SUCCESS FACTORS OF THE EMISSION TRADING SCHEME TO REDUCE EMISSION IN CHINA'S BUILDINGS

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Success Factors of the Emission Trading Scheme to Reduce Emission in China's Buildings

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CERTIFICATE OF ORIGINALITY

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ABSTRACT

An emissions trading scheme (ETS) is designed to integrate economic development with sustainable environmental planning, and to do so efficiently. In practice, ETSs have been consistently criticized for such deficiencies as the uncertainty of emissions-reduction volume and the cost distribution of emission abatement. Nevertheless, many city and regional ETSs have been established around the world; one of the most well-known and representative is the EU ETS. China initiated seven cap and trade pilots in 2013: in Beijing, Shanghai, Guangdong, Shenzhen, Tianjin, Hubei and Chongqing. The second compliance year for these schemes expired in June 2015, with several limitations emerging; for instance, the trading volume was not as expected, which delayed the establishment of the national cap and trade scheme previously scheduled for 2015. It thus becomes important to discuss ways of improving the ETS in the Chinese context.

Some public, government and commercial buildings exceeding a certain volume of emissions are included in China's ETS pilots to abate emissions. Unlike other industries, such as power plants and the manufacturing industry, the building industry is rarely covered by ETSs, and there are thus limited precedents from which to borrow. China's pilot ETSs are designed to adapt to all entities covered, without specific consideration of the characteristics of buildings. For this reason, the purpose of the present study was to identify the factors responsible for the success of the ETSs in reducing emissions in China's buildings. To achieve this aim, the following objectives were identified.

- First, to clarify the work of the ETS and understand why the ETS is used as a policy instrument to reduce emissions, conceptualizing ETS by the process and duties of different sectors;
- second, to examine the two-year experience of China's ETSs and

identify their characteristics, limitations, strengths and effects;

- third, to consider how the ETS conveys the idea of sustainable development, to establish a model to evaluate whether a certain ETS is sustainable, and to identify criteria to assess the effectiveness and success of an ETS in particular scenarios;
- fourth, to use the model to identify the most important factors responsible for the success of ETSs in reducing emissions in China's buildings; and
- fifth, to validate the highlighted factors and make recommendations to correct existing limitations.

Following these objectives, the ETS was conceptualized in the form of a process flowchart, a sectoral-duty chart, and a table linking sustainability considerations with the ETS. With this knowledge, a case study of China's pilots is carried out. The findings indicate that the National Development and Reform Commission (NDRC) and local Development and Reform Commissions (DRCs) manage China's pilot ETSs strictly, and that the authorities invest considerable effort in designing schemes adapted to local economic and social circumstances. Nevertheless, little industry awareness of carbon asset management and a weak monitoring, reporting and verification (MRV) system are critical limitations emerging over the first two-year compliance period.

Next, the driving force-pressure-state-impact-response (DPSIR) framework was borrowed to organize the findings of the literature review and case study, which linked the ETS with influential and influenced factors in an analytical framework. Delphi interviews were then conducted to identify success factors. The framework was revised to give an Indicator Assessment Model for the ETS (IAMETS) based on the driving force–state–response (DSR) framework, according to the results of the first round of open-ended questionnaires, which yielded 5 parameters and 15 corresponding indicators. Experts were asked to rate the importance of the 5 parameters; it emerged that volume of emissions reduction and quality of emissions reduction was the two most important. Subsequently, 103 questionnaires were collected from experts asked to rate the 15 indicators. Principal component analysis (PCA) was used to process the questionnaire data. By comparing these two sets of weightings, the consistency of the model was affirmed, and the key success factors were identified as an accurate verification system and a comprehensive MRV system for buildings. In addition, literature on the ETSs in China's building sector was reviewed and the case of Tokyo's cap and trade program was explored to confirm that an effective MRV system is indeed a success factor in reducing building emissions by the ETS.

Further exploration of these two success factors was conducted. It was found that the current verification system for China's ETSs does not consider buildings' characteristics. By analyzing and comparing China's representative standards and guidelines for building energy efficiency, a verification system on buildings for China's ETSs was proposed. Experts were invited to validate the findings via the analytic hierarchy process (AHP). To ensure an accurate building emissions verification system, it was recommended to use energy record and bill analysis, combining the use of a simulated calibration method that includes the assessment of external factors such as weather in the context of China's ETSs.

This study contributes to knowledge of methods of assessing the sustainability and success of ETSs. The indicator assessment model was proved to be consistent and logical, and was successfully used to identify the factors responsible for the success of the ETSs in China's building sector. The model is also available for use in other scenarios to assess the performance of ETS in different industries and identify problems requiring attention. This will help authorities to identify policy inefficiencies and provide solutions.

PUBLICATIONS

1. Faye, D.F. Ni and Edwin, H.W. Chan. (2016). Sustainability assessment model of emission trading scheme in PSR framework: the preliminary application in China's buildings. *Journal of Cleaner Production*. (Under Review).
2. Faye, D.F. Ni and Edwin, H.W. Chan. (2016). Developing a building emission verification system in the context of China's emission trading schemes. Habitat International. (Under Review).
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ABBREVIATION

AHP: Analytical Hierarchy Process
ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BJ: Beijing
CCER: China's Certified Emission Reduction
CCF: China Carbon Asset Management Co. Ltd.
CCIED: Collaborative Center for Internet Epidemiology and Defense
CCX: Chicago Climate Exchange
CDM: Clean Development Mechanism
CER: Certified Emission Reduction
COP: Conference of the Parties
CPM: Carbon Price Mechanism
CQ: Chongqing
CQC: China Quality Certification Center
DNA: Designate National Authority
DOE: Designate Operational Entity
DPSIR: Driving forces-Pressures-States-Impacts-Responses
DRC: Development and Reform Commission
EB: Executive Board
EEX: European Energy Exchange
EI: Economic Instrument
EKC: Environmental Kuznets Curve
EM: Ecological Modernization
ETS: Emission Trading Scheme
EU: European Union
EUA: European Union Allowance
EU ETS: European Union Emission Trading Scheme
EVO: Efficiency Valuation Organization
FEMP M&V: Federal Energy Management Program's Measurement and Verification Guidelines
GB: Guo Biao
GBP: Green Building Program
GD: Guangdong
GGAS: Greenhouse Gas Reduction Scheme
GHG: Green House Gas
HB: Hubei
IAMETS: Indicator Assessment Model of Emission Trading Scheme
ICE: Inter Continental Exchange
IFC: International Finance Cooperation
IPCC: Intergovernmental Panel on Climate Change
IPMVP: International Performance Measurement and Verification Protocol

JI: Joint Implementation
MIB: Market-Based Mechanism
MIIT: Ministry of Industry and Information Technology
MOF: Ministry of Finance
MOFA: Ministry of Foreign Affair
MOHURD: Ministry of Housing and Urban-Rural Development
MOP: Meeting of the Parties
MOST: Ministry of Science and Technology
MRV: Monitoring, Reporting and Verification
NAOs: National Allocation Plans
NDRC: National Development and Reform Commission
NZ ETS: The New Zealand Emission Trading Scheme
OECD: Organization for Economic Cooperation and Development
PCA: Principal Component Analysis
PPP: Polluter Pays Principle
PSR: Pressure-State-Response
RGGI: Regional Greenhouse Gas Initiative
UN: United Nations
UNCED: United Nations Conference on Environment and Development
UNFCCC: United Nations Framework Convention on Climate Change
SFETS: Sustainability Framework of Emission Trading Scheme
SH: Shanghai
SZ: Shenzhen
TCC: Shanghai Treasure Carbon New Energy Protection Technology Company
TCRRP: Tokyo Carbon Reduction Reporting Program
TJ: Tianjin
TMG: Tokyo Metropolitan Government
VER: Voluntary Emissions Reduction
WCD: World Conservation Union

CHAPTER 1 INTRODUCTION

1.1 RESEARCH BACKGROUND

1.1.1 Emissions Trading Scheme (ETS) and its Political Context

Previous political measures of environmental conservation have rarely been powerful enough to be implemented effectively. It has been widely argued that an integrated approach reconciling and addressing three fundamental aspects – economic, social and environmental – is required. Sustainable development has been proposed as a means of complementing the principles of development while maintaining economic growth as well as environmental protection. Sustainable development as a global development strategy is perceived as a challenge to previously developed strategies, in which growth and conservation were positioned as antagonistic. However, different socio-economic contexts change the outcomes of such development, and may even create concrete barriers to the promotion of sustainable development (Baker, 2006).

In industrialized countries, economic incentives are a policy instrument used to channel economic activities to meet environmental targets (Jacobs, 1991), as the polluter-pays principle (PPP) incentivizes industries to pursue cheaper ways of reducing pollution. Moreover, to reconcile business activities with environmental protection in capitalist societies, ecological modernization has been widely advocated and in some areas adopted as a strategy for greening capitalism, in contrast with the radical green restructuring of the market economy and the liberal democratic state (Carter, 2007). Economic incentives and ecological modernization are both intended to integrate economic development with sustainable environmental planning, and to do so efficiently. Although there is evidence to challenge the effectiveness of these methods, they have been shown to have some success. An ETS is one of the most popular systems based on the integration of the approaches mentioned above.

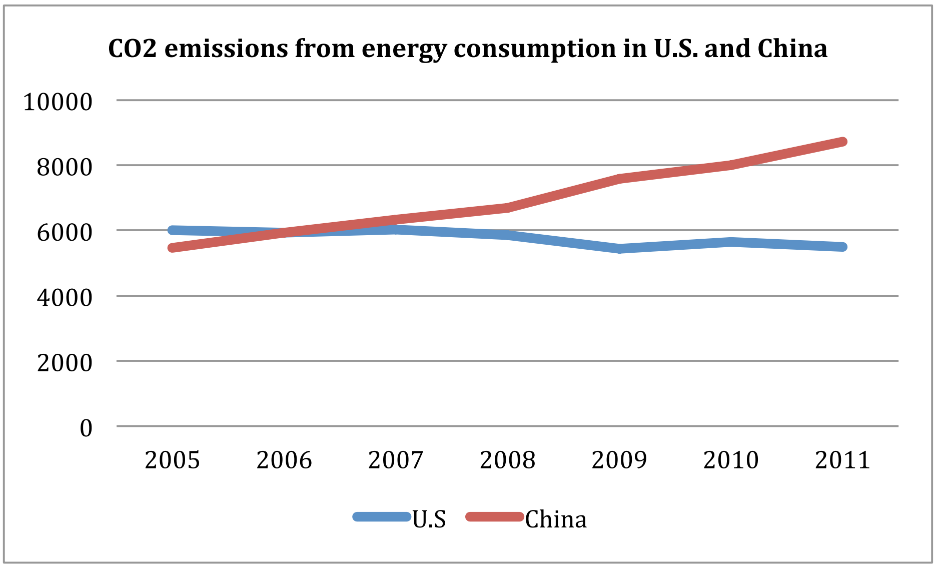
The concept of an ETS was introduced to political agendas in 1997, with the enforcement of the Kyoto Protocol. An ETS provides flexible mechanisms for polluters to reduce emissions via cheaper and economically beneficial measures. It operates in two ways: through cap and trade schemes or through offset schemes. The former are regulated by authorities and the latter are voluntary. In a cap and trade scheme, the commodity is 'allowances' or 'permits' extended by governments to firms; in an offset scheme, the good exchanged is certified emissions reduction (CER).

In January 2005, the European Union (EU) introduced the world's biggest and most ambitious cap and trade scheme, the European Union Emissions Trading Scheme (EU ETS) (Romm, 2007; Kruger, Oates and Pizer, 2007). This is the largest multinational cooperation to deal with emissions reduction, as well as the main policy instrument used by the EU to achieve the emissions-reduction targets set by the Kyoto Protocol (Jones et al, 2007; Carraro, 2014). The Kyoto Protocol's first commitment period expired in 2012, and its second commitment period runs from 2013 to 2020. The EU ETS is often viewed as a failure (Romm, 2007); however, others argue that its ambitions have largely been met to date (Skiarseth and Wettestad, 2008). In a report by the Environmental Defense Fund (EDF), the EU ETS is concluded to be a system that has achieved emissions reduction at low cost, as well as providing the flexibility needed to identify and deliver cost-effective emissions reduction (Brown, Hanafi and Petsonk, 2012). The Tokyo Cap and Trade Program and the California Cap and Trade Scheme are comparatively new schemes that promote emissions trading and build carbon markets on a regional scale. The aim of both schemes is to motivate and prepare for a national cap and trade system in the future. In addition to these regulatory carbon markets, the Chicago Climate Exchange (CCE) runs a voluntary carbon market, which was established before the launch of the EU ETS.

1.1.2 ETSs in China

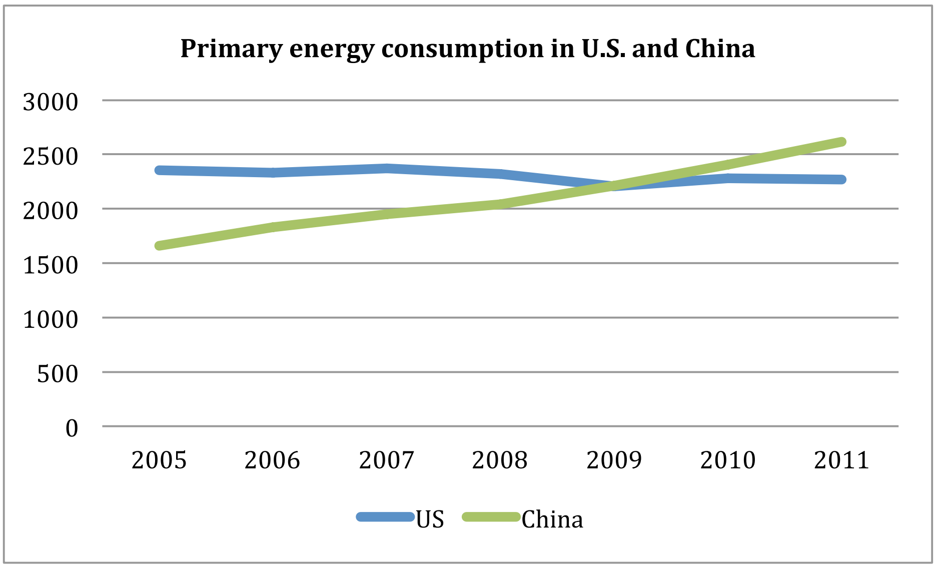
China's rapid economic growth has lasted for three decades, with GDP growth averaging nearly 10% a year, since market reforms were initiated in 1979; and it is predicted that its growth in GDP will persist, as its market reforms are incomplete (World Bank, 2016). The whole of Chinese society is undergoing a significant reconstruction process, which to a certain extent is at the cost of the country's environmental and cultural heritage. Sustainable development has been used as a strategic policy for several years in China; however, as China is a developing country, the Chinese government has always prioritized economic growth over environmental sustainability. The Kyoto Protocol did not constrain developing countries in terms of emissions reduction; nevertheless, China's impact on climate change, air pollution and massive energy consumption remain challenges that need to be confronted. In 2006, China became the largest emitter of carbon from energy consumption in the world (EIA, 2006) (Figure 1.1); in 2009, it became the largest consumer, with its primary energy consumption exceeding that of the United States (BP, 2012) (Figure 1.2). In the subsequent year, in response, China's government announced the target of lowing carbon intensity per GDP by 40% from its 2005 level, to 45%, by 2020 (NDRC, 2009). Figure 1.3 illustrates the growth rate of China's GDP and primary energy consumption.

Figure 1.1 CO_2 Emissions in U.S and China



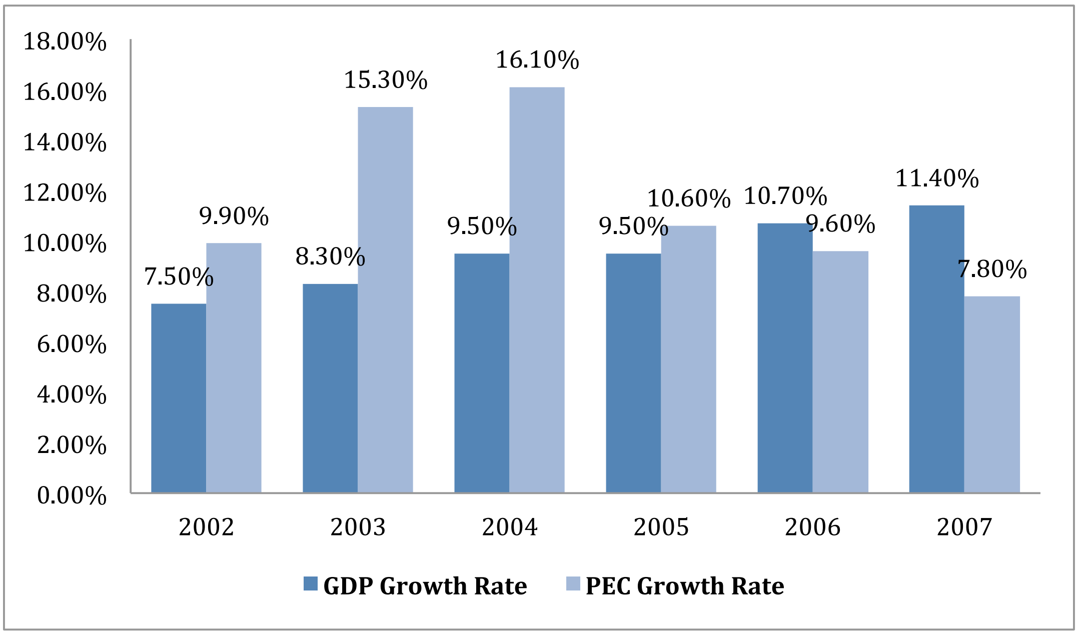
Source: Adapted from International Energy Statistics, 2012.

Figure 1.2 Primary Energy Consumption in U.S. and China



Source: Adapted from BP Statistical Review of World Energy June 2012

Figure 1.3 Comparison of Growth Rate of GDP and PEC



Source: Yang. 2011.

GDP: Gross Domestic Rate

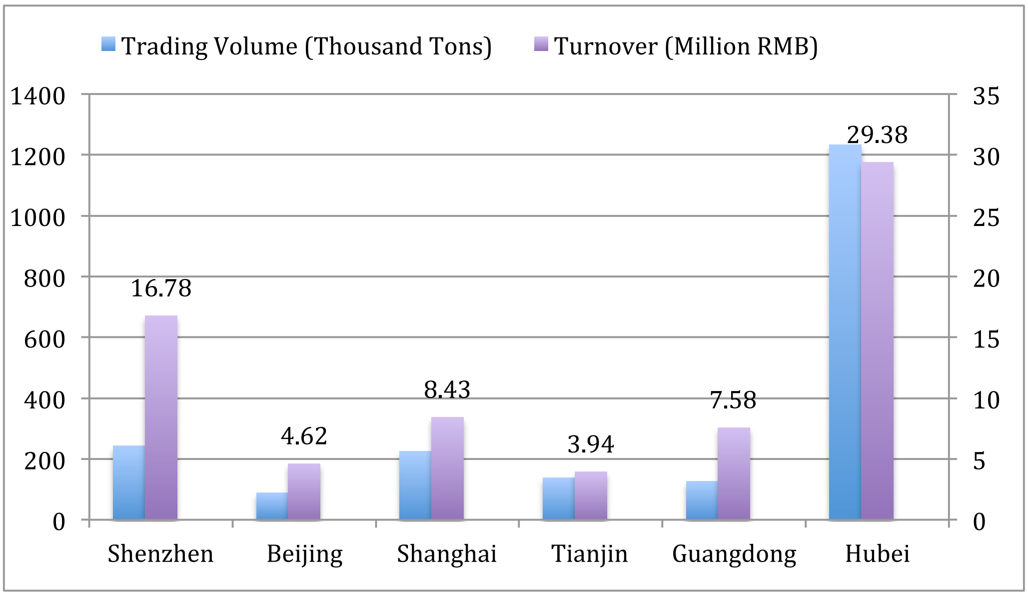
PEC: Primary Energy Consumption

The Clean Development Mechanism (CDM) in the Kyoto Protocol involves developing countries in the mitigation of global environmental problems, as well as offering subsidies and technological support. Prior to October 2008, China had provided more than 50% of the world's CERs, of which more than 80% had been bought by EU-based companies (Gemmer, 2009). In 2011, the Chinese government approved seven ETS pilots: in Beijing, Tianjin, Shanghai, Hubei, Guangzhou, Shenzhen, and Chongqing. To promote and apply emissions trading as a critical means of emissions mitigation, China began regulating the primary emissions sectors in 2013, placing caps on selected industries. On 18th June 2013, the Shenzhen Carbon Exchange, which is the smallest of the seven, was launched across 635 industries and buildings accounting for 38% of Shenzhen's total emissions in 2010 (Hook, 2013).

The other pilots also started emissions trading in 2013 and 2014, and are expected to lay the foundation for a nationwide environmental exchange platform in 2017 (European Parliament, 2016). However, in a recent article by the RTCC, it is claimed that China's national ETS faces considerable challenges (King, 2013), such as the allocation of emissions quotas, fixed electricity prices, and the ambiguity of the measures covering coal power plants (Hook, 2013). Nevertheless, China's national trading scheme is expected to be complete within the 13th Five-Year Plan period, and the experience of the seven pilot markets is important to its establishment (Liu, 2014).

According to a report in *First Financial Daily* in 2011, the trading credits used in China's three leading exchanges – Beijing, Shanghai and Tianjin - within a year are still less than those used in the EU ETS in a single day (Xu, 2011). The total trading volume of carbon emissions from all seven trading platforms from their commencement to mid-2014 was around 2 million tons; see Figure 1.4. Meanwhile, the two carbon auction platforms of the EU ETS – the European Energy Exchange (EEX) in Germany and the Inter Continental Exchange (ICE) in UK - have auctioned more than 10 million tons of carbon emissions, as of the beginning of 2014.

Figure 1. 4 Trading Volumes and Turnover of China's Carbon Market as at 11th April 2014.



Source: Chen. 2014.

Figure 1.5 Trading in EU ETS in 2014

Platform	Time	Credit Type	Volume (T)	Price （Euro/Tons）
EEX	3.31	EU EUA	1927500	4.17
EEX	4.1	EU EUA	1927500	4.9
ICE	4.2	UK EUA	2515000	4.88
EEX	4.3	EU EUA	1927500	4.6
EEX	4.4	Germany EUA	2352000	4.75
Total			10649500	

EEX: European Energy Exchange

ICE: Inter Continental Exchange

EUA: European Union Allowance

Source: Lin. 2014.

1.1.3 Economics and Emissions in China's Building Sector

Rapid economic growth and urban regeneration, including massive construction projects, have been ongoing in China for decades. The 'opening-up' policy initiated in 1978 promoted and improved the investment environment, attracting significant foreign investment and maintaining GDP at over 9% growth per year (Ahmad and Yan, 1996). China's building industry contributed to around 20% of its GDP in 2010, which was equal to an industry value of around RMB 1.14 trillion (Shrout, 2011). This indicates that the size of the building industry is much too large to be sustainable (ibid.). The huge construction market provides around 24 million job opportunities, which represent more than 5% of the country's total labor force (Ahmad and Yan, 1996).

China's rapid economic development and growing energy consumption have brought adverse consequences for the environment, such as an increase in carbon emissions (World Bank, 2006; Jalil and Mahmud, 2009). Emissions pollution statistics for China have attracted the attention of both domestic and foreign researchers. Recent research indicates that building and city infrastructure construction has driven a substantial increase in China's carbon emissions growth, with emissions almost tripling between 1992 and 2007 (UEA, 2011). Another report states that CO_2-intensive sectors linked to the building of infrastructure have become increasingly responsible for emissions growth (He, 2011). The construction industry was consuming 25% of the country's total energy at the end of 2008, and this percentage is still increasing (Hong, et. al. 2014).

1.2 PROBLEMS AND JUSTIFICATION

An ETS is designed to integrate economic development with sustainable environmental planning, and to do so efficiently. In practice, however, ETSs have been continuously criticized; for instance, for the uncertainty of emissions reduction with growing international trade (Peters et. al., 2010); for the cost distribution of emission abatement (Sheeran, 2006); for a lack of independence and openness in supervision (Li and Qi, 2011); and even for equity problems in access to environmental resources (Carraro, 2000; Buonanno, et. al. 2001). However, many city and regional ETSs continue to emerge around the world, such as the seven cap and trade pilots in China. The latter schemes indeed have limitations, which interrupted the establishment of the national cap and trade scheme previously scheduled for 2015. It is thus important to discuss how to improve China's ETSs.

The first ETS pilot was launched in June 2013 in Shenzhen, followed by projects initiated in Beijing, Shanghai, Guangdong, and Hubei. Some of the seven ETS pilots are located in the most developed cities in China, and some cover the major emissions-polluting industries in a given region, such as power stations and the manufacturing industry. Public buildings and government buildings are included in the Shenzhen, Beijing and Shanghai ETSs. To explore the implementation of ETSs in China's building sector, and to evaluate their effectiveness in reducing emissions in buildings, the following fundamental questions need to be addressed.

- How does an ETS work? Why is an ETS applied as a policy instrument to reduce emissions?

- What are the characteristics of China's ETSs? Based on two years of practical experience, what are their limitations, strengths and effects?

- How does an ETS convey the idea of sustainable development? How do we evaluate the sustainability of an ETS? Are there any criteria for assessing whether such a scheme is effective and successful?

- In a model used to assess the effectiveness of an ETS, what are the most important factors responsible for reducing emissions in China's buildings via ETSs?

1.3 RESEARCH SCOPE AND OBJECTIVES

The ETS is a comparatively new policy instrument, but is supported by many important research disciplines, such as sustainable development, environmental economics and political policy making. As an ETS is a policy instrument explicitly and practically used to implement the concept of sustainability, studies of ETS can cover social, economic and environmental factors. For instance, in the economic domain, research focuses on the relationship between ETSs and the energy market and energy pricing, the allowance allocation method, and tax provision. This kind of research usually involves the use of economic techniques and models to analyze ETSs, such as econometric analysis. From the natural environmental perspective, research is conducted on related schemes such as for soil, agriculture, forest conservation or deforestation. In research on social impact, issues relating to climate justice, social poverty and personal carbon trading guidance are addressed. In addition, technology-related studies explore carbon sequestration in specific environments. There are also many reviews of ETSs, which discuss potential improvements to these schemes to implement better policies.

The scope of the present study first extends to a review of the theories underpinning ETSs. Subsequently, the scope narrows to the context of China, focusing on the buildings subject to China's ETS pilots. The aim of this research is as follows.

To identify the factors responsible for the success of ETSs in reducing emissions in China's buildings

To achieve the research aim, the following research objectives are identified.

