for 32 percent of the market for Thai exports in 2013.¹

Industrial products are generally the top exporting goods. In 2013, its share accounted for 76 percent of the total export income. Major export industrial products were electronic equipment; automobile and parts; electrical appliances; gems and jewelry; chemical products; plastic pellets; rubber products; textile; machinery and parts; and iron & steel products. The combined share of these top ten export products was 82 percent of the total manufactured products value, as shown in *Figure 3*.

¹ Office of Industrial Economics (OIE), 2014

Figure 3 - Top Export Industry in 2013 (by value)

Key Export Industries in 2013



Source: Office of Industrial Economics (OIE), 2014

Manufacturing Sector Characterization

The manufacturing sector plays an important role in Thai economy with the production value accounted for 38 percent of the country's GDP in 2013. Although, the growth in industrial sector has greatly contributed to Thai economic stabilization, it also exploited resources especially energy consumption leading a continual upward trend in GHG emissions.

According to the third, and the most recent, *Industrial Census* conducted by the National Statistical Office (NSO) in 2007, there were 461,260 establishments under manufacturing sector or about 21 percent of total establishments of all economic activities in the whole country. The majority of manufacturing establishments (96%), considered in terms of number of persons engaged, were very small (of less than 25 persons). Considering the manufacturing establishments by form of legal founded organization, it revealed that most entities, around 92 percent, were those entities registered as individual proprietors and juristic partnership, while about 8 percent were companies, government or state-enterprise, cooperatives and others. Table 1 summarises the numbers of establishments by size and legal form in 2007.

Table 1 – Number of Manufacturing Establishments by Size and Legal Form

<i>Unit: number</i>	
TOTAL	461,206
Establishment by Size (no. of persons engaged)*	
Very small (1-25)	441,781
Small (26-50)	8,566
Medium (51-200)	7,411
Large (>200)	3,448
Establishment by Form of Legal Organization	
Individual proprietor	416,586
Juristic partnership	7,600
Company limited/PCL	24,956
Government, state-owned enterprise, cooperative and others	12,064

Source: NSO, 2007

Note: *The numbers in parentheses denote the number of persons engaged in each establishment.

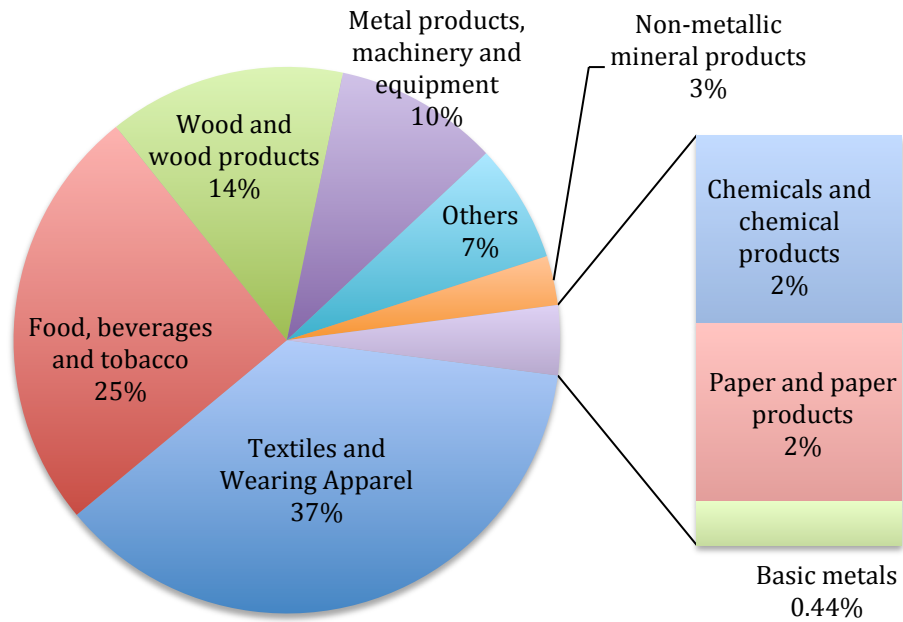
The size of industrial establishments will have an influence on the decision when considering GHG mitigation policies because the transaction cost per unit of GHG emission reduction is lower when there are only a small number of large establishments as compared to a large number of small establishments. Since most of the industrial establishments are small, the roadmap could be designed in different phases. For instance, the first phase might target the large establishments with minimal assistance and the second phase then reaches out to those small establishments with larger assistance. This phasing helps reduce the transaction cost and the resistance of the policy.

In terms of activities, there are several ways to classify activities within the sector such as the International Standard Industrial Classification (ISIC), Thailand Standard Industrial Classification (TSIC), etc. Given the limitations of availability, consistency and completeness of accessible data, it shall be clearly noted that the **Thailand Standard Industrial Classification**, developed by the Department of Labor, Ministry of the Interior, in the year **1972** (TSIC-1972) will be used because it conforms to the information currently available by the majority of the government agencies which use their own different industrial categorisation. As such, in order to keep different aspects of the analysis consistent, a broad group of the manufacturing sector in accordance with TSIC-1972 is seen most appropriated, thus adopted.

TSIC-1972 divides manufacturers into nine groups as delineated in Table 2 below. Following TSIC-1972 classification and 2007 Industrial Census, it appears that the manufacture of textiles and wearing apparel accounted for the largest portion (37%) in the industry in terms of the number of establishments, followed by manufactures of food, beverages and tobacco (25%); and wood and wood products (14%). Figure 4 and Table 2 illustrate numbers of establishments by group of manufactures and number of establishments by size, respectively.

Figure 4 – Establishment by Group of Manufactures

Manufacturing Industry Establishment by Group of Manufactures



Source: National statistical Office (NSO), 2007

Table 2 – Number of Manufacturing Establishments by Size

Code ¹ Manufacture Group	Total	Small ²	Large ³
31 Food, beverages and tobacco	116,668	110,289 95%	6,379 5%
32 Textiles and Wearing Apparel	170,190	161,564 95%	8,626 5%
33 Wood and wood products	64,748	62,601 97%	2,147 3%
34 Paper and paper products	8,224	5,786 70%	2,438 30%
35 Chemicals and the chemical products	8,747	3,831 44%	4,916 56%
36 Non-metallic mineral products	13,435	11,783 88%	1,652 12%
37 Basic metals	2,042	1,309 64%	733 36%
38 Metal products, machinery and equipment	44,803	37,644 84%	7,159 16%
39 Others	32,349	29,379 91%	2,970 9%
Total	461,206	424,186 92%	37,020 8%

Notes: 1 Codes are in accordance with TSIC-1972

2 'Small' is defined as those established under below legal forms, according to the 2007 Industrial Census, including:

- 'Individual proprietor' (privately-owned establishment or an establishment owned by or organised in the form of partnership, but not registered.)
- 'Juristic partnership' (legally registered by at least 2 persons)

3 'Large' is defined as those established under below legal forms, according to the 2007 Industrial Census, including:

- 'Company limited' (initiative group with at least 7 persons) or 'public company limited' (15 persons)
- 'Government' or 'state enterprise' (owned or >50% share by the government) and 'cooperatives' (Cooperation Active, at least 15 persons)

National Development Agenda and Sector Policies

National Economic and Social Development Plan

Thailand's development agenda have recently shifted towards green growth and low-carbon economy. The *Eleventh National Economic and Social Development Plan (NESDP)*, which is the overarching plan of Thailand's public policies, adopted Green Growth and Low-Carbon Development as part of its strategy for balanced and inclusive growth of the country. The Plan identifies climate change as one of the significant challenges that Thailand would encounter during the implementation of the Plan (2012-2016) and calls for a more rigorous policy response to address climate change. It stresses the importance of environmental management, as one of the main targets. The environmental quality needs to be improved to meet international standards, reduction of GHG emissions to be more efficient, natural resources and the environment to be managed towards sustainability, and forest areas to be expanded to restore balance to the ecology.

It is expected that green growth and low-carbon development will still be one of the country's development priorities in the 12th NESDP (2017-2021) which is currently in the development process.

Thailand's Industrial Development Plan²

In addition to the NESDP, the RTG has also recently stated its industrial development goal, given the current country context and other factors that affect the development of the industry, with a focus on sustainable development. Developed by the Office of Industrial economics (OIE), Ministry of Industry, in 2011, the *National Industrial Development Master Plan 2012-2031*, laid out the 20-year plan encompassing industrial and entrepreneurial development directions. The government aims to create development which could balance all four dimensions of sustainable development as follows:

1. **Economic Wealth:** To continue the country's economic growth by increasing productivity, enhancing production efficiency, developing supply chain and creating access to international market.
2. **Human Wisdom:** To create innovation and value added, by using human intellectual knowledge, in order to achieve sustainable development.
3. **Social Well-Being:** To focus on the development and production networks amongst communities, small- and medium-sized enterprises in order to close social disparity, as well as to create social responsibility.
4. **Environmental Wellness:** To foster awareness regarding nature conservation and the environment, to enhance more environmentally friendly production and to improve law enforcement especially those having impacts on the environment.

With the vision of the Thai industrial development “to move the industry towards creativity, balance and sustainability”, the plan has had targets divided into three phases in the next 20 years, as illustrated in Figure 5.

Figure 5 – Goals for Industrial Policy and Strategic Dimension



Source: OIE, 2011

² OIE, 2011

The goal of **Phase 1** is to create readiness for Thailand to become a major manufacturer in the region and to prepare for the AEC. The preparations would cover adjustments and/or amendments of related laws and regulations; infrastructure improvements (e.g. materials, labour, standards, new technologies, research and development, area development, etc.); cluster development; and moving towards being a manufacturer in the region by creating ASEAN supply chain and environmentally friendly manufactures.

Phase 2 aims to build on the knowledge-based foundation, focusing on productions, which require technology and innovation. In this phase, there would be an adjustment to the country's role – i.e. to become an intermediary in the management of production chain system and to be recognised in the ASEAN region. In addition, Thailand aims to be a regional commercial hub – i.e. managing production and production network in the region; to create a value-added to innovations and intellectual properties; and to create brand image of the country to be recognised in the ASEAN region.

The final phase, **Phase 3**, is to create a positive image of Thai brand, as well as to manage neighboring nations' brands, which have production networks in the region, to become recognised in global market, taken into account balance among the four pillars: Economic, social, environmental and human resources.

3. Greenhouse Gas Emissions from Manufacturing Sector

Thailand submitted its Initial National Communication (INC) and Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2000 and 2010, respectively. The main data for the following sections of this report are from the national inventory for the year 2000 reported in the SNC, prepared using the UNFCCC reporting guidelines and the IPCC technical guidelines, including:

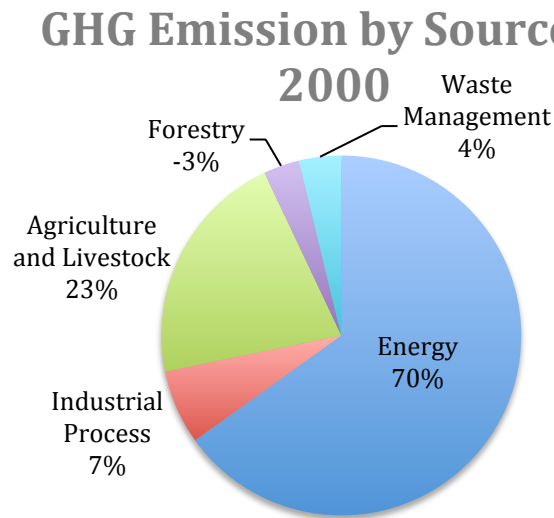
- *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories;*
- *2000 IPCC Good Practice Guidance and Uncertainty Management for National Greenhouse Gas Inventories;* and
- *2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry.*

The GHGs investigated in this study shall be limited to the six major GHGs, covered by the UNFCCC and its Kyoto Protocol, which are Carbon Dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), Hydrofluorocarbon (HFC), Perfluorocarbon (PFC) and Sulfur Hexafluoride (SF₆).

