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Strategies for Fine Particulate Matter Control

Evaluating the Kao-Ping emissions trading scheme in Taiwan

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Chao-Mei Pai

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Abstract

This thesis investigates the strategies that the Taiwan government uses to mitigate fine particulate matter (PM2.5) pollution, tiny particles in the atmosphere that can cause severe impacts to human health. Due to the complex composition of PM2.5, the strategies can be either controlling its direct or indirect sources. The Kao-Ping cap-and-trade program is a unique policy instrument that aims to mitigate PM2.5 by implementing a cap and a credit offset trading scheme on PM2.5 precursors (NOx, SOx, VOCs and PM10). An ex-post evaluation is conducted to assess the performance of this recently introduced policy instrument, by three main criteria (environmental performance, policy design criteria, and institutional feasibility) and 10 sub-criteria (effectiveness, side-effects, transparency, equity, predictability, flexibility, political feasibility, financial feasibility and implementation network feasibility.)

Key words: cap-and-trade, PM2.5, air pollution control, emissions trading.

Executive summary

Among the air pollutants, fine particulate matter (PM 2.5) is shown to have serious negative impacts on human health and life expectancy (Pope et al., 2009; Kuo et al., 2014). Although PM2.5 can cause the most severe health problems related to air pollutants, none of the air pollution control programs in Taiwan was especially designed for controlling PM2.5 before a cap-and-trade program was recently introduced in June 2015. This cap program is implemented on a regional level, in Kao-ping (Kaohsiung and Pingtung).

The objective of this thesis is to investigate the strategies that the Taiwanese EPA uses for mitigating PM2.5 pollution and health problems driven by PM2.5. The focus is on an ex-post evaluation of the recently introduced Kao-ping cap-and-trade program in terms of its environmental performance, policy design, and institutional feasibility. This evaluation is carried out in order to make recommendations for future improvement of PM2.5 control strategies in Taiwan.

Compared to other emissions trading schemes, the Kao-ping cap-and-trade system is unique in many ways. It's the only ETS that aims to reduce PM2.5 pollution instead of greenhouse gases. It's a regional-wide credit trading system that is implemented in an industrial area in southern Taiwan, covering over 600 fossil fuel and other energy intensive industries. About 80 present of the participating industries are small-to-medium size businesses, indicating that the market of the ETS is smaller than most of the other ETS.

It is also not common that two economic instruments are implemented at the same time. A combination of an air pollution fee and the cap-and-trade system created a price floor for the ERCs on the market, and surprisingly enhanced the data accountability on the emissions reporting for the air pollution fee, due to the newly introduced incentive for industry to accurately report their emissions in order to gain a larger emissions allowance under the cap-and-trade system.

The environmental effects of the cap-and-trade program are all expected to be positive according to the authority. A 5% mandatory reduction of four PM2.5 precursor pollutants and a credit trading scheme is proposed in the first compliance period (June 2015 to June 2018). It is believed that this will reduce environmental load by inhibiting any new polluter from entering the Kao-Ping area and by reducing emissions from existing industrial operators. The Kao-Ping cap-and-trade system can also have beneficial effects on ozone precursor control (NOx and VOCs). Special methods for industrial operators to gain offset credits also mean that the program will contribute to the control of mobile source emissions (by fostering a program for renewing old vehicles) and fugitive sources.

The impacts on small- and medium-size businesses is a significant factor in implementing the program. These companies have less financial capacity to deploy emission reductions and to participate in the credit market, and they constitute the majority of the market.

Several recommendations are proposed as a result of the research carried out in the thesis. The first is to improve the predictability of the cap program by setting a long-term target in order to ensure the improvement of monitoring technology, and to generate a stable political environment to allow companies to invest for the future. Secondly, transparency can be improved by providing more openness on data relating to the trading system in order to properly evaluate the success of the program. Improvement can also be made to the EPA's Open Data project, including improving the website design for better access to the information. Finally, for improving the effectiveness of the program, an expansion of the cap-and-trade program, from a region-wide program that only covers the Kao-Ping area to a bigger or a nation-wide ETS for regulating the big polluters that contribute to PM2.5.

1. Introduction

1.1 Problem identification

Among the air pollutants, fine particulate matter (PM 2.5) is shown to have serious negative impacts on human health and life expectancy (Pope et al., 2009; Kuo et al., 2014). Several studies have indicated that both short-term and long-term exposure to PM2.5 has risks of health impacts, which includes ischemic heart disease, cardiopulmonary disease, and lung cancers (Pope et al., 2002; Elliott and Copes, 2011; Hoek et al., 2013; Kloog et al., 2013; Kuo et al., 2014), and it has even been linked to neurodevelopment, cognitive function and diabetes (WHO, 2013). Actually, there is no evidence that shows that there is a minimum level of exposure of PM2.5 below which would no adverse health impacts would occur (WHO, 2013). Thus, the interventions for PM2.5 control is needed for reducing health risks.

Air pollution in PM2.5 is visible in the form of smog, and it is rather serious in Taiwan, where all the cities exceeded the WHO's suggested safety level of PM2.5 in 2015 (EPA, 2016). Although PM2.5 can cause the most severe health problems related to air pollutants, none of the air pollution control programs in Taiwan was especially designed for controlling PM2.5 before a cap-and-trade program was recently introduced in June 2015. This cap program is implemented on a regional level, in Kao-ping (Kaohsiung and Pingtung). It consists of a mandatory reduction in emissions from covered fossil fuel industries and a credit trading system for PM2.5's precursors, with the aim to reducing PM2.5 pollution.

The introduction of the Kao-ping cap-and-trade program was driven by the desire from the public and the urge from the authority for a less toxic ambient air quality. In addition, the existing policy program wasn't sufficient for tackling air pollution problems in industrial cities (Shaw D. 1999). The cap-and-trade program was finally launched in 2015, and now it is in an early phase of the policy cycle, with a flexible framework for the next compliance period beginning in June 2018. Braybrook and Lindblom; (1963) Rose and Karren (1987) believed that policy makers often can't take into account all effects relevant to a policy instrument, and the adverse side-

effects (if any) usually accumulate as time goes by. For these reasons, an evaluation of this recently introduced policy instrument (RIPI) is important, for seeing its effects and performance. In addition, when the policy becomes institutionalized, the policy is hard to change because of political inertia (Rose and Karren, 1987; Kautto and Simila 2005). Therefore, in order to cope with possible adverse effects, an evaluation for a RIPI opens the possibility for making changes to the policy instruments to cope with changes before it is too late.

1.2 Aim and objective

This thesis aims to investigate the strategies that Taiwan is following in order to mitigate PM2.5 pollution, and to gain knowledge on how the specific policy intervention (an emissions trading scheme) has an effect on controlling PM2.5 in Kao-ping as a case study. For the above aims, the objectives of this research are identified:

1. Review and analyse the current strategies for controlling PM2.5 and how policy instruments address the problem in Taiwan. The review consists of:
    a. Examining PM2.5 problems in Taiwan based on scientific research into its sources and distribution.
    b. Identifying the strategies and policy instruments in Taiwan addressing PM2.5.
2. Perform an ex-post multi-criteria policy evaluation for the Kao-ping CAT program by evaluating it according to three main criteria, including environmental performance, policy design, and institutional feasibility.

The evaluation will be useful for future improvements and provide insight to the policy makers for policy renewal and adjustments. Especially for the newly introduced policy program in Kao-ping the result of the evaluation is rather more valuable for policy makers for making adjustments by the time of the second compliance period, and for enhancing the effectiveness of the program. Furthermore, the result can be a useful reference and experience for the rest of the cities in Taiwan that are likely to introduce a program in the future. According to the Environmental Protection Administration (EPA) in Taiwan, several cities are considering to introduce a cap program, possibly in the near future.

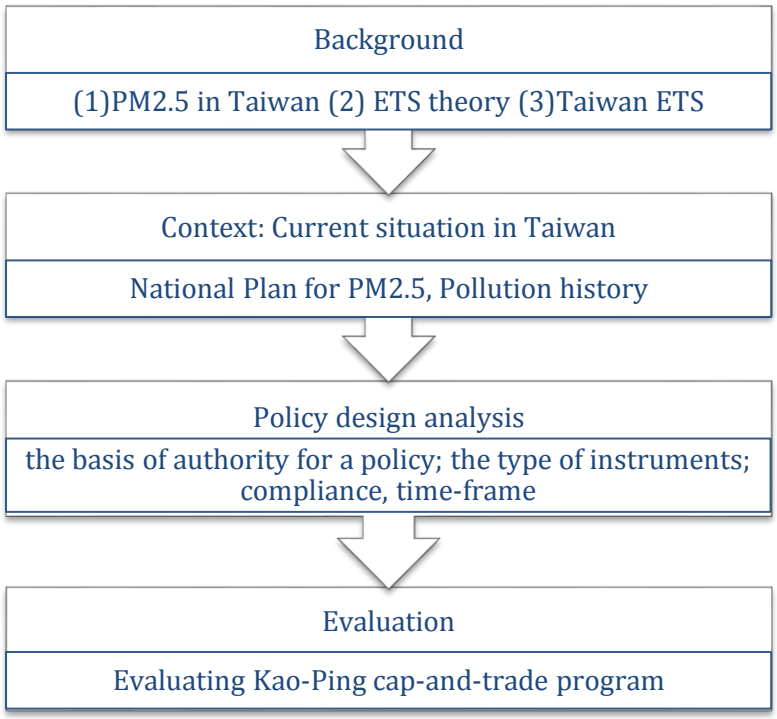
1.3 Research questions

- What are the existing air pollution control strategies and programs in Taiwan related to PM2.5?
- How is the performance of the Kao-Ping cap-and-trade program in three dimensions (Environmental performance, social aspects and Institutional feasibility)?

1.4 Methodology

The analytical framework to be used in this thesis is modified by the author from previous investigations of policy design. The three components of this analytical framework are context, policy, and evaluation (Howlett and Lejano, 2013). The underlying these is background that provides basic information relevant to this research, including PM2.5 sources and distribution in Taiwan, information about economic instruments that are used for controlling air pollution. The context is the current air pollution situation in Taiwan related to PM2.5, including the pollution history, the national target on emissions reductions, and the monitoring system of PM2.5. Policy design analysis address the strategies/instruments in use in Taiwan controlling PM2.5. Finally, a multi-criteria policy evaluation (MCPE) is applied to the selected policy instrument — the Kao-Ping cap-and-trade program. This program was chosen because it is the only instrument that is specifically designed to tackle PM2.5 pollutions. MCPE allows the policy to be assessed according to multiple criteria and aspects that are often relevant for policy evaluation (Muckwitz, 2003; Friedrich et al. 2011). For example, environmental aspects (via environmental impacts) and political aspects (such as equity, transparency), as will be discussed in the following section depending on the selected criteria.

Figure 1-1 Analytical framework for air pollution policy evaluation (Adapted from Howlett and Lejano, 2013)



Criteria selection

Multi-criteria policy evaluation is often used for evaluating the performance of air pollution policy. The selection of evaluation criteria is based on literature for policy evaluation in air pollution and emissions trading schemes. These criteria fall into three main categories. 1) Environmental performance addresses the outcomes of the policy intervention. A side-effect model is used for illustrating the anticipated and unanticipated side-effects caused by the instrument. This is important due to the complexity and uncertainty involved in an environmental policy problem (Vedung, 1997). 2) Political design criteria consist of several general criteria that can influence the usefulness of the instrument, including predictability and relevance. Transparency and equity are also basic elements for ensuring the democratic accountability and the credibility of the policy design. 3) Institutional feasibility is an important criterion that determines the successfulness of an emissions trading scheme (Gupta et al., 2007). This includes political feasibility, financial feasibility, and implementation feasibility

(Richter, 2012). The justification for this selection and the related questions that guide the whole evaluation is presented in Table 1-1.

Table 1-1 Criteria selection for evaluating policy instruments

Criteria	**Sub-criteria**	**Related Questions**
Environmental Performance	*Effectiveness*	Does the policy instrument achieve the desired outcome? (Michwitz 2003)
	Side-effects	"*Is it possible to identify impacts that are clearly due to the policy instruments and their implementation? All impacts may be considered in the light of this criteria, irrespective of their occurrence inside or outside the target area. Do the instruments have positive or negative side-effects such as ancillary benefits or unwanted distributional/equity impacts?"* (European Commission, 2016; Michwitz 2003)
Policy design criteria	*Flexibility*	*"Can the policy instrument cope with changing conditions? Can the instruments be adapted quickly and cheaply as new information arises, as conditions change, or as targets are altered?"*(European Commission, 2016; Michwitz 2003; IETA 2015)
	Predictability	*"Is it possible to foresee the outcome and outputs of the policy instrument? Is it thus possible for those regulated, as well as others, to prepare and take into account the policy instrument and its implications? As well as for the participants to be able to prepare and take into account the policy instruments and their implementations?"* (European Commission, 2016; Michwitz 2003; IETA 2015)
	Transparency	*"To what degree are the outputs, outcomes of the policy instrument, as well as the process used in the implementation observable for outsiders?* "(Gupta et al., 2007; Michwitz, 2003; Bemelmans-Videc, Rist & Vedung, 2003)
	Equity	*"How are the outcomes and costs of the environmental policy instruments distributed? Do all participants have equal opportunities to take part in and influence the process used by the administration?" (Banuri et al., 1990;* Michwitz 2003)
	Relevance	*"Do the goals of the instruments cover key environmental problems?*" (Michwitz 2003)
Institutional Feasibility	*Political feasibility*	To what extent is the Kao-ping cap-and-trade program likely to be viewed as legitimate, gain acceptance, adopted and implemented?
	Financial feasibility	Are the available funds sufficient to pay for the costs of the program?
	Implementation network feasibility	Do the participating entities have the capacity for implementing the mandatory reductions and for making use of the trading scheme?

Method for Data collection

This research collected data from various sources, including official legal documents from the government, official monitoring data and reports, interviews, as well as news reports from mass media. The legal documents were examined in detail, and semi-structured interviews were conducted with multiple stakeholders, including non-governmental organizations (NGOs), local government, the EPA, and industries who are participating in the cap program and air pollution fee program. Both quantitative (air emissions data, and cost data) as well as qualitative data were used in this research.