1. To examine the theories of and debate on ETS, conceptualizing ETS by the processes and duties of different sectors

2. To review the practice of ETSs in China, drawing conclusions on the strengths and limitations of these schemes

3. To establish a sustainable ETS model with criteria that can be used to assess the effectiveness and success of ETSs

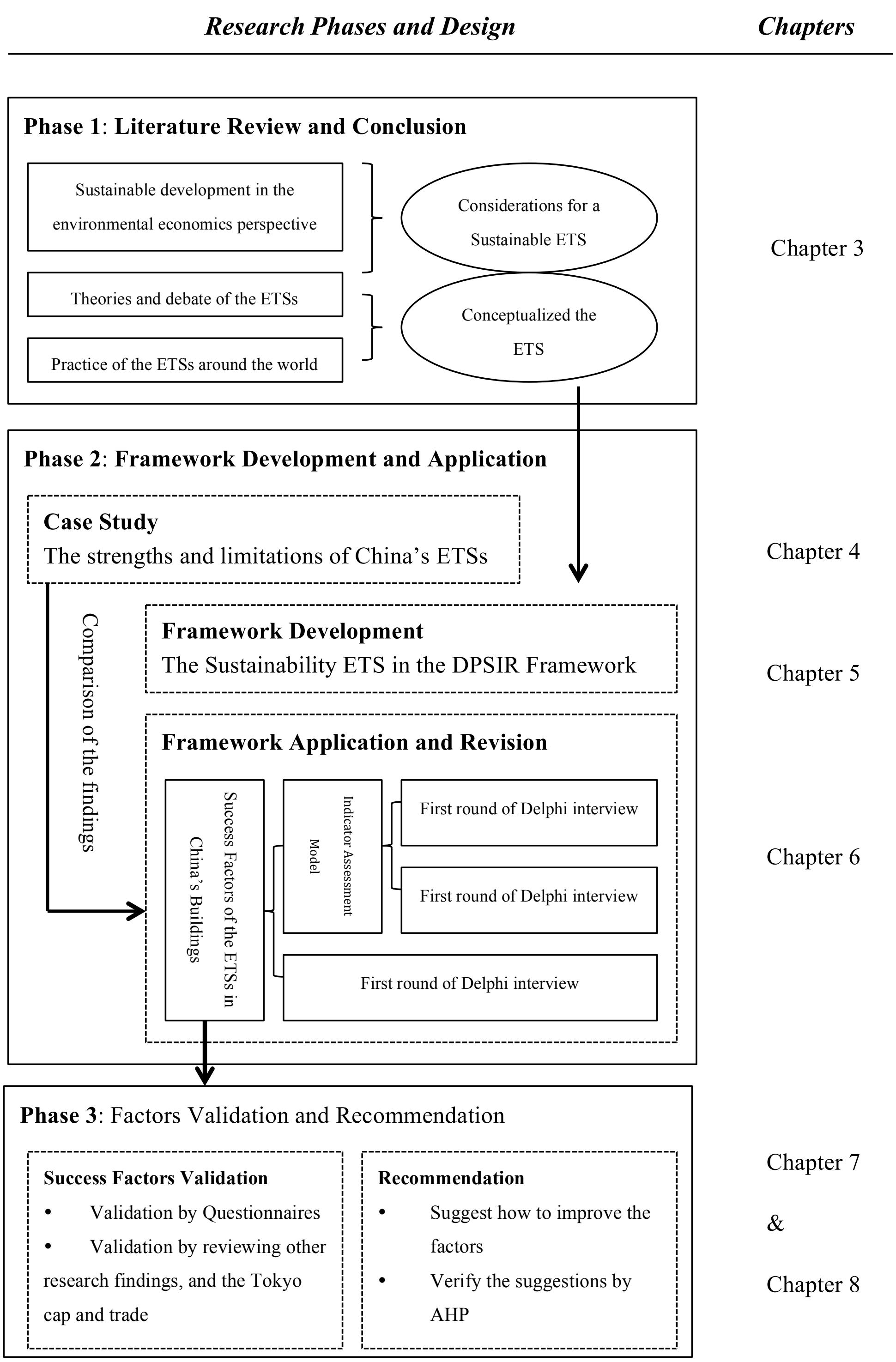
4. To apply the assessment model to buildings subject to China's ETSs, identifying the success factors involved in reducing emissions in China's buildings

5. To validate and analyze the success factors identified, making recommendations to correct existing limitations

1.4 RESEARCH METHODOLOGY

Both qualitative and quantitative research methods are used in this study. Empirical insights into ETSs and related theories are provided in the literature review, followed by an exploration of ETS trading practices in China. The literature review thus establishes a conceptual framework for analysis of emissions trading. In addition, considerations of sustainable development are extracted from the literature review and linked with the actions undertaken by ETSs. To build an assessment model, the driving force-pressure-state-impact-response (DPSIR) and driving force-state-response (DSP) frameworks, which are based on the notion of causality, are adapted to construct a sustainable ETS model and evaluation criteria. The model and its assessment criteria are refined via Delphi interviews and used to identify the factors responsible for the success of an ETS in reducing emissions in China's buildings. After identifying the success factors, they are validated. One of the validation processes involves an expert rating, with the data subject to principal component analysis (PCA); and the other form of validation is effected by reviewing published literature and comparing the findings with other researchers' work. Finally, recommendations for improving the accuracy of the success factors are summarized via the analytical hierarchy process (AHP). A flowchart for the research is shown in Figure 1.6.

Figure 1.6 Research Flowchart



1.5 SIGNIFICANCE OF THE RESEARCH

The present research explores the theories and debate surrounding the ETS model, examining ETS practices around the world and the latest progress of ETSs in China. Based on this, an ETS is conceptualized to systematically clarify its sustainability considerations, its working processes and sectoral duties, thereby reducing its complexity. The construction of a sustainable ETS model and indicator assessment model via the DSR framework enables the evaluation of emissions-trading projects in different contexts, as demonstrated by its application to the building sector subject to China's ETS pilots. Finally, as ETSs are predominantly used to reduce emissions in heavily polluting industries, the present study points out the factors influencing the success of ETSs in reducing emissions in the building sector, as well as providing recommendations to ensure the effectiveness of ETSs in the building sector.

1.6 STRUCTURE OF THE RESEARCH

CHAPTER 1 provides an introduction to the study. It includes background information on the research, the problems addressed and their justifications, the research aim and objectives, and the scope and significance of the research. A research flowchart is also presented in this chapter.

CHAPTER 2 introduces the research methodology.

CHAPTER 3 reviews the theories and debate surrounding ETSs. Based on a review of literature on sustainable development from the environmental-economics perspective, along with research on ETSs, which includes comparisons of cap and trade and offset schemes, voluntary and mandatory carbon markets, and carbon taxation and carbon trading, considerations for a sustainable ETS are extracted. In addition, ETS practices around the world are reviewed, from which a conceptual ETS framework is established. This output determines the fundamental elements of a sustainable ETS in the DPSIR framework.

CHAPTER 4 examines the implementation of China's ETSs. As China's ETS pilots have been in operation for 2 years, their strengths and weaknesses can be identified from a field study and statistical analysis. This examination reveals the characteristics of China's ETS pilots and validates the research results generated from the evaluation model.

CHAPTER 5 describes the establishment of a sustainable ETS in the DPSIR framework. The DPSIR framework is introduced, and each parameter is explained.

CHAPTER 6 introduces the process and presents the findings of the Delphi interviews. Based on the sustainable ETS model under the DPSIR framework, factors influencing the success of ETSs in reducing emissions in China's buildings are identified. Three rounds of Delphi interviews are conducted: feedback from the first round helps to evolve the sustainable ETS under the DPSIR framework into a more clear and focused set of indicators for assessment model of ETS under the DSR framework; in the second round, experts' feedback is elicited to ensure agreement on the new evaluation model; and in the third round of interviews, selected experts rate the parameters extracted, ultimately identifying the success factors. The results can be compared with the findings reported in CHAPTER 4 to identify any inconsistencies or conflicts.

CHAPTER 7 explains how the success factors are validated. The validation is undertaken via questionnaires and desk research. First, questionnaires are sent out to weight the indicators in the indicator assessment model, and the ratings are processed by PCA. By comparing the results with the findings in Chapter 6, the success factors are validated. As well as validating the results by statistical analysis, desk research is carried out. Published research papers and reports are examined to validate the findings of the present research.

CHAPTER 8 further explains the nature of the extracted success factors, as well as making recommendations for their improvement.

CHAPTER 9 concludes the research. Limitations and directions for future work are presented.

CHAPTER 2 RESEARCH METHODOLOGY

This chapter introduces the methodology used to answer the research questions identified in the previous chapter. The main qualitative methods are desk research and case studies, while quantitative research is carried out to collect and analyze the numerical data. This chapter first presents the epistemological starting point for and an account of the research paradigm. Second, a brief review of the scientific research methodologies used in emissions-trading studies is provided. Finally, the research techniques used in a later stage of the study are described in detail. A literature review, case studies and field research are the primary methods of data collection. Delphi interviews, principal component analysis (PCA) and the analytic hierarchy process (AHP) are the specific techniques used to process the data.

2.1 EPISTEMOLOGICAL STARTING POINT

Researchers are required not only to choose a particular methodology but also to have a profound understanding of the nature of different research methodologies. Hathaway (1995) notes critically that many researchers choose methods of collecting data without much thought for their underlying assumptions. To proceed logically with research, the first obligation is to look at reality. The realism adopted in this study is epistemological realism, which indicates that reality is accessible when researchers establish a frame in a specific situation (Jonker and Pennick, 2010).

Epistemologies inform rather than preclude methodological strategy (Graham, 2005). Defining an epistemological starting point can then lead the researcher to select an individual paradigm. The objects of research vary, and are constructed rather than pre-existing (Babbie, 2007). For instance, the ETS model and its underpinning theories are derived from interactions between social, economic and political activities. Therefore, when exploring the factors responsible for the success of the ETS, it is difficult to rely on examining single activities within society. Additionally, research objects seldom have "a single, unambiguous meaning" (ibid, p. 121). To conduct research in a manner appropriate to the nature of the research topic and provide a comprehensive social background, the epistemological starting point coincides with a 'social constructivist' approach. Using this approach, people make sense of their experience by inventing concepts and forming knowledge in the social process; simultaneously, these concepts are connected with – and reveal – a wider social context (Schwandt, 2000). Social constructivism also contends that reality does not exist before its social invention but is constructed through human activities (Kim, 2001). The importance of culture and context to social events is emphasized by the approach taken (McMahon, 1997), which reflects the nature of the research aim and questions.

A research paradigm is also about how researchers perceive reality, but is expressed in terms of 'basic approaches' (Jonker and Pennick, 2010). A research paradigm constitutes two basic approaches: one is gaining knowledge from empirical reality with researchers' own eyes, which is qualitative methodology; and the other is obtaining knowledge from perceived reality through somebody else's eyes, which is quantitative methodology (ibid.). In social research, the difference between quantitative and qualitative research is also evident from whether the data are in the form of numbers (Punch, 1998).

2.2 RESEARCH METHODOLOGY

Research methodology refers to principles and procedures of logical thought that can be applied in scientific investigation (Fellows and Liu, 2008). In studies of the ETS, reviewing existing schemes is a common but important method of summarizing the scheme's institutional structure. Studies of the ETS also rely on interviews, questionnaires and numerical data analysis to yield scientific conclusions. Some representative studies are presented in the literature-review chapter. Studies identifying the factors responsible for ETSs' success in reducing emissions in buildings rely on comprehensive knowledge of ETSs. Research on the building industry is usually conducted by four standard methods: literature review, case study, interview and questionnaire survey (Chow,2005). These tried and tested methodologies are also used in the current research.

This study collects numerical data addressing the development of ETSs in China and other areas. However, the linear series of steps moving from theory to conclusion entailed in a quantitative methodology (Bryman, 2008) is neither sufficient nor appropriate to fulfill the research aim and answer the research questions. For this reason, a qualitative methodology is used to effect "a continuing interplay between data collection and theory" (Babbie, 2007, p. 378). In agreement with the research objectives, the theoretical basis of the ETS helps to set up the types of data to be collected; meanwhile, the data collected help to assess whether the conceptual framework for the ETS is consistent and logical.

On the basis of both qualitative and quantitative methodological approaches, desk-based research and case study-based research are conducted. Desk research exploring the existing literature is the fundamental work of this study. It serves as a means of collecting data to provide background information, which is used as a platform for the research project and constitutes a source of data in its own right (Denscombe, 1998). Based on the terms of the case study, the general questions asked in the research lead to a complete analysis (Marshall and Rossman, 1989). When the phenomenon under the study is not readily distinguishable from its context, the case-study method is a sensible choice of research design (Yin, 2003). In this study, both holistic analysis and distinction from background information are necessary. Selecting representative case studies has the potential to reveal the "conceptual value from a single instance or example" (Rudestam and Newton, 2007, p. 50).

2.3 RESEARCH METHODS

The aim of this study is to identify factors responsible for the success of China's ETS pilots in reducing emissions in China's buildings; five objectives are pursued to achieve this goal. The research methods comprise a literature review, secondary document analysis, interview, a questionnaire survey, a case study, field study and statistical analysis and verification. Both qualitative and quantitative methods are used.

2.3.1 Literature Review

A literature review is a means of looking at and making use of the research others have carried out to shape their own projects (Rasmussen, Ostergaard and Beckmann, 2006). Its aim is to consolidate previous related studies and understand current trends (Chow, 2005). Basically, a literature review should start with a brief introduction to what is already known in the area, and progress in stages to answer the following questions.

- What is already known about the subject?
- What central concepts are found in the literature?
- What relationships can be observed between the concepts, and are they clearly defined in relation to each other?

After summarizing the literature according to these three questions, a literature review should examine the research questions, starting with the questions below.

- What theories and models are to be found?

- How do existing studies interrelate and are theoretical or conceptual deficiencies and knowledge gaps related to the research questions?

- What methods of data collection are suggested by the literature reviewed?

(Rasmussen, Ostergaard and Beckmann, 2006)

In this study, desk research on the ETS and its underpinning theories is the fundamental work undertaken to identify the model and its main factors. A review of different but representative trading schemes can help to determine which factors are useful and essential to complement the ETS model.

2.3.2 Secondary Documents

Before conducting the interview and questionnaire survey, secondary data are collected to examine the progress of China's ETSs. The strengths of secondary data are as follows: they are cheaper and quicker to obtain than primary data, as they already exist; they can provide useful contextual material for research; and their quality and reliability have already been proven (Clark, 2005). However, due to the massive amount of secondary data available, data collection may take a long time, so some selectivity is required. The secondary data collected in this research can be divided into two categories: first, from published official documents, and second, from business announcements. However, data from these two categories sometimes overlap. The secondary data from authorities on ETSs focus on positive claims, based on the assumption of a promising prospect; yet the trend of ETS development is ambiguous, so these data are limited. The secondary data from businesses subject to emissions-reduction regulations are difficult to access, but offer helpful insights into the demands placed on industries involved in ETSs. The limitations of the data can be compensated for by conducting further interviews. The secondary data in the latter category are collected primarily from the Internet, because the Web brings together a large amount of information in one place, and the content posted online is rapidly and frequently updated (Clark, 2005). Even more importantly, contrary opinions can be found on Bulletin Board Systems or in columns providing commentary on the ETS. This online discussion reveals the interaction between the government and the public, and to some extent the business sector and the public, which informs our understanding of potential difficulties in the future. These documents are used to establish a framework for analysis of the ETS and indicate general attitudes to the ETS of the business sector, which aid in the interview design. However, Web-based data are still limited. The data from each party emphasize their own interests. For instance, data from government publications mainly concern policy promotion, while data from the business sector primarily emphasize economic achievement. Therefore, information on the interaction between society, businesses and political activities is comparatively weak; in particular, the social aspects of the ETS are not reflected. Furthermore, the quality of these Web-based data cannot be guaranteed, which is one of the potential limitations of the current study.

2.3.3 Case Study

Case studies are conducted prior to qualitative data collection and followed by quantification of the data, and a relatively small number of cases should be used; sometimes just one (Hammersley and Gomm, 2000). There are four purposes of carrying out a case study: first, ensuring generalizability, to draw or provide a basis for drawing conclusions regarding a phenomenon; second, causal or narrative analysis, which is used to identify and explore causal processes in a real-world rather than an artificial setting; third, applying a theoretical framework to reveal its 'nature'; and fourth, maximizing authenticity and authority (ibid.). In this research, the cases selected are ETS pilots in China, which are used to identify the characteristics of ETSs in China.

2.3.4 Interviews

Interviews are conducted to elicit personal accounts of attitudes and experiences relating to a particular phenomenon, and target the 'discovery' rather than the 'checking' of reality (Denscombe, 1998). In case-study interviews, the researcher can ask key respondents for the facts of a matter and their opinions on events (Yin, 1994). In this study, the key respondents' opinions on the ETSs play a significant role in answering the research questions. There are three types of research interview – structured, semi-structured, and unstructured. In a structured interview, there are clearly pre-designed questions and strict management of the interaction between researcher and interviewee. A semi-structured interview can provide rich and vivid data that help the researcher to fully understand the interviewee's opinions (Bernard, 2000). In addition, interviewees answer questions more on their own terms in semi-structured interviews, compared with structured interviews (May, 2001). For these reasons, semi-structured interviews are used in the field research to discover the interviewees' opinions on the ETSs. The interviewees in a field study have to be representative. In-depth interviews are used to draw out the explicit context of each trading scheme; more broadly, they help to identify the parameters of a sustainable ETS. The semi-structured interviews are carried out primarily face to face, as well as via the Internet and telephone. As the field research is conducted by one researcher, this is done to ensure the coherence and representative nature of the data, as the selected interviewees may be located in cities far distant from each other. Internet communication has been used as a tool for qualitative research since the 1990s, as it offers access to social spaces in which relationships, communities, and culture emerge, either in real time or in delayed time sequences (Markham, 2004). As a medium for communication, online interviews can also provide a context for social construction through the researcher's witnessing and analyzing the structure of 'talk' (ibid.), which corresponds to the epistemological starting point. According to Markham (2004, pp. 106, 109), an Internet-based interview can also give interviews a greater "degree of control over the conversation" and "convey an accurate or desired sense". Another advantage is that the researcher has the opportunity to amend or complement the questions without the interviewee's feeling inconvenienced, compared with face-to-face interviews. However, the limitations of Internet-based interviews cannot be ignored. First, the data obtained may not be comparable, due to differences in interviewees' perceptions of the medium of the Internet (Markham, 2004). Second, this approach may be less in-depth than face-to-face interviews, and sometimes functions as a kind of "computerized self-administered questionnaire" (Babbie, 2007). For these reasons, face-to-face and telephone interviews are carried out alongside Internet-based interviews to increase the researcher's interaction with the interviewees and deepen the content of the interviews.

2.3.5 Survey

A survey is a comparatively cheap and convenient research method enabling the researcher to elicit responses from a fairly large population in a standardized form designed by the researcher. The advantage of survey research is obvious when the sample is out of physical reach. The questionnaire is a common and efficient tool for conducting a survey. The question design should be clear, enabling questions to be answered quickly and precisely. The aim of questionnaire research is not to obtain extensive and exhaustive data, but to allow accurate statistical inferences to be drawn from data.

Along with question design, appropriate sampling is particularly necessary for this research, as large populations are involved in emissions trading. To generalize from the data to answer the research questions, some representative small-group samples must be selected from this population. The samples have to be selected based on the following criteria: first, its members must be representative of the number of sectors or roles involved in the emissions trading process; and second, they must be from the building industry subject to China's ETSs. The targeted samples are categorized accordingly, as follows.

- Target one: building managers of buildings subject to ETS requirements

- Target two: experts working on relevant trading platforms Target three: relevant government officials

- Target three: relevant government officials

- Target four: ETS consultants and third parties

- Target five: academic staff and experts in related field

After making the initial decision on 'whom' the sample should constitute, the non-random sampling method of purposive sampling is chosen. An element of snowballing is involved in the selection of interviewees, as it is sometimes appropriate for researchers to use their own judgment and intuition to select the best people for study (Bouma and Atkinson, 1995), especially after conducting a case study and reviewing the literature in the field. Considering the time limitation on data analysis, the sample size is expected to be appropriate.

2.4 DATA COLLECTION AND ANALYSIS

All of the information generated from the literature review and collected from the interviews and questionnaires needs to be analyzed scientifically. First, the transfer of data into writing is important, as it can help the researcher to determine whether all of the data needed have been collected; in addition, written data is easier to further categorize. Categorization is important, as no conclusions can be drawn from the raw data, and producing general categories is the necessary first step in dealing with the too-detailed data elicited from interviews (Bouma and Atkinson, 1995). After categorizing and coding the data, it is easier to make comparisons and draw conclusions.

To fulfill research objective 3, the information obtained from the literature review is used to establish a sustainable ETS framework, which includes many sets of parameters and relationships. To link these parameters together and specify their causal relationships, the DPSIR framework is used to organize the information extracted from the literature review.

After the establishment of a framework for ETS sustainability, Delphi interviews are conducted in three rounds. The first round involves collecting experts' opinions on factors that can be used to evaluate the success of the ETSs in the building sector. With this feedback, the sustainable ETS framework is adjusted and improved. The second round of interviews involves presenting the revised framework to experts to determine whether they agree with the revised model. The third round of interviews involves asking experts to rate the parameters to identify the one(s) predominantly influencing the success of ETSs in the building sector. Details of the number and selection of the experts are presented in page 132.

Next, experts are asked to send out questionnaires to their colleagues to rate the indicators in the revised model. PCA is used to analyze the data and weight the indicators. The results of the rating are used to validate the success factors identified in the previous Delphi interviews. Details are provided in Chapter 7. Another validation process is undertaken to explore why these factors are critical in the real world. The existing literature is reviewed and conclusions drawn to validate the success factors identified in the present research.

It is also necessary to determine how to improve the theoretical basis for the success factors. The assumption of improved factors is verified by AHP analysis. The AHP is useful for analyzing a sophisticated design making process: to achieve a goal, certain criteria are listed and each alternative is ranked according to the criteria, yielding a score for each alternative. The ranking given by experts via the AHP indicates the best approach to refining the success factors for ETSs to reduce emissions in China's building sector, which can be compared with the findings obtained from desk research. Figure 2.1 lists the research methods used in different phases of the study.

2.5 ETHICAL ISSUES

Some of the potential limitations of the research have been addressed above. Ethical risk is another problem requiring consideration. First, the interviewees' consent to participate must be obtained. In some cases, the interviewees may ask for anonymity; if so, only background information can be used, such as whether they work in the government or business sector. The records of interviews and surveys have to be safely and appropriately preserved. Second, potential inside information and unpublished data have to be acknowledged and clearly referenced to prevent plagiarism. Inside information needs to be managed prudentially to avoid disclosing confidential information. The third potential ethical risk relates to the use of Internet resources. This information must be treated with discretion, as users may perceive their discussion to be private even if it appears public (Frankel and Siang, 1999; Sharf, 1999, cited in Markham, 2004, p. 118).

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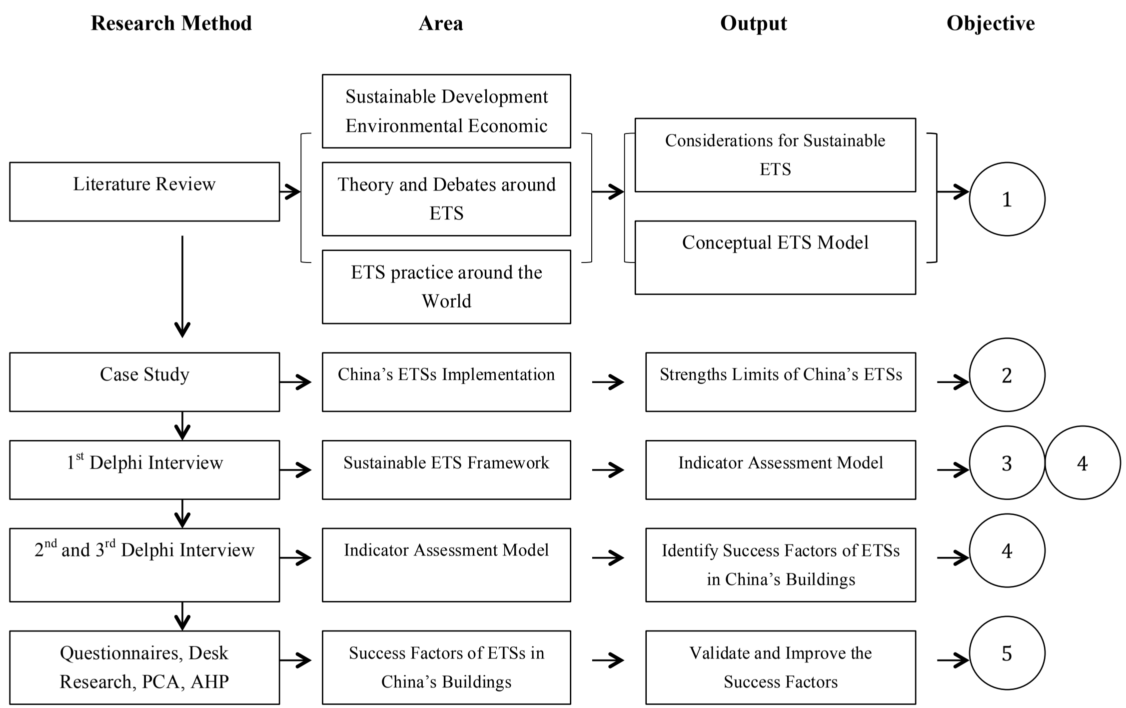
Figure 2.1. Research Methods in Different Phases



CHAPTER 3 LITERATURE REVIEW

3.1 SUSTAINABLE DEVELOPMENT FROM AN ENVIRONMENTAL ECONOMICS PERSPECTIVE

3.1.1 Theory Development and Difference in Focus

The imperative of sustainable development has dominated global development strategies for more than two decades. The Brundtland Report defines sustainable development as "development that meets the needs of present without compromising the ability of future generation to meet their own needs" (WCED, 1987), taking into account both inter-generational and intra-generational equity. During the United Nations Conference on Environment and Development (UNCED) Earth Summit in Rio in 1992, a guidebook named 'Agenda 21' was proposed, offering fundamental guidelines for the manipulation of sustainability at different levels – local, regional and global. The guidebook situated sustainable development in all areas of government policy (Jacobs, 1993). Abundant efforts have since been made to derive the concepts of sustainable development, which should combine consideration of environmental issues with the pursuit of economic growth (Dryzek, 2005). In a report by The World Conservation Union (WCD), sustainable development was conceptually divided into three co-related parts: environmental sustainability, economic sustainability and social sustainability (UCN, 2006). At the heart of sustainable development, sustainable economic growth is linked with the survival of a sustainable environment; in this respect, sustainable development is not a radical environmental or green concept, as it recognizes the need for economic growth and the importance of human welfare (Doyle and McEachern, 2008). The approach to sustainable development should be integrated, holistic and balanced across the three constituent parts.

Given the broad range of issues covered by sustainable development, different studies in the literature have taken different emphases. For instance, Connelly and Smith (2003) claim that the core idea of sustainable development is environment-economic integration, complemented by ideas of futurity, environmental protection, equity, quality of life, and participation. From another perspective, Baker (2006) stresses that countries have common but differentiated responsibilities in terms of inter- and intra-generational equity, justice, participation, and gender equality, which should be the normative principles of sustainable development. A focus has also been taken on the process of environmental valuation through the dynamic interdependency of economy and ecosystem (Turner et al., 1994). Regardless of the core ideas or normative principles identified in these works, they all indicate that governments should play the critical role in pursuing sustainable development, and that a governance approach addressing both economic and environmental considerations is needed.

3.1.2 Sustainability in China

"Sustainable urban forms will only be achievable if they are underpinned by a policy background which commits to global sustainability goals, but leaves the room for local formation and implementation of solutions" (Williams et al., 2000, cited in Jenks, 2000). In developing countries such as China, urbanization is taking place on an unprecedented scale, resulting in the intensive usage of resources, the overstretching of infrastructure, and social and economic inequalities (Jenks, 2000). Unsustainable development has been found to create problems in cities. Governance is believed to be an even more significant and intrinsic problem. According to Miltin and Satterthwaite (1996, p. 50, cited in Jenks, 2000), it is the "failure of effective governance within cities that explains the poor environmental performance of so many cities rather than an inherent characteristic of cities in general". Sustainable development offers an opportunity for the governments of developing countries, because a sustainable pattern of development "can provide enhanced opportunities for millions of people and refugees from a stifling, restrictive rural life which might be no longer economically sustainable" (Seabrook, 1996, p. 5, cited in Jenks, 2000). China is a large and densely populated country undergoing rapid industrialization, and is becoming one of the world's biggest consumers of natural resources, which indicates its significant role in the global economy (Fang, Cote and Qin, 2006). Ensuring sustainability in China would make the country's development more efficient and more strategic. It has been shown that currently, the key challenge to efforts to secure sustainability in China is the need to balance China's energy, economic and environmental goals (Byrne, Shen and Li, 1996). China's rapid urbanization and industrialization have been shown to place tremendous pressure on resources and the environment (Niu and Pan, 2007).