GHG Situation in Thailand

Using the Global Warming Potential (GWP) factors, it is estimated that in 2000, the total net GHG emission in Thailand was 229 million tons of CO₂ equivalent (MtCO₂e). The energy sector was the largest contributor at 70 percent, followed by agriculture and livestock at 23 percent. The remaining proportion was shared among industry, forest (net sink) and waste management. However, it shall be noted that rice and livestock are considered as emitters for survival; thus, a hard push to mitigate emissions from this sector would have serious impacts on lives of people who depend on such activities to survive. In the 2000 inventory, quality control and assurance were implemented and uncertainty was within an acceptable level. The GHG emissions by source in 2000 are shown in Figure 6.

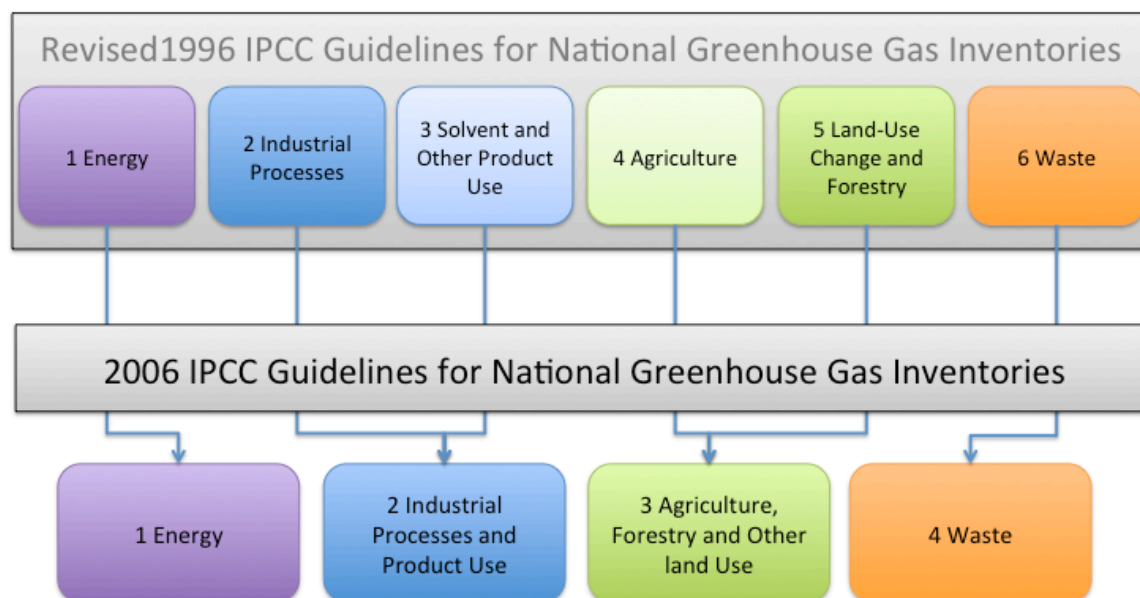
Figure 6 – GHG Emission by Sources in 2000



Source: Office of Natural Resources and Environmental Policy and Planning (ONEP), 2010:1

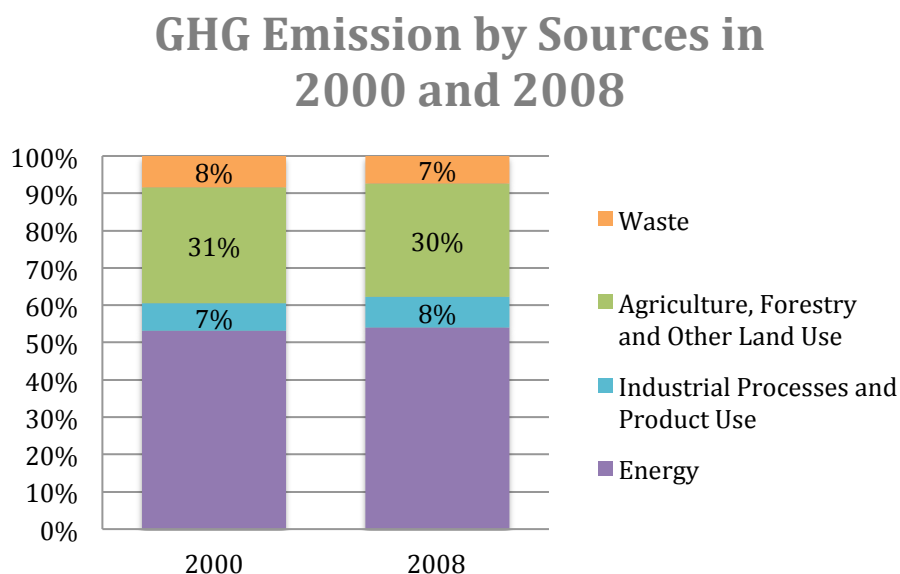
Other than the 2000 national inventory reported to the UNFCCC, there is a study on GHG inventories over the years 1990-2008 and GHG mitigation policy, conducted by Thailand Greenhouse Gas Management Organization (TGO) in 2010. The study, namely *Study on Policy Recommendation on Greenhouse Gas Mitigations in Important Economic Sectors in Thailand*, reported the GHG inventories by applying updated guidelines on national GHG inventories, “*2006 IPCC Guidelines for National Greenhouse Gas Inventories*”. Thus, the sector categorisation of the two studies is slightly different. Before discussing the results of the study by TGO, comparison and re-categorisation of the two guidelines are presented in Figure 7.

Figure 7 – Comparison and Re-Categorization of Revised 1996 and 2006 IPCC Guidelines



The TGO study reported the amount of GHG emissions in 2000 and 2008 at around 301 and 403 MtCO₂e, respectively. Having considered the GHG inventories of both years, under the categorisation of 2006 IPCC Guidelines, it appears that the proportion of GHG emissions by source is fairly similar. The share of GHG inventories by source in 2000 and in 2008 from these studies is illustrated in Figure 8.

Figure 8 – GHG Emission by Sources in 2000 and 2008



Source: Thailand Greenhouse Gas Management Organization (TGO), 2010

Note: The inventories were conducted based on the categorisation in the 2006 IPCC Guidelines.

Hence, considering the above figure together with Figure 6, it shows that the trend of GHG share from different sources remains significantly unchanged over the past years (the years 2000 and 2008). Even though there is a change in categorisation of emission sources (Revised 1996 and 2006 IPCC Guidelines), the share is rather similar.

GHG Emissions from Manufacturing Sector

According to Thailand's SNC, it is indicated that, in the year 2000, the GHG emission from the industrial processes activities accounted for 16.4 million tons of carbon dioxide equivalent (tCO_{2e}), or around 7.2 percent of the total GHG emissions in the country (ONEP, 2010). However, it is worth noting that the GHGs from the manufacturing sector are not only from its industrial processes but also from energy consumption and waste management. Thus, the industrial processes are only part of the whole story of the GHG emissions in the manufacturing sector. The actual GHG contribution from the economic activities of this sector alone is in fact much larger than 7.2 percent.

Coverage

The scope of this study is to cover the GHGs emitted from the manufacturing industrial sector in Thailand and will be based mainly on the secondary data available at the time. Out of the four main activities – i.e. energy use; industrial processes and product use; agriculture, forestry and other land use; and waste management – as sources of emissions defined in 2006 IPCC Guidelines (see Figure 7), the following activities are related to the **emissions from the manufacturing sector: (i) fuel combustion activities (energy), (ii) industrial processes and product use; and (iii) wastewater treatment (waste).**

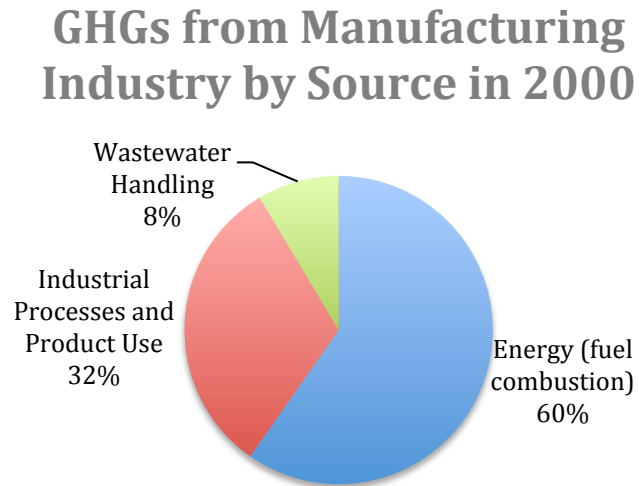
Although there have been several studies on the GHG inventories in Thailand, this report would focus on the results of the SNC. Since the SNC was completed based on *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, this report shall discuss the coverage based on the Revised 1996 IPCC Guidelines. However, the other study (TGO, 2010), which was discussed earlier, adopted the more updated version, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Details of how relevant sub-categories concerned in the manufacturing industrial sector in this study are related are shown in *Annex 1*.

Current Emission Level

From the above-defined coverage of the GHG emissions from the manufacturing sector and the data on SNC, the study found that the GHG emissions from manufacturing sector alone accounted for around 22.6 percent, or 54.66 MtCO_{2e}, of total national GHGs in 2000, of which, around 60 percent was from the fuel combustion in the industry, followed by 32 percent from the industrial processes, solvent and other product use. The rest was from wastewater handling. The

proportion of GHGs by source from the manufacturing industrial sector is illustrated in Figure 9.

Figure 9 – GHG Emissions from Manufacturing Sector by Source in 2000

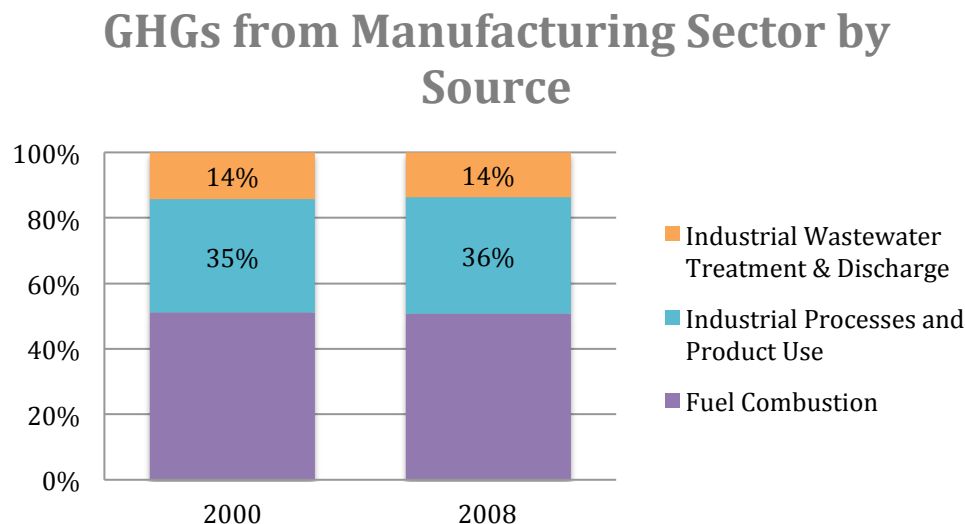


Notes: - Derived from ONEP (2010:2)

- The wastewater handling in this diagram also includes domestic and commercial wastewater due to the limited access in detailed data.

