Quantitative Analysis of HFCs, PFCs, and SF_6 Emission from Thailand Industries

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Abstract

This study is a documented research work that determines the emission quantities of HFCs, PFCs, and SF_6 in Thailand. The information included in this study is comprised of secondary data that have been collected from relevant government agency sources and the results of a field survey. The field survey provides information about the production process, the production output, and the emission factors for each specific production process, extracted from the Revised 2006 IPCC Guidelines for National GHG Inventories, Volume 3. The effect of the use of HFC-134a in the manufacturing and servicing of household refrigerators and automobile air-conditionings was calculated during 2001-2006 and the results indicated that the direct emission of HFCs based on CO_2 and carbon equivalent was 59,280,394 and 16,300,616 MT Carbon, respectively. Similarly, the effect of the use of SF_6 in the manufacture was calculated during 2001-2006 and the results indicated that the direct emission of SF_6 based on CO_2 and carbon equivalent was 29,473 and 8,038 MT Carbon, respectively. The direct emission was calculated from the amount of HFCs, PFCs, and SF_6 that had leaked or had purged directly into the atmosphere. It was found that the direct emissions from manufacturing and servicing refrigerator had increased and the different emissions depend on the amount of GHG that was converted which was compared to the amount of equivalent CO_2.

Key words: Hydro fluorocarbons (HFCs) / Per fluorocarbons (PFCs) / Sulphurhexafluoride (SF_6) / Emission Factor / Thailand

1. Introduction

The concentration of global greenhouse gas (GHG) has increased over the recent years and several states and nations are taking actions to reduce their emission of greenhouse gases. In Thailand, the impact of the potential climate change is of great concern. The potential vulnerability to climate change in such tropical region stimulates the need for comprehensive and careful adaptation plans and actions.

As a result, Thailand has a responsibility to fulfil the commitments *of the Kyoto Protocol* such as reporting the national greenhouse gas inventory (Thailand Environment Institute, 1997). *Hydrofluorocarbons* (HFCs), *Perfluorocarbons* (PFCs), and *Sulphurhexafluoride* (SF_6) have been included in the Kyoto Protocol because these are the main global warming gases. HFCs have GWPs (global warming potentials) that typically range between 1000 and 3000 times higher than that of CO_2 (March Consulting Group, 1998). Also, very powerful greenhouse gases are known to have high GWPs. These gases do not occur naturally but are generated as a result of various industrial processes. They have considerably higher GWPs than their concentration in the atmosphere and therefore have more influence on the greenhouse effect.

To resolve this problem, it is necessary to know the primary data regarding originators, the emission process, and quantitative GHGs. However, Thailand still lacks an efficient

amount of primary data that is essential for the management of GHGs inventory, for example, data on the emission factor. These primary data are essential so that an efficient strategy that is suitable to the conditions in a particular country can be determined. This would help in further planning in order to accommodate to changing situations. This study is aimed at making the emission inventory of HFCs, PFCs, and SF_6 for the industrial sector in Thailand.

2. Material and Methods

The quantitative analysis of HFCs, PFCs, and SF_6 emission from Thailand's Industries is a survey research which includes examining; 1) The production process for each specific industry; 2) The production output (in cases where this information was not available, the factory manufacturing capacity was considered); 3) The emission factors for each specific production process, extracted from the Revised 2006 IPCC Guidelines for National GHG Inventories, Volume 3. This approach has been accepted and is being popularly used in Austria, Denmark, Finland, France, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom (EPA, 2006, 2007), Bulgaria, Hungary, Poland, Romania, and Slovenia (UNFCCC, 2004). In addition to this, in some countries such as U.S.A**.** (U.S. Environmental Protection Agency, 2006) and Belgium (EPA, 2007), the model is being used to forecast the discharge amount of HFCs, PFCs, and SF_6 in the future. This research method has been defined in the IPCC Guideline National GHG Inventories and has been applied to the country. The method is explained in the following sections of this article.