Chinese planning authorities have pointed out that most high energy consuming industries in China still depend on the power generated by coal. This unsustainable development trend constrains economic development as well as environmental protection (ibid.). Efforts to reform the Chinese energy industry are in their infancy, but technical innovation is now mainstreamed. Wang (1999) claims that productivity has been one of the essential elements supporting China's rapid economic growth over the last two decades, but not the fundamental one. The most significant factor responsible for sustaining economic growth is firms' improved efficiency, especially via technological innovation and the introduction of foreign technology (ibid.). In its Eleventh Five-Year Plan, China's government demonstrated its commitment to developing technology to reconcile the conflict in economic growth and address the shortage of energy sources such as coal. In addition, Agenda 21 was issued to deal with specific sustainability issues in China. This agenda highlights the principles of and establishes guidelines for the development of industries, but it has not yet had a significant influence on the country's industrial policy in practice (Fang, Cote and Qin, 2006), due to the weak governance of environmental concerns in China. Niu and Pan (2007) also point out that the authorities' economic incentive to promote sustainability is inefficient. In addition, as the environmental tax levied by the government is far smaller than the cost of pollution control, industries prefer to be taxed than to reduce their emissions.

3.1.3 Strong and Weak Sustainability

The strong and weak sustainability framework developed by O'Riordan defines four levels of sustainability, from very weak to very strong. The concept of "capital" represents a combination of "natural resources, environmental protection systems, artificial substitutes and human ingenuity and adaptability" (O'Riordan and Jordan, 1995). To move up the levels from very weak to very strong sustainability, the significance of natural resources and environmental protection must be enhanced. Many interpretations of strong and weak sustainability based on O'Riordan's framework have been offered. For instance, advocates of weak sustainability ("optimists") argue that natural capital is unlimitedly substitutable for by man-made capital, through the application of technology; in contrast, proponents of strong sustainability ("pessimists") (Ayres, 2007) believe that natural capital cannot be substituted for by other kinds of capital, such as man-made capital, and call for a physical stock of natural capital to be maintained (Neumayor, 2003). When considering ecological damage and the depletion of resources, some explain the "weak" argument in terms of money and the "strong" argument in terms of physics (Alier, 2004); others believe that strong sustainability involves the enhancement of natural, economic and social capital (Devkota, 2005), and is the "ecological economic approach" (Turner, 1993). It is difficult to find a single interpretation that accommodates all of the practical solutions belonging to weak or strong sustainability.

Basically, the dichotomy between strong sustainability and weak sustainability has divided economists and environmentalists rather than encouraging them to integrate their perspectives to address the overall challenge of sustainable development (Hediger, 1999). In this study, the practical solutions implemented by governments or businesses are analyzed alongside these theories to facilitate self-reflection.

3.1.4 Environmental Economics

With the emergence of "sustainability fever", environmental politics in Western countries is experiencing an ideological revolution. The popularity of green issues has forced traditional parties to respond to challenges such as ozone-layer depletion and climate change, for which ample scientific evidence has been provided (Connelly and Smith, 2003). The most significant such response was a speech delivered by the UK's Thatcher government in 1988, which publicly recognized the severity of the world's environmental concerns (ibid.). This political change may be perceived as part of a tug of war between anthropocentric and ecocentric, which is similar to the theoretical debate between weak sustainability and strong sustainability. However, the conflict between anthropocentric and ecocentric did not last for long, as politicians soon realized that the radical issue was the struggle between economic growth and environmental conservation. In the realm of environmental politics, some approaches are promoted as practical solutions to manage this conflict, such as ecological modernization (EM). EM has an edge over other approaches because it rejects the fundamental restructuring of the market economy demanded by the radical green, instead offering an alternative approach to green capitalism (Carter, 2007). Following this successful paradigm, Western governments, especially those in the EU, have established policy instruments such as market-based tools to supplement traditional regulatory instruments and thereby fulfill the needs of different social sectors. These two approaches – EM and economic instruments (EI) – are both grounded in environmental economics.

The field of environmental economics emerged in the 1960s, and has since become a major sub-discipline of economics. Environmental economics is described in the following quotation.

> "Environmental economics combines traditional work in the field of welfare economics and the theory of economic growth with more recent perspectives on the political economy of choosing policy instrument and the philosophy of sustainable development."
>
> (Pearce, 2002)

This account indicates that environmental-economics researchers engage in theoretical and empirical exploration of the interaction between economic and environmental policies. The explicit concerns of the Environmental Economic Program launched by the US National Bureau of Economic Research are the costs and benefits of alternative environmental policies dealing with air pollution, water quality, toxic substance, solid waste and global warming (NBER, 2006). The objective of environmental economics is to understand the human-economy-environment interaction to direct economies toward sustainability, and it has progressed within a narrowly but sharply focused neoclassical analytical framework (Venkatachalam, 2007). In other words, environmental economics looks at sustainability from an economic perspective while still requiring sustainability to cover ecological, societal and economic dimensions (Illge and Schwarze, 2009). The central notion of environmental economics is that the market fails to allocate resources efficiently because it does not internalize the value of environmental resources, which ultimately harms social well-being. Pearce (2002) describes environmental economics as a process that maximizes human well-being and pursues traditionally oriented economic growth objectives.

Although both prioritize ecosystem over economy, the environmental-economics paradigm differs from that of ecological economics. The substantive difference is that ecological economics emphasizes strong sustainability and rejects the substitution of human-made capital for natural capital, whereas environmental economics assumes the substitutability of all forms of capital ((Illge and Schwarze, 2009; Pearce, 2002). In other words, environmental economics prioritizes environmental quality in the weak-sustainability regime, which is consistent with the emphases of EM and the economic-instrument approach.

3.1.4.1 Discourse of EM

According to Connelly and Smith (2003), EM has dominated debate around sustainable development and is garnering widespread support and interest from a range of actors, such as businesses, governments, international organizations and more mainstream environmental groups. One of the paradigmatic statements of EM was made in the 1987 Brundtland Report, entitled "Our Common Future", and the discourse shift to EM represents a general trend in the Western world, particularly in the OECD countries of Germany, the Netherlands and the United Kingdom (Hajer, 1995; Christoff, 1996; Mol and Sonnenfeld, 2000). Since its emergence in the 1980s, the EM approach has developed rapidly, eliciting diverse viewpoints and keen debate. EM theory emerged due to significant changes in the content and style of environmental policy, which exposed a deficit in the implementation of environmental goals and local variants of environmental problems (Christoff, 1996).

The Positive Claims of EM

The significant feature and indeed advantage of EM is that it does not aim to reconstruct the market economy or radically change social and political institutions;

instead, its aim is to shift industry beyond an 'end of pipe' approach towards anticipatory and precautionary solutions capable of minimizing waste and pollution through efficient resource use (Christoff, 1996; Carter, 2007). Subsequently, the 'pollution prevention pays' principle incentivizes the introduction of technological fixes into the production process (Hajer, 2005). Therefore, technological innovation was heavily emphasized in environmental reform in the early years of EM theory (Mol and Sonnenfeld, 2000). In addition, EM is believed by some to offer a holistic 'pollution in the round' approach that recognizes the complex and interdependent nature of environmental problems (Carter, 2007).

Technological innovation is expected to bring growth in the market for green technologies, along with the demand for green products, stimulating so-called 'green consumerism'. Emphasizing technological renovation, the EM approach focuses primarily on the respective roles of states and their markets in the transformation of ecological technology (Weal, 1992; Janicke, 1991; Mol and Sonnenfeld, 2000). However, increasing attention is paid by proponents of EM to institutional and cultural dynamics (Hajer, 1995; Spaargaren and Mol, 1992; Cohen, 1998; Mol and Sonnenfeld, 2000). Partnerships and other forms of cooperation between government, industry, scientists and moderate environmental groups create an excellent platform for the exchange of ideas. Not only commercial but social advantages are gained, such as jobs and better working or living environments, which is truly a positive-sum game (Hajer, 1995). In general, EM has the potential to make significant improvements at both macro-economic and micro-economic levels, and is thus presented as a means of reconciling capitalism with environmental protection, as distinct from environmental approaches perceived to threaten capitalism (Gouldson and Murphy, 1997).

Criticisms of EM

Although EM is a narrower, less ambitious and more coherent concept than sustainable development, it is not immune from criticism (Carter, 2007). The most controversial dimensions of EM are its “technological optimism” and “supposed technocratic character” (Mol and Spaargaren, 2000, p. 20), as technology and science are often claimed to be responsible for environmental degradation. Even if conventional perceptions of technology and science are excluded, “limited information, shortages of managerial capacity, the unavailability of financial capital and risk aversion can all inhibit the rate of innovation in new technologies and techniques” (Gouldson and Murphy, 1997, p. 80). Christoff shows that technology can be used to increase environmental efficiency and reduce resource exploitation, but only in relative terms, because from the perspective of environmentalism, EM is only superficial or weakly ecological due to its ignorance of the integrity of ecosystems and the cumulative impact on them (Christoff, 1996). In terms of society, the technological fixes proposed under EM may obstruct the required changes in consumption patterns of individual citizens because people may think wrongly that technology has solved the problem, especially in industrialized countries with high consumption. At the same time, however, it is not appropriate to expect EM to change consumers’ behavior by encouraging them to purchase environmentally friendly goods or engage in other consumption patterns, as “shopping to save the planet does nothing to halt the inexorable overall growth of consumption” (Carter, 2007, p. 232). Even more importantly, “the environmental impacts of what consumers do turn out to be very complex”, and “environmental sociology has not yet been able to offer promising theoretical perspectives on how to conceive consumer behavior” (Spaargaren and Vliet, 2000, pp. 50-51).

As EM originated in Western European industrialized societies, it has been criticized for its narrow focus on industrialized nation-states and consequent failure to accommodate the transformative impact of economic globalization on environmental relations (Christoff, 1996). EM has been described as Eurocentric, an emphasis that limits its global appeal as a feasible national-level environmental reform program

(Blowers, 1997, cited in Carter, 2007, p. 231). EM's nation-statist focus is believed to lead to an underestimation of the globally integrated nature of resource extraction and manufacturing and an overvaluation of local achievements and environmental impacts relative to geographically distant factors (Christoff, 1996). It has also been claimed that in practice, small or medium-sized companies have limited opportunities or resources available to gain access to EM discourse, because the costs of greening may be unaffordable and the issues of equity and social justice raised by the broader sustainable development discourse are ignored (Carter, 2007). An obvious problem is that people may not be able to participate in EM, as their basic needs are still not met.

3.1.4.2 EI

An EI is a system providing polluters with a fiscal incentive not only to avoid polluting but also to reduce their polluting activities (Connelly and Smith, 2003). EIs, also known as market-based instruments (MBIs), work alongside voluntary instruments and regulatory instruments to deal with environmental problems. The goal of EIs is to prevent market failure by applying the polluter-pays principle (PPP) and providing an economic incentive (Carter, 2007). Eco-taxes are the most common types of MBIs. An economic incentive gives polluters the option of either paying a tax or modifying their equipment, enabling them to choose how to adjust to the required environmental standard (Connelly and Smith, 2003). This is one of the advantages of EIs compared with voluntary instruments and regulatory instruments. According to economists, "the market based instrument is more efficient and effective than command and control" (ibid, p. 163) Turner, Pearce and Bateman (1994, p. 45) describe economic incentives as follows.

> *"The lack of proper prices for, and the open access characteristic of many environmental resources means that there is a severe risk that over*

> *exploitation leading to eventual complete destruction will occur. The PPP seeks to rectify this market failure by making polluters internalize the costs of use or degradation of environmental resources."*

This description indicates that economic incentives are a flexible and efficient way of achieving the desired end (Connelly and Smith, 2003). The core goal of economic incentives is "internalizing the externalities of environmental damage" (Jacobs, 1991, p. 138), which means assigning monetary value to environmental goods. Cost benefit analysis, based on monetary valuation, should be applied to investment projects and policies (Pearce and Barbier, 2001). In the discourse of EI, governments set up taxes and charges to discourage undesirable behavior; set up tradeable permits to make environmentally damaging activities illegal; and promote refundable deposits to reward environmental care by returning deposits (Jacobs, 1991). Subsequently, governments are able to manage the capital gained to subsidize efforts made by private organizations and households to carry out environmentally friendly actions. In this process, the government is perceived to be powerful and to act beneficially in controlling polluting activities. Nevertheless, the use of EIs has received criticism. For instance, it has been noted that monitoring the behavior and performance of polluters and performance is a resource-heavy, difficult and expensive process (Carter, 2007). In addition, Jacobs (1991, p. 138) notes that "some environmentalists have appeared to oppose the use of incentives because they do not like the idea of placing monetary values on the environment". Despite these criticisms, however, the EI approach is still favored by the authorities. The carbon-trading scheme introduced to deal with the tension between economic maintenance and environmental conservation has resulted in hot debate in the political, business and academic arenas, which is elaborated in the following section.

3.2 EMISSIONS TRADING SCHEME (ETS)

3.2.1 Background and History

The ETS is an instrument implemented by governments to achieve emissions reduction requirements in their respective countries. It is a market-based approach providing economic incentives to control pollution (Stavins, 2001). The ETS was officially introduced to the public in the Kyoto Protocol. The signing of the Kyoto Protocol in 1997 officially extended the ETS from the preserve of academics to political agendas worldwide. The Kyoto Protocol expired at the end of 2012. Yet the "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level" (IPCC, 2007, p. 4). In addition, the Stern Review on the economics of climate change released by the UK government indicates that economic loss caused by climate change will become increasingly dangerous and costly if no appropriate action is taken. In the same review, an international framework for emissions trading is recommended as a cost-effective solution (Stern, 2006). Against this background, despite the expiration of the Kyoto Protocol, governments will continue to face more and more stringent emissions reduction targets for the common good.

Prior to the ETS, several schemes for trading and international cooperation had been successfully introduced to deal with pollutants. For instance, the US's Acid Rain Program, promoted in the 1990s, obliged coal burning power plants to buy and sell permits for the use of sulfur dioxide and nitrogen oxides (responsible for acid rain); and the Montreal Protocol, launched in 1989 and subsequently ratified by 196 countries, represented an effort to phase out halogenated hydrocarbons (which cause ozone depletion). Scientific monitoring and analysis have confirmed a decrease in acid rain and reduced ozone depletion as a result of these two programs. Best practice in these precedents required a philosophical grounding. The theory underpinning emissions trading can be dated back to the 1920s, as advanced by Pigou; it was later articulated by Dales, in 1968 (Hepburn, 2007). Pigou developed the Pigovian tax to incentivize companies to consider their marginal private interests as well as the marginal social benefit during production. In 1960, the economist Coase suggested that negotiating and allocating trading allowance to right bearers are more efficient than imposing taxes. The main difference between the Pigouvian solution and the Coasean solution to environmental problems lies in the distinction between carbon tax and carbon emissions trading. As tax and trading are both MBIs, both Pigou's and Coase's offered market-based solutions. In 1966, the economist Crocker proposed that the most economically efficient means of reducing pollution is to set up an emission limit and allow polluters to determine how to meet that limit; this was the origin of what we now know as a "cap and trade" scheme. In 1968, Dales noted that economists have to design an artificial pricing system for resources, and that governments can set quotas, subsidies or levies or resource users. Table 3.1 details these contributions to the theory in chronological order.

Table 3.1 Historical Origins and Theory Development of ETS

1920. Economist A. C. Pigou:

"Social benefits force companies to pay for the costs of their pollution" (Hepburn, 2007). Because companies are seeking their marginal private interest, they will have no incentives to the marginal social benefit if it is diverged with their marginal private interest (Pigou, 1920). Pigou believed that tax and subsidies are powerful measures for governments to affect or control the behavior. The economic internalized externalities concept developed by Piguo contributes to the establishment of the Pigovian taxes.

1960. Economist R. H. Coase:

Legal rules are only justified by referring to a cost and benefit analysis, but it should be able to allocate rights to the most efficient right bearer, for this purpose, property rights allocation and trading allowance can yield efficient results (Pearce, 2002). On the contrary to Pigou, Coase considered property owners can internalize externalities by negotiation so that the devices (such as tax) will be unnecessary.

1966. Economist T.D.Crocker:

The most economically efficient solution to reduce pollution might be set up a emission limit and allow polluters to determine how to meet that limit, which is the origin of what we know as cap and trade regime, the polluters fall beneath the cap can sell their permits to those exceed it (Restuccia, 2010). An interesting issue is that in a recent interview, Crocker claimed that carbon tax is more efficient than cap and trade scheme.

1968. Economist J.H.Dales:

Economists have to devise an artificial pricing system to resource so as to regulate people use them wisely, and government can set the quota, can subsidy, can levy to the resource user (Dales, 1968). A charging scheme was also proposed in 1969 by Dales, based on the sale of property right, in which, a pollution level of a society was decided by government and then the pollution right are offered to sale (Sewell, 1969).Dales is the first one explicitly apply these ideas to pollution and resource (Hepburn,2007).

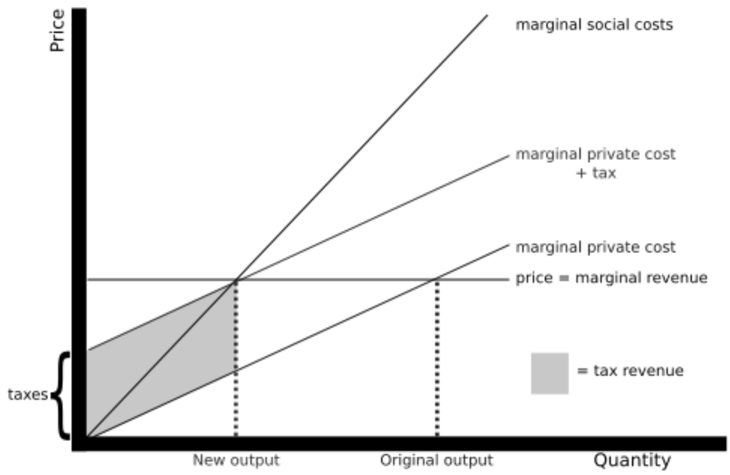
3.2.2 Carbon Tax and Carbon Trading

Both carbon tax and carbon trading are known as carbon-pricing instruments. The arguments for the advantages and disadvantages of carbon trading versus carbon tax all have solid foundations. For policy makers, the choice of carbon trading or tax rests on two main considerations: first, in practical terms, which one is easier to introduce politically; and second, in theoretical terms, how quickly the cost of emissions reduction rises at the margin (Munasinghe, 1999). For the business sector, the choice is simpler and easier: it basically depends on costs versus benefits. Carbon tax and carbon trading are also discussed in terms of the economics of climate change or carbon economic instruments, in which carbon tax is a price-based instrument and carbon trading is a quantity-based instrument (Milunovich, Stegman and Cotton, 2007). Tax and trading can be also described as market-based instruments: carbon tax presents an administered price and carbon trading presents an administered market (Pearce and Barbier, 2000).

Experts commonly consider MBIs to have advantages over the traditional command and control approach, which is in the regulatory style. In command and control regulations, governments specify legally supported standards, which may be ambient based, emissions based, product based, technology based, or design based, to be met either in the process of production or the output (Carter, 2007; Pearce, 2000). The command and control approach has existed since environmental politics was introduced to the political paradigm. Whereas MBIs perform in a highly cost-efficient way, command and control is considered to be economically inefficient due to its high overall compliance cost, and dynamically inefficient, as the polluter has no incentive to abate emissions once the standard is achieved (Pearce, 2000). For this reason, though command and control has a long history, it is insufficient and inappropriate to deal with carbon emissions reduction.

Economists help to build figures showing how MBIs can benefit business or society. The Pigovian tax constructed by Piguo (introduced in the previous section) indicates that tax can incentivize industry to reduce its social costs by decreasing emissions and pollution to an optimal level; see Figure 3.1.

Figure 3.1 Pigovian Tax: Social Cost vs. Tax

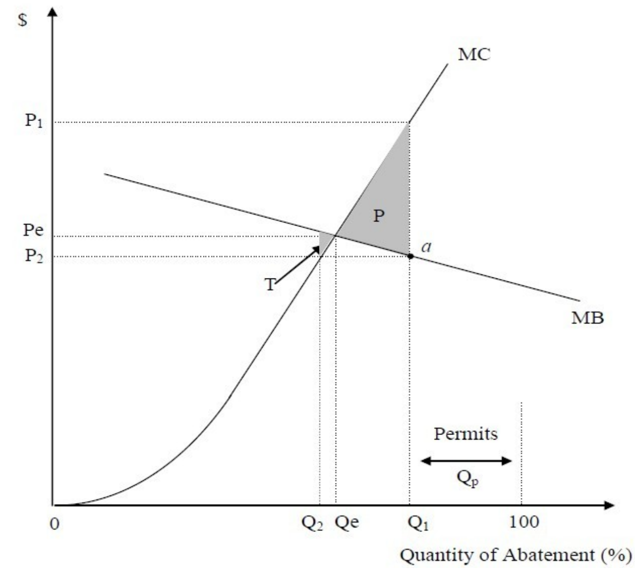


The marginal private cost curve shifts upwards by the amount of tax. If the tax is placed on the quantity of emissions from the factory, the producers have an incentive to reduce output to the socially optimal level. If the tax is placed on the percentage of emissions per unit of production, the factory has the incentive to change to cleaner processes or technology.

Resource: Eskeland, 1994

In 1974, the economist Weitzman expressed the concern that setting an inappropriate target for carbon-emission abatement can cause more social damage than setting an inappropriate level of taxation, and bring unexpectedly large costs (Milunovich, Stegman and Cotton, 2007). To address Weitzman's argument, Mckibbin and Wilcoxen (2002, p. 65) offer the diagram below (Figure 3.2).

Figure 3.2 Climate Policy under the Assumption of Uncertainty



MC = marginal emission abatement cost

MB = marginal benefit (of emission abatement)

Pe = tax on emission at an efficient rate

Qe = permit policy with efficient quantity reduction

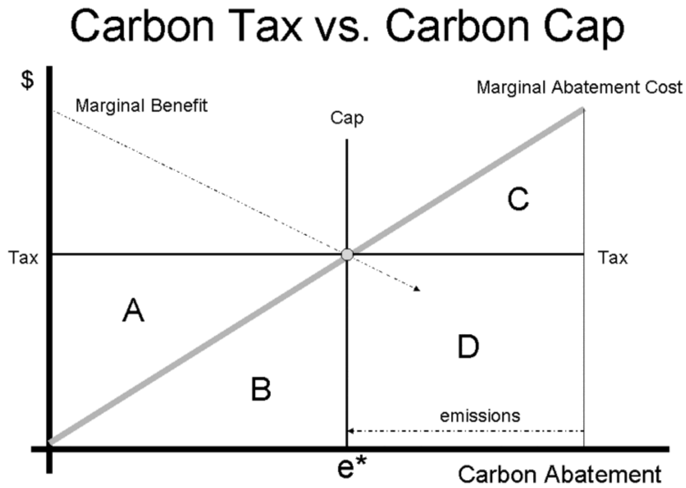
P = company has to pay value P for permit when MC is lower at the intersection point at a under a permit system

T = company has to pay value T when MC is lower at the intersection point at a as P is far more costly than T under a tax system

Resource: Mckibbin and Wilcoxen, 2002, cited in Milunovich, Stegman *and Cotton, 2007.*

Some researchers have also noted that in a single system, the abatement is either too costly or lacking in efficiency. For this reason, in the following decades, a hybrid approach combining a tax system with a permits system is considered to be more efficient for the government and less costly for business (Newell and Prizer, 2003; Mckibbin and Wilconxen, 2006, etc.). The implementation of the ETS in the Kyoto Protocol indicates that governments have begun to adopt the hybrid approach. Figure 3.3 provides a simplified model of this hybrid approach:

Figure 3.3 Carbon Tax vs. Carbon Cap

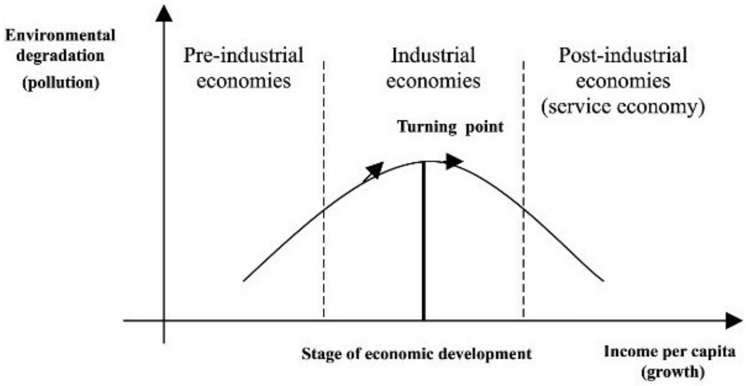


Similar to Figure 3.1, the intersection between marginal abatement cost (MBA) and marginal benefit (MB) is the most efficient abatement level represented in e, which is the level of 'cap' indicated verticality and the price of 'tax' indicated horizontally. From a cost benefit perspective, when the abatement reaches the level of e*, the cost is only area B; when the abatement is higher than e*, businesses can choose to pay the tax (area D) rather than the abatement cost (areas C + D).*

Resource: Environmental economics 101, n.d.

Figure 3.3 shows that the combination of a carbon tax and a carbon cap can constitute an efficient approach to tackling carbon emissions. Scholars have made the positive claim that when economic growth and benefits reach a certain level, the energy consumed and consequently pollution will start to decrease. This theory is visualized in the Environmental Kuznnets Curve (EKC); see Figure 3.4

Figure 3.4 The Environmental Kuznets Curve: A Development - Environment Relationship



The EKC hypothesizes that the relationship between per capita income and the consumption of natural resources and emissions forms an inverted U shape. When per capita income reaches a turning point, the impact of economic development on environmental degradation will decrease.

Resource: Panayotou, 1993, cited in Cialani, 2007.

Figure 3.1 to Figure 3.4 are introduced in chronological order, and reveal that the traditional 'tax' approach has dominated for almost a century, starting with the Pigovian tax. The EKC figure predicts that economic growth can also help to slow environmental degradation, which provides strong support for the ETS. After the Kyoto Protocol brought the ETS into practice, researchers developed comprehensive arguments for the pros and cons of carbon taxation and carbon trading. Some contested that after the heat of carbon trading, carbon taxes are ultimately the best way to control greenhouse gas emissions. Cocker argues that because carbon dioxide is not as detrimental as sulfur dioxide, its use should not be limited (Restuccia, 2010). However, other researchers feel that the ETS may usefully coexist with carbon taxes, with explicit objects and tradeoffs within the policy mix to avoid constraints from each instrument (Smith and Sorrell, 2001; Sorrell and Sijm, 2003). Based on a joint program undertaken by MIT, through the analysis of marginal abatement curves, Ellerman and Decaux (1998) conclude that no matter how constrained or imperfect a model of emissions trading, it is better than none at all. Stavins (2008) finds that both the cap and trade model and carbon taxation are good approaches, but criticizes the confused and misleading "straw man" arguments for cap and trade, arguing that both can achieve effective cost reduction depending upon design. Frankhause (2011) concludes that economists have long known and argued that tradable permit systems can be more efficient than traditional regulations, and as effective as pollution tax. Table 3.2 details the advantages and disadvantages of carbon taxation and carbon trading as highlighted by different experts. In the table, the disadvantages for one term are sometimes picked up by the other term. As stated in the latest carbon pricing report by the World Bank, it is less important to make a choice between carbon taxation and carbon trading than to design the details correctly (Kossoy et al., 2014). The latest World Bank report on the development of carbon-pricing instruments showed that both carbon taxation and carbon trading have been implemented in many countries around the world (Figure 3.5).