Table 1-2 Stakeholder meetings held under the stakeholder engagement process.

Date	Location	Attendees
December 2015	Skype	Wei-Ming Huang, Senior Technical Specialist, Department of Air Quality Protection and Noise Control, EPA
January 2016	EPA office, Taipei, Taiwan	Wei-Ming Huang, Senior Technical Specialist, Department of Air Quality Protection and Noise Control, EPA
January 2016	Taipei	Hung-Yi, Deputy Executive Secretary, Recycling Fund Management Board, EPA
February 2016	CPC cooperation Taiwan office, Taipei, Taiwan	Alec Lai, Administrator of the Formosa Plastic group. Safety health & environmental center. Mao-Cheh Shieh, Deputy director. Department of environmental protection. CPC cooperation Taiwan Jui-Hsia Weng, Engineer of CPC cooperation Taiwan Eric hsu. Exclusive secretary, Taiwan responsible care association.
February 2016	Central District waste Management Plant, Kaohsiung, Taiwan	Tsan-Ming Lin, Central District Waste Management Plant, Kaohsiung City Government Environmental Protection Bureau. Former Technical Specialist, Department of Air Quality Protection and Noise Control of Kaohsiung EPB.
February 2016	Citizen of the Earth office, Kaohsiung, Taiwan	Min-Ling Wang, Deputy Secretary General, Citizen of the Earth, Taiwan
February 2016	Skype	Tsuang, Ben-Jei. Professor in Environmental engineering, National Chung Hsing University
May 2016	Skype	Feng-Teng Chang, Kaohsiung City Council, Former Vice Minister of EPA, General Director of Environmental Protection Bureau, Kaohsiung City Government.

1.5 Limitations and scope

The focus of this thesis is the Kao-Ping cap-and-trade program for controlling atmospheric PM2.5, and so the general policy instruments used for air pollution control are mentioned, in order to provide the context for this program.

The scope of this paper from a geographical point of view is on policies in Taiwan that are relevant for PM2.5 air pollution, with a focus on the Kao-Ping area where the ETS is being implemented. Instances of ETS in other countries are used for giving a basis for comparison and giving insight into policy design. PM2.5 pollution is the core topic of this research, while other air pollutants are mentioned and discussed in this paper due to the characteristic of PM2.5 having a high degree of correlation and interactions with other air pollutants.

The evaluation covers most of the important criteria, including environmental performance, policy design, and institutional feasibility, that are adapted and selected from the literature. However, due to the Kao-Ping ETS having been implemented less than a year, this results in some constraints on the available information pertaining to the program because only some effects of the program have yet occurred. As Kautto and Simila (2005) observe with respect to RIPI, this makes it difficult to assess the extent to which the desired outcomes have been achieved.

A further limitation is that information pertaining to the cost of participating industries to comply with the program is not available. Furthermore, trading in the market system has not yet begun, and so the actual price of the credits and how the market will function is not yet known. This has meant that the economic criteria of cost-effectiveness and cost-efficiency could not be used as evaluating criteria, and so the thesis has instead focused on environmental and political criteria. The availability of information is therefore a big limitation on this research paper.

Another risk of the Multi-criteria policy evaluation can be bias on the result due to the more powerful stakeholders having greater influence over the other stakeholders (Munda, 2006). In order to overcome this constraint, apart from having interviews with representatives from major large businesses in fossil fuel and plastic industries, a

representative of an industry NGO who can represent the majority of industries was also interviewed. The records of public hearings and academic conferences are also used to capture the point of view of the other stakeholders.

1.6 Audience

This thesis targets various stakeholders, including policy makers, researchers, ETS participants, and other stakeholders who are indirectly or directly involved with policy instruments for air pollution, especially relating to PM2.5. This research provides a policy evaluation that can be useful for policy makers and researchers. The thesis also provides basic knowledge on PM2.5 and economic instruments that can be useful for students or members of the general public who are interested in the topics.

1.7 Disposition (outline)

The outline and structure of this research paper is presented below.

Chapter 1 presents the nature of the air pollution problem and consequent health problems in Taiwan. It consists of the methodology used to collect data to address the research question, including an ex-post evaluation for an RIPI. The content provided identifies research limitations. A thesis outline and the target audience are also provided.

Chapter 2-1 provides a scientific background on PM2.5 internationally and in Taiwan, in order to present the basic information that is relevant for the research question. Chapter 2-2 presents a theoretical discussion of environmental policy instruments with a focus on emissions trading schemes.

Chapter 3 provides a literature review on air pollution policy in Taiwan, and the previous evaluations of it.

Chapter 4 presents an overview of the situation in Taiwan with regard to PM2.5 policy. The national plan, air pollution monitoring system, and historical pollution data are discussed.

Chapter 5 analyses the strategies and policy instruments related to PM2.5 control, with a focus on the cap-and-trade program in Kao-Ping.

Chapter 6 evaluates the performance of the Kao-Ping cap-and-trade program according to three main criteria, including environmental performance, policy design, and institutional feasibility.

Chapter 7 summarises the main findings and lessons learned in the course of this research, highlights the main research contributions, and provides suggestions for further research.

2. Background

2.1 Background for PM2.5

Definition of particulate matters

Air pollution caused by particulate matters are defined as aerosols or suspended molecules in the air, that can be in solid particle or in liquid form. Based on the size difference, particulate matter can be categorized as fine particulate matter (PM2.5) and coarse particulate matters (PM10). The former are smaller than 2.5 μm. These are tiny airborne solid and liquid particles that can have major impacts on the climate and human health. Similarly, particulate matter that has a size smaller or equal to 10 μm is called PM10. Total suspended particles (TSP) refers to particulate matter that has the size smaller than 50 μm, including PM1, PM2.5 and PM10 (Cao et al. 2013). Different specialists have different terms for particulate matters, based on shape, size, and chemical composition. For the climatologists, they are categorized based on chemical components. The main groups of particulate matters include sulfates, organic carbon, black carbon, nitrates, mineral dust, and sea salt. However, none of the groups of categorization are perfect. In fact, particulate matters often cluster together and have a complex form of mixtures. Particulate matter with different chemical compositions would have different levels of impacts on health and the environment, which requires research to understand regionally.

Health and environmental problems caused by PM2.5

Particulate matter is one of the most dangerous air pollutants in terms of its health consequences. PM2.5 is believed to be harmful to humans due to its tiny size, allowing the particles to easily pass through the respiratory system, starting from the nose and further reaching the lungs and bronchial tubes. There is no known minimum threshold for the impact of PM2.5 on human health, which means that both short-term and long-term exposure to PM2.5 are considered to be dangerous (WHO, 2006). PM2.5 particles can interfere with lung functions on gaseous exchange, and induce an inflammation reaction. More and more research has proved that ambient particulate matter would have negative impacts on human health, and can lead to diseases such as lung cancer, asthma, bronchitis and cardiovascular diseases. (Pope et al., 2009; Elliott

and Copes, 2011; Vinikoor Imler et al., 2011; Hoek et al., 2013; Kloog et al., 2013; Martinelli et al., 2013).

PM2.5 source analysis

Understanding the sources of particulate matters is a key step for establishing policy and conducting a reduction plan. According to its origin, fine particulate matter can be identified as either primary or secondary. Primary particulate matter is released as PM2.5 naturally without any chemical formation process, which can come from natural environmental sources such as the ocean, pollen, and dust, or from the construction industry and direct emission from vehicles, etc. Secondary particulate matter is formed from precursors that have gone through complex chemical reactions and physical processes in the atmosphere. The common precursors come mostly from the emissions of industries and vehicles, such as NOx, SOx, VOCs and NH3. A fraction of PM10 might also contribute to PM2.5. According to Lin (2013), in Taiwan, the main precursors of particulate matter are SO_2, SO_4^{2-} , OC, NO^{3-} and NH_4^+. In addition, burning agricultural waste would also increase the level of nitrate, and even incense burning in the temple has been cited as contributing to the concentration of PM2.5 (Lin 2013; EPA 2015).

Research has shown that southern Taiwan has a worse ambient air quality than northern Taiwan (Wu 2014; EPA 2014). Wu has analyzed 10 years' worth of data relating to the chemical composition of PM2.5 in Taiwan. He concluded that southern cities presented a higher concentration of PM2.5 than northern cities, of which locally produced PM2.5 contributed up to 70%, with the other 30% coming from outside the country, mainly from the People's Republic of China. On the other hand, due to geographical and climatic reasons, northern Taiwan has a higher chance of being polluted by PM2.5 originating in China compared to the south. It can sometimes contribute up to 70% of the total concentration. Mostly in the winter and spring, Taiwan suffers from particulate matters that go through long transportation carried by the northeast monsoon (Wu, 2014).

According to Taiwan Emission Data system version 8.1 (TEDS 8.1), released by the EPA in 2014, the total emission of PM2.5 is 73,855 tons per year in Taiwan. Stable

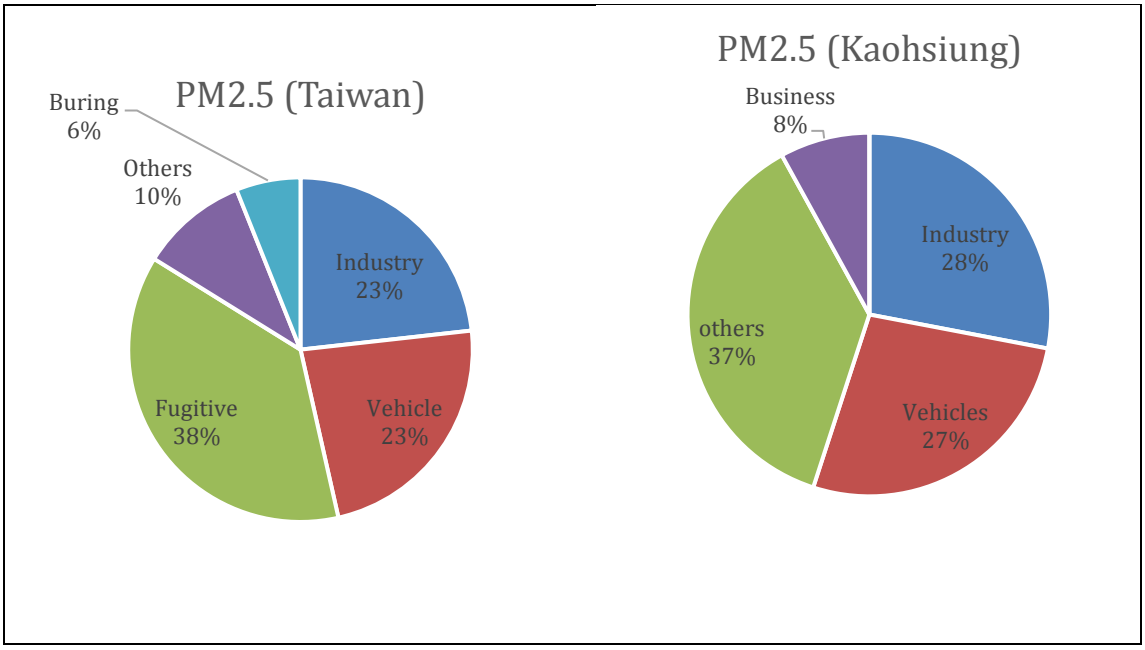
sources, including industry and the electric generation sector, contributed 25% of the total PM2.5 emissions, accounting for 16,865 tons per year. In addition, stable sources are also major emitters of PM2.5 precursors, contributing 88% (119,729 tons/year) of SOx and 41% (176,100 tons/year) of NOx. Other sources that contribute to direct PM2.5 emissions are vehicles (23%), public transportation (22.7%), agriculture (13.5%), the catering industry (8.5%), construction and mining industry (7.2%), steel industry (4.5%).

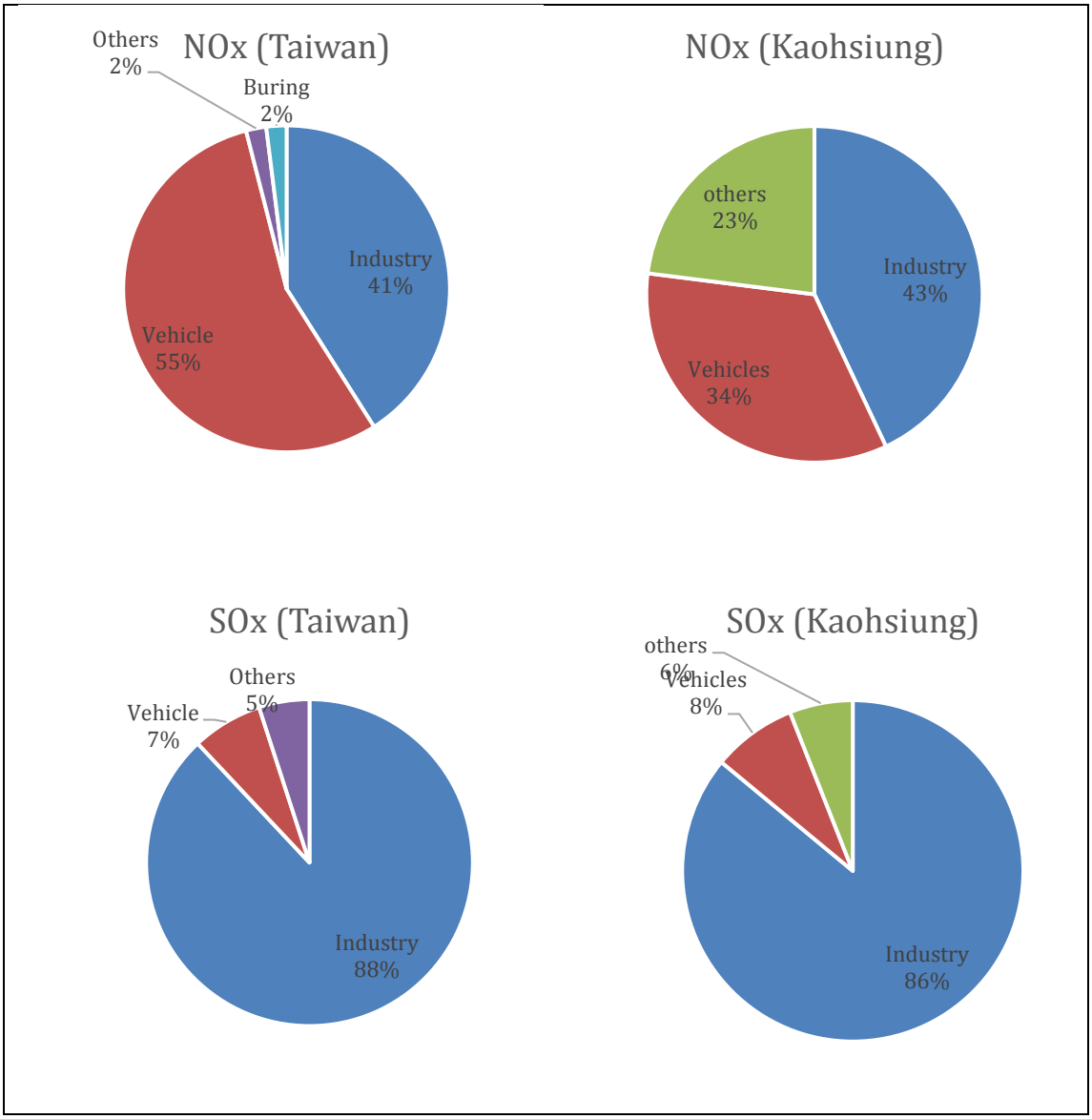
To sum up, PM2.5 concentrations are observed as being highest in Taiwan during winter and spring, between October and April, with higher concentrations being observed in southern Taiwan. From the data provided by EPA and past researches, Wu concluded that in Kao-ping and other southern cities, local industrial and vehicle emissions are the two primary contributors of PM2.5. In northern Taiwan, where few industries are located, pollution comes mostly from traffic and transportation. Thus different targets and strategies for tackling air pollution are practiced from region to region.