The TGO study (2010) showed similar results in the proportion of GHG emissions from the manufacturing sector from the national total amount, approximately 21 and 23 percent in 2000 and 2008, respectively. The share split into around 51 percent from fuel combustion; 35-36 percent from industrial processes and product use; and the rest from industrial wastewater treatment and discharge (see Figure 10).

Figure 10 – GHG Emissions from Manufacturing Sector by Sources in 2000 and 2008



Notes: - Derived from TGO (2010)

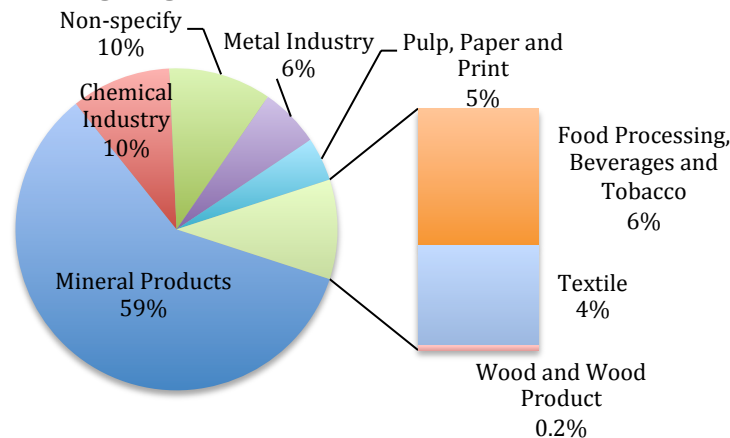
- The GHGs portion from construction sub-category is included in the diagram due to the limited access in detailed data.

From the above two figures, it can be concluded that the fuel combustion is the major contributing activity for the GHG emissions from the manufacturing sector.

Having considered the GHG emissions by manufacturing sub-sector, by combining the amount of GHGs from fuel combustion and industrial processes of the same sub-sector, it shows that more than half of the total emissions in the year 2000 was from the mineral production alone, followed by chemical and metal sub-sectors. This should be noted that the emissions from waste management were not included since the SNC did not show the contribution or breakdown from each sub-sector to the GHGs emitted from its waste treatment. Figure 11 exhibits GHG emissions from manufacturing sector by sub-sector in 2000.

Figure 11 – GHG Emissions from Manufacturing Sector by Sub-Sector in 2000

GHG Emissions from Manufacturing Industry by Sub-Sector in 2000

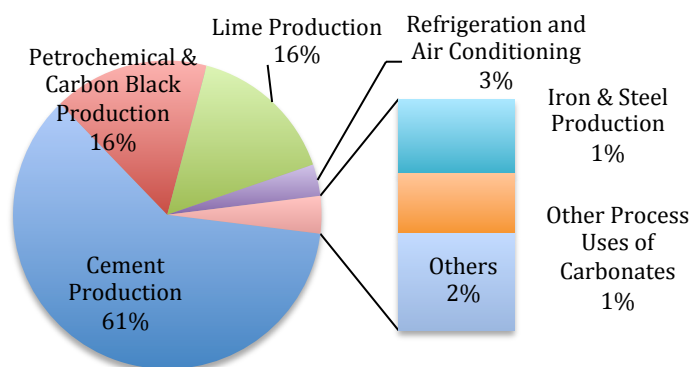


Note: Derived from ONEP, (2010:2), not including GHGs from waste sector

The TGO study (2010) reported the GHG emissions in lesser detail under the section of “fuel combustion from manufacturing and construction”. Thus, the emissions from the manufacturing sector by sub-sector as illustrated in Figure 12 shows only the amount from industrial processes and product use alone which represents only around one third of the total emissions generated from the entire sector.

Figure 12 – GHG Emissions from Manufacturing Industrial Processes by Sub-Sector in 2008

GHG Emissions from Manufacturing Industrial Processes in 2008



Notes: - Derived from ONEP (2010:2)

- Others include the productions of caprolactam, glyoxal and glyoxylic acid; nitric acid; lead; glass; carbide; and integrated circuit or semiconductor.

In fact, the determination of GHG emission level from each sub-sector, based on available literatures, is not straightforward since the reported GHG emissions following the IPCC Guidelines were computed based on its activities. The emissions from the manufacturing industrial sector are to cover the emission data from fuel combustion (energy), processes and waste management activities. Nonetheless, there are some studies which have tried grouping the GHG emissions by type of industry. Identifying the top five emitters presented in Table 3 was one of the efforts made by the TGO. It was reported in this article, produced by TGO, that in 2011 the cement industry contributed to the highest amount of GHGs from fuel combustion and processes at 35.8 MtCO₂e, or 56.7 percent of total GHGs from manufacturing sector³.

Table 3 – Top Five Manufacturing Industrial Emitters in 2011

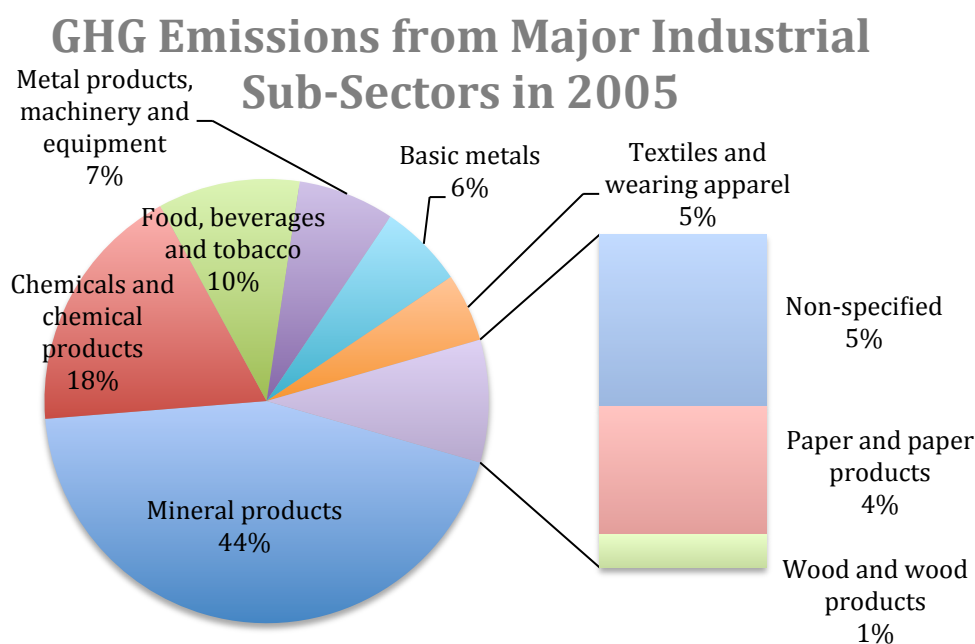
Rank	Manufacturing Sub-Sector	GHG (MtCO₂e)
1	Cement Production	35.8
2	Petrochemical and Carbon Black Production	9.1
3	Food and Beverages Industry	5.1
4	Lime Production	4.4
5	Iron and Steel Production	3.7

Source: TGO, 2012

The Department of Industrial Works (DIW), Ministry of Industry, completed a project on Strategic Planning for the Greenhouse Gas Management in Industrial Sector. According to the final report, the top three sectors contributing to the highest GHG emissions in 2005 were the manufactures of mineral products (44%); chemicals and chemical products (18%); and food, beverages and tobacco (10%). Figure 13 demonstrates the GHG emissions share from key manufacturing sector in 2005 (DIW, 2012).

³ TGO, 2012

Figure 13 – GHG Emissions from Major Manufacturing Sub-Sectors in 2005



Source: Department of Industrial Works (DIW), 2012

The sub-sectors relevant in the country's context under the two major contributing sectors – i.e. non-metallic mineral and chemical industries – are delineated in Table 4.

Table 4 – Manufacturing Industrial Sub-Sector (relevant in Thai GHG context)

Non-Metallic Mineral	Chemical
– Cement Production – Lime Production	– Nitric Acid Production – Caprolactam, Glyoxal and Glyoxylic Acid Production
– Glass Production – Other Process Uses of Carbonates	– Carbide Production – Petrochemical & Carbon Black Production

The GHG emissions from manufacturing sector accounted for 22.6 percent of total national emissions, more than half of which was from the non-metallic mineral sub-sector. The SNC shows that the GHGs from this group alone accounted for 38 and 98 percent of the fuel combustion (energy) and industrial processes activities, respectively.

From the review, it is observed that the non-metallic mineral sub-sector is the key contributor of the manufacturing sector in the 2000, 2005, 2008 and 2011 GHG inventories (see Table 5).

Table 5 – Summary of Manufacturing Sub-Sectors and/or Industries with High Contribution to GHGs

Order	Year 2000 ¹	Year 2005 ²	Year 2008 ³	Year 2011 ⁴
1	Mineral Products	Mineral products	Mineral Industry	Cement Production
2	Non-specify	Chemicals and chemical products	Chemical Industry	Petrochemical and Carbon Black Production
3	Chemical Industry	Food, beverages and tobacco	Ozone Substance	Food and Beverages Industry
4	Metal Industry	Metal products, machinery and equipment	Others	Lime Production
5	Food Processing, Beverages and Tobacco	Basic metals	Metal Industry	Iron and Steel Production

Sources: 1 ONEP, 2010; 2 DIW, 2012; 3 TGO, 2010; 4 TGO, 2012

Emission Trends

Although the GHG emission per capita of developing countries is considered low, it tends to increase in response to the demand for social and economic development. The manufacturing industrial sector is continuously vital to the Thai economy since the transition from an agrarian economy to industrial economy. The growth of this sector results in a steady increase in GHG emissions due mainly to the need in higher energy consumption. Fuel combustion is the leading cause of GHG emissions in the sector of the country.

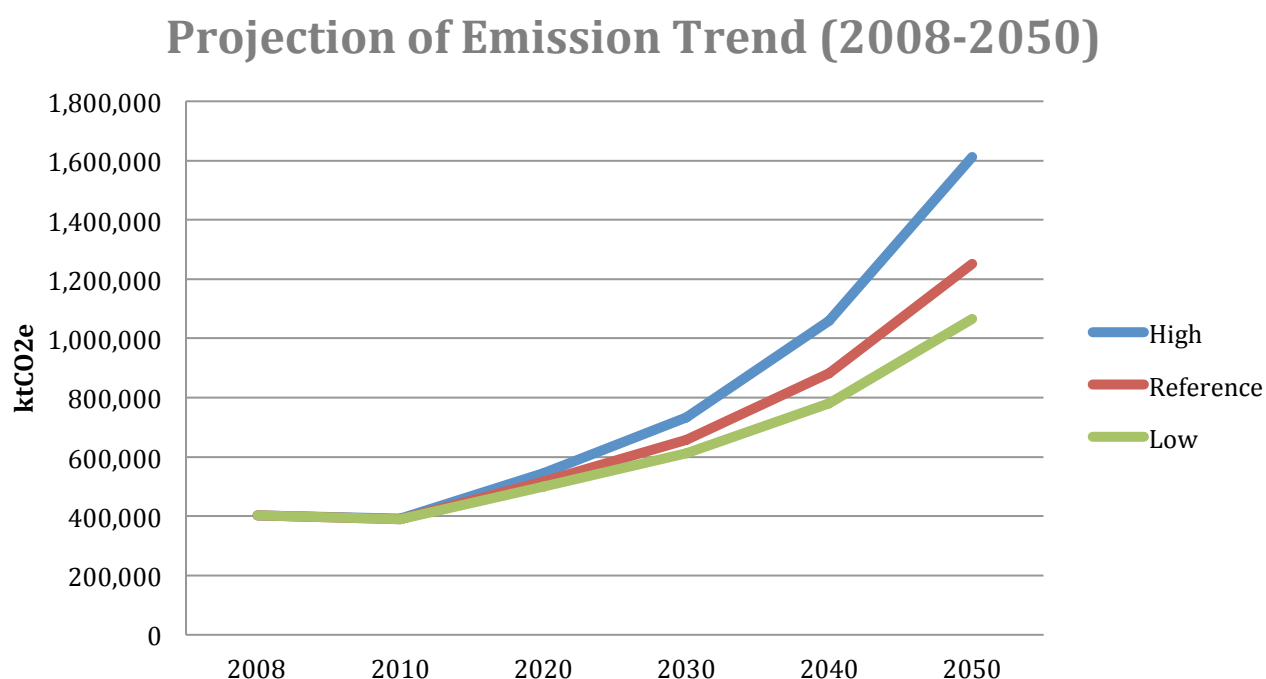
It is apparent that there is a direct correlation between GHG emissions in the industrial sector and the country's economic growth. ONEP study (2010) cited that during the period of 2000-2004 Thailand's GHG emissions increased at an annual rate of 3.8 percent, while the rate was only around 2 percent per year during 1994-2004. A similar trend can be seen for the GDP growth which was 5.1 percent during 2000-2004, compared to the lower figure of 3.8 percent during 1994-2004.