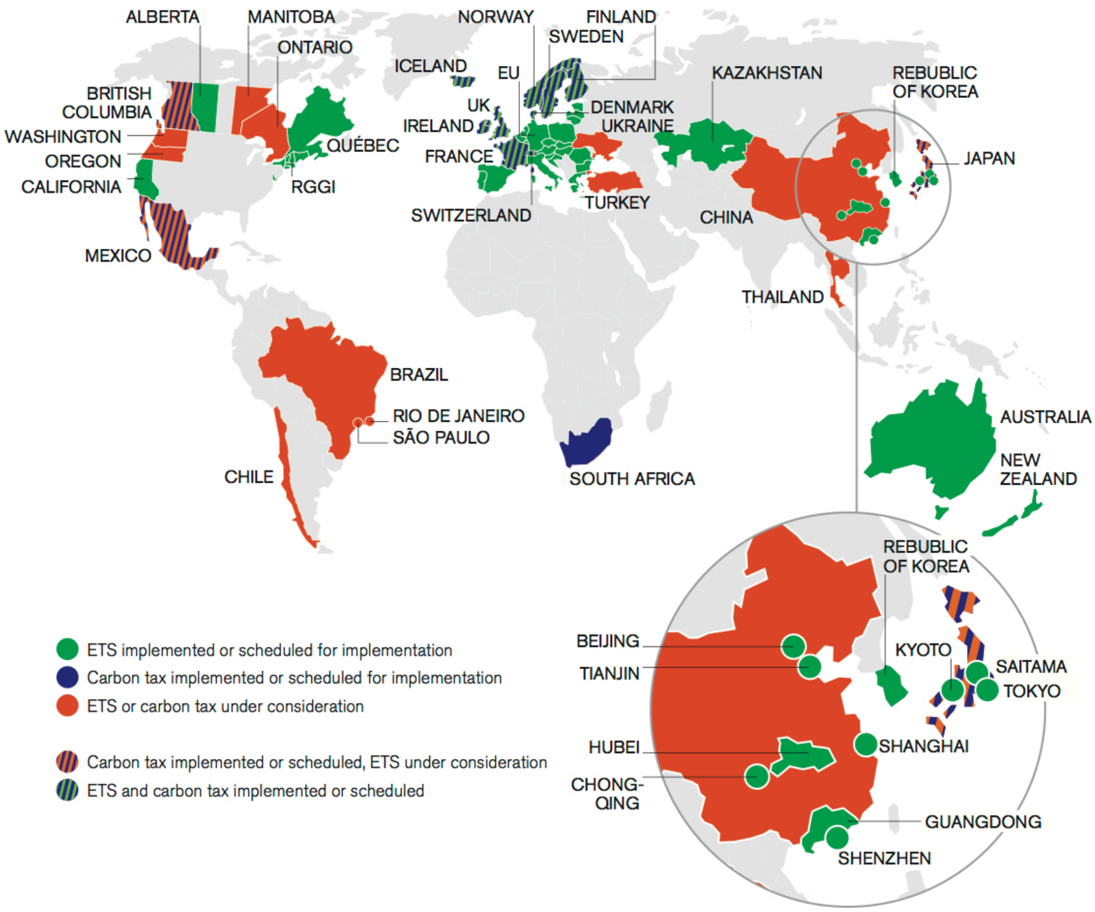
Table 3.2 The Pros and Cons of Carbon Tax and Carbon Trading

(Adapted from Perce and Barbier, 2000, Carter, 2007, Nordhaus, 2006, Smith and Sorrell, 2001, Ekins and Barker, 2001, Milunovich et al. 2007, Prins and Rayner, 2007)

PROS	***Carbon Tax***	***Carbon Trading***
	Easier to tax the pollutant when pollutant is widely dispersed;	*Easier for government to achieve the target as it is set in a form of number;*
	Polluters are flexible to decide how and how far to reduce;	*The price of permit is not solely controlled by governments;*
	Tax system provides a more clear baseline lever – zero carbon tax level;	*Polluters only have to pay for the permits needed – more flexible and cost efficient*
	Tax system would add absolutely nothing to the instruments that countries have already – the tax revenue system;	*Carbon trading can encourage industries to reduce emission through energy saving and infrastructure reform as the economic incentive;*
	Tax is a long traditional approach and has modest experience nationally;	*Tradable permit is more readily accepted by industry because less risk that government abuse it for other ends;*
	Tax provide a more stable price for industry to fulfill abatement;	*Carbon trading is helpful to establish appropriate tax level;*
	Revenue of tax can be distributed to other abatement or subsidy to R&D;	*Carbon trading make countries and industries cooperated;*

CONS	Carbon Tax	Carbon Trading
	Tax based system is unlikely to be political popular;	*Carbon trading is more complex to introduce;*
	Tax may disadvantage consumers and energy intensive producers; the incentive is very weak in tax scheme;	*Baseline is more difficult to set because of different economic growth rate and pattern, and uncertainty of technology changed;*
	Uncertainty about how business react to tax: cost may be delivered to consumers;	*According to Weitzman theorem, marginal cost is highly sensitive to the level of abatement, which may very costly*
	Tax is apply to all output but regardless of whether the output is the optimal level –the difficulty to collect accurate social cost (Pigovian Tax);	*Government and organizations vary in terms of honesty transparency and administration effectiveness, which may shift the value of permit to other benefit;*
	Governments are easily to lost sight of main purpose of tax;	*Carbon trading is likely to show extremely volatile price of permit;*
	Equity of carbon tax – influence the poor & weak industry more than the rich and strong industry.	*Equity of allowance distribution and carbon leakage.*

Figure 3.5 Carbon Pricing Instrument Development



Source: State and trends of carbon pricing.2014.

3.2.3 Cap and Trade Schemes and Offset Schemes

3.2.3.1 Cap and Trade Schemes

Cap and trade is the dominant mechanism responsible for the functioning of the carbon market. Emissions trading usually involves a cap and trade scheme, which is different from an offset scheme such as the Clean Development Mechanism (CDM) or Joint Implementation (JI). In a statement by the UNFCCC, the cap and trade model is depicted as follows.

> *"Parties with commitments under the Kyoto Protocol (Annex B Parties) have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or assigned amounts, over the 2008-2012 commitment periods. Emission trading, allows countries that have emission units to spare - emissions permitted them but not used - to sell this excess capacity to countries that are over their targets. Thus, a new commodity was created in the form of emission reductions or removals. This is known as the carbon market"*
>
> *(UNFCCC, 1997)*

Another explanation of emissions trading is provided below:

> *"Emissions trading are the process or policy that allows the buying and selling of credits or allowances created under an emissions cap"*
>
> *(Pew Center on Climate Change, 2009)*

Cap and trade is thus defined as follow:

> *"A cap and trade system sets an overall limit on emissions, requires entities subject to the system to hold sufficient allowances to cover their emissions, and provides broad flexibility in the means of compliance. Entities can comply by undertaking emission reduction projects at their covered facilities and/or by purchasing emission allowances (or credits) from the government or from other entities that have generated emission reductions in excess of their compliance obligations"*

(ibid.)

'Cap' describes the level of emissions that national authorities are permitted to distribute to industries. Emissions allowances were first assigned under the Kyoto Protocol to individual Annex B countries, in term of assigned amount units (AAUs), which could be traded among Annex B countries. Under the Kyoto Protocol, countries were categorized into four main types: Annex I, comprising industrialized countries (OECD members) and countries with economies in transition (EIT); Annex B, an amendment of Annex II, consisting only of those OECD members of Annex I; the Non Annex I category, comprising mostly developing countries; and the final category, less developed countries (LDCs), which were to receive both financial and technological help rather than being required to reduce their emissions. Only Annex B countries are regulated by emission permission, which stands for the cap imposed on each country. Figure 3.6 shows the emissions reduction target for Annex B countries.

Figure 3.6 Emissions Reduction Targets in Annex B Countries

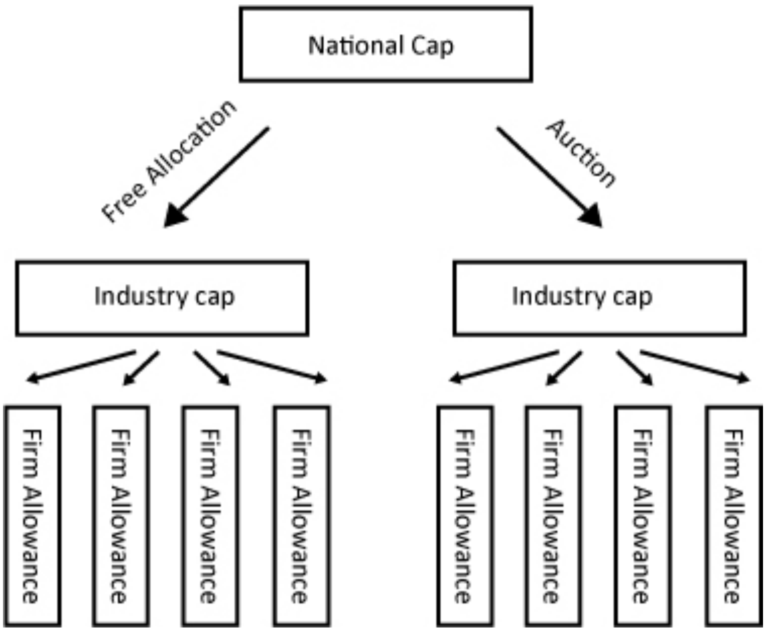
Countries included in Annex B to the Kyoto Protocol and their emissions targets

Country	Target (1990** - 2008/2012)
EU-15*, Bulgaria, Czech Republic, Estonia, Latvia,Liechtenstein, Lithuania, Monaco, Romania,Slovakia,Slovenia, Switzerland	-8%
US***	-7%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	0
Norway	+1%
Australia	+8%
Iceland	+10%

Resource: UNFCCC, 1997

Under the emissions reduction target, national authorities determine which sectors are included in the program, and distribute allowances to these industries such that each polluter receives its own cap; this process is shown in Figure 3.7.

Figure 3.7. Distribution of Emission Allowance in the Cap and Trade System



In a cap and trade system, national authorities can distribute emissions allowances in two ways: free allocation or auction. Each method of distribution has both advantages and limitations. Free allocation to certain industries, such as power plants, allows them to avoid delivering compliance costs to consumers. Free allocation is also better for companies with insufficient financial resources to mitigate emissions pollution. However, the standards applied to the distribution of free emissions allowances are tricky. If the free allocation is calculated based on industries' historical emissions and is fixed, it will disadvantage companies that have already undertaken voluntary abatement before the base year. On the other side, if free allocation is calculated based on changing circumstances, a company can increase its emissions to obtain a greater allowance in the next compliance period. In any case, the free allocation of allowance is the most simple and equitable distribution method (Pew Center on Climate Change, 2009).

Auction distribution can function as taxation to obtain revenue for further active development, such as compensating sectors influenced by the economic recession in the trading program, or establishing funding for technological research. Auctioning can also limit the benefit to companies with free allowance. In most cases, these two distribution methods are combined, as auctioning functions like taxation. If auctioning is the sole method of allocation, the compliance burden will rise sharply. However, many economists have claimed that a large proportion of the cap should be auctioned (Hepburn et al., 2006). Basic methods of distributing allowance will not affect the emission reduction target in a cap and trade system (Ellerman et al., 2003).

3.2.3.2 Offset Scheme

Although carbon taxation and carbon trading can both be used to mitigate carbon emissions, the former is less efficient, because carbon trading brings an offset scheme, but tax cannot (Sand et al., n.d.). An offset scheme provides a cheaper way of reducing emissions, which is the main reason for the claim that carbon trading is cost efficient. An offset scheme can be illustrated by the operation of the CDM, as follows.

> *"The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tone of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol."*
>
> *(UNFCCC, 1997)*

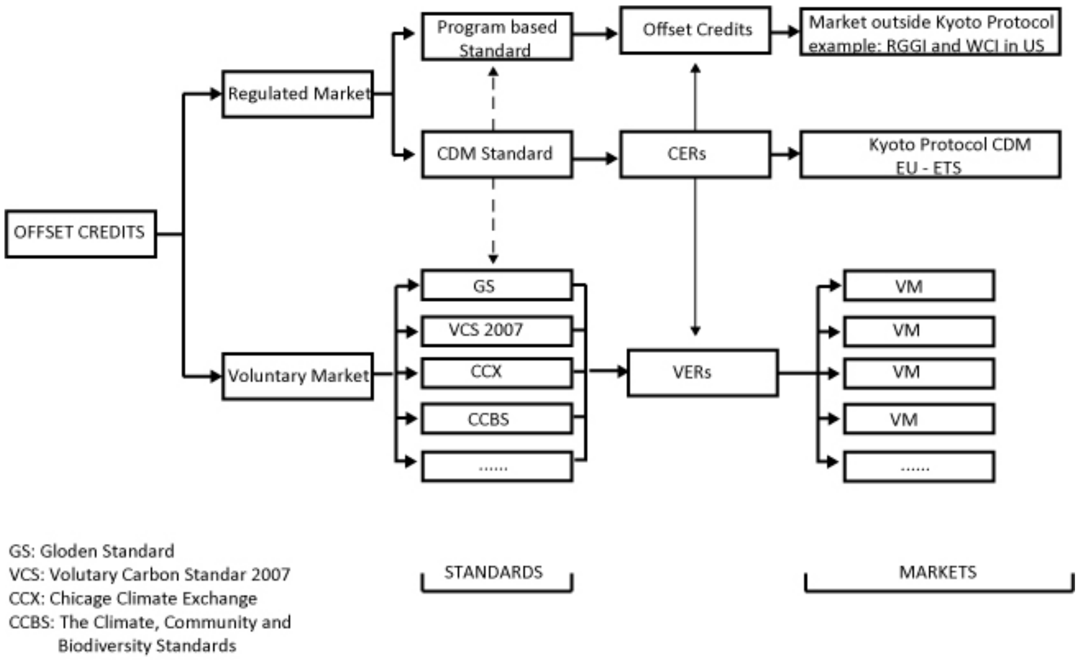
The UNFCCC also provides a clear statement of the duties of Annex B countries and the functions they must fulfill through the offset scheme, as follows.

> *"They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change. In addition, they have to 'take all practicable steps' to promote the development and transfer of environmentally friendly technologies to EIT Parties and developing countries"*
>
> *(ibid.)*

Emissions reduction credits are voluntarily initiates credits, which can exist either in the regulated market or the voluntary market. Different evaluation standards are used to validate the credits, but most are based on the CDM as a benchmark (Kollmuss et al., 2008).

Annex B countries and bringing economic benefits and even technology transfer to developing countries. Developing countries' voluntary involvement in the CDM once again proves the power of economic incentives: the CDM brought US$32 billion in CER trade in 2008, and there are already more than 4200 projects in the pipeline that are expected to reduce GHG emissions by more than 2900 million metric tons CO_2 by the end of 2012, maintaining an annual increase in emissions reduction of around 275 million metric tons during the commitment period (2008-2012) (Schmidt, 2009; Zhang and Wang, 2011; Helpurb, 2007). The linkage of the EU ETS with the CDM and JI is regarded as positive progress, because it generates considerable interest (Jaffe et al., 2009). Based on the case of the CDM, Stavins (2011) proposes that linking carbon trading systems is the best approach for the future, because such connections increase the liquidity and improve the functioning of the market; moreover, linking systems can reduce costs by shifting emissions reduction across systems.

Figure 3.8 Carbon Offsets in Different Markets and Standards



Within the offset scheme itself, incentives are provided for non-regulated sources to reduce emissions; for instance, developing countries are engaging in a serious effort to limit their emissions, and incentives help to expand emissions compliance opportunities for regulated entities (Ramseur, 2008; Wara and Victor, 2008). Furthermore, offset projects themselves have the potential to improve air or water quality due to the green technologies adopted, and offset markets can also create economic opportunities and spur innovation to seek offset (Ramseur, 2008). Although the CO_2 trade volume in the voluntary market is less than 7% of that of the CDM market, the voluntary market has advantages; for instance, it has more variables than the regulatory market, carbon trading price may be lower, and the cost of participation is also lower (Green Market International, 2007). The scale of the voluntary market can vary, and the carbon offset can to some extent inspire individual contributions to environmental problems due to profit considerations (Ovchinnikova et al., 2009).

Cap and trade systems often allow entities to purchase a limited number of offsets, representing a small proportion, to meet allowance assignments (ClearSky Climate Solution, n.d.). The proportion is limited because the CDM or offset scheme is, despite its advantages, facing mounting criticism, especially in relation to environmental integrity (the 'additionality' of the project in the literature) (Wara, 2007; Victor 2009; Jaffe et al. 2001; Zhang and Wang, 2011). Two kinds of criticism have been directed against the CDM: the first relates to the project, and the other to weak governance under the Kyoto Protocol. These two avenues of criticism are discussed separately in the following section.

First, the carbon offset project or the CDM project requires verification in basic areas.

Table 3.3 Basic Areas to Account Offset Projects to Verify

- ***Baseline and Measure:*** *can also be understood as there should be real GHG emission reduction. There should be methods to test what emission would occur in absence of the proposed project and how the emission is performed after the project.*

- ***Additionality****: the emission reduction generated from the offset project should be above and beyond business as usual, which means, the project will not happen in a status-quo situation, or its intrinsically financial worthwhile due to energy cost saving, or there are environmental laws or regulations drive.*

- ***Permanance****: the project should not have potential for a reverse; should not return the reduced emission back to atmosphere.*

- ***Leakage:*** the project should not cause higher emission outside the project boundary, should not simply shift the emission from one location to another areas.

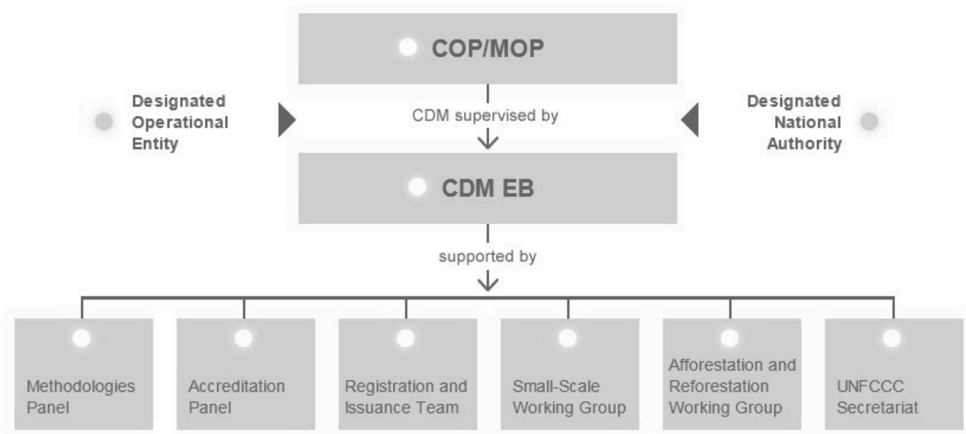
Resource: Adapted from ClearSky Climate Solutions, n.d.

A well-designed offset market can engage developing countries and encourage sound investment in low-cost strategies for controlling emissions; however, many applications of the CDM project no longer reflect emissions reduction in practice, and this trend is getting worse (Wara and Victor, 2008), which reflects the lack of additionality referred to in the literature. An offset project without additionality registration under the CDM will actually increase global emissions and jeopardize the effectiveness of the international trading system; on the other side, the Executive Board has limited time to make decisions, and additionality sometimes takes years to yield results (CDM Watch, n.d., Fischer, 2005). Moreover, the CERs, as shown in Figure 3.10, can be used for validation in other markets, both regulated and voluntary. If CERs are purchased in a given market, they should be retired from other markets. The critical point is that the linkage between these trading markets has not yet been built, and their integrity is comparatively weak, making it possible to double count credits and ultimately confounding the objectives of the CDM (Ramseur, 2008).

Some other issues are related to the design of the mechanism. The CDM brings international capital flow; regions or countries do not participate in permit trading systems, but providing an offset definitely yields benefits from international financial capital inflow, whereas Annex B countries with much higher compliance costs will be negatively influenced by capital flow, such as by the depreciation of exchange rate (Mckibbin et al., 2000). Although the CDM brings high value to the market, most of its projects (77%) are distributed in four countries: China, India, Brazil, and Mexico. China provides 55% of the world's CERs (CDM Watch, n.d.). The Kyoto Protocol committee explicitly stated that priorities would be given to CDM projects in less developed countries. Furthermore, the CDM sets the objective of achieving sustainable development for host countries. However, host countries assess their own performance without supervision from the Executive Board, and the assessment results are not reliable. For instance, China has provided a considerable number of CERs, but the CDM has done little to prevent its accumulation of coal-fired power generating capacity, and most such plants are too expensive to retrofit with carbon capture and sequestration technologies (Jackson et al. 2006). Another reality is that limited environmentally friendly technologies have been transferred from Annex B countries to developing countries. As such, the offset scheme is likely to disincentivize developing countries from enacting laws or regulations to control GHG emissions (Ramseur, 2008).

The second factor, CDM governance, is addressed below.

Figure 3.9 The Governance Tree of CDM



Source: UNFCCC

This chart identifies the governance institution of the CDM, which has been criticized on the grounds of inefficiency and sometimes unfairness. The first problem lies in the multiple roles of Executive Members: sometimes Executive Members are also the Designated National Authority (DNA) for their countries, which influences their judgment in cases of conflict of interest between countries. In some cases, the EB has approved project opportunities for their respective countries (Flues et al., 2009). The second problem is the lack of qualification of the Designated Operational Entity (DOE), which is a private certifier responsible for validating projects and verifying emissions reduction. One report indicates that 17% of 1596 projects were approved positively by a DOE, but that the Board rejected 40% of the projects after review, and there are now still 129 open projects under review (CDM Watch, n.d.). The last point is that the decision-making process is not transparent enough to the public or even individual country. The CDM is then described as a system that routinely favors environmental ineffectiveness and social injustice (Dag Hammarskjold Foundation, 2009).

As a developing and first trial mechanism, the CDM and offset schemes still offer the potential to mitigate global environmental problems. The CDM system can do a much better job by ensuring that "emission credits represent actual reduction"; "then its ability to dampen reliably the price of emission permits will be even further diminished" after reform (Wara and Victor, 2008, p. 5). The UN has confirmed that a formal review of CDM is under consideration; evidence of abuse of the CDM system will be reviewed and the UN will adjust its safeguards if necessary (Donoghue, 2010).

3.2.4 Mandatory and Voluntary Carbon Market

Regulated carbon markets are established by authorities at local, regional, national or international levels. There is a mandatory level of emissions reduction for each assigned sector in a regulated market. The regulated market is usually "large, well-funded, and followed by dozens of media outlets, hundreds of traders, and countless business" (Hamilton et al., 2007, p. 10). The Kyoto Protocol and the EU ETS are regulated markets. In contrast, a voluntary market functions without mandatory instruction, and the offset providers and buyers are individuals or companies on a voluntary basis, distinct from offset purchases in the regulated market. Some voluntary markets, such as the Chicago Climate Exchange, set a 'cap' for participants, which is legally binding to manage the market. More voluntary markets provide and retail offset only. The offset credited as CER can be purchased on the voluntary market; however, the various VERs can only function in their credited voluntary markets. The voluntary market has a longer history than the regulated market, but was soon overwhelmed by the latter, and market occupancy was also polarized. The voluntary market is perceived as an innovative, inventive and experimental mechanism, encouraging more participation with less social equity issues than a regulated trading scheme (Hamilton et al., 2007; Greenhouse Gas, n.d.). However, less regulation brings problems of quality, as per the 'additionality' issue addressed above. Some researchers have pointed out that many offset projects happen anyway (Schneider, 2007; Haya, 2007). Criticism has also been directed towards the encouragement of unsustainable lifestyles in developed countries (Eraker, 2000). The table below summarizes the characteristics of regulated and voluntary markets.

Table 3.4 Comparison of Mandatory and Voluntary Carbon Market

(Adapted from Hamilton et.al. 2007; Ellerman and Jasckow, 2008; Green Market International, 2007; Global Greenhouse Warming, n.d.)

ITEMS	MANDATORY MARKET	VOLUNTARY MARKET
Size	Large and well funded	Small but significant
History	1997 establish the framework and 2005 the first scheme started	The forest conservation project in 1989
Offset Credit Standards	Based on CDM	Various standards, but those important are based on CDM
Motivation	Mandatory emission reduction	Environmental aware or economic benefit
Price	Volatility but in a sensible range	Volatility, higher sometime and difficult to control
Transition Cost	High	Less than mandatory market
Offset Transfer	Easy to transfer to voluntary market	Difficult to transfer to mandatory market
Trading Volume	More than 97% of the world total trading volume	Less than 3% of the world total trading volume
Market Value Growth	Stable and highly planned	Rapid growth
Participation Requirement	Rigorous	Variable and depending on standards
Quantitative Data Resource	Abundant and comprehensive	Limited and even lacking
Examples	EU ETS, Kyoto Cap & Trade, RGGI, California Cap & Trade, China's carbon trading	Chicago Climate Exchange

The EU ETS is the first and largest regulated ETS in the world, responsible for the majority of trading volume as well as emissions reduction (Ellerman and Barbara, 2007). The EU ETS is believed to provide valuable insights into carbon trading; even its failure can advance the development of the concept because the experience of emissions trading is very limited; and the success of seeking agreement, negotiating, engaging in action and involving a significant segment of European industries in a multinational system has already proven that the system performs surprisingly well (Ellerman and Joskow, 2008). Some argue that the emissions-reduction target in the first trial from 2005 to 2007 failed to deliver the expected reduction and could not be sustained on the basis of evidence (Murray, 2010). Ellerman (2010) states that the volatility in carbon price is due to the over-allocation of allowance undermines investment in green technologies; however, the mechanism is now in place and has been shown to reduce emissions. The EU ETS is now progressing and improving through the experience cumulated over the first two periods, with more stringent emission permits and a higher percentage of allowance auctions.

In 2010, following the multinational ETS, the Tokyo Metropolitan Authority launched the first cap and trade system in a city. The participants are industrial and commercial electricity and fuel users in Tokyo. The owners of individual factories and tenants of commercial buildings have to take action by, for instance, effecting facility retrofits, surrendering renewable energy certificates, using domestic offsets within Tokyo's small or medium businesses, or using a small portion of offset credits outside Tokyo (Hood, 2010). The Tokyo scheme was developed from a voluntary emissions reduction program initiated in 2002, and was then improved based on the experience of the EU ETS. More than the EU ETS, the government promotes companies' corporate social responsibility (CSR), which can force companies to fulfill their duties and meet the cap (Tulloch, 2010). Meanwhile, an advanced energy usage reporting system has been adopted by the authority to check verified energy usage data; the government also extend the compliance period to 5 years to encourage the reduction of emissions before trade; the allowance credits earned in the first compliance period can be saved into the next period; green labeling is introduced to every installation (ibid.). The implementation of the Kyoto cap and trade was a trial for a further national cap and trade scheme in Japan.

The Chicago Climate Exchange (CCX) provides a voluntary market-setting cap for participants and offset projects in North America and Brazil. The US government did not ratify the Kyoto Protocol to reduce emissions, but this voluntary cap and trade market is a valuable precedent for future US cap and trade schemes. The CCX provides a platform for companies to learn about and gain experience of emissions reduction commitments for possible future mandatory cap and trade scheme. The CCX has more than 400 members, ranging from multinational companies, U.S municipalities, and educational institutes to some farmer organizations (Lavelle, 2010). The CCX was launched in 2002: even earlier than the EU ETS. The cap and trade program under the CCX was shut down in 2010, but the eight-year voluntary commitment inspired companies to continue their efforts to reduce emissions. The offset scheme under the CCX has continued, and the CCX is expected to serve as a platform for the regional or national cap and trade scheme in future, as valuable practice. On the other side, the offset scheme under the CCX has also been criticized. Many groups claim that the CCX lacks transparency, and ask states and groups not to join because the exchange was initiated only to make money (Dale, 2006). The 'additionality' of the CCX offset credits, especially those generated from non-tilled agriculture, has been fiercely questioned. Nevertheless, as a system proposed by a public company with public board participation, the CCX reveals the functionality of a carbon financial instrument.

3.3 PROPOSED AND PRACTICAL EMISSIONS TRADING SCHEMES

3.3.1 ETS Development around the World

As the most developed and well known trading scheme, the EU ETS has been continuously refined by the EU since 2005. It includes 27 European Union countries and also Norway, Iceland, and Liechtenstein. It has been described as the most forceful mechanism for reducing carbon emissions: it covers more than 10 thousand installations, which emit half of the pollution in EU countries (Liao, Shi, Li and Wang, 2012); details are provided in Table 3.5.

During the trial period for the EU ETS, governments first collected data to set up a baseline. After the development of infrastructure, more than energy intensive industries were included in the trading scheme. The World Bank's 2010 report on emissions trading (Kossoy and Ambrosi, 2010) indicated that overall carbon emissions had been reduced during the trial period. After the trial period, there was a dramatic reduction in EU emissions during the 2008-2009 economic downturn, and with the substantial investment in domestic renewable energy capacity, it is clear that the EUAs were oversupplied in periods 1 and 2 (Kossy and Guigon, 2012). This oversupply decreased the price of the EUA. However, trading volume continues to increase. The stronger carbon market in EU has inevitably expedited the birth of other emissions trading markets all around the world. A chart comparing the main trading schemes, adapted from Perdan and Azapagic (2011), is shown in Table 3.6.