2.1 Type of data

All data and detailed information in this research were collected from industrial facilities and then grouped into the categories of production data, emission factors, and the method to the data situations. The data sources in this study can be classified as follows:

1. Documentary research

The data obtained from seminars, articles, journals, and text books fall under this category. The quantity of imported HFCs, PFCs, and SF_6 was retrieved from secondary data sources that were collected by the relevant government agencies including:

- Department of Industrial Works, Ministry of Industry,
- Office of Custom, Ministry of Finance,
- Department of Industrial Economics, Ministry of Industry,
- Department of Land Transportation, Ministry of Transportation,

Information about the industries and products that use HFCs, PFCs and SF_6 was obtained from the above sources and has been included in this survey plan.

2. Field survey

The quantitative analysis of *HFCs, PFCs, and SF_6* emission from Thailand's Industries is a survey research. In order to study the appropriate guidelines and for local participation in the industrial facilities from where emissions occur, data were collected through questionnaires. The field survey included data collection from suitable sampling group for analysis and provided a conclusion of the case problem for proposing the appropriate guidelines.

The survey also included the amounts of HFCs, PFCs, and SF_6 that were used in the following enterprises:

- Manufacturing: including the charging size and the number of products that were produced per year, etc.
- Servicing sector: including the types of appliances, the charging size for each appliance, and the total number of appliances.

2.2 Tool for the research

1. Questionnaire

A number of questionnaires were used to gather information on the following:

- regarding the uses of HFCs, PFCs, and SF_6.
- regarding details of the manufacturers and service providers of refrigeration equipment.
- regarding details of automobile air-conditioning servicing centres.

2. In-depth interview

This type of interview was applied to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and it included details on:

- The production process for each specific industry.
- The amount of activity or the production of process material in the industries; in cases where this information was not available, the factory manufacturing capacity was considered.
- The emission factors for each specific production process, extracted from the Revised 2006 IPCC Guidelines for National GHG Inventories, Volume 3.

2.3 Data Analysis

The data collected by means of the above mentioned methods were carefully analyzed. The gases were separately inventoried and estimated using methodologies different from those used for the direct GHGs. The data analysis of this research included:

- The amount of products manufactured during 2001-2006
- The amount of HFCs , PFCs, and SF_6 used in the manufacturing and servicing sectors during 2001-2006
- The amount of HFCs, PFCs, and SF_6 lost in the manufacturing and servicing sectors of products
- The direct emission quantity of HFCs, PFCs, and SF_6 from the manufacturing and servicing sectors

3. Results and Discussions

3.1. Overview of HFCs, PFCs and SF_6 Imports

HFC, PFC, and SF_6 are not manufactured in Thailand. The industries in Thailand rely on imported substances.

1. Sources of Import

All of the substances are imported from a wide range of countries such as the United States of America, Austria, Australia, Germany, Finland, France, China, Korea, Malaysia, and Japan.

2. Companies Importing HFCs, PFCs, and SF_6

The Department of Customs, Ministry of Finance has classified HFCs, PFCs, and SF_6 as fluorinated hydrocarbon with a harmonized code of 2903.300.901.

A minority of consumers normally import HFCs, PFCs, and SF_6 directly from the manufacturers. However, the majority purchase these substances mainly through companies that act as agents for foreign chemical manufactures. The importers are the chemical trader companies, for example, Thai Asahi Chemicals, and Dot Bamboo.

3. The Import of HFCs to Thailand

Thailand imports a substantial quantity of HFCs since it cannot be locally produced. HFCs are used as a substitute for CFCs refrigerant which is controlled by the Montreal Protocol on substances that deplete the ozone layer.

The use of CFC-12 in the manufacturing of household refrigerators and automobile air-conditionings has been persistently phased out in Thailand since 1996.

The overall imported quantity of HFCs to Thailand was increased from 968.20 MT in 2001 to 1,681.89 MT, 3,801.23 MT, 11,712.91 MT, and 18,275.93 MT in 2002, 2003, 2004, and 2005, respectively. The amount was then decreased to 8,502.77 MT in 2006 as shown in Table 1.