Table 2-2 PM2.5 sources analysis. (Source: Wu 2014)

City	10 year annual mean(μg/m3)	Primary	Secondary	Transboundary (China)	2020 reduction target
Taipei	21.6	10.1	1.6	9.9	27%
Kaohsiung	30.7	12.4	9.8	8.5	64%
Pingtung	3.6	11.2	11.5	10.8	73%

Figure 2-1 Primary and secondary PM2.5 analyses in Taiwan and in Kaohsiung (Source: EPA 2012, TEDS 8.1)





2.2 Environmental policy instruments in theory

This chapter will discuss the theory of economic instruments including an emission fee and a cap programs (cap and trade or emission offset program). Those are the instruments that have an effect on the market and stimulate changes in the industries. Reviewing the theory of the economic instruments and how they could control pollution ideally can help the development of criteria to evaluating policies in Taiwan relating to PM2.5 by determining the successful factors of the existing cap programs and the air pollution fee as an economic instrument.

Environmental policy instruments

There are several environmental policy instruments that policy makers can use to address environmental pollution. Environmental policy instruments can be either rewarding or punitive depending on their purpose. Three main types of environmental policy instruments are identified (e.g. OECD, 1994; Veduing 1998):

- **Command-and-Control**:

  Command and control is a traditional policy instrument that uses a regulatory approach, aiming at modification of behaviors using the threat of punitive measures. Instruments used include emission standards, bans, permits, and restrictions (Mickwitz, 2003)

- **Economic instruments** or market-based instruments aim to put a price on pollutions units or emissions, thus to internalize the negative externality by making the polluter take the polluting cost into account. (European Commission, 2016). Economic instruments include:
  - Market creation through tradable permit schemes.
  - Environmental taxes and charges
  - Grants and Subsidies

- **Suasive instruments**, or so-called soft measures are policy instruments that aim to change people's environmental values and behaviors, often without penalties and enforcement. They include
  - Providing information about environmental impacts
  - Eco-labeling

- Environmental management systems (Mickwitz, 2003; European Commission, 2016)

Policy instruments comparison: CAC or Economic instruments

Economic instruments and market-based instruments are said to be powerful approaches to emissions control, now widely used in air pollution control on carbon dioxide and also other air pollutants. If an economic instrument is designed appropriately, economists suggest it could reduce emissions in a cost-effective way that is more effective than the traditional common-and-control programs.

CAC are believed to lack flexibility and usually require extra costs by installing facilities, resulting in an economically inefficient outcome. On the contrary, an economic instrument is believed to stimulate research and development (R&D) for technology change in the regulated sectors (industries) (Hansson and Ding, 2014) (Antonio et al., 2014). This statement is aligned with the Porter Hypothesis, which states that *"the environmental regulations trigger a new way of thinking, ensuring innovation of cleaner technologies, resulting in cost savings that, to a larger extent, would off-set the abatement cost to reduces emissions."* (Hansson and Ding, 20142014) To date, this hypothesis is used in the market-based instruments because of its dynamic effects on innovations.

Figure 2-2 Comparisons of policy instruments (Source: European Commission, 2016)

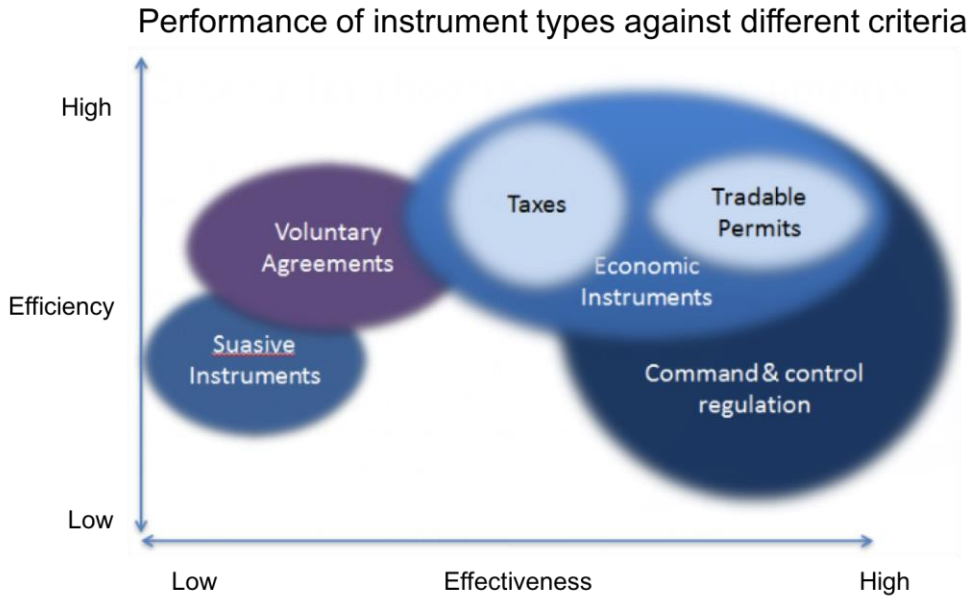


Table 2-1 Main advantages and disadvantages of an emissions trading scheme (Adapted from European Commission 2016)

Instrument	Advantages	Disadvantages
Tax	Greater flexibility- overall cost minimization	Distributional impact of rising prices
Cap-and-trade	1. Certainty about the environmental outcome(=cap) 2. Allocation as a design parameter to distribute impacts	1. Uncertainty about the resulting price. 2. Higher administrative burden

To achieve the aim of emission reduction of an air emission program, an emission market requires:

- *"Scarcity of emission allowances in order to create the price signals for low-carbon investments*
- *Long-term clarity and predictability of rules, targets and the regulatory systems guiding emissions markets worldwide*
- *Adequate compliance periods, allowing companies to structure a "make or buy" approach to their emissions reductions over time*
- *Cost containment provisions, allowing efficiency in discovering of lowest-cost solutions wherever they are to be found Offset-based mechanisms offer the opportunity for countries or sectors that have yet to introduce an allowance-based approach to participate in the market." (IETA 2016)*

Economic instrument: Emissions trading

Credit trading system (CTS) and allowance trading system (ATS) are two types of emissions trading scheme. The fundamental difference between the two systems is the different trading unit. The trading unit in CTS is credit, which represents a real reduction from the last compliance year. Credits must be traceable, requiring monitoring, reporting, and verification, resulting in a rigid trading system. ATS is simply trading the allowance that was allocated to the entities after the initial assessment. Most of the existing carbon dioxide emissions trading schemes worldwide are allowance trading. The Taiwanese emissions trading program is a credit offset trading system with a rigid framework for regulating the trading (Yin, 2007; Shaw 1999; Huang W.M. personal communication, 2016).

1. Credit offset trading system (CTS)

The trading unit of a credit trading system is referred to as a "credit" or "certified emissions reduction" credit. In the Taiwanese cap-and-trade program, the tradable unit is called an "Emissions Reduction Credit" (ERC). One example of a CTS is the Clean Development Mechanism (CDM) that is under the framework of the Kyoto Protocol. CDM provides for emissions reduction project activities undertaken in the Annex I countries (developed countries). Those countries can use the certified emissions reduction (CER) credits to offset their own emissions to help the achievement of their Kyoto target (European Commination, 2016). Another example is the Emissions Credit Trading program in the United States. It was established in 1997 for "criteria pollutants" including carbon monoxide, lead, nitrogen oxides, particulate matter, and volatile organic compounds. This program ended up performing poorly, mainly because of high uncertainty, high transaction costs and high regulatory risks, as it required a lot of verification, monitoring and reporting work on each trading process, that diminished the tradable commodity nature of the trading system (Tietenberg et. al, 1999; Shaw, 1999). In Taiwan, experts have suggested that the EPA implement an allowance trading

system instead of credit trading to enhance the feasibility of implementation. However, the EPA retained the same plan of a credit trading system.

2. Allowance trading system (ATS)

Considering the environmental and economic outcomes, allowance trading has proved to be superior to the credit trading scheme, having a higher flexibility on the trading system. The Acid Rain program in the US is one of the most successful allowance trading programs in the world, which has reduced industrial emissions of sulphur dioxide significantly in the 90s (Tietenberg et. al, 1999).

Allocation methods

Grandfathering, benchmarking and auction are three basic methods of distributing emission allowances to participating entities.

1. *Grandfathering* is typically established by an entity's average annual emissions. Each entity would receive free allowances according to its average annual historic emissions (European Commission, 2016). Common problems regard to grandfathering are:
    - *"How to define the base period?*
    - *How to account for early action?*
    - *How to factor in special circumstances?*
    - *How to avoid overallocation? (*European Commission, *2016)"*
2. *Benchmarking* is to allocate allowances on the basis of past performance and the quality of installations, using a performance standard for all comparable installations that produce the same good (European Commission, 2016). Benchmarking is consider fairer compared to the grandfathering method, because it reflects the entity's actual circumstances, and it can avoid the problem of perverse incentive. However, it requires more data than grandfathering for measuring the actual activities of the entities (European Commission, 2016).

3. Literature Review

3.1 Policy instruments evaluations

There have been three different policy instruments applying in Taiwan, including the traditional Command-and-Control (CAC) and two economic instruments applying at the same time. This part of the literature review will assess the current stage of the policy instruments in Taiwan and how their performance is evaluated in the existing literature.

Table 3-1 Policy instruments for stable air pollution source in Taiwan. (Source: EPA)

	Air pollution fee	Cap: Kao-Ping total emission reduction plan
Place	Whole Taiwan	Kao-Ping area
Regulated pollutant	NOx, SOx, VOCs, PM10	NOx, SOx, VOCs, TSP (PM2.5 precursor)
Time	Since 1995	Since 2015 June
Rationale	1995, SO2: acid rain. 1997, PM10: Lung disease 1998,NOx: Ozone depletion 2007, VOCs, Ozone depletion	PM2.5 pollution prevention
Instrument type	Green tax	Market-based instrument

CAC in Taiwan

Before 1995, when the air pollution control fee was introduced in Taiwan, there were two policy instruments in effect. One was the CAC and the other was a tax-subsidy program, this program included a tax allowance and soft loans for enterprises, that were administrated by the Industrial Development Bureau (IDB). Lin has found some ineffectiveness in these programs, including the incompleteness of the environmental law, CAC wasn't incentivizing participants to comply, small size companies have less capacity to compliance than the large scale company, among others. (*Lin et al., 1988).*

In the 1960s, a series of economic liberalization policies came into Taiwan. However, before public awareness was raised in the 1970s, the value of environmental protection and the quality of the environment was totally ignored. We can see how public concern can push the evolution of the policy since the eras of economic growth from the 50s. The increase of personal incomes seems to be one of the contributions to make people pursue a better quality of life. Therefore, the central government released a series of important laws for environmental protection including the Air Pollution Control Act (1975), which is an important legally binding policy source for CAC. Other environmental policies came roughly at the same time. A large problem was that there were weaknesses in the implementation of the policy act observed by Shaw and Hung (2001). The act was poorly enforced and a lack of funding and personnel rendered the control of air pollution ineffective at that time.

Air pollution fee

The polluter-pay principle was not commonly recognized in Taiwan until the 80s. Before this time economic development had always been the priority. The air pollution fee is one of the policy instruments that followed from the polluter-pay principle and was put into practice in 1995. The first fee was introduced in 1995 for regulating SOx emissions, which are the main source of acid rain. While NOx and PM10 fees were later introduced with different rationales. The last one was a VOCs fee which was launched in 2007. None of the air pollution fees were primarily aimed at controlling particulate matter. However, those four regulated pollutants are significant precursors of fine particulate matter (Shaw and Hung 2001).

Concerns with the air pollution fee

According to the EPA (2015), the air pollution fee has partially contributed to the improvement of air quality in Taiwan since 1995. Shaw and Hung (2001) showed a similar point of view that in the first five years, the PSI index of Taiwan was gradually improving, which means the overall ambient quality of air was improving as a whole. However, another study doubted the effectiveness of the fee program (Chan 2008), and in so doing sided with environmental NGOs.

Theoretically, an air pollution fee would be able to achieve a specific target and incentive for participants to reduce emissions, and the income from the fee would be used for further investment in other air pollution programs. Chan (2008) evaluated the Taiwan air pollution fee, showing that the stated rationale of this policy instrument was to give an economic incentive for reducing air pollution. However, Chan concludes that the main motivation for the policy is as a means of gaining income in the name of environmental protection so as to cover shortcomings of the administration's expenses. Another concern with the fee is that, although individual firms reduce their emissions, new polluting enterprises nevertheless emerge, causing a net increase in total emissions. Thus, the effectiveness of the air pollution fee used as an incentive for industry to invest in pollution control is doubted by some experts. Therefore, concerning the above point, the EPA has proposed to implement a cap program for a more effective reduction on local pollution.