The TGO (2010) conducted a study on the future trend of Thailand's GHG emissions covering the period of 42 years, from 2009 to 2050. The projection was carried out in three cases – i.e. high, reference and low investment cases (investment expansion rate at 5, 3.9 and 1.3 percent, respectively). Figure 14 shows the projection of

emission trend all three scenarios and the conclusions derived from the TGO study are summarised as follows:

- GHG emissions are continually increasing in all cases over the period.
- Energy sector remains the main contributor to GHG emissions in the country.
- The highest GHG increasing rate is from the industrial processes and product use sector.
- It is projected that the proportions of emissions from agriculture, forestry and other land use; and waste sectors will be smaller.
- The projected annual growth rate of GHG emission in the high, reference and low investment cases are 3.36, 2.74 and 2.35 percent, respectively.

Figure 14 – GHG Emissions Projection till 2050 (three scenarios)



Note: Derive from TGO (2010)

Completeness, Accuracy and Quality Control of Industry Emissions

In the development of 2000 GHG inventory reported in the SNC, the Tier 1 method, which is the least-detailed level among three estimation methods advised under the IPCC Guidelines, was applied in most cases, including the industrial processes sector. Tier 2 and local emission factors are used in manure management, rice, forest and waste management.

For the development of GHG inventory as reported in the SNC, the *2000 IPCC Good Practice Guidance and Uncertainty Management for National Greenhouse Gas Inventories*; and *2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* were employed to ensure good quality control and assurance. It was

estimated that an aggregate uncertainty of GHG emission for 2000 was at 7.39 percent. The least uncertainty was the industrial process sector (7.2 percent), while the waste sector, which contributed only a small fraction of total emission, had the highest uncertainty of 7.8 percent. The improvement of the uncertainty level can be done only through the adaptation of a higher Tier and that will be discussed in the final chapter of this study. This low level of uncertainty also means that if we move to a higher tier, it is unlikely that the emissions from the industrial sector, which are mostly generated from the energy and the industrial process activities, will deviate from the referred study.

4. Preliminary Sub-Sector Selection Analysis

Perspective and Issues related to GHG Mitigation Action in the Country

Since the main concern of the **GHG reduction roadmaps** is the GHG mitigation measures, this section will provide a preliminary analysis of approaches specifically related to GHG mitigation. Although there might be many different methods for the purpose of sub-sector selection, given data limitations or unavailability, some methods may not be appropriate to be used in this analysis. Discussions about these approaches are presented below.

Historical Greenhouse Gas Data

To envisage the GHG reduction potential, one may initially look at the amount of GHG emissions from each industry itself. Basically, the industry that emits more is likely to have higher reduction possibility. However, the amount of emissions may not reflect the mitigation potential because there are other factors involved, such as production process or technology used in production, production efficiency, efficiency of energy usage, types of fuel used in the production process and so on.

Carbon Intensity

Another method to initially assess the GHG reduction potential is to compare the overall carbon intensity of a domestic industry with other countries, but the data on carbon intensity for the industry in Thailand is very limited. Nonetheless, it should be noted that there are several limitations of comparing the carbon intensity, as the calculation may not be on the same basis. For example, some plants may use ready raw materials; thus, these plants consume less energy or less complicated processes. In some cases, the definition of product in the industry with a variety of finished products, e.g. chemical industry, may cause the uncertainty in the comparison. Lastly, the calculation in such manner shows no indication to the abatement costs. Eventually, even if the data of carbon intensity is available, it may not be used for decision making because of the abovementioned reasons.

Reduction Potentials and Cost-Effectiveness

Another approach is to explore the reduction potential of each activity in each industry. This approach is conducted to review the current processes being employed, and explore the possibility to improve and/or change the current practices, as well as how much GHGs can be reduced and at what cost. This requires a substantial investment, time and various experts. Nonetheless, the study (TGO,

2010) based on the secondary data allows us to see initial mitigation potentials using this approach.

From the cost and the potential for GHG reductions of these activities, it produces a marginal abatement cost curve (MACC), which is a set of mitigation options shown by their reduction potentials, and put in order of their abatement cost. The study of MACC is a collective assessment on the mitigation potentials, together with related costs, of each measure or technology in order to reduce or absorb the GHGs from each industry sector. The mitigation activities are recommended to be collectively considered into three groups, which are:

- **Group A**, consisting those measures with **negative costs**, refers to the investments which eventually reduce the overall manufacturing costs. The measures under this group are believed to be profitable to manufacturers in the long run but were not implemented for some reasons such as the lack of knowledge, the lack of investment, etc.
- **Group B** covers those with **positive, but not too high, cost** and that is possibly be invested by the manufacturers.
- **Group C** is those with **high cost** and likely to require substantial support or promotion schemes to implement.

Existing GHG Reduction Policies

Apart from the *Thailand Climate Change Master Plan 2014-2050*, there is the other climate change master plan proposed concurrently a few years ago by a different department of the RTG. *Master Plan for Global Climate Change, Fluctuation of Fuel Price and World Food Crisis* (NESDB, 2010) stresses on green investment, low carbon society and sufficiency economy. In order to move towards the low carbon society, the Master Plan defines a plan to enhance highly efficient technologies and to improve production activities, focusing on alternative energy sources with relatively low carbon intensity. However, the plan suggested that the government played a supportive role and did not suggest any legal measures to limit GHG emissions. Although it mentions the expansion of compulsory measures from large factories and buildings to small-sized, it is added that “under supporting plans and incentives in various forms.”

In addition, the *National Industrial Development Master Plan 2012-2031* (OIE, 2011) clearly indicates that climate change is one of the four key factors that will affect the industry in Thailand, in terms of consumers’ demand for higher environmentally consciousness of the manufacturers and inputs that might be in short supply in the future. The role of the government under this Master Plan is to focus on helping the industry prepare to adapt and to cope with the changes rather than to introduce any legislation to enforce the manufacturers to implement GHG reduction measures.

Past experiences on GHG reductions in Thailand were mostly on the voluntary basis, such as the Clean Development Mechanism (CDM) or Voluntary Emission Reduction

(VER) projects. Most of these projects were related to energy generation through biogas and electricity generation using biomass. In addition, the recently released domestic market-based schemes, namely Thailand Voluntary Emission Reduction Program (T-VER)⁴ and Thailand Carbon Offsetting Program (T-COP)⁵, are all voluntary and not focused on any particular activity or industry. These schemes significantly resulted in an increase in the awareness of the industry in reducing emissions.

Currently, there are no clear measures to support on the GHG reductions from the manufacturing industrial sector in the country, but it has taken other measures, which indirectly result in the GHG reduction such as Designated Factories and Buildings Act. The Act requires the factories and buildings as defined under the Act to submit the energy management report (covering energy consumption reduction plan) to the Ministry of Energy. Though the Act has no standards set for the factories to follow, the preparation of energy management report provides useful information on investment decision making on energy efficiency, which promisingly leads to the reduction of GHG emissions, in the factory.

Preliminary Analysis: Precondition and Selection Criteria

Due to the complication of the issue, as well as conflicting objectives of criteria, the multi-criteria analysis (MCA) approach has been adopted. The approach allows decision makers to accommodate a combination of various issues which should be considered in the decision making.

Given the availability of data, the MCA can only be conducted at a broad level of sub-sectors as defined in TSIC-1972. Provided that the objective of this study is on the ground of Thailand's economic, environment and government policies, the below precondition and criteria have been agreed by the Project Steering Committee (PSC)⁶ for the selection of the three sub-sectors under the study.

- Precondition: Ongoing activities
- Criterion 1: Abatement Potentials
- Criterion 2: Economic Importance
- Criterion 3: Readiness and Sustainability
- Criterion 4: Government's Priorities

Precondition: Ongoing Activities

The project team held several meetings with representatives of government agencies, other donors and experts to receive information on ongoing activities in

⁴ Thailand's domestic GHG crediting mechanism (a project-based program similar to CDM), launched in October 2013

⁵ Thailand's carbon offsetting program (demand from participant to offset its own carbon footprint), launched in March 2013

⁶ From the PSC Meeting on 24 November 2014

the area of manufacturing industrial sector and its GHG mitigation plan. It was found that the largest emitters have been first selected for the studies on GHG inventory and mitigation potential assessments. The manufactures and sectors which are currently under studies by either the RTG, national experts or other donors include:

- Petrochemical, under sub-sector 'chemicals and the chemical products'⁷;
- Iron and steel, under sub-sector 'basic metals'⁸; and
- Cement, under sub-sector 'non-metallic mineral products'⁹.

Hence, in order to avoid duplication of similar work, the above three sub-sectors will not be treated as priority in the following MCA. The interest in the mitigation roadmap development will be shifted towards other sub-sectors, rather than the above three.

Criterion 1: Abatement Potentials

From the review of the abovementioned master plans¹⁰, the proposed policies have mainly focused on support from the government, not through enforcement by law. Therefore, it is somehow apparent that any actions to be taken by the manufacturers would be the measures with negative costs (Group A). To promote the adoption of measures with not very high cost (Group B), it is foreseen that the financial support from various funding sources is required. For high-cost measures (Group C), they may not be suitable for the current circumstance. Figure 15 illustrates the mitigation potentials (tCO₂e/year) and abatement cost (US\$/year) of each sector, considering only measures with negative costs (Group A).