4. The Import of PFCs to Thailand

PFCs are also imported to Thailand for various uses. However, the total amount of imported PFCs is not very significant owing to the high price and an acute demand. In fact, PFCs are very specific and are used only for the purpose of electronic circuit board cleaning. Thus, a very small amount of PFCs are used in Thailand in comparison to HFCs (Table 1).

5. The Import of SF_6 to Thailand

In Thailand, SF_6 is mainly used as an insulator in power-related applications. The total quantity of imported SF_6 was increased from 3 MT in 2001 to 13.47 MT and 18.19 MT in 2002 and 2003, respectively, followed by a decrease in 2004 and 2005 (14.59 MT and 8.57 MT, respectively). This fluctuation continued in 2006 with an increase in importation to 65.50 MT, as shown in Table 1.

Table 1 Amounts of HFCs, PFCs, and SF_6 imported to Thailand during 2001-2006

Year	Imported Amount (MT)		
	HFCs	PFCs	SF_6
2001	968.20	21.35	3.00
2002	1,681.89	436.24	13.47
2003	3,801.23	81.86	18.19
2004	11,712.91	27.46	14.59
2005	18,275.93	49.64	8.57
2006	8,502.77	60.36	65.50

Source: Department of Industrial Works, Ministry of Industry (2001-2006)

3.2. Effect on the Global Climate Change by HFC, PFC, and SF_6 Emission in Thailand

The calculation in this study is based on the HFC, PFC, and SF_6 usage in the industries. The figures obtained from this calculation are the CO_2 equivalent, caused by the leakage. The method is demonstrated as follows:

Direct Emission (Equivalent CO_2) = Leakage Amount* GWP

The carbon equivalent can be determined based on the carbon content and the CO_2 equivalent as follows:

Direct Emission (Equivalent Carbon = Direct Emission (Equivalent CO_2)*12 /44

1. The Use of HFCs

Manufacturing

- Household refrigeration industry

It has been found that approximately 1% of the amount of refrigerant charged is released to the atmosphere during the use of automatic charging machines or by any other cause such as leakage systems.

The use of HFC-134a in the manufacture of household refrigerators *was calculated* and is shown in Figure 1. The direct emission of HFCs based on CO_2 and carbon equivalent was found to be 4,837 and 1,319 MT, 5,532 and 1,509 MT, 6,501 and 1,773 MT, 7,611 and 2,076 MT, 7,947 and 2,167 MT, and 8,282 and 2,259 MT in 2001, 2002, 2003, 2004, 2005 and 2006, respectively.