Are those policy instruments a success?

The two policy instruments comprising CAC and the air pollution fee cannot be evaluated as successful policy instruments in Taiwan according to the literature. However, they are somewhat effective in some ways. For example, this is suggested by the historical data provided by the EPA, which shows that the overall air pollution quality has been improving gradually. Furthermore, the percentage of purple level (bad) quality days has been significantly declining for the past two decades. Therefore, the scientific data didn't correspond to the feeling of local people and the unusual increasing lung cancer number (Tsuang 2014). Most importantly, the effectiveness of the economic instruments in providing an incentive for cleaner production in the industry is doubted from the literature on the air pollution fee. (Shaw 1999, Chan 2008)

On the other hand, some other issues that can affect the effectiveness of the current instruments are mentioned in the literature. Among these is a principal-agent problem between the Parliament and the EPA, resulting in a conflict of interests between the producers of legislation and the enforcing entity (Shaw and Hung 2001; Chan 2008). A further problem with the act is that interest groups can lobby the government and affect the air pollution standard achieved. In addition, there are variations in the standard between the regional and national levels, as well as between different firms.

These issues all contribute to leniency in the setting of standards for air pollution and the ineffectiveness of the policy instruments.

3.2 Air pollution control strategies in literature

Wu (2013) suggested that Kaohsiung city prioritize SOx reduction from stable emission sources as the most substantial strategy for PM2.5 control, because SOx pollution has the highest levelsamong other precursor gases in the region. Stable emission sources contribute 90% of SOx in the region. Suggested strategies for Kaohsiung are a stringent standard for sulfur in fuels, and to increase the air pollution fee on SOx.

Another study uses an optimization technique to rank the priority of economic control strategies for air pollution control in Taichung, a central city in Taiwan. The top 6 strategies ranked by cost-effectiveness are 1) placing an emission fee on construction fields, 2) using chemical dust suppressant on exposed surfaces, 3) stringent monitoring of steel and coal-burning plants, 4) using chemical dust suppressants in construction fields, 5) stringent monitoring of diesel autos, 6) reimbursing low-sulfur gasoline usage (Tsuang 1997).

No policy review of the Kao-Ping cap-and-trade system has appeared since its implementation. Furthermore, there is little literature analyzing air pollution control policy in Taiwan. Most papers that deal with the issue focus on monitoring technologies and other scientific health aspects of PM2.5. An ex-post evaluation of the cap-and-trade system therefore fills a gap in this literature.

4. Context: Overview Taiwanese air pollution policy related to PM2.5

4.1 National Air Pollution Reduction Targets for PM2.5

The EPA announced the new Air Pollution Control Act in 2012. The Act regulates the ambient concentration of particulate matter including PM2.5 and PM10 and has short-term and also long-term targets. According to article 5 of the Air Pollution Control Act, three classes of air pollution control region were identified based on the air quality, the class III regions being most polluted. The Kao-ping area, including Kaohsiung and Pingtung is one of the most polluted areas and it was listed in the ozone and particulate matter class III air pollution control region, and has a different standard which is looser than the National one. For this special area, EPA prioritized Kao-Ping to be the first area to implement the cap program controlling the total emission from the stable sources in industry, in order to improve the area's air quality and to meet standards.

Improving the Kaohsiung city from the class III to class II level air pollution control region is a short-term target for Kaohsiung city government. The long-term target for the city is to reduce the concentration of PM2.5 to an annual mean lower than 15 μg/m3 by the year 2036. (EPA)

After adopting the Kao-ping area air pollutant total emission control plan, the air quality of Kaohsiung city is expected to be improved gradually. (Kaohsiung city government, 2013) However, there is still a long way to go to reach the given target, and the Kaohsiung standard is lower than the Taiwan national standard, where the latter sets a goal to meet the PM2.5 annual mean no higher than 15 μg/m3 by the earlier date of 2020. Furthermore, the suggested standard for PM2.5 provided by WHO is hardly achievable at the current stage (WHO).

Table 4-1 PM2.5 standards in various countries (EPA, 2014)

PM2.5 (μg/m**3**)	Taiwan	US	EU	China I	China II	Japan	Singapore	WHO
Annual mean	15	12	--	15	35	15	15	10
24-hour mean	35	35	25	35	75	35	35	25

Table 4-2 Particulate matter standards and targets in Kaohsiung city (Kaohsiung city government, 2013)

(μg/m**3**)	Kaohsiung Target by 2036		2013 record	Short-term targets			WHO standard
				2015	2017	2020	
PM2.5	**Annual mean**	**15**	**30.5**	**29.7**	**28.9**	**27.7**	**10**
	24-hour mean	35	78.5	74.4	66.0	56.1	25

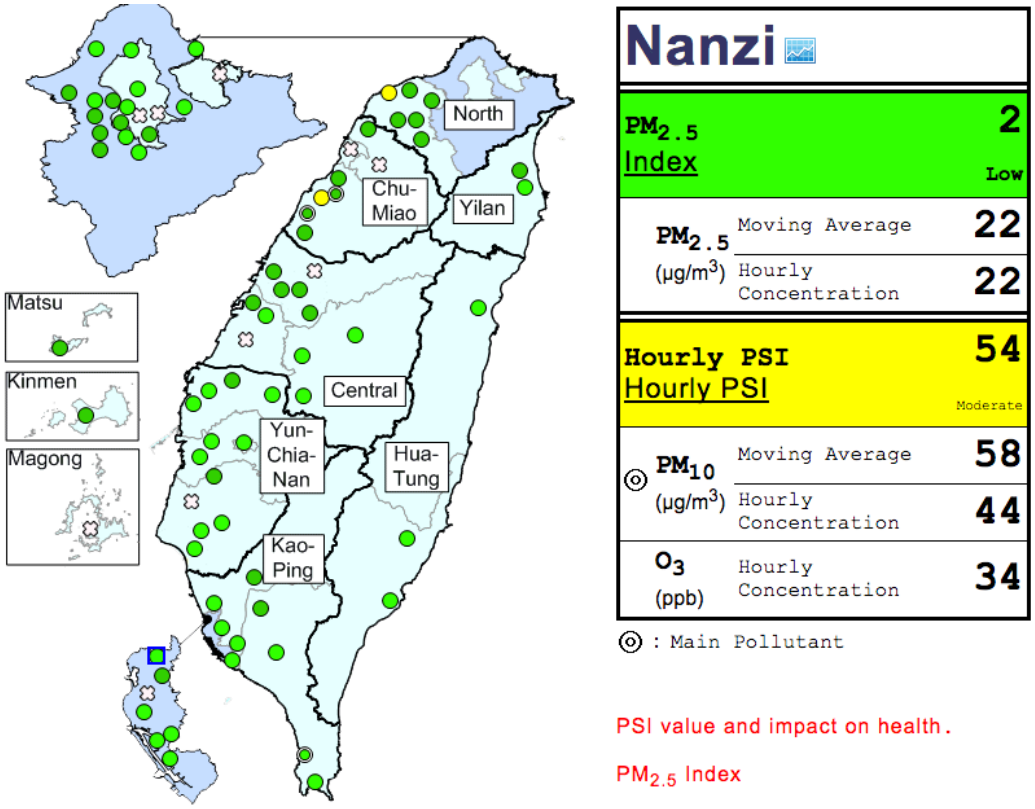
4.2 PM2.5 monitoring system

The Environmental Protection Administration (EPA) in Taiwan uses two systems for reporting daily air quality, including Pollution Standard Index (PSI) and PM 2.5 index. PSI measures five pollutant indicators and produces a number out of 500 to identify the overall air quality. EPA has been evaluating air quality according to PSI for the last two decades, however, considering the pollution caused by ozone and fine particulate matter which are excluded from the system, PSI is limited for representing real air quality in Taiwan (Liu 2013), as well as for policy design.

The PM2.5 index is a rather new tool in Taiwan, launched in 2012 and introduced into the air quality reporting system. Similar to the monitoring system in the U.S., FRM are used to detect the concentration of PM2.5 in 24 hours mean, measured by manual method. The data is available on the EPA website since December 2012. Apart from the manual method, the auto monitoring system of PM2.5 and PM10 was started in 2005, using β-ray attenuation method. EPA tested the correlation between both methods, 76% difference has found, in which auto monitoring method is higher than the manual. Results can be different due to various factors, including seasons, location, environment and the equipment. EPA adopted the data collected from auto monitoring method and transfer to manual data by timing 0.7. The auto collected data is only for urgent air quality prevention, and for long-term monitoring (EPA 2014).

According to the geographical political region, seven air quality areas were delineated including the North, Chu-Miao, Central, Yun Chia-Nan, Kao-Ping, Yilan and Hua Tung area. Results from both the PSI and PM2.5 monitoring tools are shown together on the EPA website for the public.

Figure 4-1 PM2.5 index and PSI reporting on EPA website. (Source: EPA website)



Pollutant Standards Index, PSI

Since 1975, according to the Air Pollution Control Act, the Taiwan government used the Pollutant Standard Index (PSI) as an indicator for monitoring air pollution. PSI is based on concentrations of five different pollutants, including particulate matter (PM10), sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone (O3), non-methane hydrocarbons (NMHC), and total hydrocarbons (THC). The data are quantified in number ranged from 0 to 500, and further classified into 5 levels indicating different health concerns. The levels and description of health concern of PSI is shown in table 4-3.

Table 4-3Levels and descriptions of Pollution Standard Index in Taiwan (Reference: adopted from EPA Taiwan)

PM2.5 Index										
Level	1	2	3	4	5	6	7	8	9	10
Air pollution Banding	Low	Low	Low	Mid	Mid	Mid	High	High	High	Very High
PM2.5 (μg/m³)	0-11	12-23	24-35	36-41	42-47	48-53	54-58	59-64	65-70	>71
Accompanying health message for general populations	**Enjoy** your usual outdoor activities.			**Enjoy** your usual outdoor activities.			Anyone experiencing discomfort such as sore eyes, cough or sore throat should **consider reducing** activity, particularly outdoors.			**Reduce** physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.
Accompanying health messages for at-risk individuals	**Enjoy** your usual outdoor activities.			Adults and children with lung problems, and adults with heart problems, **who experience symptoms**, should **consider reducing** strenuous physical activity, particularly outdoors.			Adults and children with lung problems, and adults with heart problems, should **reduce** strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also **reduce** physical exertion.			Adults and children with lung problems, adults with heart problems, and older people, should **avoid** strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.

Fine Particulate Matter (PM2.5) index

Following the success of the anti-fossil fuel movement in 2011, Former president Ma adopted the suggestion of adding PM 2.5 to form a more comprehensive air pollution monitoring system. (Ju, 2015) Therefore, EPA Taiwan has adopted the PM 2.5 index from the UK system. The new Air Pollution Control Act was adopted in August 2012.

The PM 2.5 index classified 10 levels according to the concentration and its impact on human health, from the lowest lever 1 to the highest level 10. More details are shown in Table 3.

4.3 PM2.5 and air pollution history

Figure 4-2 Year average of PM2.5 in Taiwan and in Kao-Ping (Adapted from EPA)

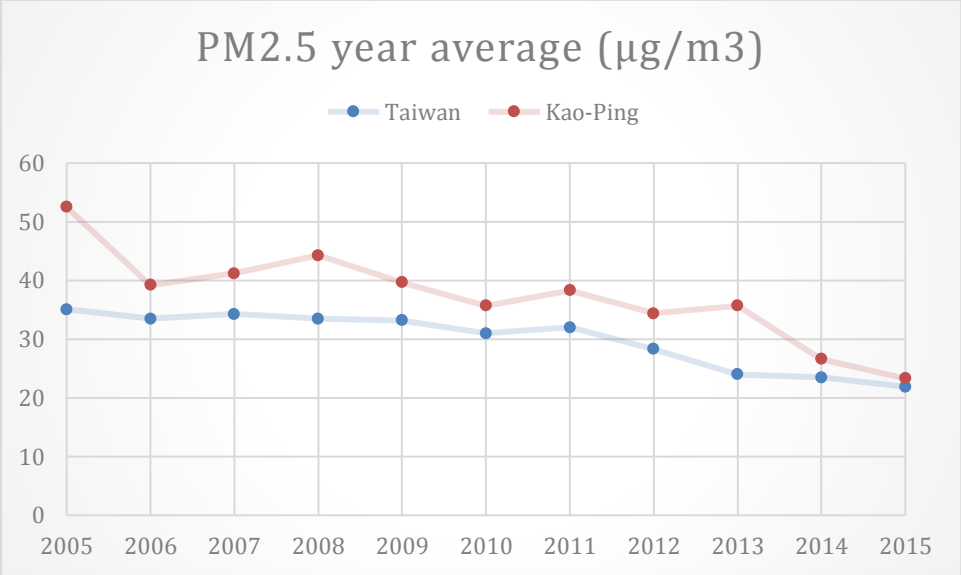
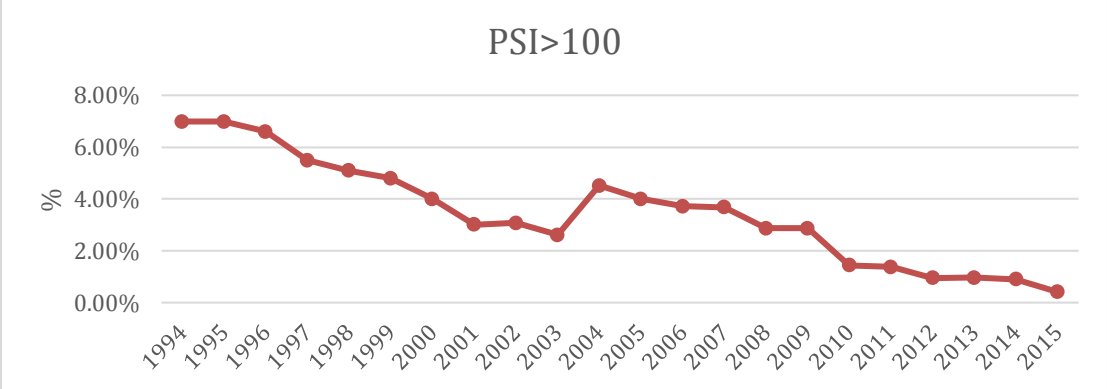


Figure 4-3 Percentage of PSI >100 in Taiwan (Adapted from EPA).