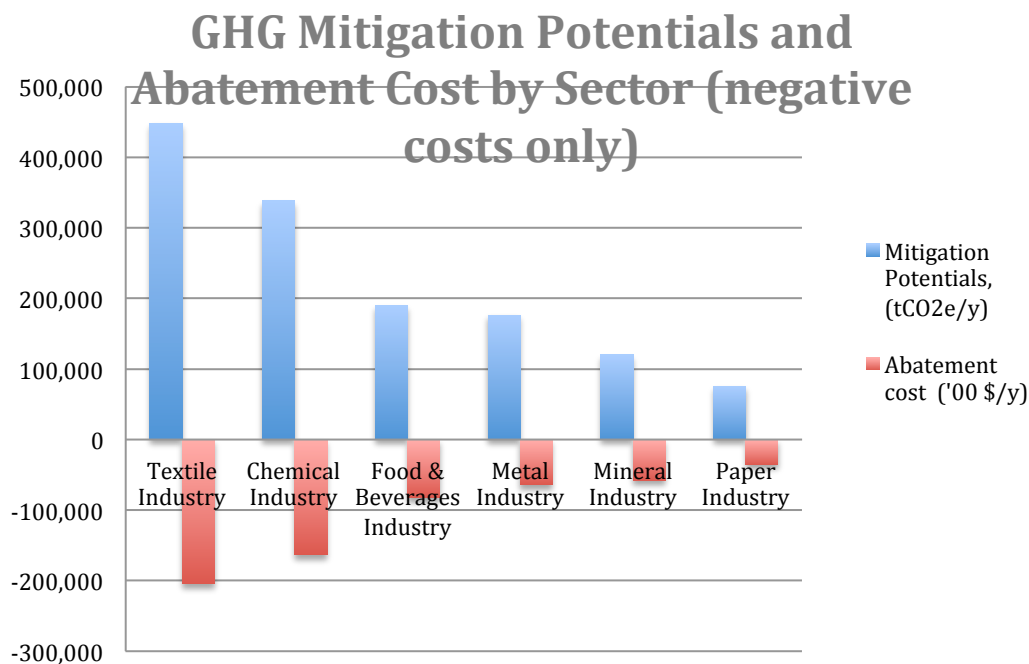
⁷ Funded by the Thailand Research Fund

⁸ By the United Nations Development Programme (UNDP) in collaboration with Thailand Greenhouse Gas Management Organization (TGO)

⁹ *ibid*

¹⁰ *Thailand Climate Change Master Plan 2014-2050* (ONEP, 2014), *Master Plan for Global Climate Change, Fluctuation of Fuel Price and World Food Crisis* (NESDB, 2010), and *National Industrial Development Master Plan 2012-2031* (OIE, 2011). See Section Existing GHG Reduction Policies for discussions about the Plans.

Figure 15 – GHG Mitigation Potentials and Abatement Costs by Sector (considered only mitigation measures with negative costs)



Even though, this data set used to generate the above figure is the best available, its original source is relatively old (IIEC, 2000). Important factors in determining the abatement cost of each measure are investment cost and energy prices. These two factors have changed a lot over the past decade. It is likely that high-cost activities in this study may now have a lower cost and the manufacturers might have already taken some measures.

Since the objective of this report is to identify and confirm the most appropriate three sub-sectors to engage with and to keep up with Thailand economic development, the “abatement potentials” criterion is the first to be considered. The criterion concerns the total abatement costs required to reduce a certain amount of GHGs, as well as the total amount of emissions to be potentially reduced by applying a particular set of mitigation measures. It shall be noted that the abatement potentials criterion to be discussed below was derived from the measures with negative costs only (see *Figure 15*), assuming that the manufacturers would not invest in the mitigation options with positive costs.

From the first criterion presented in *Figure 15*, it can be seen that the “**textile industry**” is clearly attractive in terms of potential and cost effectiveness. It shows the highest annual GHG mitigation potential at 448,182 tCO₂e, with the lowest total abatement cost of –US\$204,564. The industries, which came second and third are chemicals and food & beverages. Both show similar and not-conflicting results, i.e. lower reduction potentials with higher cost.

Criterion 2: Economic Importance

Considering the key export sectors, the top three of 2013 are manufactures of electronic devices, automobile and parts and electrical appliances, accounted for about half of the export value (US\$85,462). Since the top three, together with machinery and parts (ranked no. 9), are all categorised under the manufacture group “**metal products, machinery and equipment**”, this group arrives to the topmost in terms of economic importance, followed by the chemical industry, with high export values from chemical products, plastic pellets and rubber products, counted for US\$26,653 in 2013. Top ten manufactured products with its export value in 2013 and its categorisation into manufacture group (TSIC-1972) are presented in Table 6.

Table 6 – Top Ten Export Sectors in 2013

Products (top ten of 2013)	Export value (m US\$)	Category in TSIC-1972
1. Electronic devices	31,765	Metal products, machinery and equipment
2. Automobile and parts	30,697	Metal products, machinery and equipment
3. Electrical apparatus	23,001	Metal products, machinery and equipment
4. Gems and jewelry	10,085	Others
5. Chemical products	9,105	Chemicals and the chemical products
6. Plastic pellets	9,037	Chemicals and the chemical products
7. Rubber Products	8,511	Chemicals and the chemical products
8. Textile	7,483	Textiles and wearing apparel
9. Machinery and parts	6,787	Metal products, machinery and equipment
10. Iron & steel products	6,348	Basic metals

Source: OIE, 2014

GHG reduction activities in the industrial sectors normally promote environmental awareness of the economic activities. The applied abatement actions, especially those with negative costs, might further lower the production cost leading to higher financial value of the products. Therefore, assuming that the manufacturers would not employ any mitigation measures with high positive cost, the application of GHG emission measures with the negative costs will only benefit all industries, regardless of whether it is an export-oriented industry.

Criterion 3: Readiness and Sustainability

One fact which cannot be avoided is the willingness of the manufacturers in any particular industry to participate. It is obvious that engaging each and every one in

the industry is not possible and the procedures would be complicated, especially without the appropriate legal enforcement. In the initial analysis on the sub-sector selection, the size, together with the number of the establishments, could be one factor to be considered. An engagement of one large factory could obviously result in a bigger amount of GHG reduction as compared to several small factories. It is believed that the large establishments tend to have stable management objective; thus, ensure the sustainability of the Project in a longer term. Moreover, the number of these establishment could indicate possibility to capture the key players and majority of the mitigation potential in the sector. As such, the number of large-sized establishments is adopted as a criterion in order to mark out the level of sub-sector readiness and its likelihood of sustainability beyond the completion of the Project.

Following the *2007 Industrial Census* (NSO, 2007), this study will focus on only large-sized manufacturing establishments by the formation of legal organizations. 'Large' would cover the establishments legally registered as:

- '*Company limited*' refers to an establishment, which was established and legally registered by an initiative group of at least 7 persons.
- '*Public company limited*' refers to an establishment, which was established and legally registered by an initiative group of at least 15 persons.
- '*Government*' or '*state-owned enterprise*' refers to an establishment, which entirely owned by the government or more than 50 percent of its shares belonged to the government.
- '*Cooperatives*' refers to an establishment, which was organised on cooperative lines and registered under the Cooperation Act, with an initiative group of not less than 10 persons.
- '*Others*' refers to establishments other than those mentioned earlier, and neither individual proprietor' nor 'juristic partnership'.

According to the number of large-sized manufacturing establishments in Thailand (Table 2), as per the above definition, the concentration falls into three sub-sectors: food, beverages and tobacco; textiles and wearing apparel; and metal products, machinery and equipment. There are more than 6,000 large establishments in each sub-sector. Meanwhile, there are only around 700 and 1,600 large registered establishments in GHG-intensive manufactures: non-metallic mineral products and basic metals, respectively.

Criterion 4: Government's Priorities

In order to ensure that the GHG reduction roadmaps to be developed for the selected three sub-sectors come into practice, it is apparently important to consider the government's priorities. As such, the project team considered the priorities of the RTG regarding the advancement strategy for the country's manufacturing industry as one of the key criteria. According to the *National Industrial Development Master Plan 2012-2031* (OIE, 2011), there are eight individual industries chosen

under the RTG's pilot-staged development plan. The concept and selection framework of the pilot industries are:

- *To cover all industry segments:* considering skilled labour, social development, technology, infrastructure and the environment;
- *In accordance with the industry selection criteria:* in-country maximum benefits; response to globalization and the country's policies; concrete foundation to the development of Thai industry, etc.; and
- *To cover all levels of the industry's potential:* industries with high potential, needed adaptation and emerging industries.

Following the selection concept and framework mentioned above, the list of eight selected pilot industries based on the *National Industrial Development Master Plan 2012-2031* (OIE, 2011) includes:

- 1) Food and beverages;
- 2) Rubber;
- 3) Textiles and wearing apparel;
- 4) Automobile and parts;
- 5) Gems and jewelry;
- 6) Electrical apparatus and electronics devices;
- 7) Machine and equipment (moulds); and
- 8) Renewable/alternative energy

Scoring, Weighting and Performance Matrix

At this stage, the scoring and weighting system was proposed and mutually agreed by the members of the PSC. Details of scores and weights employed in this analysis are delineated below.

Scoring

A numerical score was assigned for each sub-sector under each criterion. Basically, more attractive sub-sectors score higher on the scale, and less preferred ones score lower. In this analysis, scales extending from 0 to 100 were applied, where 0 represents a real or hypothetical least attractive sub-sector, and 100 is associated with a real or hypothetical most desirable. The score of each sub-sector considered in the MCA would then fall between 0 and 100. *Table 7* denotes scoring details of each criterion for the MCA.

Table 7 – Scoring of each Criterion

Criterion	Indicator (unit)	Scale/relationship	Score
1. Abatement Potentials	Mitigation potentials (tCO ₂ e/year); Abatement cost (US\$/year)	Linear relationship	0-100 (0-50 for each sub-criterion)

Criterion	Indicator (unit)	Scale/relationship	Score
2. Economic Importance	Export value in 2013 (US\$/year)	>30,000	100
		26,001-30,000	90
		22,001-26,000	80
		18,001-22,000	70
		14,001-18,000	60
		10,001-14,000	50
		6,001-10,000	40
		<6,000	30
3. Readiness and Sustainability	Number of large establishments	< 500	100
		501-1,000	90
		1,001-1,500	80
		1,501-2,000	70
		2,001-2,500	60
		2,501-3,000	50
		3,001-3,500	40
		3,501-4,000	30
		4,001-4,500	20
		>4,500	10
4. Government's Priorities	Selected industries for pilot development phase	Selected	100
		Not selected	0

Weighting

Numerical weights are assigned to define the order of magnitude for each of the four criteria. These weights, shown in Table 8, were mutually understood and agreed among the members of the PSC¹¹, which comprises of relevant ministry bodies and experts on the area of industry in Thailand.

Table 8 – Weights assigned to each Criterion

Criterion	Weight (%)
1. Abatement Potentials	20
2. Economic Importance	30
3. Readiness and Sustainability	20
4. Government's Priorities	30

Performance Matrix

From the above substantiation of selected criteria, scoring and weighting, the MCA arrives to the below performance matrix (Table 9), which shows the results based on which three sub-sectors shall be selected for the development of the GHG reduction roadmaps.

¹¹ From the PSC Meeting on 24 November 2014

Table 9 – Performance Matrix of the Sub-Sector Diagnostic

Manufacturing Group (TSIC-1972)	Reduction Potential	Economic Importance	Readiness	Government's Priority	Score
<i>Weight</i>	<i>20%</i>	<i>30%</i>	<i>20%</i>	<i>30%</i>	<i>100%</i>
31 Food, beverages and tobacco	41	30	10	100	49
32 Textiles and wearing apparel	100	40	10	100	64
33 Wood and wood products	17	30	60	0	24
34 Paper and paper products	17	30	60	0	24
35 Chemicals and the chemical products	78	90	10	100	75
36 Non-metallic mineral products	28	30	70	0	29
37 Basic metals	35	40	90	0	37
38 Metal products, machinery and equipment	35	100	10	100	69
39 Others	17	50	50	100	58

Note: Scoring details shown in Annex 2

Result from Preliminary Analysis

According to the scores from the performance matrix, it shows that the three manufacturing groups (with highest scores), which are appealing to the next stage of this study are: (i) metal products, machinery and equipment; (ii) textiles and wearing apparel; and (iii) Others. It should be noted that although the chemicals and the chemical products received the highest score, it was not selected because there is other organization working on the development of GHG roadmap for the sector.

Moreover, the sub-sectors included in 'Other' manufacturers¹² are those not specified under the other groups, and there is only the manufacture of gems and jewelry was of important to the criteria considered in the MCA. Thus, the group 'Others' shall refer to this manufacture in particular. However, due to a lack of key basis data on abatement potential and GHG inventory of the gems and jewelry industry at the time of this analysis, it is assumed that its potentials would likely to be relatively insignificant and the sub-sector will be omitted. Therefore, the third place from the matrix will be replaced by the following manufacturing group, which is food, beverages and tobacco.