Table 3.5 Three Periods of EU ETS

	The First Period (2005-2007)	The Second Period (2008-2012)	The Third Period (2013-2020)
Periods	Trial Period	Kyoto Period	Post Kyoto Period
Annual Emission Permit	2.299 $MtCO_2e$. NAPs in each states contribute to EUAs	2.083 $MtCO_2e$. NAPs in each states contribute to EUAs	1.720 $MtCO_2e$. EU set up the allowance
Regulated Emissions	CO2	CO2, N2O	CO2, N2O, PFC
Regulated Sectors	Electricity, refining, iron and steel, cement, glass, ceramics, pulp and paper	Same as first period and aviation industry	Same as previous sector and petrochemical, ammonia and aluminum
Allocation Methods	95% free allocation and 5% auction	At least 90% free, rest for auction	Electricity: 100% auction; potential carbon leakage industry: 100% free; the other industry: 80% free, but auction percentage is increasing year by year and will achieve 100% until 2027
Banking and Borrowing	No banking and borrowing	Potential banking No borrowing	Unlimited banking No borrowing

$MtCO_2e$. : Metric tons CO_2 equivalent

NAPs: National Allocation Plans

EUAs: European Union Allowances

Source: Liao, Shi, Li and Wang, 2012

Table 3.6 Comparison of Carbon Emission Trading Schemes

(Perdan and Azapagic, 2011)

	EU ETS	RGGI	GGAS	NZ ETS	Tokyo-ETS
Participating countries and regions	27 EU Member States + Iceland, Liechtenstein and Norway	10 US states: Connecticut, Delaware, New Jersey, New York, Maine, Maryland, Massachusetts, New Hampshire, Rhode Island, Vermont	New South Wales	New Zealand	Tokyo Metropolitan Area
Regulated sectors	*Phase* 1: Electricity, refining, iron and steel, cement, glass, ceramics, pulp and paper *Phase* 2: Phase 1 sectors + nitric acid *Phase* 3: Phases 1 and 2 sectors + petrochemicals, ammonia, aluminium and aviation	Electricity generating facilities ≥ 25 MW primarily fired by fossil fuels (coal, natural gas, oil), feeding more than 10% of their generated electricity into the grid	Electricity sellers, retailers and generators in New South Wales	*Phase* 1: Forestry *Phase* 2: Liquid fossil fuels *Phase* 3: Stationary energy, industrial processes *Phase* 4: Agriculture, waste	All large installations such as office buildings and factories in Tokyo that use energy equivalent to 1500 kl of oil a year
Regulated emissions	CO_2; N_2O from production of nitric, adipic and glyoxylic acids; PFCs from the aluminium sector	CO_2	CO_2, CH_4, N_2O, HFCs, PFCs and SF6	CO_2, CH_4, N_2O, HFCs, PFCs and SF6	CO_2
Time scales	*Phase 1*: 2005–2007 *Phase 2*: 2008–2012 *Phase 3*: 2013–2020	2009–2018	Initially 2003–2012, extended to 2020	*Phase 1*: 2008–2009 *Phase 2*: 2009–2010 *Phase 3*: 2010–2012 *Phase 4*: 2013–2020	*Phase 1*: 2010–2014 *Phase 2*: 2015–2019
Reduction goals	• 8% below 1990 levels in 2008–2012 period • 20% (or 30%) below 1990 levels by 2020 • 60–80% below 1990 levels by 2050	• 2009 cap: 5% above 2005 levels will remain until 2015 • 10% reduction below this cap by 2019	5% below 1990 levels	Carbon neutrality: electricity by 2025; stationary energy by 2030; transport by 2040	25% below 2000 levels by 2020
ETS cap	*Phase* 1 (2005–2007): Cap was set below the full range of "business as usual" estimates, with the objective of establishing the infrastructure for trading, not to achieve significant reductions. The cap reflected a 4.3% reduction by the European Commission in the quantity of allowances that had been proposed by member states *Phase* 2 (2008–2012): Annual cap 11.8% below the number of allowances in Phase 1, 6.5% below 2005 verified emissions. The cap reflects a 10% reduction by the European Commission in the quantity of allowances that had been proposed by member states	Target for initial five-year period is stabilisation of emissions for 2009–2014. Individual state emissions budgets and the overall cap are based on historical (2000–2002) average emissions and negotiation. State emissions budgets will then reduce 2.5% per year over 2015–2018, giving a 10% reduction on 2009 levels by 2018	No cap. State-wide annual greenhouse gas "benchmark" set (the "baseline") and apportioned to individual participants. The "benchmark" expressed in tonnes of CO_2 eq. per capita. Initial benchmark 8.65 t on CO_2 eq., dropped to 7.27 in 2007; remains at that level until 2012	No explicit cap or domestic target for emissions reductions. The scheme is fully linked to the international Kyoto Protocol market: New Zealand companies can emit as much as they wish as long as allowances are purchased to cover these emissions. The government will issue free allowances to the agricultural sector, energy-intensive industries and post-1990 forest owners who have opted in corresponding to forest growth. Participants without sufficient free allocation can purchase allowances from foresters or from the international Kyoto market to meet their obligations.	*Phase* 1 (2010–2015): 6% on base levels for factories and buildings receiving energy from district heat and cooling; 8% for other buildings *Phase* 2 (2015–2020): reductions around 17% envisaged. Facilities that have made outstanding progress can have compliance factor reduced to one-half or three-quarters

Continued

	EU ETS	RGGI	GGAS	NZ ETS	Tokyo-ETS
	Phase 3 (2013–2020): Cap to decline linearly to 21% below 2005 verified levels by 2020. This is intended to deliver a large part of Europe's reduction of 20% on 1990 levels by 2020. If Europe adopts an overall 30% by 2020 target, the EU ETS cap will be reduced to 34% below 2005 levels by 2020				
Allocation method	Grandfathering; benchmarking; max. 10% auctioning followed by a progressive move towards full auctioning of allowances. From 2013 at least 50% of allowances will have to be bought at auction and the aim is to reach full auctioning by 2020 for power sector, and by 2027 for all sectors	Auctioning minimum 25%; decision over remaining 75% left to individual states; approximately 90% of allowances auctioned	An annual State-wide GHG benchmark for the electricity sector—the "benchmark". Benchmark participants are allocated the mandatory GHG benchmark based on their share of NSW electricity demand. To be compliant, benchmark participants must surrender abatement certificates created from project-based emission reduction activities	*Phase* 1: Free allocation *Phase* 2: Auctioning *Phase* 3: Some free allocation for industrial processes *Phase* 4: 90% free allocation for agriculture	Free allocation; grandfathering. Allowances: base year emission × compliance factor × compliance period (5 years)
Unit	1 metric tonne CO_2 eq.	1 short ton CO_2 eq. (0.9 metric tonnes)	1 metric tonne CO_2 eq.	1 metric tonne CO_2 eq.	1 metric tonne CO_2 eq.
Compliance period	1 year	3 years	1 year	1 year (*Phase 1*: initially 2 years)	5 years
Penalty system	Delivery of the non-delivered allowances in the next period + €100 penalty per tonne (2008–2012)	Three times of the non-delivered certificates to be delivered at next compliance date	AUD11.50 per tonne; 10% shortfall allowed without penalty, provided the shortfall is made up the following year	Delivery of the non-delivered allowances (can be extended to two times of the non-delivered allowances) + NZ$30–60 penalty per tonne	Fines (up to ¥500,000), publication of the breach and a type of surcharge collected in proportion to the failure to fulfil the obligation
Banking	Yes—unlimited	Yes—unlimited	Yes—unlimited	Yes—unlimited	Yes—unlimited
Borrowing	No	No	Yes—up to 10% of the subsequent year's target is allowed	No	No
Offsets	Kyoto Protocol JI and CDM allowances within limits. Assigned Amount Units or Removal Units (forestry) not allowed	Credits are accepted from programmes in RGGI states or any other US state or jurisdiction	Unlimited use of domestic, project-based offsets	Unlimited use of Kyoto Protocol CERs (CDM credits), RMUs (forestry credits), ERUs (JI credits) and "approved" AAUs (Assigned Amount Units)	Participants may use unlimited offset credits related to reduction of emissions by SMEs within Tokyo. Unlimited use of renewable energy certificates for compliance. Offsets may also be generated from installations outside Tokyo—they are treated as if covered by the scheme and reductions beyond their "target" can count as offsets. Use limited to one-third of base year emissions

The Regional Greenhouse Gas Initiative is the first and the most well known ETS in the United States. The participating states are mostly from the east coast, and the first commitment period ran from 2009 to 2014. The key feature of this trading scheme is that it includes only the electricity sector. On 1st January 2013, the California Cap and Trade Program was officially launched. This program applies to the most developed US states with economic power, and diverse industries are included in the emissions reduction list, such as petroleum, natural gas, LPG, and transportation fuel providers (Lu and Zhou, 2013). No timeline has been set for the future of this program. However, it took six years of preparation and planning to launch the program, which demonstrates a solid foundation and consistent intention to reduce carbon emissions in California. Although the US did not sign the Kyoto Protocol on emissions reduction, ETSs are still happening across the country.

The New South Wales Greenhouse Gas Reduction Scheme was one of the first mandatory greenhouse gas emissions trading schemes to be launched worldwide; it was established in 2002 and commenced on 1st January 2003 (Booz & Company, 2010). This scheme is a 'rates-based' form of emissions trading (Perdan and Azapagic, 2011). The government sets a baseline of per capita emissions according to the state's reduction target, which constitutes the benchmark; the baseline in the years after will decrease and last until 2020. On a national scale, Australia established a carbon price mechanism (CPM) in July 2012, whose aim is to lower emissions in Australia by 5% by 2020 and 80% by 2050 (Kossy and Guigon, 2012). In 2014, an overall emissions cap was set in Australia.

The New Zealand Emissions Trading Scheme (NZ ETS) does not have a clear cap, but its aim is to meet the Kyoto Protocol obligations. The NZ ETS relies heavily on international offset credits. Since the crash of the CDM program, this program is suggested to slow down the pace and build a connection with the Australia scheme.

In Asia, the Tokyo ETS is the first cap and trade program at the city level, starting in 2010 (Lee and Colopinto, 2010). Energy-based CO_2 is the only gas included in the Tokyo ETS, as 95% of Tokyo's emissions are from energy-based CO_2, and these emissions are mainly from commercial buildings, enabling electricity meters to provide precise data; furthermore, this eases participants' burden (ibid.). Korea started promoting the Framework Act on Low Carbon and Green Growth in 2010, and in 2012, the Act on Allocation and Trading of the GHG Emission Allowance was passed, which indicates that Korea's ETS will be launched in 2015 (Kossy and Guigon, 2012). In South America, Mexico and Brazil are both progressing in low carbon economic development, with strong legislative support. In Brazil, the city of Rio de Janeiro imposed a legally binding obligation on private companies in its ETS in 2013 (ibid.). Table 3.7 provides another overview of ETSs in operation worldwide.

Table 3.7 Overview of ETSs in Practice Worldwide

(*Lee and Colopint, 2010)*

Governmental Unit	Name of ETS	Target Pollutant	GHG	Target Organization
International ETSs				
European Union	EU-ETS	CO_2, CH_4 (methane), N_2O (nitrous oxide), HFCs (hydrofluorocarbons), PFCs (perfluorocarbons), SF_6 (sulfurhexafluoride)	Yes	Electricity generation and energy-intensive industries
Country-Based ETSs				
United Kingdom	CRC[4] Energy Efficiency Scheme	Energy-based CO_2	Yes	Large organizations with high energy consumption (although exempts those covered by Climate Change Agreements or the EU-ETS)
Sub-National ETSs				
Northeastern & Mid-Atlantic region, United States	Regional Greenhouse Gas Initiative (RGGI)	Energy-based CO_2 from power plants	Yes	Electricity generators
New South Wales, Australia	Greenhouse Gas Reduction Scheme (GGAS)	GHGs from electricity production	Yes	Energy producers and highly energy-intensive users
City-Based ETSs				
Los Angeles, United States	Regional Clean Air Incentives Market (RECLAIM)	nitrogen oxides (NO_x), sulfur oxides (SO_x)	No	Facilities emitting more than 4 tons a year of either gas.
Chicago, United States	Emissions Reduction Market System (ERMS)	Volatile organic materials (VOMs) (particularly tropospheric ozone)	No[5]	Stationary sources emitting more than 10/tons per season (2 seasons per year)
Santiago, Chile	Emission Offset Program of Supreme Decree No. 4	Total suspended particles (TSP)	No	Stationary combustion sources with a rated exhaust gas flow rate greater than 1,000 m^3/hour

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3.3.2 Summary of Previous Work

Reviewing ETSs around the world is one of the best ways to understand how the scheme is designed and operated. Four review papers on ETSs are selected to summarize the structure of an ETS. Eighteen ETSs are examined in the EDF report by Peltz, Sopher, and Hanafi in 2013. It covers almost all of the representative trading schemes around the world today. In a discussion paper published by Brunner et al. in 2009, many detailed aspects of designing a trading scheme are addressed, although the paper only reviews five trading schemes. In Boemare and Quirion's (2002) paper, published prior to the commencement of the EU ETS, the prototype and structure of a trading scheme had already been formulated. The cases selected in this paper are somewhat different from the other three papers, such as the US acid rain program, the Netherlands NOx emission permits, and company-based trading programs such as those of BP and Shell. Comparison with other studies reveals that ETSs place more focus on reducing cost burden by mechanisms such as banking and borrowing, opt-in, phase in, and even subsidies in the early days. In Hood's (2010) IEA information paper, ongoing and proposed trading schemes are analyzed, and basic features and suggestions for further development are concluded. Table 3.8 summarizes the items introduced in these four papers, and the essential elements of an ETS are identified and applied in the following chapters.

Table 3.8 Structure of the ETSs' Review

(Adapted from Boemare and Quirion, 2002; Brunner, et. al. 2009; Hood, 2010; and Peltz, et. al. 2013)

Items	Peltz, A. et. Al.	Brunner, S.et. Al.	Boemare, C. et.al.	Hood, C.
Bilateral trade			√	
Registry	√	√	√	√
Historical emission trends		√		
Future projections		√		
Ratification of K.P. *		√		
Implementation stage/Status	√	√		
Participating sub-regions		√		
Emission reduction goals	√	√	√	
Trading period	√	√		√
Entity coverage	√	√	√	√
Energy mix by sectors		√		
State of economy wide emissions		√		
Threshold	√			
Regulated emission source	√	√		
Opt in			√	
Unite of measurement		√	√	√
Design of cap		√		√
Point of obligation	√	√		
Allowance allocation method	√	√	√	√
Import of export allowance				√
Credit for early action	√			
Cost containment	√	√		
Offset resource	√	√		
Offset resource quality	√			
Offset limits or unlimited	√	√	√	√
Banking and borrowing	√	√	√	√
Allowance reference period			√	
Domestic credit program	√	√		
Price cap		√		√
Price floor		√		√
Phase in			√	
International connections	√			
Competitiveness protection	√		√	√
Subsidiarity / compensation			√	√
Avoid carbon leakage	√	√		
Penalty system		√	√	
Liability			√	
MRV system		√	√	

3.4 FINDINGS AND CONCLUSION OF LITERATURE REVIEW

3.4.1 Considerations of Sustainable Emissions Trading Scheme

Based on the literature review above, considerations relating to the sustainability of the ETS are summarized in Table 3.9. The three aspects of sustainability have corresponding indicators in the field of environmental economics. These indicators also instruct the considerations needed to be addressed and fulfilled in an ETS so as to be a sustainable ETS.

3.4.2 Conceptual Framework of Emissions Trading Scheme

To establish a trading scheme, governments first provide dominant power and legal support; for instance, developing emissions reduction targets as national development strategies or offering legal contract binding for certain voluntary emissions reduction activities. Carbon tax and carbon trading are the two main policy instruments used to achieve emissions-reduction objectives. Carbon taxation is a more straightforward and less costly tool, but less flexible. On the other side, carbon trading is more flexible but more complicated too. To start the trading, a trading organization is built. There are two kinds of trading organizations: the first is regulated and the other is voluntary. The regulated carbon market is adequately designed and dominated by governments, aiming to incentivize and encourage carbon reduction through bargaining. Voluntary carbon markets are initiated by civil-society organizations but supported by governments, and their operation is similar to that of regulated markets. In either market, there are usually two operating schemes:

Table 3.9 Considerations of Sustainable Emissions Trading Scheme

S. D.	Environmental Economics	Considerations
Environmental Sustainability	Internalized environmental value	1.Set price on emission allowance 2. Allocate emission allowance 3. Establish emission reduction target
	Natural capital can be substituted	1.Techonology research 2. Encourage offset scheme 3. Stringent emission reduction verification
	Maximized environmental quality matters	1.Effecient MRV scheme 2. Transparency of each party, especially regulator and verification sector
	Traditional command control is not effective	1.Emission tax is effective to encourage emission trading 2. Revenue goes to environmental or social benefits
Economic Sustainability	Appropriate economic growth	1.Industry adjusts growth rate when emission cost internalize 2. State considers carbon intensity into
	Polluter pays principle	1.Set emission tax and emission trading, which are auxiliary to each other at an effective level
	Economic incentives	1.Free allowance first and transit to auction allowance 2. Introducing offset /green label scheme 3. Tax waiver
Social Sustainability	Economic equity for all participants	1.Assessing carbon leakage 2. Financial support to small industry 3. Should not deliver cost to consumer
	Misleading by green consumerism	1.Promote green life style 2.Industry lowers emissions by operation pattern more than technology
	Developing and developed countries	1.The cooperation of carbon markets and unifying standards 2.Contribution to poverty and basic needs

cap and trade and offset. The difference between cap and trade and offset schemes lies in whether industries' emissions are restricted. For industries obliged to reduce emissions, trading operates under a cap and trade scheme; industries without an emission cap enter the market by providing CER units under the offset scheme. CERs can be purchased and used in cap and trade schemes in a certain percentage – usually 5% to 10% of their cap. Figure 3.10 provides a detailed structure from the perspective of the operation of emissions trading. Over the last decade, some emission markets have established their own spot markets, as well as futures and options markets, which is also why people sometimes perceive the emissions trading market as similar to the stock market and define it as a tool for yielding benefit in business. Carbon trading does involve many economic activities; however, as Pearce (2002) states, it combines some traditional economics work with recent perspectives on choosing policy instruments as well as the philosophy of sustainable development.

Although differences in national institutions lead to different designs of ETSs, the duties of governments, the carbon market, industries and service sectors are similar. Around the operation of a carbon market, the responsibilities of the government, the service sector and industry are closely interconnected. The government is the organizer and regulation designer, which establishes the market, authorizes the service sector for trading, and selects participating industries. The industries selected are more like the recipients of regulations, but with flexible compliance measures. Service sectors also play an important role in activating the market, guaranteeing the market, or improving the market. Figure 3.11 presents a framework of ETS sectoral duties. There are still many eristic issues surrounding this progressive scheme, such as the following. Which is the better scheme: carbon taxation or carbon trading? Is an allowance auction a better approach than free allocation? Can banking and borrowing benefit the industry? Therefore, governments must determine most of the details at the beginning and propose a timetable for possible improvements in the future.

Figure 3.10 The Structure of ETS

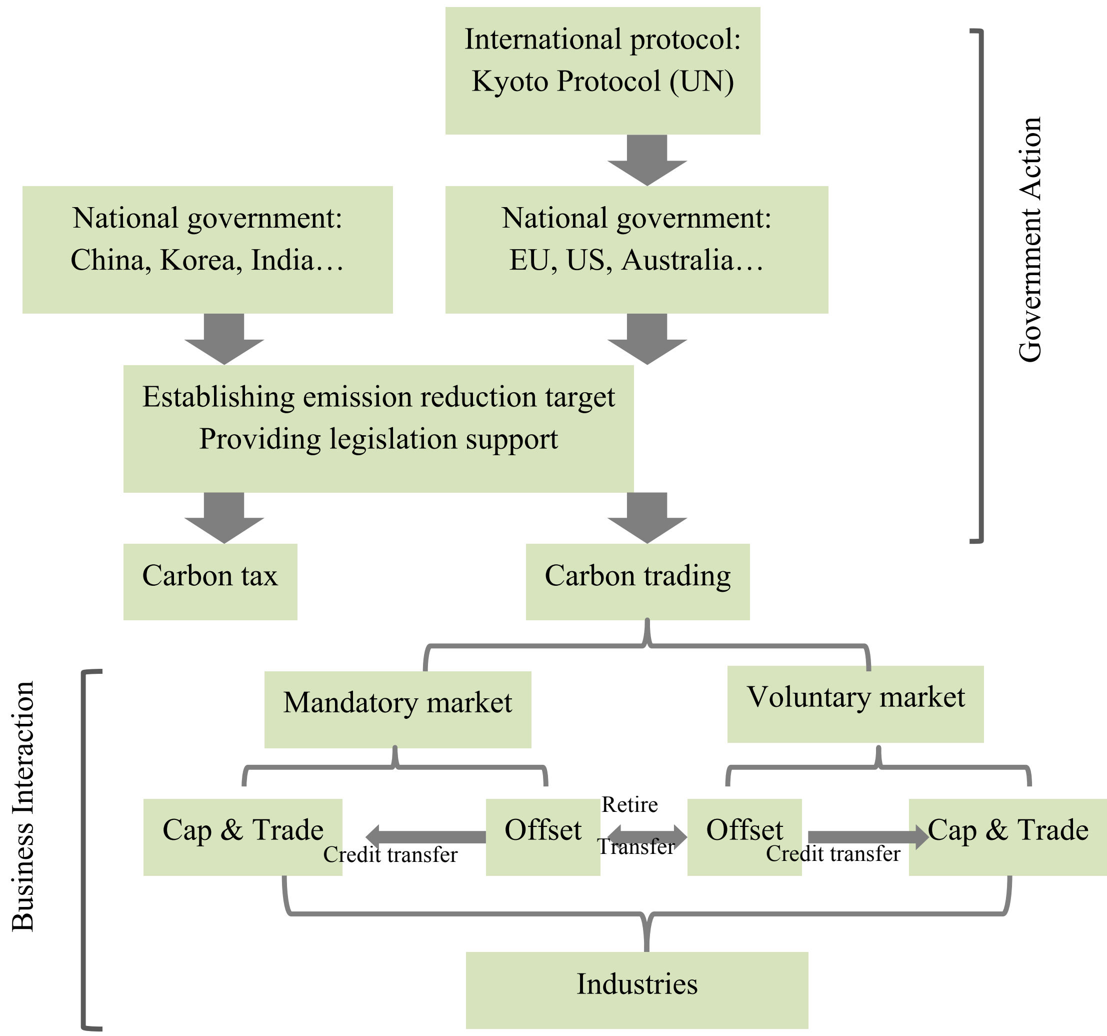
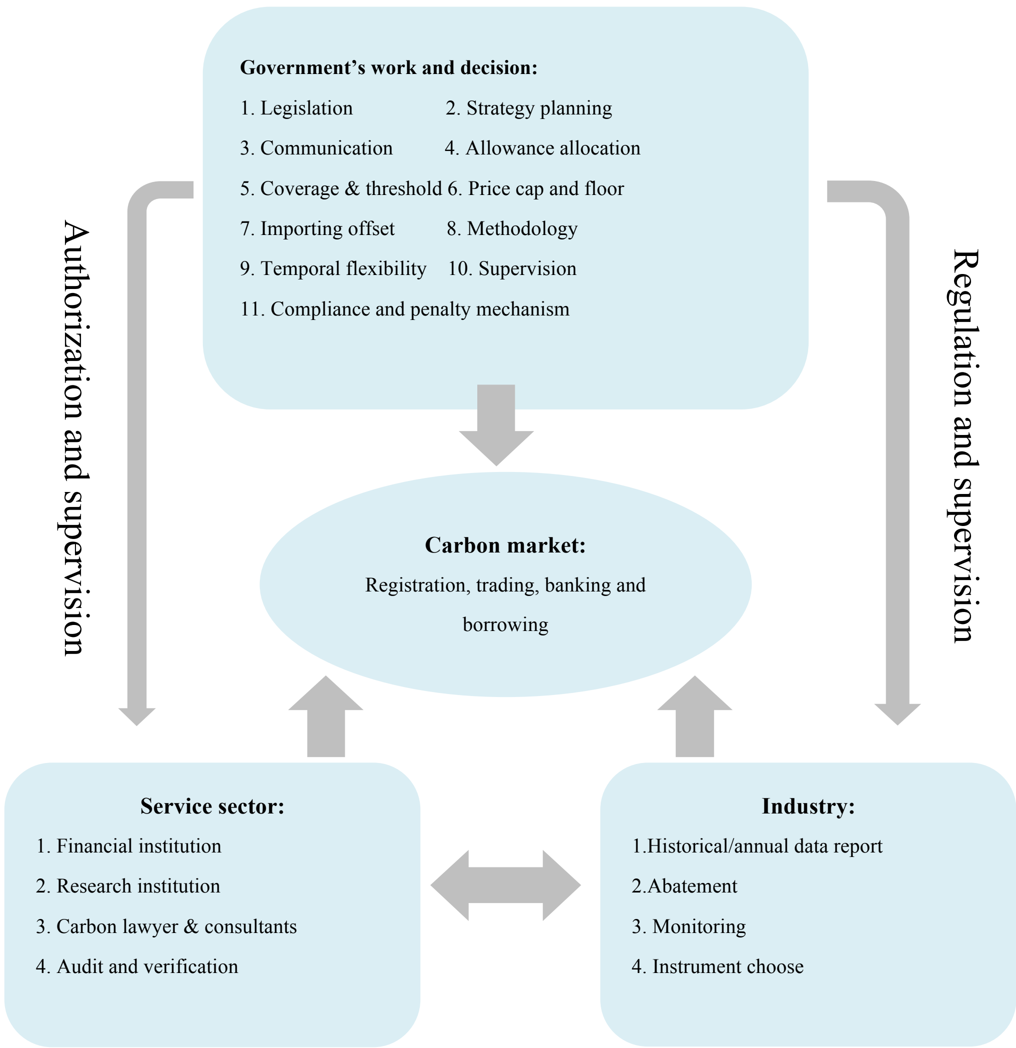


Figure 3.11 The Framework of Sectoral Duties in ETS

(Adapted from Boemare and Quirion, 2002; Brunner, et.al. 2009; Fankhauser, 2011;Hepburn, 2007; Hood, 2010; Lu and Zhou, 2013; Peltz, et. al. 2013)



CHAPTER 4 CASE STUDY: CHINA'S PILOT EMISSIONS TRADING SCHEMES

4.1 THE DESIGN OF THE SEVEN CAP AND TRADE SCHEMES IN CHINA

China started preparing to establish ETSs in 2011. The governing authority for the seven pilots is the National Development and Reform Commission (NDRC), which usually communicates and cooperates with the Ministry of Science and Technology (MOST), the Ministry of Foreign Affairs (MOFA) and the Ministry of Industry and Information Technology (MIIT). First, the NDRC establishes emissions-reduction targets and general guidelines. Based on the framework published by the NDRC, provincial DRCs design regulations for the selected seven pilot cities with attention to each city's characteristics. Carbon tax and carbon trading are the two main policy instruments used to achieve emissions-reduction objectives. In the context of China, carbon tax is still under-researched. China currently has only a mandatory carbon market. Cap and trade and CCER offset are the two schemes used in China's carbon market. Industries can purchase Chinese Certified Emission Reductions (CCERs) to offset their emissions. Figure 4.1 shows the structure of China's ETSs. Figure 4.2 shows the framework of sectoral duties in China's ETSs. Despite their short preparation period—2 years, compared with 10 years for the EU ETS and 6 years for California's cap and trade scheme—these pilots have gained much from similar schemes implemented around the world. Table 4.1 summarizes the design of trading schemes by the NDRC and local DRCs.