According to TEDs 8.1, data analysis was based on emissions in 2010, total emission of PM2.5 was 73,855 tons per year in Taiwan. Stable sources including industry and electric generation sectors contributed 25% of the total PM2.5 emissions, accounting for 16,865 tons per year. In addition, stable sources are also major polluters of PM2.5

precursors, which contribute to 88% (119,729 tons/year) of SOx and 41% (176,100 tons/year) of NOx.

Other sources that contribute to direct PM2.5 emissions are vehicles (23%), public transportation (22.7%), agriculture (13.5%), catering industry (8.5%), construction and mining industry (7.2%), steel industry (4.5%).

Due to the significant contribution of primary and secondary PM2.5 that can be attributed to stable sources, the EPA announced to strengthen the regulatory programs for industry and incentivize industry to aim for emission reduction via economic instruments (EPA, 2016).

4.4 Air Pollution Fund

- The revenue of the air pollution fund comes from the fee on air pollution on stable and mobile sources. The total revenue from the fee is around 3.8 billion NTD each year, including a fee on four air pollutants (SOx, NOx, VOC and PM10); and a charge on fuel (diesel and gasoline) (Air Pollution Fund board meeting, 2016). The rate for various pollutants and sources of emissions is shown in Table 3-3.
- 40% of the air pollution fund is allocated to the central government (that is, to the EPA), and 60% is allocated to regional governments for air pollution control programs each year (Air Pollution Fund board meeting, 2016).
- How does the EPA allocate their 40% share of the fund (9.8billion) on air pollution control each year?

  The majority of the fund is used to control mobile source emissions. This accounts for 46% of the total cost. Air quality management also costs a lot, accounting for 18%, including implementing the newly introduced 2015-2020 Clean Air Action Plan. On the other hand, stable source control only amounts to 7%, including the regulatory cost of the Kao-Ping cap program. Monitoring air pollution accounts for 6%, supporting regional air pollution control programs accounts for 10%, Greening city and River management programs account for 4%, Low carbon homeland program accounts for 7%, and the administration fee costs around 2%.

Table 4-4 Air pollution fee (Source: EPA, 2014)

Air pollution fee	***Stable source (NTD/Ton)***			***Mobile source (NTD/litter)***	
Item	NOx	SOx	VOCs	Diesel	Gasoline
Rate (NTD)	5000-8500	6000-10000	5000-30000	0.2	0.2
Fee in 2015 (NTD)	23,2799,000	47, 8731, 000	75, 1080,000	9 billion	19 billion

5. Policy design analysis

Due to the complex formation of particulate matter, PM.2.5 is controlled either from its primary sources or by regulating its precursors, including NOx, SOx, VOCs and PM10. Taiwan is following the latter approach. The applied policy instruments are CAC, the air pollution fee, and the total emission control plan, which includes a trading program for stable sources at a regional level. Strategies for controlling PM2.5 can be categorized according to its sources. The two main sources which are the focus of the EPA's control efforts are stable and mobile sources.

Mobile sources reduction

The number of vehicles including cars and motorcycles is slightly increasing each year, as is the number of vehicles each person has. In 2016, data shows one out of every three people owns a motorcycle; nine out of ten people has a car in Taiwan. Due to the high contribution from the vehicles emissions, various programs are conducted by the EPA, including promoting electric vehicles (including electric buses and motorcycles), putting a tax on the fuel for vehicles, and other programs for greening transportation (EPA, 2015). Half of the EPA's budget is used on the programs mentioned above. The policy instruments used therefore encompass CAC, an air pollution fee, and a suasive instrument.

Stable sources reduction

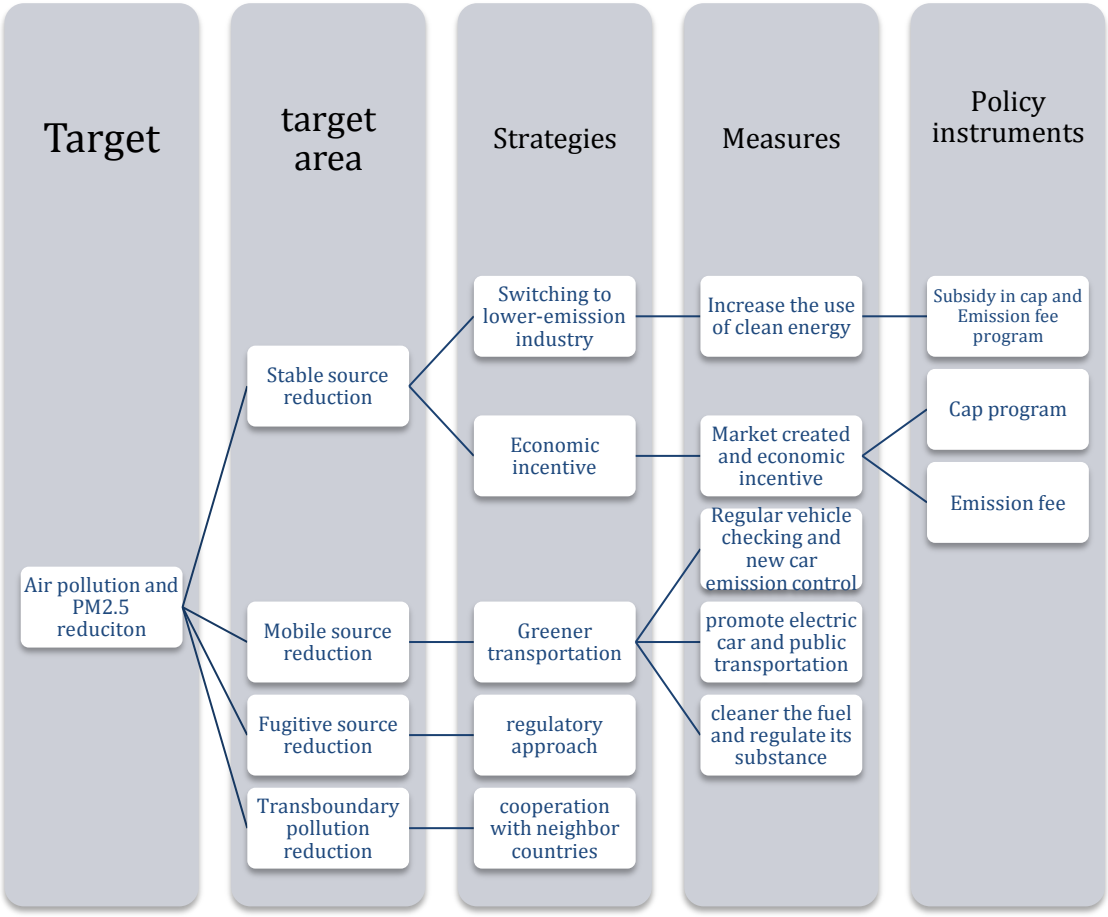
Three policy instruments are used in controlling emissions from the industries, including several emission permit regulations and standards on exhaust emissions. A fee is charged on four air pollutants, with a subsidy on green energy use to incentivize industry to use less high-polluting fossil fuel. A cap-and-trade system is also used for controlling stable sources in areas which have failed to reach a given standard of air quality.

Other minor sources

PM2.5 is also a transboundary air pollution due to its propensity to be carried long distances. Taiwan suffers from heavy transboundary PM2.5 pollutions during the winter. The sources of PM2.5 pollution in Taiwan can be identified as being 56.7%

local anthropogenic emissions, with the remaining 43.3% originating from China (EPA, 2015). In 2015, The EPA launched a 2015-2020 Clean Air Action Plan coordinated among many stakeholders for improving air quality in 5 years with a focus on PM2.5. The cooperating parties were the Ministry of the Interior, the Economic Administration, the Ministry of Transportation and Communication, the Ministry of Science and Technology, the Ministry of Health and Welfare, and the National Development Council. The strategies are project-oriented, combining mostly CAC and suasive policy instrument for the problem, the surgeries for PM2.5 control is summarized in figure 5-1.

Figure 5-1 Strategies for PM2.5 control in Taiwan (Source: own)



5.1 Kao-Ping Cap program: Emissions offsets trading scheme

Background of implementation

Kao-Ping was prioritized as the first area to deploy a cap program, including a emission trading scheme, due to the area recording the worst air quality in Taiwan for a long time. According to Air Pollution Control Act Amendments in 2012, the region falls into the category of "class III" air quality which means the region has a bad air quality and fails to meet the given standard. "Class III" regions have to establish a cap program to enable control of the stable source emissions in a concrete way. Kao-ping is the only class III air quality region which has exceeded the standard for PM10 and ozone concentrations for at least three years. In fact, if considering the performance of PM2.5, all the west coast cities fail to meet the national standard for PM2.5. According to this, introducing a cap program to all the west coast cities is a possible option for the future. (EPA 2016)

Simply put, the Kao-ping cap program regulates industry sector under a given cap. Existing industries who exceed a certain threshold of emissions are required to participate in the emissions trading scheme, with a mandatory emissions reduction. New industry and the existing industry who are planning to expand are required to procure emission reductions credits (ERCs) on the market or by auction. Allowances and ERCs offsets are two compliance instruments in this cap-and-trade program. Allowances was allocated initially freely based on past emissions or can procure via auction held by EPA. Unlike other emissions trading scheme, allowance can't not be trade between industries, instead ERCs can be trade and banked.

According to Huang. EPA expects this scheme could be efficient by regulating major polluters in Kao-ping, they account for 90% of the industries. The minor polluters, 10% of the total industries are not obliged to follow the mandatory reductions, while they still have to follow the other existing regulatory rules, including implementing BAT and paying air pollution fee. They can participate in the emission offset and trading program on a voluntary basis.

For existing polluters: Mandatory reductions and Emissions credit trading

The Kao-Ping cap program applies to stable sources of emissions above a given threshold depending on their activities. Around 90 percent of the industries, which accounts for 643 industries located in Kao-ping, exceed this threshold according to their emissions records. Among all the participating industries, 20% are large

companies and 80% are small and medium size enterprises. The activities are emissions of four PM2.5 precursors, including PM10, SOx, NOx, VOCs. Primary PM2.5 are excluded in the scheme. Distribution of allowances is through grandfathering. Regulated industries have to submit their historic emissions data going back 7 years before 2015 and apply for emissions permission from the EPA. All four pollutants will be evaluated. The allowance is calculated for each entity from their base-year emissions, which is the amount emitted in their highest emissions year over the last 7 years. If the base-year emissions exceed the threshold, the given pollutant emissions will have to be reduced by 5%. Whereas, if the pollutant didn't exceed the given threshold, that means the industry allowance will be the full amount of their base-year emissions. In other words, only big polluters have to make a mandatory reduction, while the small polluters don't have to make a reduction but are subject to a cap on their emissions. An example for allowance on four air pollutants is shown in table 4-1. The first compliance period lasts for three years, from June of 2015 to June of 2018. Allowance for the compliance period can be formulated in this way:

*Allocated Allowance = Base-year emissions amount * (100% - Mandatory reduction) * three year*

Table 5-1 Thresholds for air pollutant, an example. (Source: adopted from EPA)

Air pollutant	*PM10*	*SOx*	*NOx*	*VOCs*
Base-year emissions	10,000	5,000	8,000	2,000
threshold(tons)	10,000	10,000	5,000	5,000
Mandatory Reduction	5%	0%	5%	0%
Allowance	9,500	5,000	7,600	2,000

In the beginning of each compliance period, allowances are freely allocated to the entities. When the participating industries succeed in reducing their emissions further than the 5% target, they can apply for the verification of emissions reduction credits (ERCs), which can be released to the market for trading, or the industries can choose to bank it for the second period.

The price for the credits on the market is not decided yet. According to the act, the price will be based on current rate of air emissions fee.

For the New Entrants: require Emissions Reduction Credits (ERCs)

In order to establish a new industry or to make expansions to existing ones, ERCs must be bought which will offset the projected emissions of the expansion. These credits can be bought through direct exchange or at an auction that will be held twice a year by EPA. New industries and expansion to existing industries must also implement best available technology (BAT) in the production process.

In case of the closure of a factory, the company can apply to the regional government for emissions verification to get the released credits. The application should be submitted in 30 days, otherwise, the company will lose the credit. In some cases, the authority can decide to release the credits to the market directly.

In article 9 of the Air Pollution Control Act, regulations for accessing ERCs for new entrants are given in detail. Five ways of accessing credits are:

1) By direct exchange with existing industries.
2) Buying credits from auction held by EPA. The EPA will launch a public auction every 6 months under the circumstance when the verified ERCs reaches over 50 tons. The price of each pollutant will not lower the current air pollution tax for ensuring market incentive. However, the actual price of the each regulated air pollutant remains unknown at the moment. There are regulatory controls to prevent a single industrial operator from buying credits that are more than 2/3 of the total ERCs on the market. The results of the emission auction will be published on the online platform.
3) Apply for NOx credit from reducing mobile sources emissions by procuring second hand vehicles and taking them out of use.
4) Apply for PM10 credit from reducing fugitive source emissions by vacuum cleaning streets.
5) Other emissions reduction methods approved by EPA.

3) and 4) are flexible mechanisms of the cap-and-trade program allowing entities to acquire credits by reducing emissions from fugitive and mobile sources. For all the methods mentioned above, the entities have to apply to the local authority for ERCs verification. After approval and calculation based on an emissions rate, the entities then acquire the ERCs for banking or trading.

ERCs represents real emission reductions that have already occurred and verified by the authority. How to make sure emission reductions are genuine is by requiring industries to give proof that they have implemented *preventive actions*. For example, these actions might be the installation of new technology to reduce air pollution, an improvement of facilities that can prevent emissions, or using clean energy sources such as renewable energy and natural gas. The available preventative actions are listed in the Air Pollution Control Act, article 8.