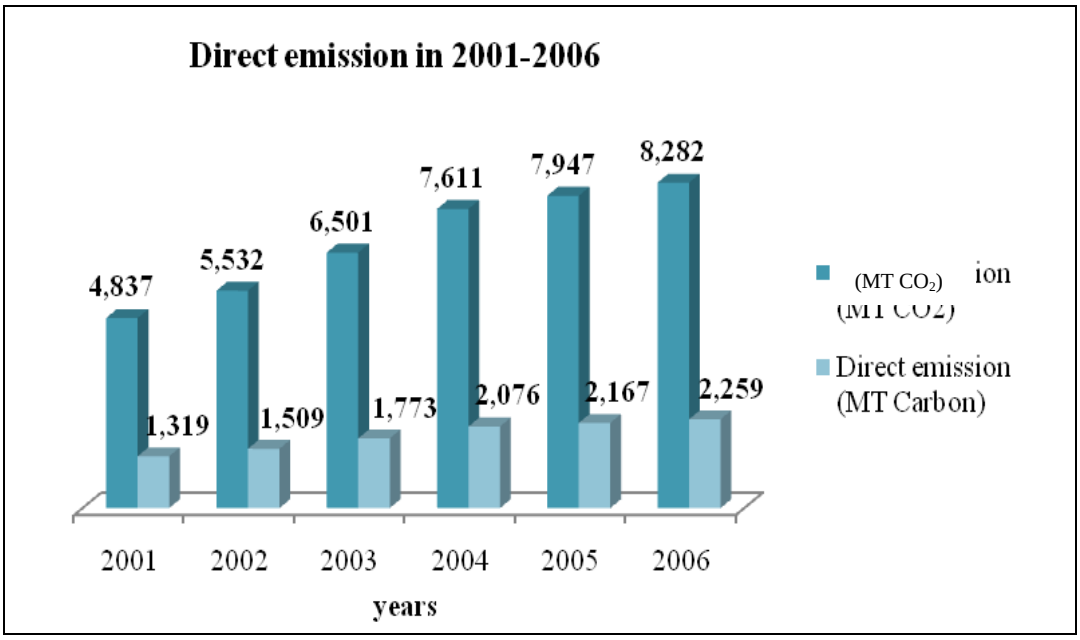

Figure 1 Direct emission of HFCs from the manufacture of household refrigerator in 2001-2006.

- Automobile air-conditioning industry (MACs)

The seepage rate of HFC-134a from refrigerant charging machines or by any other cause such as leaking systems in MACs is approximately 1% of the charged size. The amount of HFC-134a leakage owing to the manufacturing process of MACs *was calculated* and is shown in Figures 2 and 3.