Figure 4.1 The Structure of China's ETSs

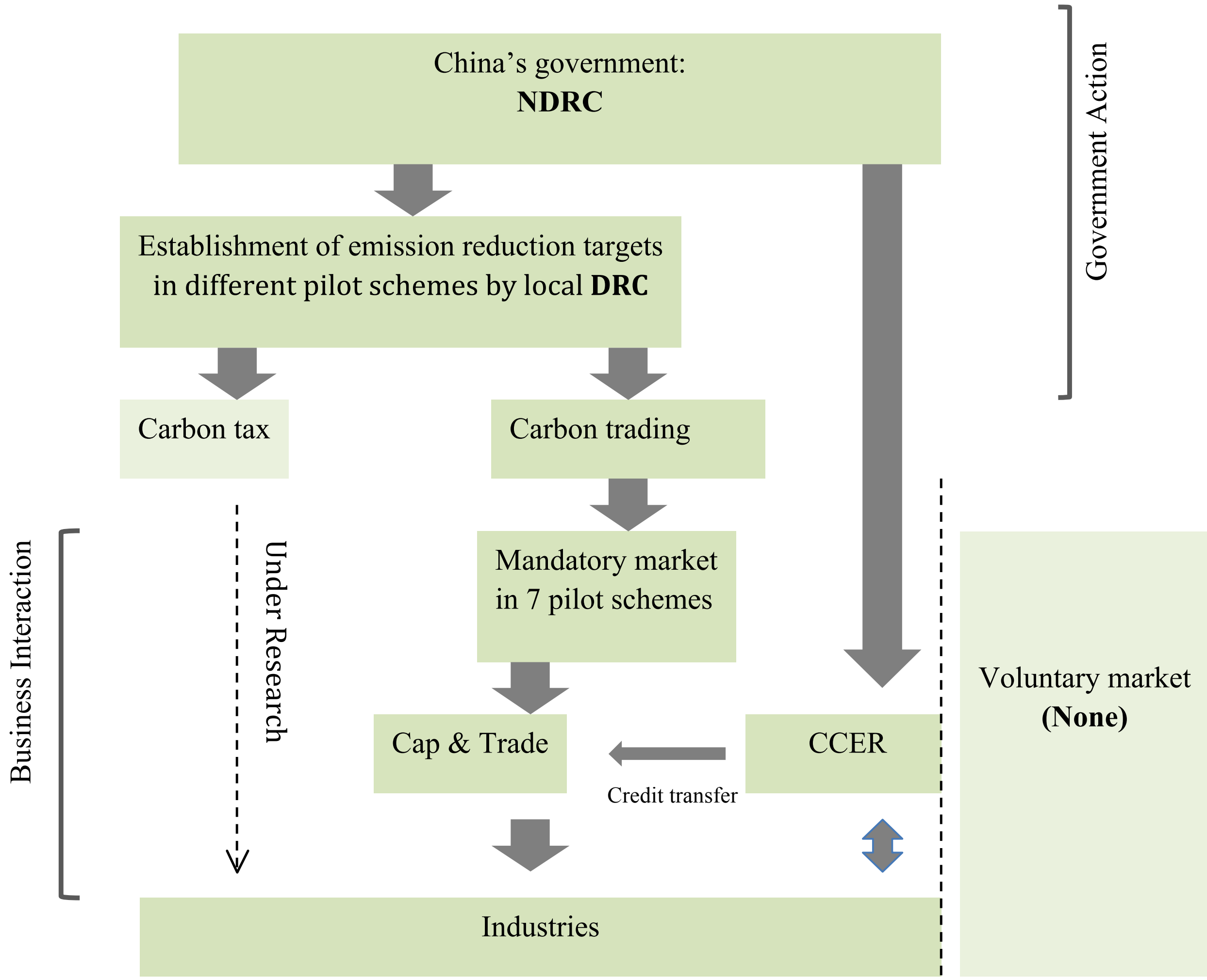


Table 4.1 The Design of ETSs in China

(Adapted from Chen, 2013; Chen, 2014; Duan, et.al. 2014; Jiang, Ye and Ma, 2014; Mei, 2013; Zhang, et. al. 2014; Zhang and Wei, 2014; Zhao, 2014)

Government:
State Council / NDRC / Provincial DRCs / Local People's Congress / Local People's Government / Local Office of Legislative Affairs / Emission Exchange

Major Legislation:

- *The Twelve Five Years Plan – Notification of the controlling greenhouse gas emissions program.*
- *National Notification of carbon emissions trading pilot projects.*
- *Management of carbon emissions trading in Shenzhen, Beijing, Shanghai, Guangdong, Tianjin, Hubei, and Chongqing (separately).*

Strategy Planning:

- *The beginning of voluntary emission reduction in China; CCERs are allowed to be registered and traded in 2013.*
- *The proposed national ETS in the .13th five year plan.*

Communication and Cooperation:

- *With MOST, MOFA, MIIT*
- *With local financial agencies*
- *With major emitters*

Coverage and threshold:

- *Shenzhen - Industries emission ≥ 5000 tons, public building ≥20000 m^{2}, government building ≥ 10000 m^2*
- *Shanghai - Industries emission ≥ 20000 tons, non industries (aviation, commercial buildings) ≥ 10000 tons*
- *Beijing - Industries and service industries ≥ 10000 tons*
- *Guangdong - Industries ≥ 20000 tons*
- *Tianjin - Industries ≥ 20000 tons*
- *Hubei - Industries ≥ 60000 tons*
- *Chongqing - Industries ≥ 2000 tons*

Allowance Allocation:

- *Allowance allocation is free (90%-95%), and amounts for auction are small (5%-10%) at the beginning, but the plan is to implement allowance auctions as a major method in the coming future.*
- *Free allocation based on grandfathering and benchmarking. In order to secure economic growth, there are absolute caps and intensity-based caps, calculated based on grandfathering.*

- *Shenzhen is the most particular one as it is using game theory for its intensity-based caps and benchmarking.*
- *Besides the electricity and heat industry, Beijing, which is the only city to show a determination for environmental improvement rather than economic growth, places absolute caps based on grandfathering,.*

Price Cap and Floor:

- *There are not fixed carbon price caps or floors in China's carbon market, but there are some other market stabilization mechanisms.*
- *Shenzhen introduced two safety valves: government reserves and allowance buybacks to control price fluctuations.*
- *Shanghai introduced a maximum allowance holdings policy.*
- *Beijing introduced allowance buybacks for when there is abnormal price fluctuation.*
- *Guangdong and Hubei introduced a government reserve allowance for securing the price.*
- *Beijing and Tianjin restrict the price limit on 20% and 10%, respectively, based on daily benchmark prices; Shanghai, Guangdong, and Shenzhen restrict the price limit on 30%, 10%, and 10%, respectively, based on the previous day's closing price.*

Importing Offset Credits:

- *The CCER online information system online was implemented on 24 October 2013.*
- *Beijing, Tianjin, Shanghai, Guangzhou, and Shenzhen are eligible for trading CCERs.*
- *Three CCER verification institutions are authorized.*
- *54 methodologies were introduced in 2013.*
- *121 methodologies were introduced in the first half of 2014.*
- *Shanghai and Beijing allow the use of CCERs at no more than 5% of the allowance.*
- *Shenzhen, Guangdong, Tianjin, and Hubei allow the use of CCERs at no more than 10% of the allowance.*
- *Chongqing allows the use of CCERs at no more than 8% of the allowance.*
- *Beijing, Guangdong, and Hubei require the use of local CCERs for at least 50%, 0%, and 100%, respectively.*

Methodology:

- *Most of the CDM methodologies are learned and translated with few adjustments.*

- *There are a total of 176 methodologies published by the NDRC so far.*
- *China's GB are referred in selected sectors.*
- *2007/589/EC, 2009/339/EC*
- *ISO 14064 is the verification methodology adopted by the third party verification institution, supplemented with GB 24064.*

Temporal Flexibility:

- *Unlimited banking, no borrowing.*

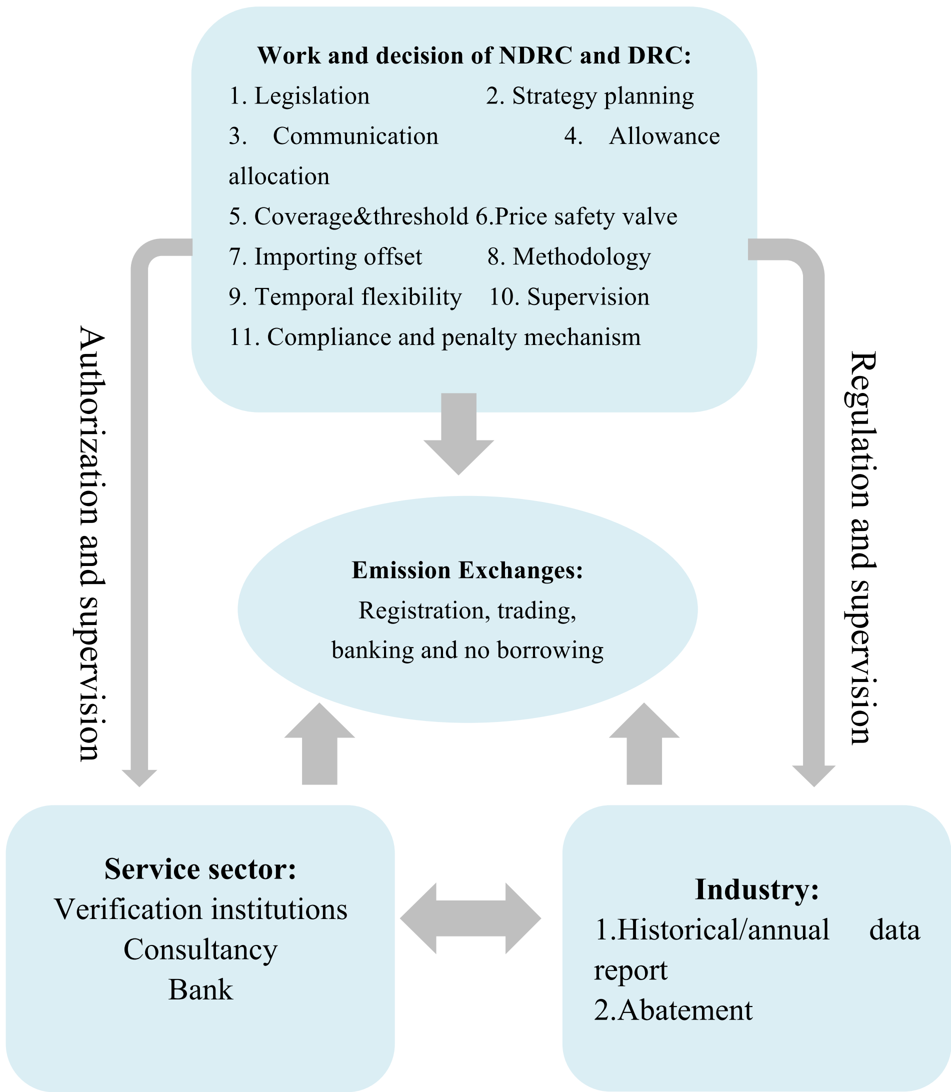
Supervision:

- *Daily market supervision.*

Compliance and penalty mechanism*:*

- *The compliance period in six of the pilot cities is year by year, except Chongqing, whose compliance period is two years.*
- *Overall, the maximum penalty is 50000 RMB.*
- *The deduction of next year's allowance.*
- *Shame and name.*

Figure 4.2 The Framework of Sectoral Duties in China's ETSs



4.1.1 Key Features of China’s ETSs

One of the most remarkable features of China’s ETSs is that each pilot was designed with full consideration of local economic development patterns and city characteristics. SZ is a highly economically competitive city, with many dynamic small and medium-sized enterprises. Thus the allowance for SZ must be stringent but also sufficient to maintain economic growth, as its favorable economic environment is the city’s key advantage. For this reason, the design of the emissions allowance for the SZ pilot is based on economic output, creating a so-called intensity-based cap. However, an intensity-based cap cannot decrease absolute emission levels in the short term. In contrast, as a capital city with critical environmental problems, BJ applies a strict absolute cap on industries. Some small manufacturing industries have already shut down or moved outside the city. BJ has obviously prioritized the task of solving the atmospheric haze problem. In the GD pilot, the capped industries initially had to bid for the first 3% of their allowance to get the rest of the 97% allowance for free, but this regulation was cancelled in the second compliance year due to resistance from industries. These pilots are also driving innovation. For instance, the SZ pilot assigned the International Finance Corporation (IFC) to conduct research on public transportation, expanding its scope from private vehicles to carbon trading in the subsequent years (Bu, 2014). The SH pilot requires local registered aviation enterprises to participate in trading. Governments update their regulations according to feedback on implementation and the latest information on ETSs around the world. At the same time, the diversity of the pilot schemes drives authorities to explore ETSs adapted to China’s characteristics. The significant differences between these pilot schemes have been described as their strengths (Duan et al., 2014). A unique system that is tailored to local circumstances and operates in a relatively free and competitive way will ensure the success of China’s overall ETS initiative (Kerr and Duscha, 2014).

From the perspective of the service sector, financial institutions have little involvement in China’s carbon market. With the exception of some carbon-financing business from banks, carbon stocks, futures, and related derivative trading are not yet popular and receive only weak support in China. Some local and foreign consultancy companies are already involved or trying to involve themselves in China’s carbon market, such as Beijing Sino Carbon, Beijing Easy Carbon, Crystal Carbon, Shenzhen GDP Carbon and Ernst & Young. However, enterprises, especially small and medium-sized enterprises, lack an understanding of ways to include carbon asset management (Bu, 2014). The most developed and significant service sector in China today is constituted by third-party verification organizations. All such organizations are qualified and approved by provincial DRCs. Shenzhen and Beijing have 21 and 19 verification organizations respectively, Shanghai and Chongqing 10, Guangzhou 16, Tianjin 4, and Hubei only 3. The China Quality Certification Center participates in all seven pilot schemes. As China is at an early stage in its emissions trading, the government initially bore the cost of verification work. This cost was transferred to enterprises when the market reached maturity in around 2015. Provincial DRCs play a crucial role in the carbon market, publishing verification report templates, detailing emission accounting methods in different industries, setting an inventory boundary, developing a manual for the reporting system and devising regulations to guide and constrain verification organizations. To date, no foreign verification organizations have been permitted to enter China’s carbon market, nor has a schedule been developed to recruit them. The limited financial activity in China’s carbon market reflects the government’s current commitment to encouraging enterprises to reduce emissions rather than to building an active carbon financing market.

4.1.2 Deficiency of China’s ETSs in Practice

A national ETS was expected to be launched as early as 2016. Many studies have addressed the difficulties ahead. For instance, China lacks the stable and mature free market necessary to operate a strong market-based instrument (Wang, 2012; Bo et al., 2014); a fixed power price will bring opposition from state-owned power generators (Wang, 2012; Hook, 2013); a poor emissions database and MRV system will leave the effects of emissions reduction ambiguous (Wang, 2012); and promoting harmonization, unification, and cooperation between pilots and institutions at both national and local levels is challenging (Wang, 2012; Lo and Chang, 2014). Exceeding even these theoretical predictions, two years of practice have revealed deficiencies in implementation.

During the first compliance period in June 2014, compliance rates in SZ, BJ, SH, GD, and TJ were higher than 95%, and the rate of conformity in SH reached 100% (see Figure 4.3). The performance of these pilots seemed to be excellent. However, some issues remained to be addressed. First, the compliance deadlines in BJ, TJ, and GD were deferred for more than 10 days. This was officially assumed to be due to a low compliance rate before the original deadline. Second, the compliance rates ten days before the deadline were not promising, especially in BJ and SZ. Many industries subject to the requirement were sitting on the sidelines, waiting for the government to reaffirm its stand. In BJ, only 233 of the 490 industries subject to the scheme were fulfilling the requirements 10 days before the deadline, representing a compliance rate of less than 50%. In SZ, 400 of 635 industries under the scheme (less than 70%) were fulfilling the requirements. However, the capped industries in SH performed better than those in the previous two pilots, with a compliance rate of around 80% within 10 days of the deadline (see Figure 4.4).

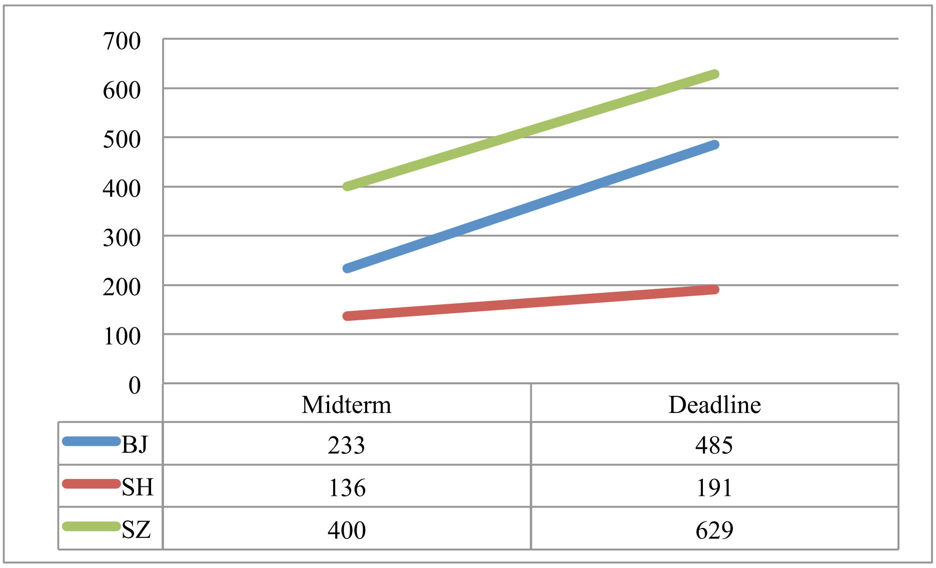
Figure 4.3 The Compliance Rates of Obliged Industries in China in 2014

	Numbers of obliged industries	Numbers of compliance industries	Compliance rate
BJ	490	485	99%
TJ	114	110	96.5%
SH	191	191	100%
SZ	635	629	99%
GD	184	182	98.9%

** The first compliance period for the Hubei and Chongqing pilots will be in 2015.*

Data source: BJ DRC, TJ DRC, SH DRC, SZ DRC, and GD DRC. 2015.

Figure 4.4 The Compliance Tendencies from Midterm to Deadline in 2014 in China

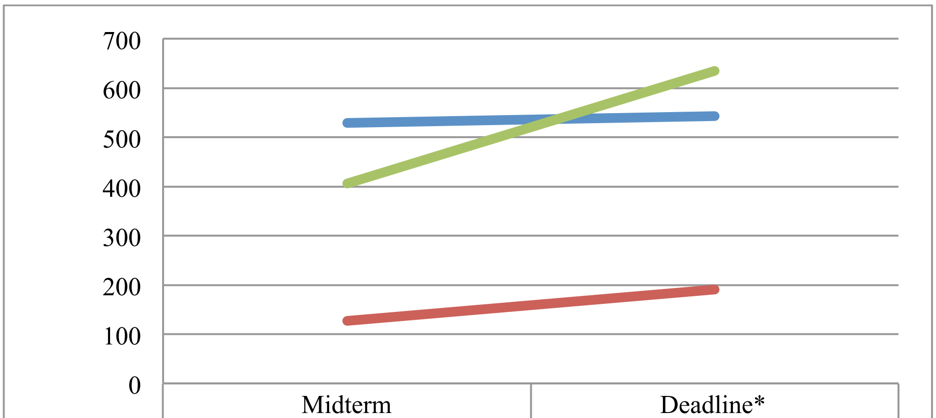


** Midterm indicates 10 days before the deadline*

Data source: BJ DRC, SH Environment and Energy Exchange, and SZ Emission Exchange. 2015.

During the second compliance year, 2015, some pilots published their midterm compliance rates. The number of industries in BJ subject to the pilot had increased from 490 to 543. BJ's compliance rate had also risen, with 529 industries meeting requirements in 2015. Detailed figures are provided in Figure 4.5. The other pilots have not yet published relevant data. The situation in SH and SZ was almost the same as that in the previous year.

Figure 4.5 The Compliance Tendencies from Midterm to Deadline in 2015 in China



	Midterm	Deadline*
BJ	529	543
SH	127	191
SZ	406	635

** A 100% compliance rate for the 3 pilots is assumed for the purpose of assessing the tendency*

Data source: BJ DRC, SH Environment and Energy Exchange, and SZ Emission Exchange. 2015.

Industries subject to the scheme are currently adjusting to the carbon market. However, this trading market is led by the government, and industries are not participating in the market actively enough, even with government incentives. The government can enforce many regulations and a strict penalty system to maintain the market. Nevertheless, without active participation and greater 'low carbon' awareness from industries, the market will ultimately fail. In this circumstance, industries' capacity building, such as specialists' training and MRV system improvements, becomes significant. The involvement of financial institutions in China's carbon market is not popular. An investigation initiated by SH Energy and Environmental Exchange and Environomist Ltd. revealed that 80% of the organizations surveyed did not estimate the potential costs of emission reduction, 82% did not have an independent carbon management department, and 86% had not created a budget for emissions trading (Mao, 2014). These data imply that much effort will be needed to build and strengthen industries' capacity to participate in the ETSs, and that these efforts cannot be regulated by government policy alone.

4.2 CHINA'S CERTIFIED EMISSIONS-REDUCTION SCHEME

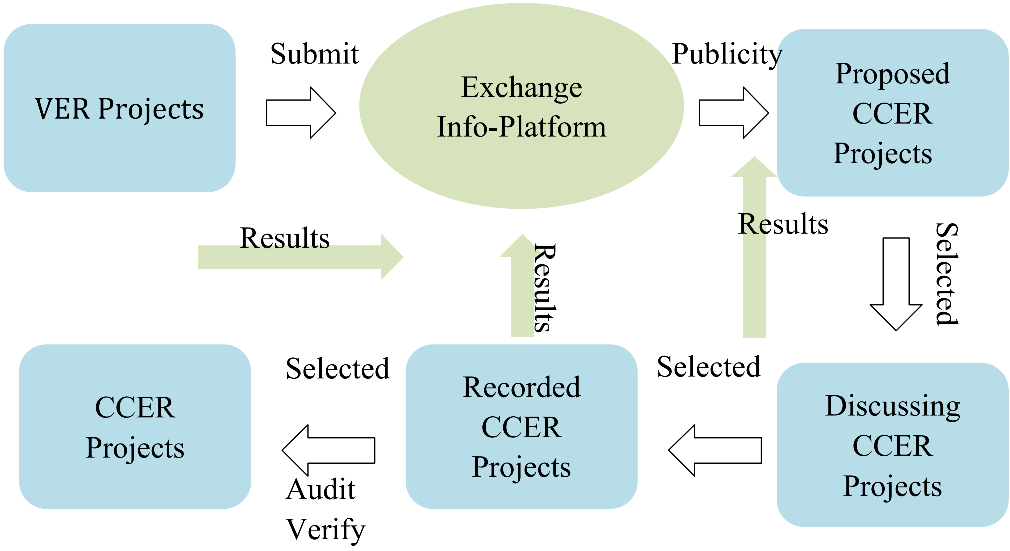
4.2.1 Design of China's CCER Scheme

The first voluntary emissions reduction (VER) trading in China took place in BJ in 2009. At that time, the Clean Development Mechanism (CDM) was still popular in China. In 2012, the NDRC published the "Interim Management Measures of Voluntary Greenhouse Gas Emission Trading". On 24 October 2013, China's CCER Exchange Info-Platform, built by the NDRC, went online. Industries in the BJ, SH, TJ, SZ, GD, HB, and CQ pilots were all eligible to trade CCERs. Nine verification organizations were permitted to verify CCERs. These verification organizations also played a role in the cap and trade market.

Qualifying CCERs enter the market for sale. In the market, project owners are the producers of credits; industries subject to the scheme represent the ultimate demand side; and other investment agencies are able to activate the market (Lin,[a] 2015). There are three types of CCER credit trading. First, project owners sell CCERs to industries subject to the scheme or CCER investors. The second type is trading between CCER investors. Third, CCERs can be submitted by industries to meet requirements (Lin[b], 2015). The CCER Exchange Info-Platform is a nationwide platform, established separately from the other seven pilot schemes, which only serve their regions. Project owners around the country can voluntarily participate in trading by certifying their VER as CCER.

Each VER project must undergo a lengthy process to verify its VER as CCER. First, the proposed CCER projects must be publicized. Second, the NDRC organizes meetings to discuss selected proposed CCER projects and identify recorded CCER projects. Lastly, authorized verification organizations audit and certify CCER projects, which can then be put on the market and their credits sold. During this process (see Figure 4.6), the NDRC can filter project types as well as constraining the number of available projects, to some extent resolving supply and demand inconsistencies.

Figure 4.6 The Flowchart of CCER Project Selection



**Discussing CCER Projects means the NDRC organizes meeting to discuss the proposed CCER projects.*

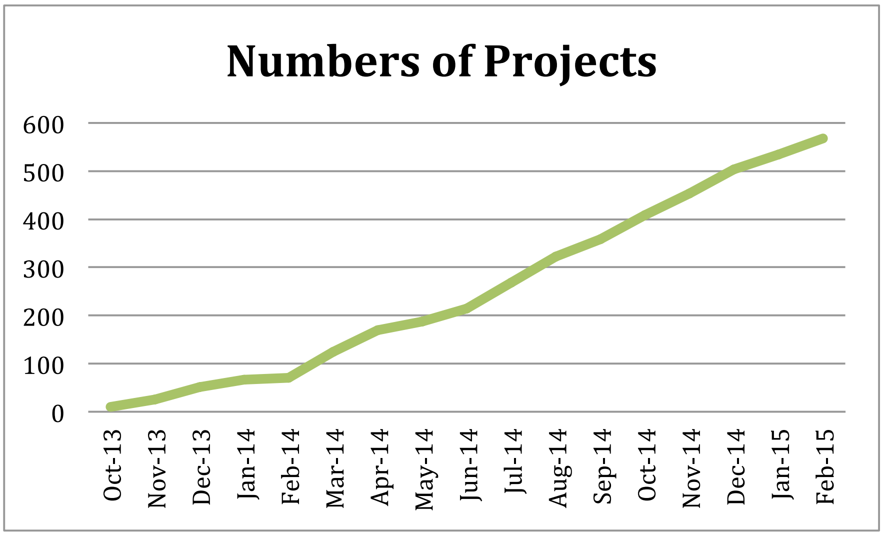
**Recorded CCER Projects means the NDRC selects some proposed CCER projects as Recorded CCER projects after discussion.*

**CCER Projects are projects with CCER certification after the selection by the NDRC and auditing by the verification organizations.*

4.2.2 Status of CCER Market

Since the CCER Exchange Info-Platform went online, the number of proposed CCER projects has experienced stable growth. Since February 2014, around 40 new projects have been added each month (see Figure 4.7). At that time, the commencement of the pilot schemes — except HB and CQ — brought confidence to the markets and attracted more participation from VER project owners. Almost 600 publicity projects were scheduled through the end of February 2015 (Meng[a], 2015).

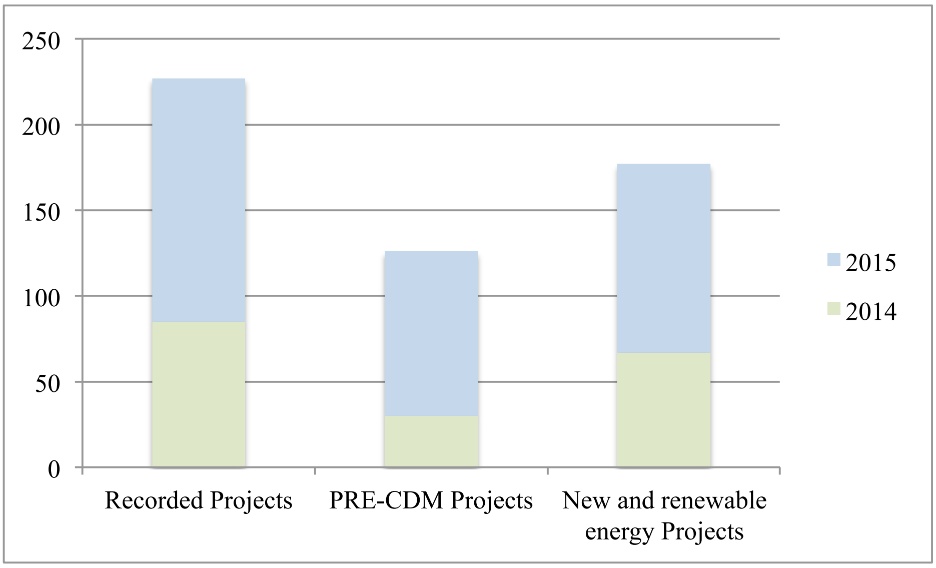
Figure 4.7 The Growth of Proposed CCER Projects



Data source: CCER Exchange Info-Platform. 2015.