¹² Covered manufactures of furniture; gems and jewelry; musical instruments; sports goods; and games and toys.

Hence, the result concluded from the MCA shows the appealing manufacturing groups including:

1. Manufacture of metal products, machinery and equipment;
2. Manufacture of textiles and wearing apparel; and
3. Manufacture of food, beverages and tobacco.

5. Proposed Sub-Sectors and Chosen Specific Industries

This Chapter provides the final judgment on the agreed selected sub-sectors and the specific industry within each sub-sectors. Since the published data and information are not available at detailed level, the preliminary analysis (see *Chapter 4*) was able to analyze at only a broad level¹³ of sub-sector of the manufacturing sector. An expert judgment from the PSC, which consists of 14 representatives from key government agencies, industry group, academic institutes, and expert, was then sought to specify which industry would be selected for the development of GHG reduction roadmaps in the following component of the Project.

The result of the MCA in *Chapter 4* suggested three sub-sectors for roadmap development which were presented to the PSC members at the PSC meeting on 24 November 2014. The PSC has agreed with the analysis on some sub-sectors but also provided recommendation on a prospective sub-sector that was not selected and on specific industry to focus from each of the selected sub-sector. In addition to the advice from the PSC, the project team has actively engaged several public and private associations in order to inspect the level of interest and willingness of the industries to collaborate in the next step of the Project. The detailed discussions were around the following sectors:

1. Manufacture of metal products, machinery and equipment;
2. Manufacture of textiles and wearing apparel;
3. Manufacture of food, beverages and tobacco; and
4. Manufacture of non-metallic mineral products.

Metal Products, Machinery and Equipment

From the application of MCA, the ‘metal products, machinery and equipment’ sub-sector appears the most appropriate for GHG reduction roadmap development. The abatement potential of this sub-sector was estimated to be 176,505 tCO₂e reduction at minus US\$64,248 cost per annum based on the data of basic metal sub-sector which was used as a proxy for the metal products, machinery and equipment sub-sector. Although it came fourth in terms of abatement potentials, this sub-sector or any industry within the sub-sector is always one of the top five industries contributing to GHG emissions. Considering the importance to Thai economy, its export value in 2013 accounted for 65 percent (US\$92,249) of the total value from the top ten industries. The key export products were electronic devices; automobile and parts; electrical apparatus; and machinery and parts.

From the presentation of this sub-sector as one or the three proposed to be selected under the Project based on the preliminary analysis, the PSC agreed on the sub-sector and provided suggestion of the specific industry, which is the **‘Automobile**

¹³ Based on TSIC-1972, which divided into only 9 manufacturing sub-sectors.

Parts' industry, that deserve a special attention. This industry is an energy-intensive industry with a room for energy efficiency improvement. In terms of readiness and sustainability of the future implementation of the roadmaps for this industry, it is considered relatively high (i.e. number of large establishments under this industry is relatively low, 833). Besides, given that more than 50 percent of the products from this industry are exported, the industry was chosen as one of the eight pilot industries under the Industrial Development Plan (OIE, 2011).

Having visited the Thai Autoparts Manufacturers Association (TAPMA) at its Board of Directors meeting on 16 December 2014, the project team received strong interest and willingness in contributing to the roadmap development. Having direct experience in energy consumption inspection at his own facilities, the meeting chairman perceived the high potential in energy cost saving for automobile parts industry and saw direct benefits from GHG reduction roadmap and measures. Also, the project team was informed by the association that there is a large room for improvement in terms of GHG reduction and energy efficiency. Thus, with strong interest from the sector and high GHG reduction potential, the sector will be selected.

Textiles and Wearing Apparel

The result from the MCA suggested 'textiles and wearing apparel' could be one of the sub-sectors to be chosen for the GHG reduction roadmap development. Its final score appeared very high, especially on the reduction potential and government priority criteria. Concerning the abatement potential, this manufacturing group shows highest potentials in terms of both annual cost (-US\$204,564) and reduction potential (448,182 tCO₂e), while its contribution to GHG emissions based on the SNC was relatively low (4 percent). It is also one of the industries to be driven by the Ministry of Industry according to the *Industrial Development Plan* (OIE, 2011).

Although it was one of the top ten exporting products in the year 2013, the experts' view derived from the PSC members suggested that the industry has been moving away towards a lower labour cost bases, like Vietnam and Cambodia, in the past years. Given that it is a labour-intensive industry and since it has been enjoying the export market for some time, it is believed that the mitigation options might have already been adopted in order to maintain its foreign markets worldwide. Thus, it was agreed that this sub-sector would be dropped from the shortlist.

Food, Beverages and Tobacco

The abatement potential from 'food, beverages and tobacco' sub-sector is considered moderate (189,620 tCO₂e reduction at -US\$82,325 per year), after the manufactures of textile and chemical products. Though its export value was not among the top ten, this sub-sector has significant impacts to the nation with the highest output value, the number of establishments and workforce in the

manufacturing sector.¹⁴ However, as the government aims to develop the sector to be the “kitchen of the world” by supplying food globally, this sector will be very essential for the country in terms of the long-term economic development and job creation.

Provided that the nature of this sub-sector is highly diversified with a significant number of registered large establishments (more than 100,000), ranging from different dairy products to frozen and packaged food, the roadmap development should be assigned to (a) specific industry(ies). Due to limitation to data and information at this stage of the Project, some specific industries were derived from the agreement of the PSC members, as well as recommendations from the National Food Institute (NFI)¹⁵ which have strong experiences and have been working on GHG-related subjects for the food industry. Potential industries from this sub-sector include: Palm oil, sugar and frozen food. Some information of these three suggested industries in the country is to be separately discussed below.

Palm Oil Industry

Palm oil is an important economic crop of the country. In 2012, it was observed that there were over 128,000 households of palm oil growers in Thailand. The plantation generates income to farmers at approximately THB 6 billion per year. In recent years Thailand has seen its palm oil industry growing at a rapid rate¹⁶. The increase was a result from the RTG’s strategic plan laid out for the industry during 2008-2012 with the aim to support the country’s alternative energy strategy, as well as to mitigate the risk of food scarcity. In 2014, Thailand exported around 500,000 metric tons of palm oil, the fourth palm oil exporting country after Indonesia, Malaysia and Papua New Guinea, while its annual growth rate is at the topmost rank, as high as 25 percent.¹⁷

Not only does the palm oil industry appear directly as part of the food and beverage sector which is among the eight targeted pilot industries under the Industrial Plan, the industry is directly linked to the alternative/renewable industry. More than one fourth of the crude palm oil productions are used to produce biodiesel, consequently decrease dependent on conventional fuel, enhance energy security and lessen the impact on the environment.

According to the information received from the NFI, it was mentioned that most, if not all, large-sized manufacturers have developed their own carbon footprint (CF) and implemented measures to reduce their emissions. However, since most of the

¹⁴ OIE, 2011

¹⁵ A meeting between the NFI and GGGI country team was held on 24 December 2014.

¹⁶ Available from: <http://www.ksmecare.com/Article/82/28155/ธุรกิจปาล์มน้ำมันหลังก้าวเข้าสู่-AEC>. [27 January 2015].

¹⁷ Available from: <http://www.indexmundi.com/agriculture/?commodity=palm-oil&graph=exports>. [7 December 2014].

CF completed was for the end-used products (downstream industry), it is believed that there are still remaining GHG reduction potentials especially from the midstream industrial activities, or mill processing plants. Based on the product carbon footprint information available, only one product out of 30 was crude palm oil and reported on its CF¹⁸, which shows that almost 50 percent of the total emissions was from the industrial activities. Using this piece of information to establish a ballpark figure of the emission from the exported portion only, around 290 ktCO₂e¹⁹ were emitted from this cluster. In-depth carbon emission inventory and the mitigation pathway will be studied and determined under Component 2 of the Project.

Therefore, given the GHG reduction potential and economic importance of the sector, the palm oil industry will be selected as part of the Project.

Sugar Industry

Among the main food sector, special attention on the GHG emissions has been called upon the sugar industry. Thai sugar industry relies mainly on the sugarcane, which is one of the world's major food-producing crops providing about 75% of the sugar for human consumption. Thailand is currently the second largest sugar exporting country worldwide, only after Brazil, in 2013/14. In that year, the country exported approximately 7.5 million metric tons of sugar.²⁰ At present, it is reported that there are 51 sugar mills in the country²¹, concentrated in the northeastern part surrounded by the sugarcane plantations.

In terms of GHG emitted from the sugar production process, the study regarding the GHG emission associated with sugar production in Brazil (De Figueiredo, 2010) shows similar results as compared to the product carbon footprint (PCF) accessible from the TGO website. From the Brazilian case, on average 241 kg CO₂e were released to the atmosphere per a ton of sugar produced. One of the white sugar products shows its PCF of 285 kg CO₂e/ton, of which only around 20 percent is from the production process²².

Up to the present time, the NFI revealed that they had surveyed and developed the good product program, and the carbon footprint program for almost all large sugar manufacture factories during 2013-2014. Thus, comprehensive information on GHG emissions from the sugar industry is available. The NFI expressed its industrial

¹⁸ Available from: <http://thaicarbonlabel.tgo.or.th/carbonfootprint/index.php?page=3>. [29 January 2015].

¹⁹ Estimated based on secondary data: the export value of crude palm oil (~500,000 metric tons) and the CF of crude palm oil product (production process only, ~50% of 1.17 kg CO₂e/kg CPO).

²⁰ Available from: <http://www.statista.com/statistics/273437/exported-amount-of-sugar-in-leading-countries/>. [7 December 2014].

²¹ Data available from: <http://www.ocsb.go.th/th/factory/index.php>. [31 January 2015].

²² Available from: <http://thaicarbonlabel.tgo.or.th/carbonfootprint/>. [31 January 2015].

expert view that most of GHG reduction potentials in the sugar industry had been captured and there is very limited reduction potential remained. Having considered the constructive progress in Thai sugar industry, the value-added from the Project would be very small. It is, therefore, not advised to focus on the sugar industry.

Frozen Food Industry

Driven by modern lifestyle, the demand for faster-to-prepare foods is growing rapidly. It is expected that the global frozen food market would be worth US\$293.75 billion by 2019, up from US\$224.74 billion in 2012.²³ In Thailand, important frozen food products, including chicken, shrimp, other seafood and vegetable, are among the key agricultural commodities contributing to the export value. The President of the Thai Frozen Foods Association (TFFA) provided his vision that the export of frozen seafood has a potential to reach its export value of THB 130,000 million (US\$3,955 million²⁴) or around 10 percent of agricultural export value in 2012.²⁵ This sector is also a major source of employment as it employs millions of people especially in the central and southern parts of the country. However, with global concerns on the sustainability and human right issues, the sector is facing a challenge posted by non-tariff barriers (NTBs). Developing GHG roadmap for the sector will provide an opportunity to show the sector's commitment on the sustainability issue.

During 2009-2013, the processed, frozen food market in Thailand has been continually expanding. Over the said period, its average annual growth rate in terms of volume is 7.94 percent, or 8.73 percent per year in terms of its value.²⁶ The NFI recommended that the frozen food industry would have high potential for emission reduction because the activities in this industry contribute a large amount of GHG emissions from energy consumption (from both boiler and freezing process), the wastewater discharged from the preparation process, as well as refrigerants leaked in the freezing process which have extremely high Global Warming Potential (GWP). It is suggested that the sector should be included in the Project.