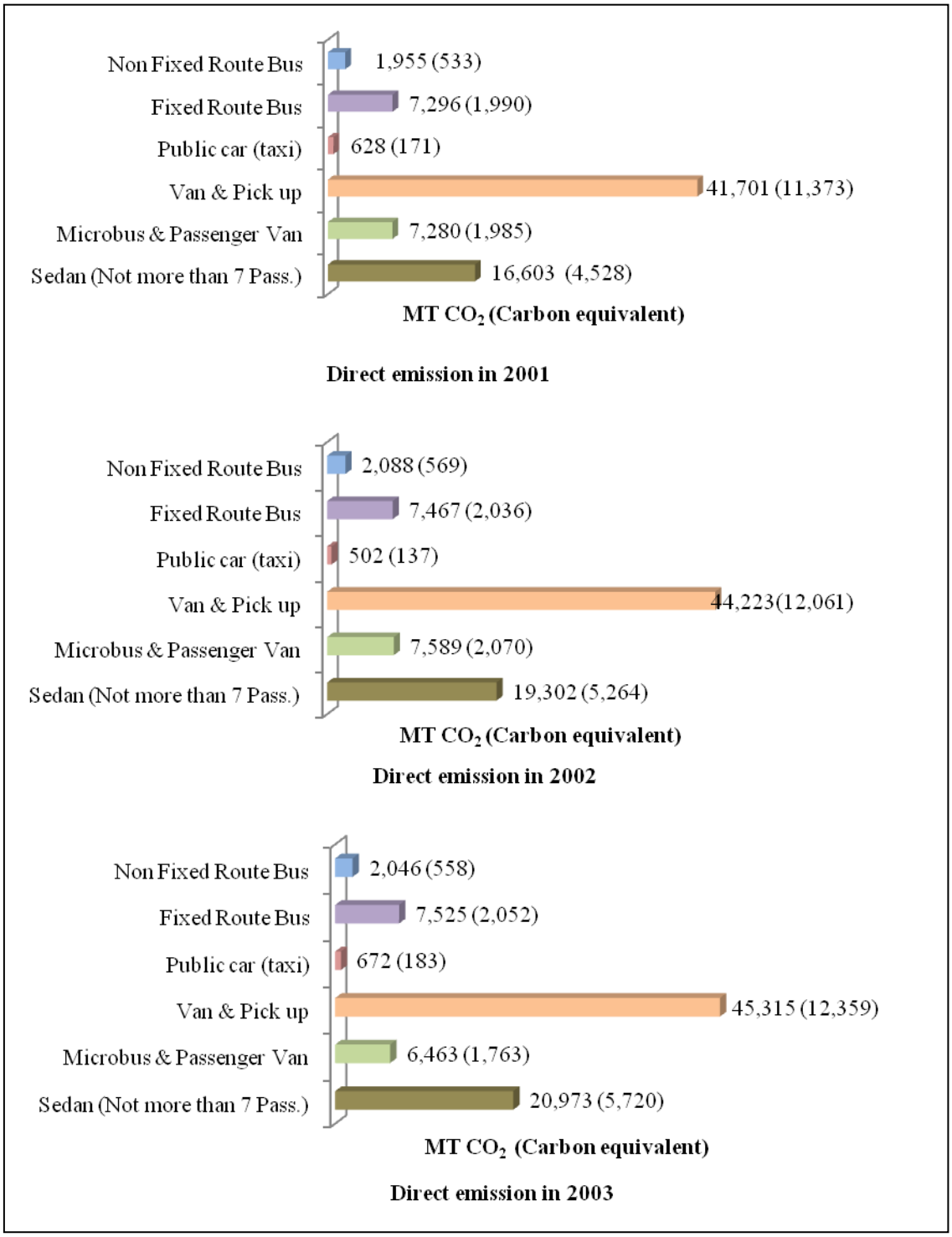

Figure 2 Direct emission of HFCs from the manufacture of mobile air-conditioning in 2001-2003.