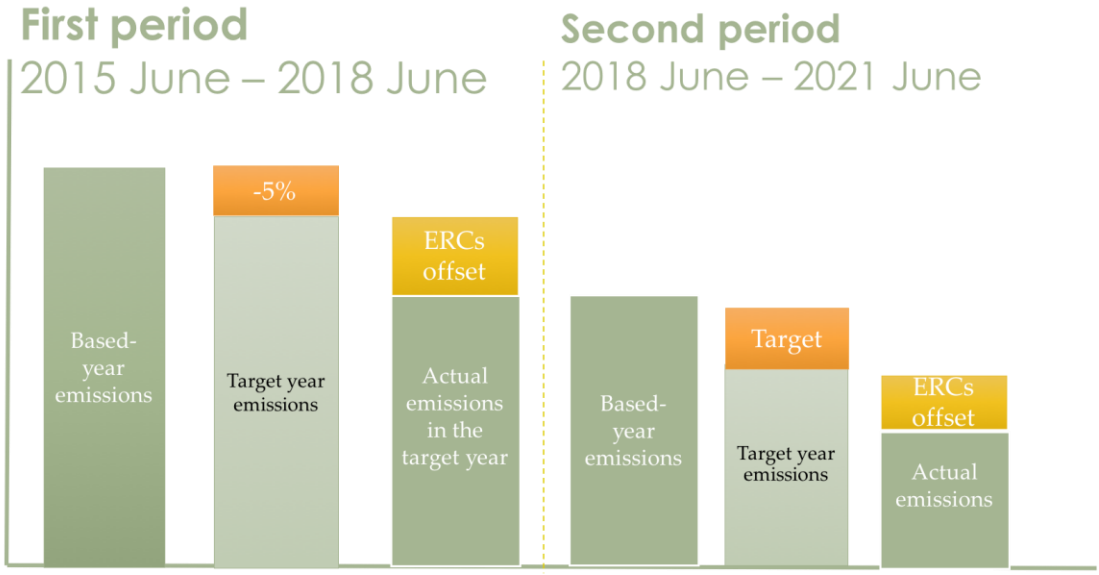
The trading system is subject to a rigid procedure of reporting and verification. Every single trade must be examined by the authority, and reported to the online system by both seller and buyer.

According to the act, the price of the ERC per ton will not be lower than the cost per ton of the current air emissions fee. The EPA estimates that the price per ton will be between 30 thousand to 50 thousand NTD (Chinese Daily News, 2015)

Timeframe of cap program

Half a year before the end of the first three-year reduction period, the EPA will evaluate the current achievement and the industrial development, and further set the second emissions reduction target for the next three-year reduction period. It is estimated that there will be a further reduction in emissions standard of between 5% to 10% for the second phase according to EPA. The target year will be the last two seasons of 2017 and the first two seasons of 2018, by which time 5% emission reductions should have been reached.

Figure 5-2 Timeframe for cap program (Source: EPA)



Non-compliance

According to article 51 of the Air Pollution Control Act, industrial operators that don't fulfil their 5% reduction target, will be fined 100 thousand to one million NTD. With regard to other minor mistakes such as false data, the allocated allowance will be suspended.

Stakeholders analysis

Environmental Protection Administration

The EPA hold a positive view on the implementation of the cap program. They expect a significant reduction in emissions of air pollutants from the industrial sector in Kao-ping. The expected result is still under estimation. They don't deny the deficiency of the policy itself due to its not being clear enough on the details and doesn't have a concrete timeframe for achieving national standards for air quality. Nevertheless, they believe it's a good first step to start implementing the cap policy and make immediate effects, by inhibiting new factories to enter and establish in the area to increase the emission level. EPA expect that at least 5% reduction in emissions from stable sources will happen in the next three years and slowly achieve the national air quality goal for PM2.5.

Shortages of the program:

- Reducing emissions from mobile sources could be exchanged/offset to the reduction in industry sector. This could lead to failure of reductions in emissions from industrial stable sources. Similarly, street vacuuming is listed as one of the offset choices for the industry, which means the emission reduction from street vacuuming can be counted as a reduction for industry. Huang admitted the rule of the offset choice is not really logical, inhibiting industry on real reduction from the stable sources, and enabling them to borrow credit from fugitive and mobile sources. He said the EPA would use the advantage of the flexible article restricting industry from really using such ways for emission reduction.
- Air quality standard achievement is a national long-term goal. Looking at the historical data, we have gradual improvement.
- Financially, an air pollution tax supports the trading scheme. However, looking at the whole air pollution management in Taiwan, transportation is the main pollution source. Thus, 40% of the fund is allocated to relative policy (Air emissions Fund board meeting, 2016).

Local government: Kaohsiung city government

Kaohsiung city government hold a similar with EPA, having a positive view on the implementation of the cap-and-trade program. Other issue they concerns are:

- Only four air pollutants including PM10, NOx, SOx, and VOCs are controlled as air pollutants in the cap program. PM2.5 should also be controlled in such framework.
- Regional control on air pollution is limited, it is suggested that other western cities in Taiwan should also implement total emission control to reduce PM2.5 pollutions as a whole and eliminate the long transportation of pollutants from major emission sources in the central and Southern regions of Taiwan.
- According to the year average concentration of Ozone and PM10, Kao-Ping was the only region that didn't meet the national air quality standard. However, if considering the concentration of PM2.5, all of the west coast cities in Taiwan also failed to meet the national standard, and so the cap and trade program for total emission control could also be applied to them. Kaohsiung city government has suggested that all the major cities should implement such a cap program and listed PM2.5 as the target air pollutant for designing regional air pollution control plan.

- The cap program was delayed by a decade due to the Economic administration holding a negative view of the cap program, and according to article 12 of the air pollution control act, both the EPA and Economic administration should agree on the implementation of a cap proposal of the region. Kaohsiung city government stated that such a bureaucratic deficiency that hinders regional air pollution control should be amended.
- Environmental Protection Bureau of Kaohsiung city government showed positive view on the cap program
- Cap program is believed to have a positive impact on air quality in Kao-Ping, and it is believed to foster transformation of fossil-fuel industry to a more suitable industry chain by providing economic incentives, including providing an incentive to use clean energy.

Industry

Overall, the industry gives a negative feedback toward the cap program. The whole complex chemical and oil industries chain would be influenced by the policy in a negative way. They believe they could face difficulties in renewing and enlarging factories, and face the risk of factory closure due to the new regulation of cap program. In addition, they have concerns on the issue of equity in the policy planning, a lack of representation in the auditing group, and technical difficulties on more reduction. Thus, there is no incentive at all for more emission reduction nor an active market on trading emission credit we can expect in the future.

- **Equity in allocation**: The equity aspect of allocation of the allowance is one of the concerns from the industry in the Kao-Ping area. National Oil Company suggested that the current 5% reduction for all the industries is not fair for those who had made efforts on emission reduction.
- **Equity**: Industry should have more representatives working in the auditing group of total emission reduction to ensure their perspectives are heard. There are 17 people in the auditing group drawn from multiple stakeholders and experts, but only one represents the industry sector.
- **Negative view on the cap-and-trade program**: offset and trading program is designed to regulate industry in Kao-ping. It would be harmful to the Taiwanese economy by negatively affecting from the upstream to downstream of the

chemical industry and oil industry. The policy inhibits the enlargement of factories and even the renewal of existing factories, compounding the strict regulation on the industrial land and residential land usage. Kao-ping is an area that planned to be industrial area and could become useless land with a dying industry chain.

- **Banking for survival**: According to the interview, there is no incentive for industry doing additional emission reduction because the existing regulation is strict enough, and if they have any ERCs, they would plan to save the credits for future planning such as renewal or expanding of their facilities. *"A sustainable company has a need of renewal factories, and the renewal also means the expansion of factories"* stated by the reprehensive of a plastic industry. Under the cap regulation, they think it would be difficult for them getting credits for expansion. Selling ERCs is impossible for industry since having credit is related to the survival right of the company.
- **Unpredictable future**: There is no concrete goal written in the CAP program articles, it is hard to persuade them to support this policy with an unknown future.
- **Technical difficulty and abatement cost**: Lin Fossil Fuel Park stated that for those who have already been using BAT there are technical difficulties for further improving reductions, and an abatement cost is needed. Suggested discount should be given to companies who have applied BAT or have used natural gas or renewable energy as fuel.

Non-governmental organizations

Environmental NGOs are still in a position of observing the new policy instrument. They have supported the implementation of the CAP program in Kao-ping for years. As such, they expect the EPA to stop the air quality from getting worse. However, they are still not satisfied by the 5% reduction goal. They expect something visible and fast because the health issue caused by the PM2.5 cannot be neglected.

- **Transparency:** The Earth Citizen worried that black box trading would happen under the direct credits exchange scheme. In addition, open information on emissions and allowances could enhance the incentive for emission reduction in industry due to the availability on estimating potential abatement cost. Thus, they

suggested that trading information be frequently updated and published on the Internet.

- The calculated total emission couldn't well present the real total emission. Industry provide the emission data that represents the highest emissions among last 7 years, which is an outdated data considering the technology is advancing every year.
- **Effectiveness**: The effectiveness is a main concern among the local environmental organizations; they have doubts about achieving the reduction under the current circumstance, with a low standard on giving the emission permit though environmental impact assessment, adding on the first three years 5% reduction setting which could make the outcome of emission reduction hard to foresee.
- Goal setting: lack of holistic planning, the first three-year period is only 5% reduction, estimated to increase to a 5-10% reduction target for the second three-year period. 15% total emissions reduction is suggested by an NGO. And it is suggested to remove the allowance released due to the closures of an oil industry (EPA 2015).

Unique features of Taiwanese cap-and-trade program

- **Credit trading scheme**

  The Taiwanese cap program is different from most of the other emissions trading schemes in the world. Instead of an allowance trading system, Taiwanese emissions trading is a credit trading scheme. The design of this program focuses on implementing a fixed cap for all entities in Kao-Ping, and is expected to produce real reductions via mandatory reduction and emissions reduction credits verification system. However, trading presents a minor role in the program according to the interview with the EPA's representative.

- **Small market size**

  Apart from that, the Taiwanese cap-and-trade system consists of a relatively small market compared to other ETS. 80% of the participating entities are small or medium-size entities, while most of the other ETS mainly regulate large-size businesses. The other schemes usually operate over a wider geographical scope, are mostly national-wide programs, especially in the case of small countries, such as Korea, Switzerland, New Zealand, Norway…etc. Japan and the United States

have region-wide schemes, but their markets are considered to be big. Kao-Ping refers to two counties in Southern Taiwan which are relatively small compared to the schemes mentioned above.

- **Allocation method of allowance**

  The typical grandfathering method on allocating allowance is based on the annual 2-3 historical data of emissions. *(European Commission, 2016)*" Compared to this definition provided by the European Commission, the Taiwanese method for setting base-year emissions is very special, using the highest emissions of the past 7 years.

- **ERCs offset**

  Mobile and fugitive sources can also be reduced in order to gain emission reductions credits for offsetting emissions from stable sources, which is not a common feature for an ETS.

- **Policy instruments mix**

  Only a few countries combine two economic instruments - a fee and an emissions trading scheme implemented at the same time. Taiwan is one, while Norway is another one where they have a carbon tax and ETS.

- **Rationale of the emission trading program**

  Most of the existing ETS are created under the framework of the Kyoto Protocol, including CDM for developing countries and ETS for carbon dioxide. However, Taiwan has limited participation in the United Nations system. As a consequence, the development for ETS or other policy instruments for carbon dioxide emissions is relatively slower. On the other hand, air pollution contributing to PM2.5 is more visible to the public. Taiwan is the first country to introduce a cap-and-trade program for reducing the pollution of PM2.5.

6. Evaluating Kao-Ping cap program

This thesis evaluates the newly introduced cap-and-trade program related to fine particulate matter, by an evaluation that consists of environmental performance, policy design criteria and feasibility of implementation with 10 sub-criteria. The evaluation result is based on the literature review and interview. The result of the evaluation with regard to each of the criteria is shown by a number between -1 and 1, with 5 ranks.

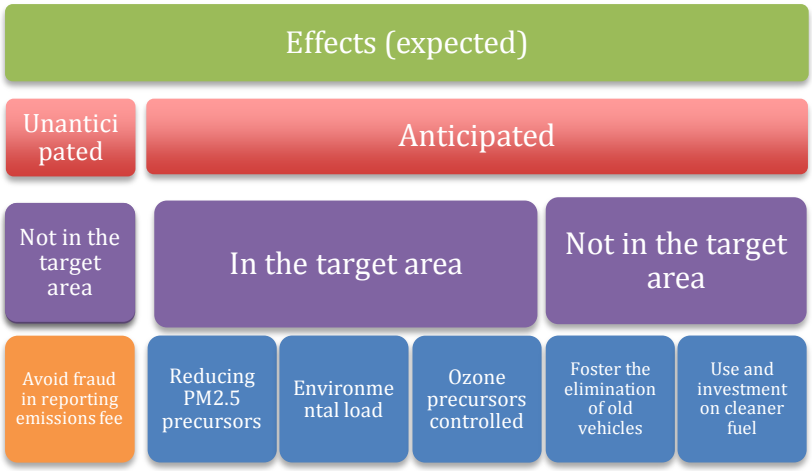
Table 6-1 Evaluating Kao-Ping cap program with criteria.

Criteria	Sub-criteria	Score
Environmental Performance	*Effectiveness*	0.5
	Side effects	1
Policy design criteria	*Flexibility*	0.5
	Predictability	-1
	Transparency	0
	Equity	0
	Relevance	1
Institutional Feasibility	*Political feasibility*	0
	Financial feasibility	1
	Implementation network feasibility	0

6.1 Environmental performance

Environmental performance is the crucial outcome which determines the successfulness of the policy instrument. Despite the fact that the actual environmental outcome is not available at this point, this evaluation provides the expected evidential outcome that is provided by the authority. Side-effect evaluation is used for this policy evaluation. Considering the complexity and uncertainty of the environmental policy problem, unanticipated outcome might result (Vedung, 1997). However, not all the side-effects can be evaluated at any point in time (Mickwitz, 2003). For instance, unanticipated effects must be evaluated after the policy has actually been implemented. The effects and side-effects of Kao-Ping cap-and-trade program are identified in the figure 5-1.