In early 2014, China had 85 recorded CCER projects, of which 30 were pre-CDM projects (TCC, 2014). By mid-2015, the total number of recorded CCER projects had increased to 142, of which 96 were pre-CDM projects (Yang, 2015). New energy and renewable energy projects made up a large proportion of the recorded CCER projects—79% in early 2014 and 77% in mid-2015. Figure 4.8 summarizes the development tendencies and composition of recorded CCER projects in China.

Figure 4.8 Recorded CCER Projects and Composition in 2014 and 2015 in China



Data source: CTT; Sino Carbon.2015.

China had 74 certified CCER projects at the end of May 2015. The total volume of CCERs was around 20 million tons, of which 3.5 million tons had already been traded (Zhao, 2015). There was a three-month gap between announcements of the first three rounds of the CCER projects, but the last round's announcement was made only a few days after that for the third round. The NDRC promoted more CCER trading among industries in the seven pilots before their compliance periods were completed at the end of June 2015. The government also sought to bolster the CCER market, providing confidence for project owners, investors, and capped industries.

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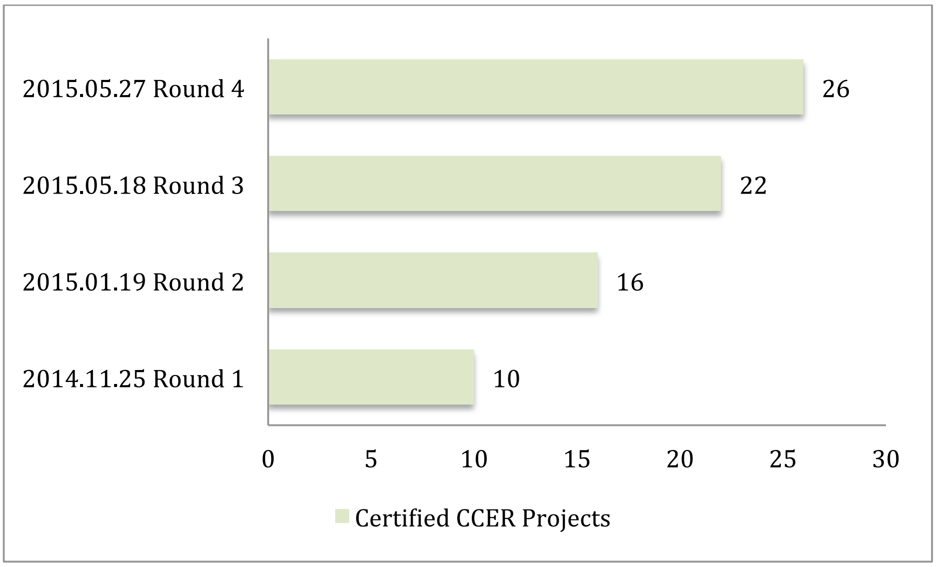
Figure 4.9 Certified CCER Projects Numbers from 2014 to 2015 in China



Data source: CCER Exchange Info-Platform. 2015.

4.2.3 Strengths and Deficiencies of CCER Market

The oversupply of CDM offset credits is a reminder that effective supply and demand management is critical to the success of the offset scheme. As the major offset credits provider under the CDM, China generates a considerable amount of CCERs. CCER projects can be divided into four categories, based on the methodology applied and the verification organization operating (see Table 4.2). Almost 72% of the total certified CCER projects are pre-CDM projects, with no category 4 projects yet developed (see Table 4.3). There has clearly been a major recent increase in category 1 projects.

Table 4.2 CCER Projects Categories

	NDRC methodology	CDM approved by NDRC only	CDM approved by CDM EB (Pre-CDM)	Registry at CDM EB* without approved
Category 1	√			
Category 2		√		
Category 3		√	√	
Category 4				√

**CDM Executive Board*

Table 4.3 Certified CCER Projects Categories

	CA.1	CA.2	CA.3	CA.4
Round 1 & 2	1	/	25	/
Round 3	5	2	14	/
Round 4	11	/	14	/

**CA means category*

Data source: CCER Exchange Info-Platform. 2015.

The demand for CCERs depends on three factors: the offset percentage in each allowance case; the type of approval extended to CCER projects; and the needs of end users (Zhang, 2014). The offset percentage of the seven pilot schemes ranges from 5% to 10%. Most pilots refuse CCERs from hydropower projects; and some pilots require CCERs to be generated locally. This explains why project approval type and the needs of end users so significantly influence the demand for CCERs. Table 4.4 lists the restrictions of the seven pilot schemes in purchasing CCERs to offset.

Table 4.4 Restrictions on the CCER Use of the Pilots

	CCER percentage	**Localization**	**Project type restriction**	**CCER effective date**
BJ	5%	50%	NO H.P	After 2013.1.1.
SH	5%	/	/	After 2013.1.1.
GD	10%	70%	NO Category 3 NO H.P.	/
SZ	10%	/	NO H.P.	/
HB	10%	100%*	NO H.P.	/
TJ	10%	/	NO H.P.	/
CQ	8%	100%	NO H.P.*	After 2010.12.31 (except carbon sink)

** HB also includes CCER projects happening in Shanxi, Henan, Anhui, Hunan, and Jiangxi according to agreements signed in 2015.*
** CQ also requires that the projects reduce energy use, increase energy efficiency, use clean energy and non-hydro renewable energy, promote carbon sink, and reduce pollution.*
Data source: CCER Exchange Info-Platform. 2015.

It is estimated that in the first compliance year, 2014, the total available amount of CCERs was more than 29 million tons: less than half that demanded in 2014 (see Table 4.5). Overall demand and supply are quite balanced, and CCER price is likely to remain stable under such circumstances. However, according to the restrictions in

Table 4.4, no qualified CCER projects were available for BJ and SH industries under the scheme in its first two rounds, and only one eligible CCER project was available for GD and HB industries, respectively. To increase the availability of CCERs, the NDRC sped up the release of the third and fourth rounds of the CCER projects, notably adding more category 1 projects to the pilots with strict requirements for project type. Theoretically, therefore, industries involved in the TJ and SZ pilots can offset through all of the certified CCER projects. The CCER projects released in the last two rounds provide many more options for industries under the scheme in BJ, SH, GD, and HB (see Table 4.6), and 11 CCER projects have been made available for capped industries in CQ (Zhao, 2015).

Table 4.5 Comparison between Allowance and CCER Amount in 2014

	B.J.	**S.H.**	**G.D.**	**S.Z.**	**H.B.**	**T.J.**	**C.Q.**	**Total**
Annual Allowance	47	160	388	30	190	160	N.A.	975
CCER Percentage	5%	5%	10%	10%	10%	10%	8%	-
Maximum CCER Needed	2.35	8	38.8	3	19* (2015)	16	N.A.	87.15/ 68.15 (2014)

Units: million tons

** The first compliance period of the Hubei pilot is in 2015, so the total Maximum CCERs needed in 2014 is 68.15 million tons.*

Source: Shanghai Treasure Carbon, 2014

Table 4.6 Available CCER Projects in 4 Pilots

	B.J.	S.H.	G.D.	H.B.
Round 4	9	12	9	4
Round 3	6	7	8	4
Round 1 & 2	0	0	1	1

Data source: Zhao, 2015.

The NDRC has made noticeable efforts to improve the CCER market, and the market has responded actively: each of the pilot schemes except that in CQ had completed almost 30 CCER trades by the end of June 2015. The first CCER spot trading took place in the GD pilot in March 2015, taking the form of an online transfer between a carbon service company and a CCER project owner. Table 4.7 shows the chronology of China's CCER spot trading.

Table 4.7 CCER Spot Trading through the End of June 2015

Time and Place	Transaction Mode	Buyer	Seller
3.9. GD.	Online	TCC[1]	001 CCER Project
3.12. BJ.	Agreement	SH. Zhixin. [2]	008 CCER Project
3.24. TJ.	Online	Cap. In. *	CCF[3]
4.23. TJ.	Agreement	Timing Carb.[4]	025 CCER Project
4.27. TJ.	Agreement	CCF	041 CCER Project
4.27. SZ.	Agreement	CCF	001 CCER Project
4.27. SH.	Agreement	Cap. In.	CCER Project
4.28. SH.	Agreement	Cap. In.	CCER Project
4.28. SH.	Agreement	Cap. In.	CCER Project
5.28. BJ.	Agreement	Green. Tech.[5]	067 CCER Project
5.28. GD.	Agreement	Cap. In.	021 CCER Project*
6.2. BJ.	Agreement	Cap. In.	Green. Tech.
6.4. HB.	Online	Cap. In.	China Wind P.[6]
6.5. BJ.	Online	Cap. In.	Timing Carb.
6.5. BJ.	Online	Cap. In.	Timing Carb.
6.5. BJ.	Online	Cap. In.	Timing Carb.
6.9. SH.	Agreement	Cap. In.	Timing Carb.
6.15. SZ.	Online	Cap. In.	CCF

** Cap. In. means obliged industry in the pilots*

** 0021 CCER project is the first forest carbon sink project in China.*

1. Shanghai Treasure Carbon New Energy Protection Technology Company

2. Shanghai Zhixin Energy Saving and Environmental Protection Company

3. China Carbon Asset Management Co. Ltd.

4. Timing Carbon.

5. Green Technology.

6. China Wind Power.

Source: CCER Exchange Info-Platform. 2015.

By the end of June 2015, CCER trading volume took up 33% of the total volume in the SH scheme, but not in the HB or CQ pilot schemes, due to the comparatively flexible CCER trading regulations in the SH pilot scheme (Meng,[b] 2015). It has been noticed that more trades have been completed between participating industries and consulting companies.

Timing Carbon and TCC are the two most active consulting companies in China today. In addition to CCER investment, most service companies also provide industries with carbon asset management, carbon-financing services, and energy efficiency technology consultancy. These service companies facilitate not only CCER spot trading, but also several forms of voluntary trading, such as CCER options business, mortgage loans on CCER credits, and carbon neutral business support (see Table 4.8). The SH pilot scheme displays advanced financial strengths, contributing to several carbon-derivatives businesses. These service companies play a significant role in the CCER market.

Table 4.8 Carbon Derivatives Businesses through the End of June 2015

Time and Place	Business Type	Buyer	Seller
2014.11.4. TJ.	CCER options trading by agreement	Cap. In.	CCF.
2014.12.11. SH.	Mortgage Loans on CCER	TCC	SH Bank
2014.12.26. SH.	CCER purchasing right trading	TCC	CCER Project Owner
2015. 4.8. SH.	CCER trading by agreement	Financial. Inst.[1]	TCC
2015.5.28. SH.	Mortgage Loans on CCER	SH. Zhixin.	SPD Bank
2015.6.9.HB.	Voluntary trading*	Voluntary Industry in Wuhan	Voluntary Industry in Taiwan
2015.6.9. GD.	Carbon neutral business	NGO[2]	CDM Project Owner
2015.6.23. SH.	Carbon neutral and carbon footprint certification	Voluntary Industry from Taiwan	CCER Project Owner
2015.6.25. SH.	CCER asset trading by clearing account	Industrial Bank	TCC

1. *Financial Institution of AJC.*
2. *NGO: Guangdong Low Carbon Development Promotion Association.*

** This voluntary trading is not CCER trading, but VER from the Taiwan industry.*

Source: CCER Exchange Info-Platform. 2015.

In the forthcoming new compliance period, the CCER market continues to face challenges. The most critical is the nontransparent price of CCERs in trading, which may increase the cost of CCERs and obstruct the flow of capital. Most importantly, it conflicts with the purposes of applying CCERs in the carbon market: to reduce the cost to the industries involved and attract more public participation in the reduction of emissions. As shown in Table 4.7, more than half of CCER trading is completed by agreement transactions, which means that sellers and buyers don't have to publish CCER prices. Prices have only been announced in the BJ pilot, even for online transactions. As shown in Table 4.8, a Wuhan company purchased VERs from a Taiwan company in the HB pilot scheme, and an NGO bought credits from a CDM project for carbon neutral development in the GD pilot scheme; however, some news media misunderstood these activities as CCER trading. The effectiveness of these forms of trading is uncertain. Some VER standards, such as Panda Standards, existed prior to the establishment of the CCER market (Wang, 2012). The VER of the Taiwan industry may be certified by a certain standard, but it is not the same standard as that published for the CCER market by the NDRC. The carbon-neutral business of an NGO is under the same conditions: a CDM project is not necessarily a CCER project. Although more diverse carbon businesses can benefit the carbon market, a clear and sound regulation system is needed to maintain a healthy market. Voluntary industries can be protected from false or useless offset projects by comprehensive support and supervision from the government. Furthermore, in a national trading market established prior to the national cap and trade platform, a CCER price evaluation system should be built to assess whether the price is reasonable and fair for all capped industries in all schemes. The uncertainty of CCER project types, and the different restrictions in each scheme on buying CCERs, can impact the capped industries' efforts to offset emissions in cheaper ways. All efforts made to improve the CCER market are certain to contribute to the establishment of the national cap and trade platform in the near future.

4.3 DEVELOPMENT OF CARBON TAX IN CHINA

The other carbon-pricing instrument, carbon tax, was brought onto the agenda by China's Ministry of Finance (MOF) in 2007, yet remains under-researched. The Research Institute of Fiscal Science under the MOF, the Chinese Academy for Environmental Planning, the Energy Research Institute under the NDRC, and Tsinghua University are all participating in the carbon tax research program (Lin and Yang, 2012). In the first period of this research program, the focus was the application of energy tax. Between 2008 and 2009, the research focus shifted to carbon tax. At that time, it was assumed that new environmental taxes, including a carbon tax, would be launched in China in 2013. China's ETSs pilots were initiated in 2013, but a carbon tax was not launched at this time. Although many press reports have announced that a carbon tax will be officially levied in China's 12th Five Year Plan, the latest news is that an Environmental Tax Draft excluding carbon tax has been submitted to the State Council for deliberation.

4.3.1 Difficulties in Reforming Environmental Tax

China's environmental-protection instrument has long emphasized 'pollution charges'. The problem is that these charges are calculated according to resource input rather than pollution output, and the result is usually to undercharge polluters. Therefore, pollution charges will soon be replaced with environmental tax. With the objectives of 'simplifying the tax system, broadening the tax base, reducing the tax rate and strengthening enforcement', China's green tax reform includes the design of various taxes directly and indirectly related to environmental protection and energy saving (Yang et al., 2011). In most OECD countries, environmental tax includes fuel tax, energy tax and consumption tax, which are imposed on both residents and industries. However, China's pollution charges in China are imposed only on industries with the heaviest pollution, such as power plants, the chemical industry, the steel industry, the papermaking industry and the cement industry. In the 2011 CCIED annual report, a framework for environment-related tax in China was proposed (see Figure 4.10). There are two considerations when introducing such a tax: first, whether the tax will be effective for its purpose, such as environmental protection or emissions reduction; second, whether the tax will place an extra burden on industries. Policy makers may emphasize the first consideration, whereas industries are more concerned with the extra cost, due to the ambiguity of the boundaries between tax types. For instance, energy taxation sometimes takes related emissions into account, and may thus overlap with the carbon tax or emissions tax (see Figure 4.11). From the perspective of China's Ministry of Environmental Protection, the tax base should be simple and accurate, and its application should improve the environment. From the perspective of China's Ministry of Finance, the boundary of environmental tax with other tax requires a lot of effort to delineate to avoid imposing excessive levies on the industry. Negotiation and cooperation between departments are critical to the formulation of tax in China today.

Figure 4.10 Future environmentally related tax structure of China

(Adapted form CCICED Annual report in 2011)

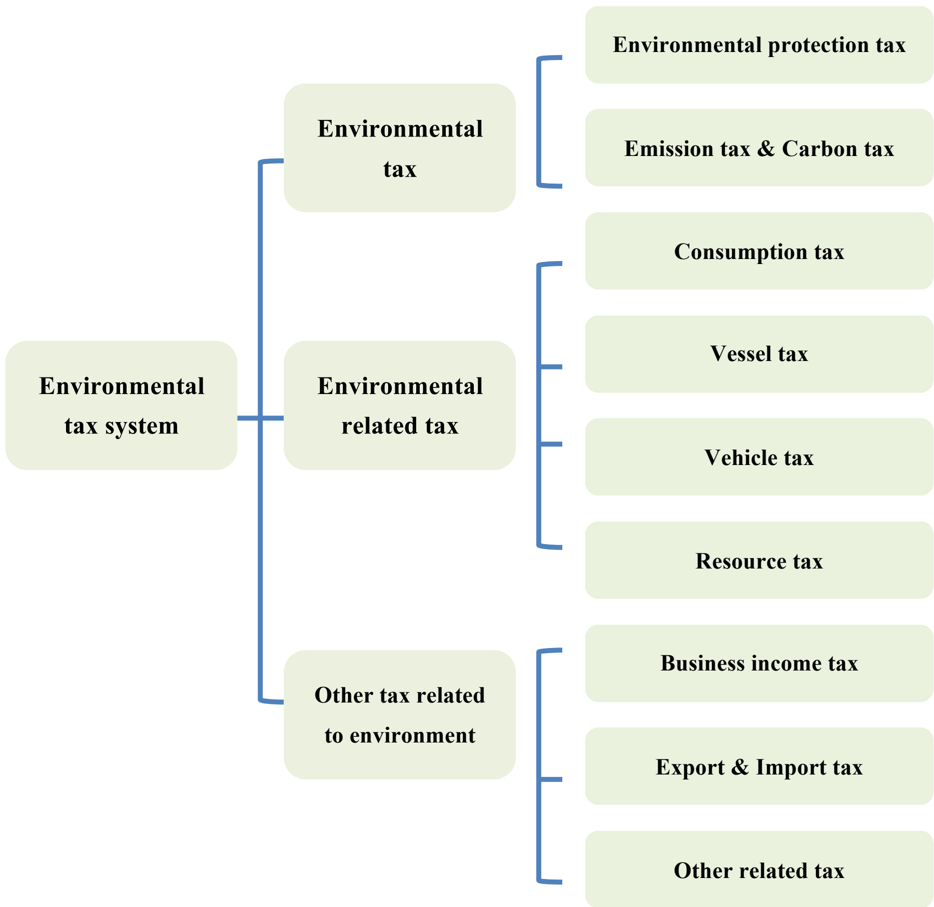
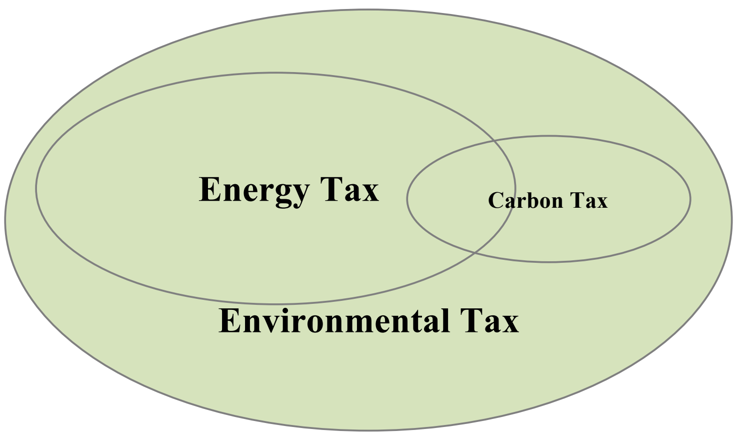


Figure 4.11 The Scope of Different Tax



4.3.2 Benefit and Limitations of Carbon Tax in China

It is clear that a green tax revolution will happen in China. As a representative green tax, a carbon tax offers a means of improving the quality of human life and contributing to the evolution of economic structure. In China's particular circumstances, the carbon tax has remarkable strengths. First, the pattern of high resource input, high energy consumption and low energy efficiency in some areas of China, especially the central and western regions, is no longer a favorable development strategy. Taxing these industries will force local governments to pursue economic development and optimize their industrial structure to maintain competitiveness. The elimination of backward production capacity is imminent in China, as a major manufacturing country, to ensure a sustainable economic or natural environment. Second, some carbon-tariff policies will disadvantage the competitiveness of export enterprises. As a major exporting country, China has levied a carbon tariff on 56 kinds of high energy consumption products before exportation at a rate of 10%, which demonstrates China's commitment to reduce emissions and avoids an environment or energy tax levied by importing countries (Meng, 2010). Third, an appropriate carbon tax levy in China will not affect overall GDP growth but incentivize economic growth in most areas (Hassler, 2013; Meng, 2010; Wang et al., 2009; Zhang et al., 2009).

On the other hand, the tax burden on China's industries is already heavy, and enterprises will inevitably be displeased if the carbon tax is not designed appropriately (Meng, 2010). One of the possible solutions, albeit under-researched, is to fix the total amount of tax and adjust the proportion of the previous tax structure (Jiang et al., 2009). However, as stated above, this requires a lot of negotiation and cooperation from different government sectors. Moreover, some experts propose that the major energy consumption from coal in China will make the carbon tax ineffective, as the capacity to improve coal efficiency and emissions output is very limited, and coal exploration is highly uncertain. The inconsistency between theory and practice has shown up in many countries applying a carbon tax, such as Denmark, Switzerland, Finland and the Netherlands. These countries do not include all fossil energy in their taxation schemes, and some even omit taxes for electricity industries or other major energy users, which makes the effect of the carbon tax uncertain (Wang, 2009).

4.3.3 Co-existence of Carbon Tax and Carbon Trade

Some people assume that the North European countries mentioned above levy much higher carbon taxes on residents than on industries because the EU ETS has constrained emissions from industries. Many experts believe that carbon tax and carbon trading should co-exist in China. In the latest report by the NDRC, China is establishing a carbon pricing system that will combine carbon trading and a carbon tax; it is expected to incentivize industrial restructuring, especially in the central and western areas of China (Idea Carbon, 2014). Experts have pointed out that if carbon trading allowance is auctioned, carbon trading is similar to carbon taxation from the perspective of enterprises; if tax revenue is refunded to support industries, carbon taxation is similar to carbon trading with a free allowance (Stavins, 2008). Carbon taxation is effective in encouraging highly polluting industries to reform in the short term, and carbon trading can provide sustainable and market-oriented incentives for long-term innovation, inducing international carbon trading markets to undertake responsibility for mitigating climate change (Zeng, 2009)

4.4 CHINA’S PILOT SCHEMES: CONCLUSION

Carbon pricing does not simply involve paying for emissions. Both carbon taxation and carbon trading will increase the cost to industries due to 'environment internalization'. However, an appropriate design trading scheme can mitigate emissions, and opportunities for industry compliance are more flexible than those of traditional command and control measures. A mandatory carbon market is more regulated and better organized. A voluntary CCER market is easier for the public to access. A combination of top-down and bottom-up approaches will support China's carbon market.

China's pilot ETSs are strictly managed by the NDRC, especially the cap and trade scheme, which is a top-down approach. The ETSs are characterized by differences in cap settings, industry coverage, and emissions-reduction targets between regional pilots, based on the economic geography of each area. In addition, limitations on industry capacity are emerging after two years' practice. These include a lack of awareness of carbon asset management, not enough specialists, and an inadequate MRV system. A mandatory carbon market is more suitable for China than a voluntary market, as it is more difficult to promote industries' capacity building by voluntary rather than government supervision, and more difficult to encourage industries' emissions reduction through voluntary than government regulation. The establishment of a carbon market requires a lot of effort from a powerful authority in terms of designing policies and assigning tasks to different parties. Given that China's industries have limited experience of emissions reduction, it is better for the Chinese government to build a mandatory carbon market.

On the other side, the theoretical benefits of a national CCER market include attracting more participants to the carbon market, encouraging the construction of renewable energy projects, improving the flow of capital in the market, and providing an experimental platform for the forthcoming national cap and trade scheme. However, as most CCER projects evolved from pre-CDM projects, CCERs may not be sufficient to encourage the required amount of voluntary participation. Hand in hand with the theoretical merits, the more active the carbon derivatives business becomes, the more the government needs to supervise the service sector and CCER prices. Regardless of whether CCER prices are published, the purposes of applying CCERs cannot be changed.

There are good reasons for promoting both carbon taxation and emissions trading in China, but sectoral cooperation and negotiation pose challenges in the future. From the government's perspective, carbon taxation has to effectively reduce emissions; from industries' perspective, the carbon tax cannot overlap with existing energy taxation or environmental taxation, otherwise it will place an extra burden on industry. Lastly, enormous effort is needed to reconcile the differences between regions, unifying quantification methods and carbon prices on a regional basis to maximize the function of emissions trading and aid the construction of a national ETS in 2017.

CHAPTER 5 SUSTAINABILITY FRAMEWORK OF EMISSIONS TRADING SCHEME

In the previous chapter, ETS-related theories and practices are reviewed and concluded. Table 3.9 presents the requirements that must be met for an ideally sustainable ETS, maximizing the positive outcome of an ETS from a theoretical perspective. This table provides an account of the relationship between sustainability and the ETS scheme. To organize these considerations in an analytical framework, as well as linking ETS with the aspects of Chinese society it affects (such as the contents of Figure 3.10 and Figure 3.11), the driving force–pressure–state–impact-response (DPSIR) framework is adopted.

5.1 INTRODUCTION OF DPSIR FRAMEWORK

The function of a conceptual framework for indicators is to focus on and clarify what should be measured, what to expect from the measurement and what kinds of indicators to use (UN, 2007). Big international organizations, such as the OECD, UN and EEA, tend to use so-called state-response models to deal with environmental issues (RSC, 2008). The four most commonly used and recommended models are the pressure-state-response (PSR) model developed by the OECD; the driving force-state-response (DSR) model developed by the UN Commission of Sustainable Development; the DPSIR framework developed by the European Environmental Agency; and the Framework for the Development of Environmental Statistics (FDES) developed by the UN Statistical Commission.

Table 5.1. The Four Main Environmental Indicator Development Models

(Adapted from RSC, 2008)

PSR (OECD)	**DSR (UNCSD)**	**DPSIR (EEA)**	**FDES (UN Statistical Commission)**
Human activities exert pressures on the environment, and that these pressures can induce changes in its state. Society then responds to changes in pressures or state through different environmental and economic policies.	The term 'pressure' has been replaced by 'driving force' in order to accommodate more accurately the inclusion of social, economic and institutional indicators. In addition, the use of the term 'driving force' allows for both positive and negative impacts on sustainable development.	There is a chain of causal links from 'driving forces' through 'pressures" to 'states' and 'impacts', leading eventually to 'responses'. Describing the causal chain from driving forces to impacts and responses is a complex task that tends to be broken down into sub-tasks. The DPSIR framework is useful in describing relationships between the origins and consequences of environmental problems.	FDES is a conceptual framework that could assist in the development, coordination and systemization of environmental statistics. It is a combination of the media and stress-response approaches. It connects environmental components to information categories.

The FDES model requires the input of environmental statistics, which is not suitable for the present study. The difference between the PSR model and the DSR model is that the latter includes the social, economic and institutional changes caused by human activities, rather than simply environmental changes, as in the PSR model. ‘Driving forces’ in the DSR model allow for both positive and negative effects on sustainable development, but ‘pressure’ in the PSR model usually indicates negative environmental changes. DPSIR combines the PSR and DSR models, and thus better describes the relationships between the origins and consequences of environmental problems. Therefore, the choice is made between the DSR and DPSIR models, as exploration of ETS sustainability requires attention to all of the relevant social, economic, environmental and institutional changes.

The origin of the DSR and DPSIR frameworks is the PSR framework. The PSR framework was produced by the OECD based on the notion of causality. The PSR model provides a core set of indicators for environmental performance reviews, based on the principle of dealing with environmental issues in their economic context (OECD, 1993). There are three categories of indicators in a PSR model: environmental pressure, environmental conditions or state and societal response. These three categories are summarized below (OECD, 1993; Linser 2001; Wolfslehner and Vacik, 2007; Hughey et al., n.d.).