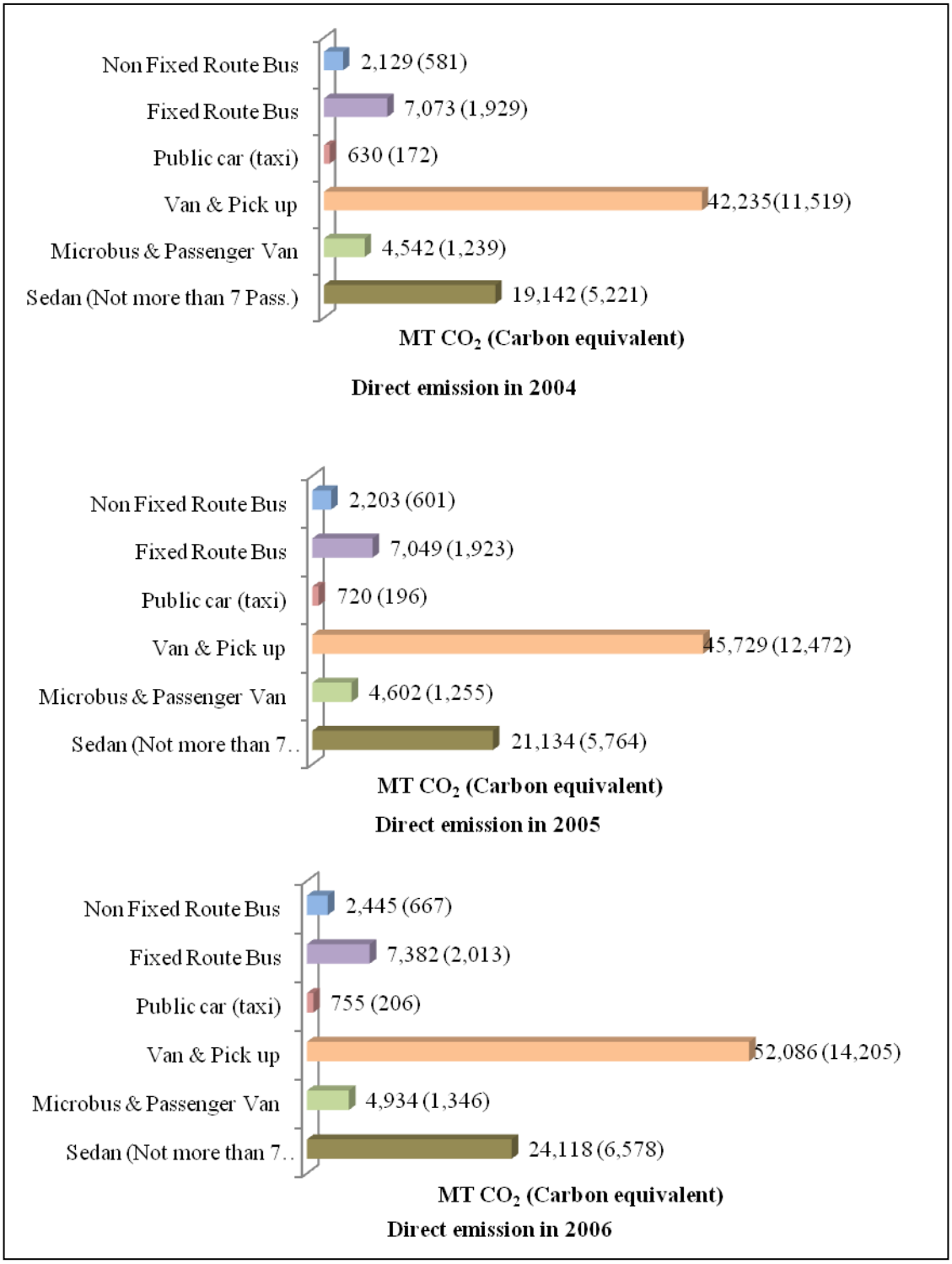

Figure 3 Direct emission of HFCs from the manufacture of mobile air-conditioning in 2004-2006

Servicing

- Household refrigeration industry

The use of HFC-134a in the servicing sector of household refrigerators was calculated and is shown in Figure 3. The direct emissions of HFCs based on the CO_2 and carbon equivalent were 11,397.62 and 3,108.44 MT, 10,915.06 and 2,976.83 MT, 11,991.98 and 3,270.54 MT, and 12,768.08 and 3,482.20 MT in 2003, 2004, 2005, and 2006, respectively.

- Mobile air-conditioning industry (MACs)

It was found that the number of vehicles installing MACs to be serviced was 36,917,252 units and the amount of HFC-134a used in servicing MACs was 91,065.56 MT. The effect of the use of HFC-134a in servicing MACs is shown in Figure 4. The direct emissions of HFCs based on the CO_2 and carbon equivalent were 59,192,612 and 16,143,440 MT, respectively.

2. PFCs Consumption

The imported amount of PFCs to Thailand as shown in Table 1 are minute when compared to HFCs due to their expense. However, PFCs are used as the lubricant for hard disk drives and as a cleaning solvent in some electronic devices. It could not find out the amount using of PFCs and direct emission of PFCs due to unidentified the classification of products and the volume of PFCs products.

3. The Uses of SF_6

The use of SF_6 in Thailand establishes the result that the leakage rate of SF_6 during the operation is less than 1% per year according to the standard for SF_6 insulated electrical equipment and the amount of SF_6 imported during 2001-2006. Figure 4 shows the imported rates and the use of SF_6 in Thailand.