Figure 6-1 Side-effects of the Kao-Ping cap program (Source: own)



6.1.1 Effectiveness

The outcome has yet to be empirically assessed for this newly implemented policy. The EPA expects that the Kao-Ping cap-and-trade program will reduce the overall environmental load of the industrial city. Huang is firmly sure the outcome of this cap-and-trade scheme can control the total emissions by its definition. 5% of the emissions would be eliminated in the first compliance period, and other industrial pollution would also be controlled. New entrants and expansion of existing industries would be inhibited by the difficulty of obtaining credits. As Huang says, "At least industry could buy the credits in order to establish a new factory, however, it's rarely possible." (Huang W.M., personal communication, 2016). The regional government also has an overall positive expectation toward its environmental outcome due to this policy, especially since the system could inhibit new entrants from establishing new factories in the Kao-ping area. Chang believes that this policy could transform the fossil-fuel industry into a comparatively low-polluted and sustainable industry by encouraging industry to renew their facilities and work on technological innovations to reduce the emissions. Apart from that, given that practicing BAT and other preventive actions for reducing air emissions are essential measures to participate in the trading scheme, all those activities would have a positive impact on the environment (Chang F.T. Kaohsiung City Council, Personal communication, 2016).

Combined with other policy instruments including the air pollution fee and other CAC, the air emissions on two major pollutions from stable source and mobile sources are expected to decrease. However, Chang worried to what extent it will affect the real air quality in Kao-ping, since the actual concentration of PM2.5 could still be influenced by some other uncontrollable factors, for instance the long-distance pollution from China and other big polluters.

6.1.2 Side-effects

A few beneficial side-effects driven by the implementation of the Kao-ping cap program were observed by the EPA, both anticipated and unanticipated side-effects.

Effects of policy mix

A hybrid policy instrument with a tax and a cap creates a price floor for the trading unit. The price per credit on the market is set not lower than the air pollution fee according to various pollutants. Traditionally, a price floor can reduce the risk and volatility in the market and provide an incentive for the development of low-emissions infrastructure (Wood and Jotzo, 2009; OECD& IEA, 2010).

In Taiwan, an unanticipated benefit derived from this combination of the air pollution fee and the cap-and-trade program was to enhance the credibility from the reporting of data for the air pollution fee. Industries have an incentive to report their emissions accurately because their allowance depends on this data. Cases of false reporting on the air pollution fee program have been discovered after implementing the cap program. Those industries were possibly aiming to avoid paying the air pollution fee. According to Huang W.M. (personal communication, 2016). a company wrongly reported to EPA on emission of VOCs for the past few years. The original reporting was zero on VOCs emissions. Now they hope to provide correct data and pay the omitted air pollution fee ever thought they would have to pay double as a penalty for fraud, because the company found that it would be a problem when showing the wrong data while participating in the trading program because their emission allowance would be lower. In fact, either reporting more on the emission data or reporting less would be bad for a company. If a company reports more on the emission data than the actual number, e.g. for gaining credits in the cap program, they would end up paying a higher air pollution fee. On the other hand, as in the case

mentioned above, reporting less also means the company would have a lower allowance. EPA showed this unexpected side-effect would certainly have positive effects on the implementation of both economic instruments

Anticipated side-effects

Cap program is promoting cleaner forms of energy by giving an economic incentive to switching from oil to natural gas. Additionally, cap program is expected to have a positive impact on ozone pollution, because the program is also controlling precursors of ozone including NOx and VOCs (Air Pollution Fund second board meeting, 2015).

Overall, those side-effects are likely to have positive impacts on the environment, and the implementation of two economic instruments. On the other hand, industry sector is worried the negative impact on economic growing might be occurred in Kao-Ping due to the implementation of cap program.

6.2 Policy design

6.2.1 Flexibility and Predictability

Due to the fact that flexibility and predictability can sometimes conflict with each other (Mickwitz, 2013.), the evaluation of these two criteria will be discussed together in order to see their correlation. The Taiwanese's cap-and-trade program is very new and still in the stage of doing-by-learning.

The whole program can be seen as very flexible. It has the capacity to cope with changes, for instance in policy design, the methodology for gaining ERCs and the implementation on the local level are all flexible. However, at the same time it can be described as unpredictable and full of uncertainty.

A lack of predictability is observed in the Kao-ping cap program because of its ambiguous timeframe and unpredictable reduction target in the long run as well as the uncertain market of the cap program. Although now have known the bottom price for the credit per unit is based on the air emissions fee, however, the actual price is still remaining unknown (Personal communication with Chang F.T. Kaohsiung City Council, 2016). The relative reviews or discussion on the market is also very limited,

which has caused problems and dissatisfaction towards the EPA among various stakeholders. The unpredictability and uncertainty of the cap program may have a negative impact on the outcome of the program.

The timeframe and the target is only available for the first period from 2015 to 2017, while the new target for the reduction in the second period is a decision that remains to be made based on the situation during the first period. Not only is the goal for the second period undecided, but the price of the credit for the four controlled air pollutants remains to be decided pending further discussion in the EPA. Looking at a successful experience from the US, predictability was identified as one of the crucial successful factors in the Sulfur Dioxide Emission Trading program (Schmalensee et.al, 1998). During the first period of the program, industry could foresee that the price of credits would increase in the second period, which created an incentive for reduction. The result showed a significant emission reduction came before the second period. (Schmalensee et.al, 1998). This showed that a predicable plan can influence strategies and behaviour effectively in the industrial sector.

According to the interviews, members of the industrial sector are eager to know the detailed plan of the cap program. For instance, where the cap program will lead them to? How much reduction will the industrial sector contribute to Taiwan as a whole? If the EPA could provide answers for the above questions and a concrete reduction plan, this would be more persuasive for industry to actively participate in the cap program. Each period consists of three years for implementation. The industrial sector showed a negative view on the undecided goal for the second period and a long-term plan.

From the EPA's perspective, they admitted that the current cap program is not perfect and some details need more research and discussion. However, the fact that the reduction target for the second period is not yet set leaves high flexibility for making adjustments. Another source of flexibility comes from the EPA’s ability to introduce further methods for entities to gain ERCs, and to set penalties for non-compliance within a relatively wide range. Predictability and flexibility is a trade-off in the policy instruments. EPA chose the latter one, since they see it as a matter of urgency to implement the cap program in Kao-Ping and to inhibit new polluters and the chance

of expansion of fossil-fuel intense industry, regardless of the uncertainty of the program.

In addition, the local government has the right to add local acts that only regulate activities in the region. Kaohsiung city government has utilized the local act in order to manage mobile source emissions (Personal communication with Chang F.T. Kaohsiung City Council, 2016).

To sum up, evaluating the two social criteria of predictability and flexibility and their trade-offs, the cap program performs well on flexibility, but there remains a lot to be improved in term of predictability.

6.2.2 Transparency

Transparency means the disclosure of monitoring data, policy processes and other implementing information. Transparency is important for developing and promoting civil science and social participation, because to be able to access the policy information and data is a basic step for researching. Transparency ensures trust and credibility and has been used as important criteria in policy evaluations (Gupta et al., 2007; Michwitz, 2003; Bemelmans-Videc, Rist & Vedung, 2003).

Evaluating Question:
"To what degree are the outputs, outcomes of the policy instrument, as well as the process used in the implementation observable for outsiders?"

The transparency of the air pollution program, Kao-ping cap program, and air pollution fee are reviewed by considering the availability of the data, and how easy it is to access. Data for PM2.5 and its precursors is provided but not easy to access for outsiders.

Monitoring data of air pollutants are all available on the EPA website that can be traced back to the time when it was first measured. The data provided are raw data according to date and location. Annual reports of air quality are also published online, and can be accessed either on the Taiwan Air Quality Monitoring Network page of the EPA's website, or on the EPA Open data website (http://opendata.epa.gov.tw/).

Open data is established by the EPA and is promised to give useful information about environmental performance and other important information about environmental disclosure. However, the system wasn't user-friendly enough for the general public to access useful information. The EPA also admitted that some data might be hard to find for those who are not familiar with the EPA's system (EPA news, 2016). In fact, most of the monitoring data is published online, while other data that is related to policy process and information related to air pollution fee and cap program is limited.

Information and data on the implementation of the policy instruments is more limited. Entities must report their emissions each year for the air emissions fee system. An authority verifies these submitted reports. Emissions and allowance data are available for the participating entities and authority, but because of consideration for the privacy of these entities, they won't be available for the general public. The author has asked both a representative of the EPA and of the local government in Kaohsiung about the availability of air pollution fee emission data of each industry. Because of the privacy and the unwillingness of the industrial sector, relevant data won't be available online, and companies also won't be able to check each other's data. This means that doubt remains with regard to the transparency of the coming credit auction and emission offset trading system. NGOs have also shown concern with the level of transparency of the trading system. Thus, the transparency for PM2.5 and emission offsets credits data leaves a lot to be desired, falling short of public expectations.

6.2.3 Relevance

Evaluating question for relevance:
"Do the goals of the instruments cover air pollution problem including PM2.5."
This evaluating criteria is considered trivial to some of the policy instrument. However, the relevancy is crucial for this cap-and-trade program evaluation because it aiming at controlling PM2.5.

It was the first time that Taiwan has implemented a cap on air pollution that placed a limit on the volume of emissions. This is different from the previous CAC regulations, such as the operating permit and other emission standards which sought to reduce environmental impacts without placing a set limit on them. Focusing on a limit to total emission is more relevant for environmental protection.

Air pollution policy in Taiwan monitors and regulates total suspended particles (TSP), which means particulate matter that has a size between 0.1 to 1 um, including PM1, PM2.5 and PM10.

PM2.5 control in Taiwan is on the right track, for deploying multi-pollutant strategy, targeting both PM2.5 and its precursors. The EPA stated that a multi-pollutant strategy is a common strategy for controlling PM2.5 internationally. They suggested that particulate matter couldn't be regulated as a single pollutant by only focusing on its emissions, which is not enough due to the complex formation and diverse sources of PM2.5, which can be produced from VOCs, NOx, SOx and NH3, etc. Those precursors also have strong impacts on human health. Thus, in order to control PM2.5 successfully, a multi-pollutant control strategy should be integrated and adopted for PM2.5 control that regulates both the primary and secondary sources. A Chinese study for PM2.5 control strategy also showed the same view for PM2.5 control by controlling multi-pollutants (Wang et al. 2012). In addition, this strategy was also deployed by the US, while the single pollutant monitoring strategies have showed insufficient for achieving the national ambient air quality standards (Hu et al., 2013; Cao et al., 2013).

The fact that precursors of PM2.5 are regulated, while PM2.5 itself is not at the moment is because of the existing monitoring programs — the air pollution fee program provides the data for precursors, while PM2.5 is a relatively new pollutant to control. The monitoring technique for PM2.5 is still improving and under investigation. Kaohsiung city government is actually considering to improve the relevance of the Kao-Ping trading program by adding PM2.5 into the emissions trading scheme (Chang F.T. Kaohsiung City Council, Personal communication, 2016). This proposal is currently under discussion in the EPA.

6.2.4 Equity

Evaluating questions: "How are the outcomes and costs of the environmental policy instruments distributed? Do all participants have equal opportunities to take part in and influence the process used by the administration?"

There is a supervision group for tracking and supervising the implementation of the Kao-ping cap-and-trade program. It consists of 17 people from different stakeholders, including NGOs, industry sector experts, and other local communities to make sure the voices of different stakeholders can be heard. However, there is only one representative for the industrial sectors. Groups representing industry, including the Taiwan Responsible Care Association, Formosa Plastic Group, and Chinese Petroleum Corporation (CPC), Taiwan (Personal communication, 2016), argue that the current structure of communication makes their needs hard to be heard. They suggested that there should be a platform for them to communicate with the EPA and the Economic Administration, especially in this cap and trade program that involved both sides.

6.3 Institutional feasibility

This section evaluates the feasibility of implementing the program, by assessing political feasibility, financial feasibility and implementation network feasibility. Another analyst has shown that political feasibility is one of the criteria that determines a successful emissions trading scheme (Gupta et al., 2007). Financial feasibility is important because fiscal resources are required for a successful implementation of a policy instrument (Richter, 2012). The following question guides the evaluation of institutional feasibility:

"To what extent is the Kao-ping cap-and-trade program likely to be viewed as legitimate, gain acceptance, adopted and implemented?"

6.3.1 Political feasibility

Political hurdles for implementing cap program

Looking back at the history of implementing the Kao-ping cap-and-trade program, there was a political hurdle which stopped its implementation for over a decade. This delay (from 1999 to 2012) came from a long negotiation between multiple stakeholders, including the Economic administration (who hold a firmly

negative view towards the implementation of the cap program) and the EPA and Kaohsiung city government (who view the program favourably).

Since health issues and PM2.5 pollutions are major factors in Kaohsiung city, residents of the city and local environmental NGOs signed a petition to introduce a cap program in the city, and the Kaohsiung city government adopted this idea, agree to push the first cap program in this heavily polluted industrial city. However, according to Air Pollution Control Act, to make a policy instrument really implement in Kaohsiung city, both the Economic administration and EPA have to both agree to the proposal (EPA, 2016). The Economic administration stood for the mass industries in Kaohsiung, and worried that the emissions reduction plan would have negative impacts to the Taiwanese economy, especially for the wide fossil fuel and plastic industry chain, which are important for the Taiwanese economy. Once the area was regulated, the whole value chain would be affected from the up-stream to down-stream industry. Also, there had been an emissions fee and serval CAC instruments regulating the air pollution of industries. They hold that there is no need for the third policy instrument coming to Kao-ping the cap program, if it is implemented, the mandatory emissions reduction target for the first phase should remain zero.

Even though almost of the important stakeholders (Kaohsiung city government, local NGOs, local communities, experts in health and EPA) showed the willing implementing a cap, expect for the polluters and the Economic Administration. The cap proposal remained in this bureaucratic deadlock in the parliament for years. This situation continued until 2012, when president Ma of Taiwan had a meeting with the EPA and some environmental NGOs, and made a sudden public announcement in front of mass media, saying that a 5% reduction would be set, and that the government will be implementing the cap program in Kao-ping. This is a surprise given by the president Ma, thus, the cap proposal finally skipped the negotiation dilemma and went straight to the 5% reduction plan (Huang W.M.; Wang M.L. and Chang F.T., personal communication, 2016).

The EPA also believe that the political hurdle was the main difficulty with designing and implementing a cap program, since local and central authorities had a conflicting

political stand (Haung 2016, Personal communication). It required long negotiations on the policy planning and design, especially on the target setting for the mandatory reduction and the method of allocation, which overall have a big impact on the outcome of the policy instrument.