Non-metallic Mineral Products

As a result of the suggestion by the PSC to drop the textiles and wearing apparel sub-sector, the 'non-metallic mineral' was advised to be reconsidered. The sub-sector has relatively low GHG reduction potentials as compared to the others (reduction 120,216 tCO₂e, cost -US\$58,216 annually). According to the SNC, almost

²³ Available from: <http://www.transparencymarketresearch.com/pressrelease/global-frozen-foods-market.htm>. [31 January 2015].

²⁴ Exchange rate of THB32.8677/US\$ as of 30 January 2015 (Source: Bank of Thailand, <http://www.bot.or.th/English/Pages/BOTDefault.aspx>)

²⁵ Derived from the total agricultural export value of THB1,268,217 million. Available from: http://www.oae.go.th/oae_report/export_import/exp_topen.php?imex=2. [31 January 2015]

²⁶ Thai Food Market Report (NFI, 2014)

all (98%) GHG emissions from industrial processes activities were from this sub-sector and cement industry was the key contributor (60%). Based on the review of various studies, it can be confirmed that the manufacture of cement has the highest contribution to GHG emissions from manufacturing sector. However, since it was investigated that the cement industry has been under a similar study being conducted by the United Nations Development Programme (UNDP) in collaboration with Thailand Greenhouse Gas Management Organization (TGO). Therefore, as it was stated as the precondition to the MCA, the cement industry would not be taken into account.

Nonetheless, the PSC recommended another industry within the same sub-sector: The ceramic industry. The project team has considered this advice and sought cooperation and viewpoint from the two industrial groups– i.e. Thai Ceramic Society and the Ceramic Industry Group of FTI²⁷ Both industrial groups indicated similar standpoints that the group members might not be much interested in the proposed activities because from their experiences, the ceramic industry is highly competitive, so that the manufacturers would be reluctant to share their information and cooperate with such project. Furthermore, some large-sized ceramic companies have already participated in the product carbon labelling program²⁸ so that the industry is familiar with the information about emission reduction and might not need help from this study. Given the reluctance of the industry itself, the ceramic industry shall be excluded.

Conclusions

After the in-depth review of the available data and a series of consultations with stakeholders, the Project has selected three industrial sub-sectors, for which the GHG reduction roadmaps will be developed: **Manufactures of palm oil, frozen food and automobile parts**. Figure 16 summarised the steps how the decisions were made:

²⁷ The meetings between the GGI country team and the two ceramic groups, i.e. the Ceramic Industry Group of FTI and Thai Ceramic Society, were held on 20 and 22 January 2015, respectively.

²⁸ Initiated by the TGO (<http://thaicarbonlabel.tgo.or.th>)

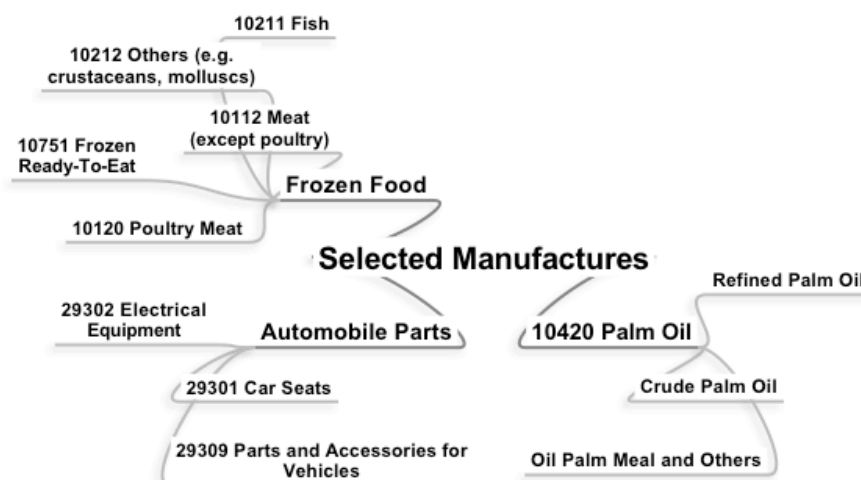
Figure 16 - Summary of Analysing Steps and Final Selection of Industries

Preliminary MCA	PSC Advice	Interest/Willingness*	Conclusion
Metal Products, Machinery and Equipment	Automobile Parts	Interested	✓
Textiles and Wearing Apparel	<i>Excluded</i>	N/A	✗
Food, Beverage and Tobacco	Palm Oil	CF completed. Remaining potentials.	✓
	Sugar	Almost all capable to conduct mitigation measures. Small potential.	✗
		Frozen Food recommended	✓
	Ceramic (non-metallic mineral)	No interested	✗

Note: *Interest/opinions perceived from relevant industrial associations: automobile and parts (TAPMA); all food (NFI); and ceramic (Thai Ceramic Society and the Ceramic Industry Group of FTI)

In order to ensure that the activities to be covered in the roadmaps would reflect the actual economic activities to date, the most recent TSIC version (B.E. 2552 or 2009)²⁹ will be used to refer to the relevant activity codes as an initial scope for the next step of the Project. Figure 17 shows selected industries and corresponded economic activities codes. In addition, GHG inventories for each sub-sector will be thoroughly reviewed and updated as part of the Project.

Figure 17 - Selected Industries and Corresponded Economic Activities Codes



Note: 5-digit codes referred to relevant activities of the selected industries (based on TSIC-2009)

²⁹ Revised by the National Statistical Office (NSO) in 2010.

6. Recommendations

In order to develop the GHG reduction roadmaps for these identified manufacturing industrial sub-sectors, there are several factors to consider in the upcoming Component of the Project. This Chapter aims to point out some challenges, which include:

- Readiness, consistency and completeness of data;
- Supplement and integration with other sectors;
- Stakeholder engagement; and
- General policy advice.

Readiness, Consistency and Completeness of Data

The information on GHG inventory as reported in, for example, SNC, was mostly estimated based on the least-detailed level – Tier 1. In order to improve the quality of GHG inventory, more detailed data will be required, moving to a higher Tier method for the GHG emission calculation and thereby arriving at lower uncertainty of the reported information. Since the data collection from various governmental bodies might have different key purposes, and might not always be suitable for the development of inventory in particular, the RTG may first well enhance the quality on some selected sub-sectors, especially those with the high impact on both the economic and climate problems. These sub-sectors may include, but not limited to, chemical (i.e. petrochemical), non-metallic mineral (i.e. cement), etc.

It is possibly a good start for Thailand to seriously consider developing sectoral GHG abatement potentials, applying Marginal Abatement Cost Curve (MACC) concept, in the country's context in addition to the MACCs that will be developed for the three sub-sectors under the Project. In addition to MACC study, the Project could provide general advice regarding capital intensity and prioritization of abatement actions. Taking into account the upfront investments, manufacturers might choose to invest in the opportunities with the lowest capital intensity rather than the lowest cost over time. Moreover, the importance of time, any delay in the decision to implement abatement actions could result in not only additional emissions in the business-as-usual (BAU) scenario, but also even a lock-in effect from any high-carbon infrastructure.

Supplement and Integration with Other Sectors

Climate change and GHG emissions are considered crosscutting. There are many different industrial sectors which contribute to these issues, as well as are affected from it. To efficiently develop the mitigation roadmap for any particular sub-sector, it is noticeable that other national, and even international, policies should be studied in parallel. Other existing and in-the-pipeline policies could undoubtedly contribute

to high relevancy to the roadmaps to be introduced under the Project. Thus, the development of the roadmaps shall be designed taking into account other related policies.

In addition to the economic impact analysis for the reduction measures, co-benefits approach should be introduced. For instance, the benefits of high-energy efficiency equipment are not only to reduce energy usage, but also to solve multiple environmental problems. Its co-benefits may include the mitigation of CO₂ and air pollutants. The total economic co-benefits of each measure would even be much higher than the energy savings. These intangible values can in fact be translated into the monetary term; thus, reflecting real benefits of the application of that particular measure.

Stakeholder Engagement

With the aim of achieving the advantage of the roadmap, it is important to push it towards the actual implementation stage. In doing so, the stakeholder engagement is vital. Other than the manufacturers under the selected sub-sectors/industries, relevant key stakeholders, including government departments, industry associations, and academic institutions, have been identified and engaged at the very first stage of the Project. The PSC members have been designated and the nomination letters, dated 27 October 2014 were sent out to the potentials. Table 10 presents the current list of key stakeholders under the Project. More entities might be connected in the future, should it deem appropriate when the Project advances.

Table 10 – Key Stakeholders under the Project

Organization/Individual Expert	Original Affiliation/Type of Organization	Specific Role (if any)
Secretary General, ONEP	MONRE	PSC Chairman
Department of Alternative Energy Development and Efficiency (DEDE)	Ministry of Energy	PSC
Energy Policy and Planning Office (EPPO)	Ministry of Energy	PSC
Office of the National Economic and Social Development Board (VESDB)	Office of the Prime Minister	PSC
Department of Industrial Works (DIW)	Ministry of Industry (MOI)	PSC
Thailand Greenhouse Gas Management Organization (TGO)	Public organization	PSC
The Joint Graduate School Of Energy And Environment (JGSEE)	King Mongkut's University Of Technology Thonburi (KMUTT)	PSC
Good Governance for Social Development and the Environment Institute (GSEI)	Non-profit organization	PSC
The Federation of Thai Industries (FTI)	Non-profit organization, under supervision of MOI	PSC
Prof. Chullaphong Chullabodhi, PhD	School of Energy, Environment and Materials, KMUTT	PSC

Organization/Individual Expert	Original Affiliation/Type of Organization	Specific Role (if any)
Assoc. Prof. Chart Chiemchaisri, PhD	Department of Environmental Engineering, Kasetsart University	PSC
Director of Office of Climate Change Coordination, ONEP	MONRE	PSC Secretary
Head of Mitigation Mechanism Development Section, ONEP	MONRE	PSC Assistant Secretary
GGGI	Development Agency	PSC Assistant Secretary
Asst. Prof. Siriluk Chiarakorn, PhD	School of Energy, Environment and Materials, KMUTT	-
Thai Autoparts Manufacturers Association	Non-profit organization	-
National Food Institute	Independent organization, under MOI	-
The Thai Ceramic Society	Non-profit organization	-
Ceramic Industry Group, FTI	Non-profit organization, under supervision of MOI	-
Thai Frozen Foods Association (TFFA)	Non-profit organization	<i>To be engaged</i>
Palm Oil Industry Group, FTI	Non-profit organization, under supervision of MOI	<i>To be engaged</i>
Thai Oil Palm and Palm Oil Association	Non-profit organization	<i>To be engaged</i>
Thai Palm Oil Refinery Association	Non-profit organization	<i>To be engaged</i>

General Policy Advice

Under the profit-driven environment, another key force to the actual implementation of the roadmaps would surely be the government policies. From the review, there is no clear indication that Thailand would introduce any forcible regulations to reduce GHG emissions in the short and medium terms. As such, the plausible way to engage manufacturers to implement the GHG mitigation measures would likely to be in different forms of government supports – e.g. tax incentive, market-based scheme, technological advice/promotion, etc. Nonetheless, the government budget would be limited at a certain level; thus, international supports could be a supplement to the national actions.

Market-based mechanisms are instruments widely applied during the last two decades. Though the instruments for mitigation prove successful, there are key lessons learned below that should be carefully observed and taken into consideration in the design of market mechanisms for adaptation.

- 1) **Demand** should be created and must be effectively managed throughout the operational period of the schemes.
- 2) **Pilot phases** are important to test an instrument and to correct design flaws.
- 3) **Regulatory uncertainty** reduces the efficiency gains.
- 4) **Cost of project management** – including project registration, monitoring, verification, etc. – can be a burden to project operations.