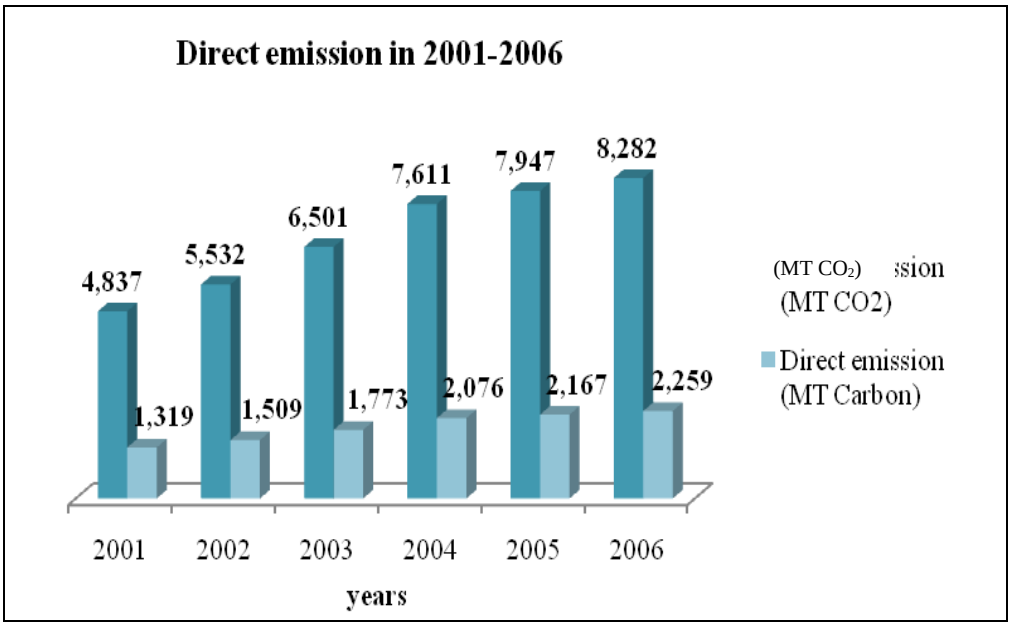

Figure 4 The Total Equivalent Warming Impact of SF_6

4. Conclusion

The Montreal Protocol has urged industries to phase out the use of CFCs to a considerable extent. It is known that the Department of Industries Works has an active role to play in phasing out the use of CFCs in the industrial sector. For this purpose, the quantity of HFCs imported to Thailand was decreased to 8,502.77 MT in 2006 from 968.20 MT, 1,681.89 MT, 3,801.23 MT, 11,712.91 MT, and 18,275.93 MT in 2001 2002, 2003, 2004, and 2005, respectively.

PFCs can be used as alternatives for CFCs that are being used as solvent; however, the use is only in some specific areas owing to the high price. It has been found in this study that PFCs are used as solvent for cleaning purpose in equipments that require high accuracy and precision. However, the amounts of PFCs used and their direct emission cannot be determined owing to the unidentified classification of products and the volume of PFC products.

The use of SF_6 is found to be very specific. More than 90% of SF_6 usage is in the form of insulator in power-related applications such as insulator in circuit breaker, switch gear for high or mid-voltage switch at the high voltage substation. The other use is as a degasser in the aluminium-casting industry. The effect of the use of SF_6 was calculated during 2001-2006, and the results indicate that the direct emission of SF_6 based on carbon equivalent was 29,473 and 8,038 MT Carbon, respectively.

The use of HFCs has been found in manufacturing. *The effect* of the use of HFC-134a in the manufacture of household refrigerators *was calculated* during 2001-2006, and the results indicate that the direct emission of HFCs based on carbon equivalent was 40,709 and 11,102 MT Carbon, respectively. *The effect* of the use of HFC-134a in the manufacture of automobile air-conditionings *was calculated* during 2001-2006, and the results indicate that the direct emission of HFCs based on carbon equivalent was 488,534 and 133,236 MT Carbon, respectively.

The effect of the use of HFC-134a in the servicing of household refrigerators was examined and the results indicated that the direct emission of HFCs based on CO_2 and carbon equivalent was 47,073 and 12,838 MT, respectively. In addition, the effect of the use of HFC-134a in mobile air-conditioning servicing was studied and the results indicated that the direct emission of HFCs based on CO_2 and carbon equivalent was 59,192,612 and 16,143,440 MT, respectively.

The total direct emission of HFCs based on CO_2 and carbon equivalent was found to be 4,837 and 1,319 MT, 5,532 and 1,509 MT, 6,501 and 1,773 MT, 7,611 and 2,076 MT, 7,947 and 2,167 MT, and 8,282 and 2,259 MT in 2001, 2002, 2003, 2004, 2005, and 2006, respectively.

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