To what extent is the policy accepted by the public?

The evaluation is guided by the question *"To what extent does the public accept the cap-and-trade program?"*

The PM2.5 index, established in 2012, and the implementation of the Kao-ping cap program are examples of how policy evolution is pushed and followed by the expectations of public society in contemporary Taiwan. Chou (2013) investigated the public perception of climate change in Taiwan, and has shown that people tend to reject the high-polluting and energy-intensive industry. The abundant social and environmental movements reflect the fact that in Taiwanese society there is a lack of trust between people and government. There is also no trust of the fossil fuel industry in Taiwanese society, especially after several social events and movements, including an anti-fossil fuel development in 2012 and the Kaohsiung gas blast in 2014. Adding on the mass reporting about health impacts caused by air pollution in Taiwan, particularly by fine particulate matter, public awareness of air pollution issues has raised in some groups and individuals in Taiwan, and it leads to more and more demonstrations and demands to improve air pollution policy.

Based on the literature review and interview, introducing a cap to control air emissions in industry is surely desired by the public. However, the public didn't show the same desire for a trading program.

The proposal and petition drafted by NGOs and Kaohsiung city government was aiming for implementing a cap program instead of a cap and trade program (Citizen of the Earth, 2015). The title of the petition can be literally translated as 'total emissions control'(空汙總量管制). In this context, the number of times 'Trading' showed up in the petition was zero, which might indicate the wide acceptance of a cap program by the general public, but this acceptance is not for a trading program. The

NGOs that initiated the Kao-ping cap petition also showed concern with an emissions trading program due to the controversy of EU ETS (Wang M.L, Citizen of the Earth, Personal communication, 2016).

6.3.2 Financial feasibility

Based on the EPA's report on their costs for the air pollution control programs, they have found that they have sufficient capital due to the income from the air pollution fee. Since 1996 to 2015, the air pollution fee has seen an income from stable emissions (industry sector) of 64.5 billion. 8.1 billion hasn't been used in the air pollution fund (EPA website, 2016). This is because the program is cost-effective and so produces a surplus in the budget.

Economic instruments including emissions trading programs are considered cost-efficient according to the literature review. This can also be shown in the case of the Taiwanese cap-and-trade program. The budget for controlling stable source air emissions only accounts for 7% of the total budget in 2016 according to the EPA (Air Emissions Fund board meeting, 2016). A majority of the budget goes to mobile source control, including several CAC regulations and subsidy policies.

- Stable sources contribution in Kao-Ping accounts for 31% of the total PM2.5 emissions, and uses only 7% of the air emissions fund.
- Mobile sources contributed 37% of the PM2.5 emissions in Kao-ping, however, schemes to control these use almost half (46%) of the revenue from the air emissions fee.

The budget used for air pollution control comes mostly from the air emissions fee from stable source emissions and a fuel tax on vehicles. The air emissions fee was implemented in the late 1990s. There is still a lot of budget to be utilized.

6.3.3 Implementation network feasibility

Technical difficulty for small and medium enterprises to comply with reduction.

According to the Economic Administration, around 80% of the participating industries in the Kao-Ping area are small and mediums size enterprises, accounting for

25% of the companies located in Pingtung, and 56% of those located in Kaohsiung (Based on data in 2016). Unlike large enterprises which have more resources and more capacity financially, and so can participate more actively on reduction, small companies might face shortages of revenue and human resources, and a lack of capacity for research and development on deploying reduction. The Economic administration shows the need of cooperation with the EPA on facilitating and supporting small companies to participate in the cap program by providing several supporting services (Air pollution fund board meeting, 2016). In case in other ETS, large companies are observed to be more active in participating in emission trading programs than smaller companies. For instance, a study shows that larger companies typically fully utilize the offset credits that were created under the Kyoto Protocol (DIW, 2016). The difficulty for small and medium size companies might also influence the feasibility of the cap-and-trade program. Shaw (1999) and Economic Administration (Udn news, 2015) showed a concern about the cap program due to the small size of companies.

On the other hand, according to representatives from the industrial sector, large industries also face technical problems in deploying emissions reduction. In the industrial sector, SOx emissions are a major source of pollution that is prioritized to be eliminated, because the industrial sector is the largest contributor of SOx (Wu, 2013). Two common techniques used for reducing SOx are scrubbing and switching. Scrubbing is to decrease the sulfur emissions by installing desulfurization facilities; switching is burning fuel with less sulfur (Schmalensee et al, 1998). Both techniques made a contribution to the success of the US sulfur dioxide emissions trading scheme. However, in Taiwan, the sulfur content of fuel for vehicles has decreased to 10 ppm compared to 2000 ppm in 1973. This was a result of serval CAC programs in Taiwan since the 80s (EPA, 2016). The capacity for further decreasing the sulfur in fuel seems to be a difficulty according to the industry (Lai, Weng and Shieh, personal communication, 2016).

Difficulty in accessing ERCs for industries might influencing the market behavior

According to article 9 of the air pollution control act, the five ways for accessing allowance for additional emissions are: 1) Banking ERCs from the first period of

reduction 2) Auction from EPA 3) Reduction credit exchange from mobile sources, procuring second hand vehicles. 4) Street sweeping 5) Other ways approved by EPA. These five ways of accessing ERCs are all considered difficult for industries according to the Economic administration and the three interviewed industry representatives (Air pollution fund board meeting, 2016; Lai, Weng and Shieh, personal communication, 2016).

7. Conclusion and recommendation

The objective of this thesis was to investigate the strategies that the Taiwanese EPA proposed to tackle the air pollution and health problems driven by PM2.5, as well as to examine an ex-post evaluation of the recently introduced Kao-ping cap-and-trade program in term of its environmental and social performance and institutional feasibility, in order to gain knowledge of the PM2.5 control strategies in Taiwan for future improvement.

What are the strategies for controlling PM2.5?

The strategies that EPA used for controlling PM2.5 are mostly project-oriented, according to the sources of the PM2.5 emissions. An air pollution fee is used for controlling four air pollutants for various reasons, but these four are also precursors of PM2.5, and so the fee has an unintended effect of PM2.5 levels. Kao-Ping cap-and-trade program is the only policy instrument that with a focus on reducing PM2.5 emissions.

How does the Kao-ping cap-and-trade program perform in environmental effectiveness and side-effects?

The environmental effectiveness of the instrument is highly expected by the authority. The emissions of PM2.5 precursors is expected to decrease due to the mandatory reductions. However, economists worried that the current credit trading system won't work well in such a small size market in Taiwan and this would influence the overall effectiveness of the program. An expected environmental side-effect of the program is the control of ozone due to the multi-pollutant control strategy.
The cap will reduce the environmental load in Kao-ping by inhibiting the expansion of energy-intensive industries. The only unanticipated effect observed by the EPA is that the policy mix of a fee and an ETS actually enhances the accountability of reporting emissions data, and actually avoids fraud on reporting.

How does the Kao-ping cap-and-trade program perform in policy design criteria?

The only policy design criterion that was evaluated positively is relevance. The cap-and-trade program is highly relevant to the control of PM2.5 and Kao-ping is planning to achieve the target of having average annual PM2.5 concentrations lower than 15 micrograms per cubic meters by the year 2036.
Uncertainty is an issue that one needs to be aware of in this cap-and-trade program. At this time the instrument has been implemented for less than a year. The design of the program and structure seems to be very flexible and is ready to cope with changes. However, the unpredictability on the timeframe and the market of ERCs may have a negative impact on the outcome of the program and influence the behavior of industries. Another social issue is equity and transparency. Industry representatives are arguing that there should be better communication between the EPA and Economic Administration. The transparency issues result from the privacy of entities.

How does the Kao-ping cap-and-trade program perform in terms of institutional feasibility?

The income of the program comes from the air pollution fee and the cost-effective characteristic of the ETS ensures that the program is financially feasible The production of air pollution policy has changed from being more purely technocratic to being more informed by social preference (Shaw, 1999). The cap-and-trade program and the air pollution fee were both influenced by the civil society and grassroots organizations. However, different stakeholders, such as the industrial sector, with different interests can also influence policy design. This conflict of interests can sometimes lead to ineffectiveness due to political delays, and the policy design that is ideally need to be set based on science would have to be compromised by political negotiations. For example, this was the case with the methodology of base-year emissions and the mandatory reduction target. In terms of political acceptability, a cap program is highly accepted by the public and was proposed by multiple stakeholders except from the polluters. However, a trading system was rarely mentioned by the mass media and pubic, and so the acceptability of this aspect of the program is less than for the cap.

The impacts on small and medium-size business is also a significant factor in implementing the program. These companies have less financial capacity to deploy

emission reductions and to participate in the credit market, and they constitute the majority of the market.

Recommendations for Kao-Ping cap-and-trade program

1) Improve the predictability of the cap program by setting a long-term target to ensure the improvement of monitoring technology, allowing companies to invest for the future.
2) Transparency: More openness is required on data relating to the trading system in order to properly evaluate the success of the program. The volume of credits traded, the buyers and sellers, and the price of credits on the market are not currently publicized, nor is information regarding non-compliance. Furthermore, information about the source of the emission credits, whether they are obtained through stable source reductions in PM2.5 precursors or through the various methods provided for offsetting these, is not currently available. Improvement can also be made to the EPA's Open data, including improving the website design for better access to the information.
3) Expansion: The results of this study and interviews with various stakeholders suggested an expansion of the cap-and-trade program, from a regional-wide that only cover Kao-Ping to a bigger or a national-wide ETS for regulating the big polluters that contribute to PM2.5 pollution nationally, including in Kao-ping, for instance the Tai-Chung power plants and other fossil-fuel industries.

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Interviews

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Appendixes

Stakeholder analysis: interview questions

Industry:

- What is your opinion about the green taxes on NOx and SOx that have been used in Taiwan?
  Do you think these taxes have worked better than regulation?
- What incentives did your company have to reduce NOx - and SOx emissions during the last ten years with green taxes?
- What is your opinion about Emissions Trading with Allowances for PM2.5? Is it better than using an emission tax for PM?
- What is your opinion about the allocation of allowances?
- Do you plan to buy more allowance or to sell allowances?
- Do you think there will be a difference in opinion between your company as a private company and a governmental owned company?

Environmental Protection Administration:

- What is your general opinion about regulation of emissions vs. using a green tax for air emissions?
- What's the rationale of choosing kaou-ping area as the first PM2.5 control region?
- What are the pos and cons of Green Taxes vs Trading with Emission Allowances?
- What about the expected outcome of the trading scheme for PM2.5 emissions? Do you think It will work better than a green tax?
- It was early in 1999, the ceiling control of air pollution idea was firstly introduced in Taiwan, came with the implementation of air pollution tax, however, the ceiling control goal was set and launched until this year, 2015. What's the reason for such a delay?
- What are the main hurdles of implementation? (Financial? Technical issues on monitoring pollutant?)
- So far, over 500 factories are regulated in the PM.25 trading scheme. What Is the formula (principle) of distributing allowances to industry (Grand-fathering based on historical emissions, or performance based criteria, where companies receive the same amount of allowances based on production volumes?
- How will one allowance be formulated (e.g. will 1 kg of PM2.5 and 1 kg of PM10 add up to 2 kg of particles, or are the weights differentiated for different sizes of the particles?) Will the emissions be monitored (measured) or will they be calculated?
- How will the emissions be verified? What happens If there is Non-compliance, i.e. emissions exceeding the number of allowances?

NGOs and local organizations:

- What are the pros and cons of Regulation vs Market-based instruments?
  What are the pros and cons for Green Taxes vs Trading Schemes for emissions?

- In the policy aspect, do you think the current PM2.5 trading scheme in Kao-Ping area will be an effective policy to achieve PM2.5 reductions? Will it be cost-efficient compared to a regulatory approach?

Appendixes: ETS in the world

Program	US Acid Rain	Kao-Ping Cap-and-trade	Tokyo ETS	Korea ETS	Norway ETS	Switzerland ETS
Sectors covered	Eclectic generation plants	Fossil-fuel industries	Office, Commercial and buildings, district heating and cooling plants	23 sub-sectors from steel, cement, petro-chemistry, refinery and power	Power and heat generation, industrial processes	Cement, chemicals, refineries, paper, heat and steel
Size	263 registered in the first phase, a lot of volunteer participants	635 registered, 20% large company, 80% Small and medium size business	1232 (cap-and-trade system covered large business, a program for reporting on measures against Global Warming targeting small and medium-size businesses)	573 large business entities	273 (approx.)	55
Rationale	Acid Rain	Air pollution: PM2.5	Climate Change	Climate Change	Climate Change	Climate Change
Gas covered	SO2	PM2.5 precursor: SOx, NOx, VOC, PM10	CO2	GHGs: CO2, CH4, N20, HFC, PFC, SF6	CO2, N2O, PFCs	GHGs: CO2, N2O, CH4, NF3, SF3, PFCs, HFCs
Allowance	Grandfathering	Grandfathering	Grandfathering (any 3 years averages between 2002-07)	Allocation	Grandfathering (3 years average)	Allocation: based on potential via technical and economic standpoint
Compliance tools		Combine with part of transportation emission	Offsets, banking, free allowance	Offsets, free allowances, banking, borrowing (not across phases)	offsets, free allowance, banking	Allowance allocation, benchmarks, banking, borrowing and offsets

Unique		One of the few countries combines a fee and an ETS at the same time	1. Long compliance periods: 5 years. (New Zealand: one year, California: 3 years)	1. Early reductions can be awarded in the form of affectional allowances up to 3% of the total emissions 2.The scheme covers both direct and indirect emissions 3. Sector based emission reduction targets	One of the few countries combines a fee (on the petroleum sector) and an ETS at the same time	1. The small size of this market results in less cost-effective reduction potential, liquidity, price stability, and flexibility of in achieving targets 2. During period 2008-12, ETS worked voluntarily, having and option with a carbon levy.
Penalty	124,000 per unit	100 thousand to 1 million NTD	Very expensive	Max $9100/tCO2		
Outcome	Overcomplicate	N/	N/	N/	In the Phase I, supply exceeded demand	From 2008 to 2010, ETS emissions were lower than targeted levels