Reference

Bank of Thailand 2014, *Thailand at a Glance*. Available from: http://www.bot.or.th/English/EconomicConditions/Thai/genecon/Pages/Thailand_Glance.aspx. [19 October 2014].

Carbon Footprint: Companies and Product Approvals, 2015. Available from: <http://thaicarbonlabel.tgo.or.th/carbonfootprint/index.php?page=3>. [29 January 2015].

De Figueiredo et al 2010, 'Greenhouse gas emission associated with sugar production in southern Brazil', *Carbon Balance and Management* 2010, 5:3. Available from: <http://www.cbjournal.com/content/5/1/3>. [31 January 2015].

Department of Industrial Works (DIW) 2012, *Strategic Planning for the Greenhouse Gas Management in Industrial Sector*, Ministry of Industry, Bangkok, Thailand.

Intergovernmental Panel on Climate Change (IPCC) 1996. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*. Available from: <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html>. [26 October 2014].

Intergovernmental Panel on Climate Change (IPCC) 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*. Available from: <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html>. [26 October 2014].

McKinsey & Company 2009, *Pathways to a Low-Carbon Economy*. Available from: http://www.mckinsey.com/client_service/sustainability/latest_thinking/pathways_to_a_low_carbon_economy. [1 November 2014].

National Economic and Social Development Board (NESDB) 2011, *Master Plan for Global Climate Change, Fluctuation of Fuel Price and World Food Crisis*, Office of the Prime Minister, Bangkok, Thailand.

National Economic and Social Development Board (NESDB) 2011, *Eleventh National Economic and Social Development Plan (2012-2016)*, Office of the Prime Minister, Bangkok, Thailand.

National Food Institute (NFI) 2014. *Thailand Food Market Report: Market and Consumer Behavior of Processed, Frozen Food in Thailand*. Available from: http://fic.nfi.or.th/broadcast/Thailand%20Food%20Market_Frozen%20Processed%20Market-OIE.pdf. [31 January 2015].

National Statistical Office (NSO) 2007, *Industrial Census*, Bangkok.

National Statistical Office (NSO) 2010, *Thailand Standard Industrial Classification B.E. 2552 (Revised Version by the National Statistical Office)*, Bangkok Block Limited Partnership, Bangkok, Thailand.

Office of Industrial Economics (OIE) 2011, *National Industrial Development Master Plan 2012-2031*, Ministry of Industry, Bangkok, Thailand.

Office of Natural Resources and Environmental Policy and Planning (ONEP) 2010:1, *Thailand's Second National Communication under the United Nations Framework Convention on Climate Change*, Ministry of Natural Resources and Environment, Bangkok, Thailand.

Office of Natural Resources and Environmental Policy and Planning (ONEP) 2010:2, *Development of Greenhouse Gas Inventory*, Ministry of Natural Resources and Environment, Bangkok, Thailand.

Office of Natural Resources and Environmental Policy and Planning (ONEP) 2014, *Thailand Climate Change Master Plan 2014-2050*, Ministry of Natural Resources and Environment, Bangkok, Thailand.

Palm Oil Business After Entering the AEC, 2012. Available from: <http://www.ksmecare.com/Article/82/28155/ธุรกิจปาล์มน้ำมันหลังก้าวเข้าสู่-AEC>. [27 January 2015].

Palm Oil Exports by Country in 1000 MT, 2014. Available from: <http://www.indexmundi.com/agriculture/?commodity=palm-oil&graph=exports>. [7 December 2014].

Principal sugar exporting countries in 2013/2014 (in million metric tons), 2014. Available from: <http://www.statista.com/statistics/273437/exported-amount-of-sugar-in-leading-countries/>. [7 December 2014].

Quarterly Industrial Economic Report: Q2 2014 (April-June 2014), 2014. Available from: http://www.oie.go.th/sites/default/files/attachments/industry_overview/r_aprjun57.pdf. [16 October 2014].

Thailand Greenhouse Gas Management Organization (TGO) 2010, *Study on Policy Recommendation on Greenhouse Gas Mitigations in Important Economic Sectors in Thailand*, Bangkok, Thailand.

Thailand Greenhouse Gas Management Organization (TGO) 2012, *Greenhouse Gas Emissions from Industrial Sector in Thailand*. Available from: http://conference.tgo.or.th/download/tgo_or_th/Article/GHG_Emission/Thailand_Industry_Top5GHG_2011.pdf. [26 October 2014].

Transparent Market Research 2014, *Global Frozen Food Market to Reach US\$ 293.75 billion by 2019*. Available from:
<http://www.transparencymarketresearch.com/pressrelease/global-frozen-foods-market.htm>. [31 January 2015].

World Bank 2014, *2014 World Development Indicators*. Available from:
<http://data.worldbank.org/sites/default/files/wdi-2014-book.pdf>. [19 October 2014].

Annex 1: Relevant Sub-Categories Contributing to GHG emissions in Manufacturing Industrial Sector

Revised 1996 IPCC Guidelines	2006 IPCC Guidelines
Energy	
1A Fuel Combustion Activities 1A2 Manufacturing Industries & Construction	1A Fuel Combustion Activities 1A2 Manufacturing Industries & Construction
Industrial Processes and Product Use	
2A Mineral Products 2A1 Cement Production 2A2 Lime Production 2A3 Limestone & Dolomite Use 2A4 Soda Ash Prod. & Use 2A5 Asphalt Roofing 2A6 Road Paving with Asphalt 2A7 Other (please specify)	2A Mineral Industry 2A1 Cement Production 2A2 Lime Production 2A3 Glass Production 2A4 Other Process Uses of Carbonates 2A5 Other (please specify)
2B Chemical Industry 2B1 Ammonia Production 2B2 Nitric Acid Production 2B3 Adipic Acid Production 2B4 Carbide Production 2B5 Other (please specify)	2B Chemical Industry 2B1 Ammonia Production 2B2 Nitric Acid Production 2B3 Adipic Acid Production 2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production 2B5 Carbide Production 2B6 Titanium Dioxide Production 2B7 Soda Ash Production 2B8 Petrochemical & Carbon Black Production 2B9 Fluorochemical Production 2B10 Other (please specify)
2C Metal Industry 2C1 Iron & Steel Production 2C2 Ferroalloys Production 2C3 Aluminum Production 2C4 SF ₆ Used in Aluminum and Magnesium Foundries 2C5 Other (please specify)	2C Metal Industry 2C1 Iron & Steel Production 2C2 Ferroalloys Production 2C3 Aluminum Production 2C4 Magnesium Production 2C5 Lead Production 2C6 Zinc Production 2C7 Other (please specify)
2D Other Production 2D1 Pulp & Paper 2D2 Food & Drink	(2H Other) 2H1 Pulp & Paper Industry 2H2 Food & Beverages Industry 2H3 Other (please specify)
2E Production of Halocarbons and Sulfur Hexafluoride 2E1 By-Product Emissions	2D Non-Energy Products from Fuels and Solvent Use Industry 2D1 Lubricant Use

Revised 1996 IPCC Guidelines	2006 IPCC Guidelines
2E2 Fugitive Emissions 2E3 Other (please specify)	2D2 Paraffin Wax Use 2D3 Solvent Use 2D4 Other (please specify)
	2E Electronics Industry 2E1 Integrated Circuit or Semiconductor 2E2 TFT Flat Panel Display 2E3 Photovoltaics 2E4 Heat Transfer Fluid 2E5 Other (please specify)
2F Consumption of Halocarbons and Sulfur Hexafluoride 2F1 Refrigeration and Air Conditioning 2F2 Foam Blowing 2F3 Fire Extinguishers 2F4 Aerosols 2F5 Solvents 2F6 Other (please specify)	2F Product Uses as Substitutes for Ozone Depleting Substances 2F1 Refrigeration and Air Conditioning 2F2 Foam Blowing Agents 2F3 Fire Protection 2F4 Aerosols 2F5 Solvents 2F6 Other Applications (please specify)
2G Other	2G Other Product Manu. & Use 2G1 Electrical Equipment 2G2 SF ₆ and PFCs from Other Product Uses 2G3 N ₂ O from Product Uses 2G4 Other (please specify)
3 Solvent & Other Product Use 3A Paint Application 3B Degreasing & Dry Cleaning 3C Chemical Products, Manufacture & Processing 3D Other	
Waste 6B Wastewater Handling 6B1 Industrial Wastewater	4D Wastewater Treatment and Discharge 4D2 Industrial Wastewater Treatment & Discharge

Annex 2: Scoring Details of the MCA

Scoring for Criterion 1: Abatement Potentials

	Mitigation Potentials, (tCO ₂ e/y)	Abatement cost ('00 \$/y)	Score		
			for mitigation potentials	for abatement cost	Total
Textile Industry	448,182	-204,564	50	50	100
Chemical Industry	338,421	-163,221	38	40	78
Food & Beverages Industry	189,620	-82,325	21	20	41
Metal Industry	176,505	-64,248	20	16	35
Mineral Industry	120,216	-58,216	13	14	28
Paper Industry	75,685	-35,614	8	9	17

Note: Data originally based on IIEC (2000)

Scoring for Criterion 2: Economic Importance

Products (top ten of 2013)	Export value (m US\$)	Remark in TSIC-1972	Range	Score
Electronic devices	31,765	8 Metal products, machinery and equipment	>30,000	100
Automobile and parts	30,697	8 Metal products, machinery and equipment	26,001-30,000	90
Electrical apparatus	23,001	8 Metal products, machinery and equipment	22,001-26,000	80
Gems and jewelry	10,085	9 Others	18,001-22,000	70
Chemical products	9,105	5 Chemicals and the chemical products	14,001-18,000	60
Plastic pellets	9,037	5 Chemicals and the chemical products	10,001-14,000	50
Rubber Products	8,511	5 Chemicals and the chemical products	6,001-10,000	40
Textile	7,483	2 Textiles and wearing apparel	<6,000	30
Machinery and Parts	6,787	8 Metal products, machinery and equipment		
Iron & Steel Products	6,348	7 Basic metals		

Source: Quarterly Industrial Economic Report: Q2 2014 (April-June 2014), 2014. Available from: http://www.oie.go.th/sites/default/files/attachments/industry_overview/r_aprjun57.pdf. [16 October 2014].

Scoring for Criterion 3: Readiness and Sustainability

TSIC-1972	461,206	Small	Large*
Food, beverages and tobacco	116,668	110,289	6,379
Textiles and Wearing Apparel	170,190	161,564	8,626
Wood and wood products	64,748	62,601	2,147
Paper and paper products	8,224	5,786	2,438
Chemicals and the chemical products	8,747	3,831	4,916
Non-metallic mineral products	13,435	11,783	1,652
Basic metals	2,042	1,309	733
Metal products, machinery and equipment	44,803	37,644	7,159
Others	32,349	29,379	2,970

Source of data: NSO 2007, Industrial Census, Bangkok.

* 'Large' defined as those established under legal forms, according to the 2007 Industrial Census: 'Company limited' (initiative group with at least 7 persons) or 'public company limited' (15 persons), 'Government' or 'state enterprise' (owned or >50% share by the government) and 'cooperatives' (Cooperation Active, at least 15 persons)"

No. of establishments	Score
< 500	100
501-1,000	90
1,001-1,500	80
1,501-2,000	70
2,001-2,500	60
2,501-3,000	50
3,001-3,500	40
3,501-4,000	30
4,001-4,500	20
>4,500	10

Scoring for Criterion 4: Government Priorities

In accordance with the National Industrial Development Master Plan 2012-2031 (OIE, 2011)

- 100 Sub-sector/industry included in the pilot phase (Industrial Master Plan)
- 0 Otherwise