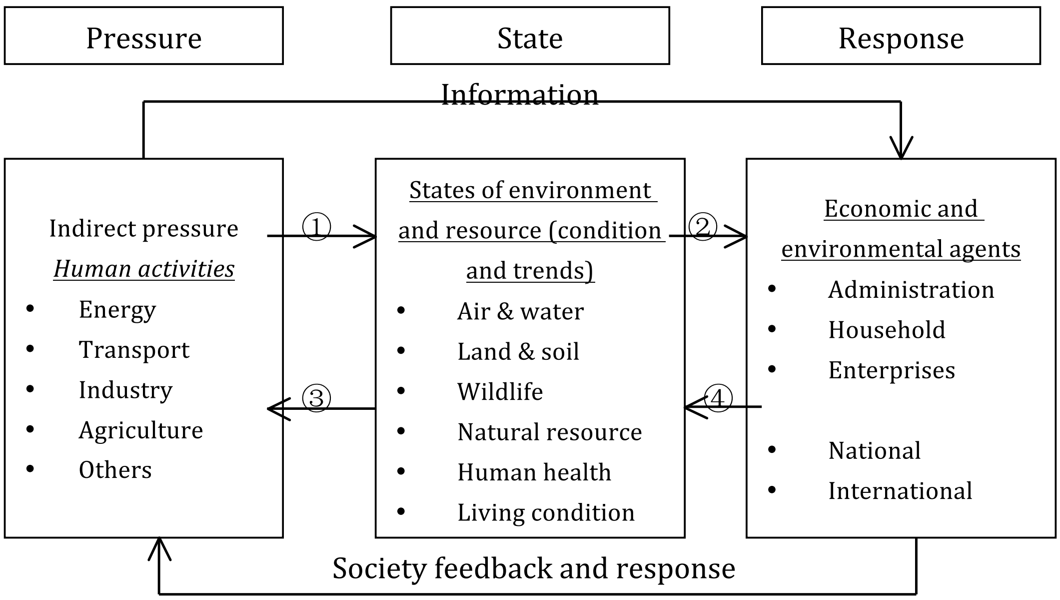
- Environmental pressure describes the activities that exert pressure on the environment, including the quality and quantity of natural resources, such as emissions, the mining of raw materials and fertilizer input.
- Environmental conditions or state describes the status quo of the environment and the quality and quantity of resources and their changes over time, such as in forest areas or areas subject to protective measures.
- Societal response describes human management responses to changes, including any form of organized behavior that seeks to reduce, prevent or ameliorate undesirable changes. This may involve the number and kind of measures taken,

the effort of implementing such measures, or the effectiveness of policies. Responses may range from public activities, such as legislation, taxation, and promotion, to private-sector activities, such as reducing consumption and recycling.

Table 5.2 details the PSR framework.

Table 5.2 PSR Framework

(Adapted from OECD Environmental Indicators)



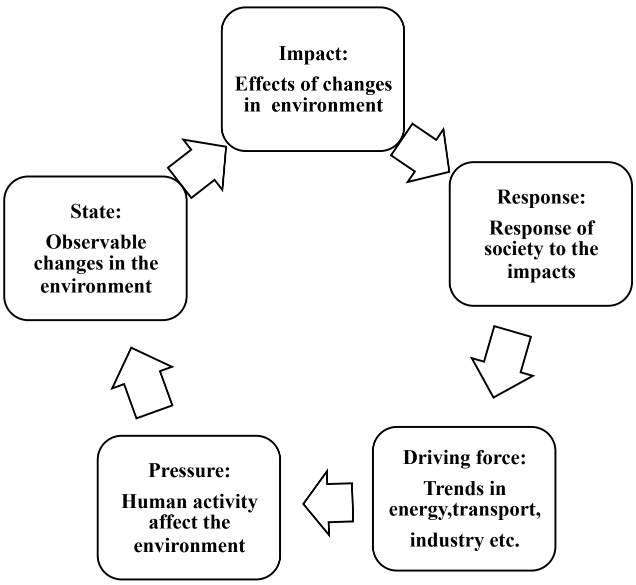
① Pollutant and waste input ② Providing information

③ Resource use ④ Decision feedback

The DPSIR framework is perceived as an extension of the PSR model. In a DPSIR model, driving forces are human activities making environmental changes, and impacts are the results of pressure caused by human activities (Rao and Rogers, 2006). The DPSIR framework is represented in Table 5.3. Driving forces are more likely to affect various aspects of life with changing trends in social development. Pressure refers to specific activities causing changes. In this study, the state parameter is identified as the volume of carbon-dioxide emissions and related environmental issues. Impact is addressed from a socio-economic perspective. Response concerns activities related to the carbon emissions trading process.

Table 5.3 DPSIR Framework

(Adapted from Woodhouse et al.)



PSR and DPSIR are powerful approaches to communication and opinion forming, but limited in terms of scientific analysis (Wolfslehner, 2007). As ETSs cover not only environmental changes caused by human activities, but also social, economic and institutional changes, the DPSIR framework is first selected to establish a

Sustainability Framework for the ETS (SFETS) for further scientific analysis. The SFETS is developed based on the findings in Table 3.9, and its aim is to address the complexity of China's ETSs, including related environmental, economic and social variables. Particularly in the state column, indicators involve not only environmental parameters but also the changing state of industry and society. The environmental system and human activities are linked by the SFETS. The variables and parameters in the SFETS are selected according to the principles of measurability or observability.

5.2 ANALYZING THE SFETS BASED ON THE DPSIR

5.2.1 Driving Forces

Although the original definition of driving forces excluded natural phenomena, some environmental reports have recommended that natural conditions be included as driving forces (Walmsley, 2002). Carbon emissions trading focuses on greenhouse gas emissions, and the volume of emissions is closely related to ecological degradation. For instance, massive forest loggings decrease the area of arable land and reduce the absorption of carbon emissions. This is a vicious circle whose cause and impact are difficult to define, because so many other factors are involved in the ecosystem. However, it is clear that the growing demand for and increasing price of natural resources are the driving forces to which carbon emissions trading constitutes a response.

It is undeniable that industrialization has vigorously encouraged certain economic activities over the last few decades. Human beings are consuming approximately 12,000 times more energy today than they did 400 generations ago (Munasinghe and

Shearer, 1995, cited in Walmsley, 2002). Maintaining this production pattern and economic structure has long relied on massive energy consumption and a high density of human labor, which are today acknowledged to make up an unsustainable economic pattern. The consequence is that markets demand energy fiercely.

From social and political perspectives, a growing population and its increasing demand directly influence resource input and waste output. Although behavior studies have provided many suggestions for a sustainable living pattern, policy regulations and incentives rather than voluntary behavioral changes are still the main instruments. Economic growth has historically been the policy priority, and command and control the most popular policy instrument. However, with further reflection on ecological degradation, authorities realize the need for changes to adapt to a new environment. Furthermore, in addition to economic equity, environmental equity has been brought onto today's political agenda. These are all observable tendencies driving a response in the form of the ETSs.

5.2.2 Pressures

Pressures represent specific activities that happen in the background to driving forces. Similar to the indicators of driving forces, environmental, economic and social pressure indicators are closely related. The environment is degraded by the unconstrained resource use and unlimited pollution output of both individuals and industries. The earliest conscious attempts to protect the natural environment occurred in Tanzania from the late 1800s to the early 1900s. Environmental protection became one of the central government policies around the world from the 1970s, and is considered increasingly important. Reduced energy use and pollution monitoring have long been advocated. Although monitoring is an 'end of pipe' solution to environmental protection, it offers straightforward and evident insights into the situation.

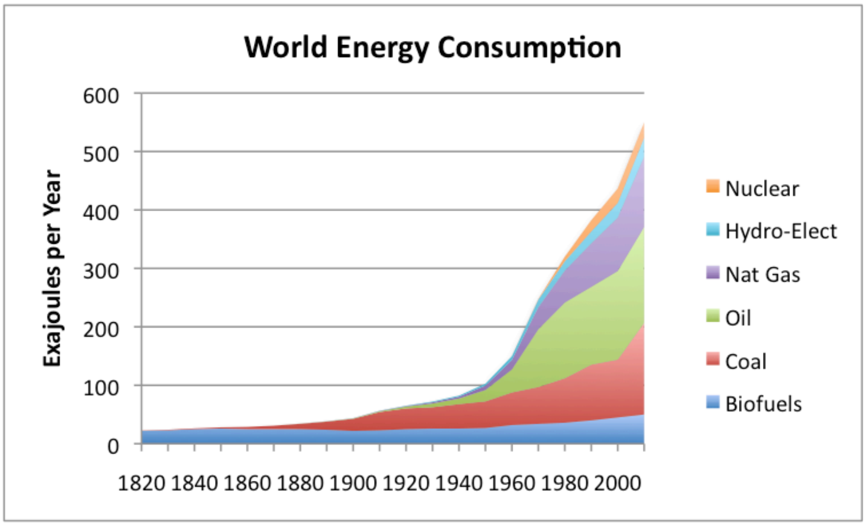
GDP is one of the significant parameters used to evaluate the economic performance of a country; it also highlights the contributions of different industrial sectors. In developed countries, governments usually pursue steady growth in per capita GDP. In contrast, GDP growth targets in some developing countries are sometimes ambitious, and fail to accommodate the need to consider the global environmental crisis. Economic gain is the priority of industries in a country for which GDP is the most important issue. In the struggle between GDP growth and environmental protection, governments apply fines to encourage industries to make changes. However, to maintain their competitiveness, industries are willing to choose the comparatively lower cost of a fine over investing in renovations and upgrading their facilities.

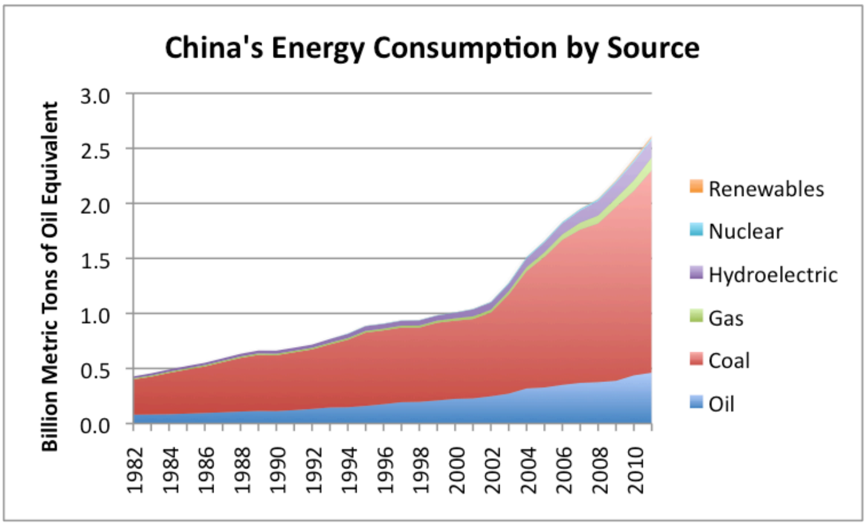
An overall increase in energy demand and consumption, especially the large proportions of oil and coal consumption, has taken place over the last 200 years across the world. In China, coal is the most critical energy resource, and its consumption has increased dramatically over the last decade. Figure 5.1 illustrates both world energy consumption and energy consumption in China by source. It indicates that a dependence on non-renewable energy has been mainstream for the last few decades, or even the last century, and will continue for some time.

The result of overexploiting non-renewable energy resource is an increase in carbon dioxide emissions. Tverberg (2012[a]) displays the changes by area in Figure 5.2, indicating that Southeast Asian countries have significantly contributed to the increase of carbon emissions in the last decade. However, a growth in emissions has a global impact. In response, protective measures are emerging to mitigate ecological deterioration in many societies around the world.

Furthermore, due to their high reliance on natural resources and environmental conditions, districts develop in uneven patterns. China’s coastal areas are more economically active, with a steady growth in per capita GDP; its inner regions, and especially its western areas, are less competitive. But environmental degradation happens everywhere. Figure 5.3 describes the relative per capita GDP rankings of Chinese provinces in 2010; Figure 5.4 illustrates energy consumption from 2010 to 2014 in the various regions, and Figure 5.5 indicates the presence of environmental problems in China. In Figure 5.3, the eastern and southern coastal districts are shown to be most economically competitive; the western and some inner regions are relatively underdeveloped. Energy consumption in the blue areas is expected to be higher than that in the red zones. Figure 5.4 affirms this assumption: economically active areas consume more energy than lower per capita GDP districts. However, environmental degradation still happens in less developed areas. Air pollution has become a national problem, and economically active areas even endure severe acid rain and water scarcity (see Figure 5.5). For this reason, environmental equity, which means that everyone has an equal right to access resources and enjoy a high-quality living environment, has become one of the most important policy objectives.

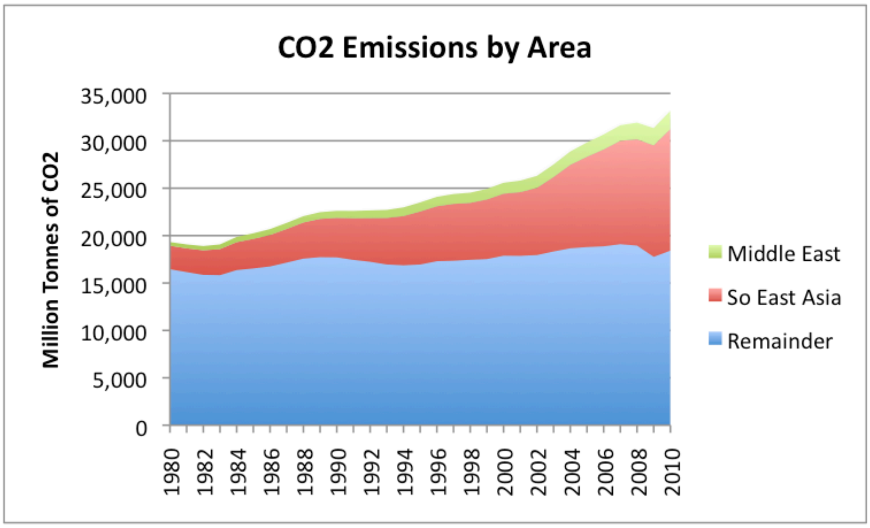
Figure 5.1 World and China's Energy Consumption by Sources





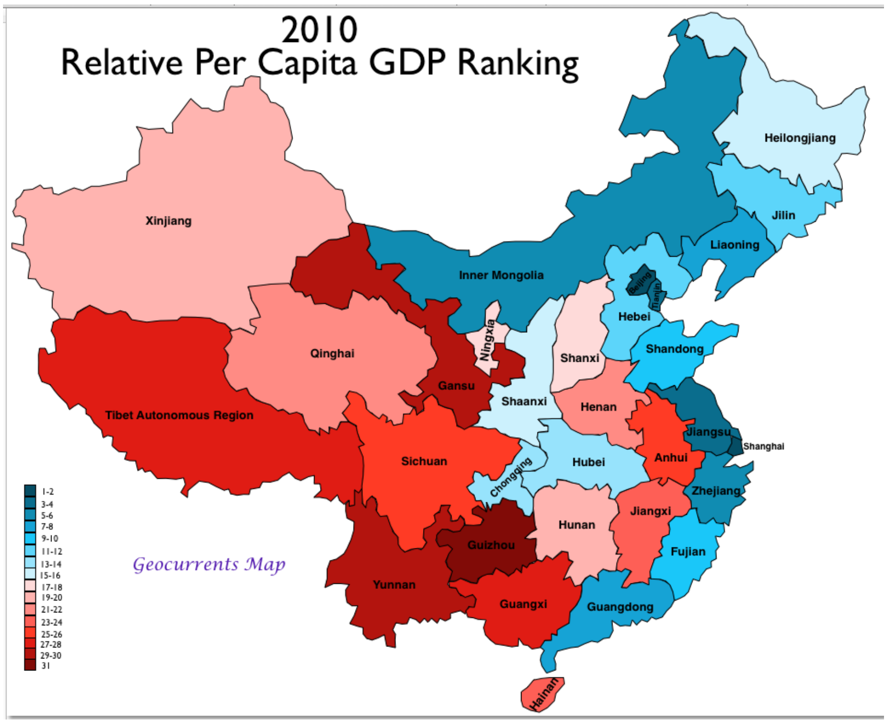
Source: Tverberg, 2012[a, b]

Figure 5.2 Carbon Emissions by Area



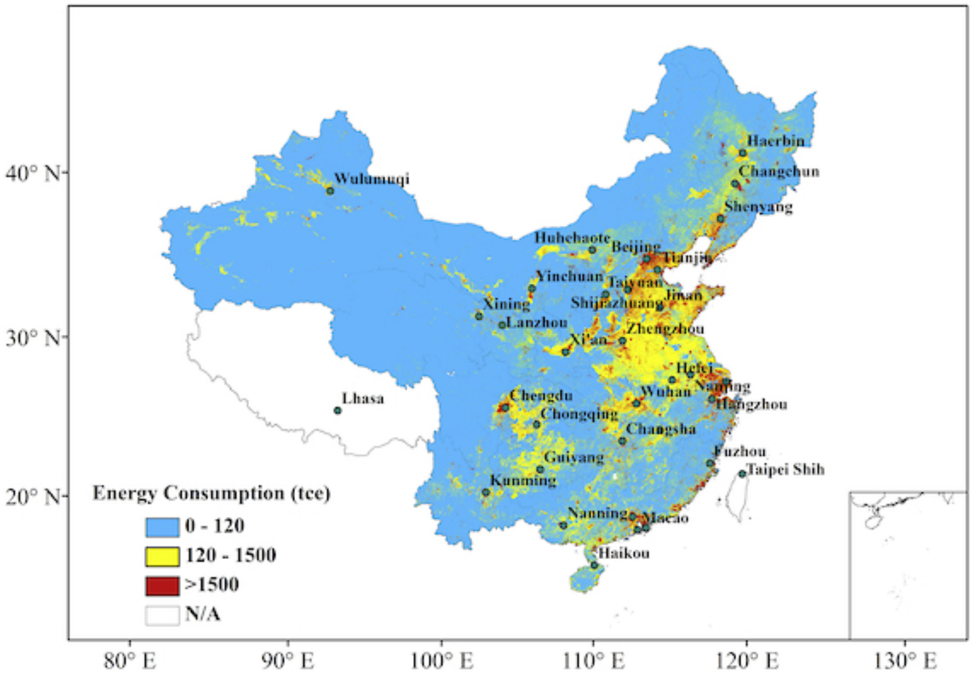
Source: Tverberg, 2012[a]

Figure 5.3 Relative per Capital GDR Ranking in 2010



Source: Lewis, 2013

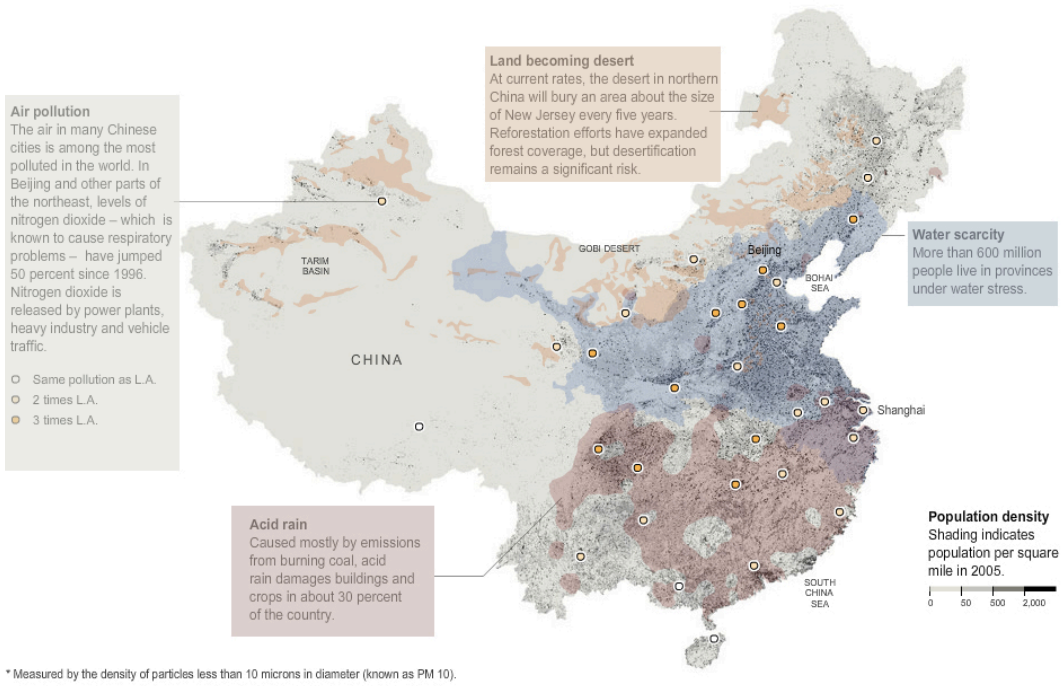
Figure 5.4 Energy Consumption from 2010 to 2014 in Chin



Source: Lu, 2015

Figure 5. 5 Severe Pollution and Environmental Degradation Zone

(Adapted from Carter, et. al., 2007).



5.2.3 States and Impacts

When examining state factors related to the ETSs, one of the most important parameters is the volume of carbon dioxide emissions. Another broader issue relating to carbon emissions trading is climate change, with the increase in frequency of extreme weather around the world. The Earth is expected to become 4-6 degrees Celsius warmer within this century if current emission trends continue (Lynas, 2015). Human activities release the most carbon dioxide and other greenhouse gases into the atmosphere, and are thus primarily responsible for climate change (EPA, n.d.). For this reason, it will be important to constrain individuals' activities, industrial activities, and even government activities to lower emissions and mitigate climate change. More specifically, it is efficient to assess changes and differences in the volume of pollution output from or energy input to individuals or industries. Another parameter selected to evaluate emissions reduction activities is energy pricing. Energy pricing includes carbon pricing, electricity pricing, petroleum pricing, gas pricing and so on. The retail prices of various energy products offer important insights into the energy market. They also relate closely to public life. Incentive schemes such as energy tariff and time-of-use electricity pricing have been used to encourage more economic and energy-efficient activities.

In this study, "impacts" are defined as the social and economic changes caused by pressures. Based on the items shown in Table 3.9, the selected socio-economic parameters reflect impacts on the government and the industry. Under the pressure of an emissions increase, authorities start to realize the importance of balancing economic growth and ecological conservation, considering more diverse policy instruments to implement environment policies. Policy makers also have to examine the effectiveness of existing schemes such as environmental penalties, and supervise the pricing of 'green' products or the quality of emissions-reduction projects. In addition, administrators need to adjust their strategies according to the characteristics of different areas. From the perspective of industries, the pressure of emissions can influence economic strength and capacity, which directly impacts on their willingness to reduce emissions, as well as encouraging the reform and renovation of industries. From a broader perspective, key issues arise in response to pressures, such as the green-technology "fever". Meanwhile, opponents declare that a change in consumption pattern or production pattern is the fundamental approach to confronting such pressures.

5.2.4 Responses

"Response" here is defined as the solution provided specifically by the ETSs to cope with the impacts and confront the pressures. These parameters are extracted from the considerations in Table 3.9, and used to establish a sustainability framework for the ETS. The DPSIR structure is adapted from Rao and Rogers's (2006) research (See Appendix 7).

5.3 ESTABLISHMENT OF SFETS

Table 5.4 shows the SFETS built from the DPSIR framework, which is expected to link ETS with its outcomes within an analytical framework.

Table 5.4 Sustainability Framework of Emissions Trading Scheme

Driving force → **Pressure** → **State** → **Impact**

Tendency forcing changes

Activities stressed on emission

Changes relating with emission and in society

Ecology degradation:
Resource prices
Demand of resource
Economic activities:
Industrial development
Production pattern
Economic structure
Market demand for energy
Social and political development:
Population growth
Consumption pattern
Political priority
Policy instrument
Environmental equity

Environmental aspect:
Unconstrained resource use
Unconstrained pollution
Weak energy and pollution monitor
Economic aspect:
Ambitious GDP
Benefit is priority
Fine is easy to afford
Maintain competitiveness
Social and political aspect:
Energy and resource demanding
Ecology protection demanding
Uneven development of different area

Environmental parameters:
Climate change
Carbon emission
Pollution output
Energy input
Energy price

Socio-economic parameters:
Authority perspective
Balance of economic growth and ecology protection
Chose of policy instrument
Level of environmental fine
Different developing strategy of different areas
The quality of emission reduction
Industry perspective
Economic strength and capacity of industry
The willingness and compliance rate to reduce emission
The reform and reputation of industry
Society awareness
Research of green technology
Changing of consumption pattern

Response: carbon emission trading scheme

Giving price to emission
Setting allowance to emission
Energy technology research and promotion
Monitoring, reporting and verifying scheme
Co-work of carbon tax and carbon trading
Subsidy to emission reduction
Stringent fine and punish to failed reduction
Foster voluntary emission reduction, both offset and trade
Transform from free allowance to auctioned allowance
Price supervision of green product
Efficient level of carbon tax
Integration of carbon market

CHAPTER 6 SUCCESS FACTORS OF EMISSIONS TRADING SCHEME IN CHINA'S BUILDING

In the previous chapter, the ETS was systematized in a DPSIR framework and its effects on the natural environment, economy and society were combined. The SFETS was established to provide an outline for the ETS, indicating how it conveys the principle of sustainable development. However, it is difficult to maximize economic competitiveness, environmental conservation, social equity and governance efficiency at the same time; indeed, in practice, ETSs are barely able to achieve positive effects in all of these areas. The current chapter establishes a conclusive model of the parameters influencing the success of an ETS, and identifies the major factors responsible for the success of China's ETS pilots in reducing emissions in the buildings covered by the scheme. Delphi interviews are selected as the research technique, and DSR is used to build the model.

6.1 DELPHI INTERVIEWS

6.1.1 Selection of Research Techniques

In this study, the parameters used to evaluate the success of China's ETSs were suggested by experts. As the data collected were expert opinions, the research was qualitative. Interviews and focus groups are the most common methods of data collection in qualitative research: a focus group is a group discussion guided, monitored and recorded by the researcher, while interviews require interpersonal skills such as questioning, conversing and listening (Gill. et. al. 2008). Table 6.1 lists the features of interviews and focus groups. Interview may be structured, semi-structured or unstructured; a focus group is a form of group interview (McLeod, 2014). Interviews are usually compared with questionnaires (Surbhi, 2016). Interviews provide in-depth insight into participants' attitudes, thoughts, and actions, while questionnaires provide evidence of patterns within large populations (Kendall, 2008). Table 6.2 offers a comparison of interviews and questionnaires.

Table 6.1 Summary of Interview and Focus Group

Focus Group	Interview
• A group of individuals selected and assembled by researcher to discuss and comment on (Powell, et.al. 1996). • Rely on interaction within the group based on topics supplied by the researcher (Morgan, 1997). • Focus group usually last one to two hours at a neutral location so as to avoid either negative or positive association with a particular site or building (Powell and Single, 1996). • Enable researcher to gain a larger amount of information in a shorter period of time (Gibbs, 1997). • The role of moderator, usually the researcher, is critical. Especially in terms of providing clear explanation of the purpose of the group, and facilitating interaction between group members (Gibbs, 1997).	• Interview is to explore the views, experiences, belief or motivations of individuals on specific matters (Gill, et.al.2008). • There are structure interview, semi-structure interview and un-structure interview; all of them have strengths and limitations. For instance, structures interviews can obtain results from a large sample in a short time, but the results are usually quantitative data; un-structure interview can generate qualitative data but it is time consuming and sometimes expensive (McLeod, 2014). • Semi-structure interview allows respondents to express their views in their own terms, which can provide reliable, comparable qualitative data (RWJF, 208).

Table 6.2 Comparison of Interviews and Questionnaires

(Surbhi, 2016)

BASIS FOR COMPARISON	QUESTIONNAIRE	INTERVIEW
Meaning	Imply a form consisting of a series of written or printed multiple choice questions, to be marked by the informants	A formal conversation between the interviewer and respondent wherein the two participates in the question answer session
Form	Written	Oral
Nature	Objective	Subjective
Questions	Closed Ended	Open Ended
Information Provided	Factual	Analytical
Order of Questions	Cannot be changed	Can be changed
Cost	Economical	Expensive
Time	Informant's own time	Real time
Communication	One to many	One to one
Non-response	High	Low
Identity of Respondent	Unknown	Known

The aim of the present research is to identify the factors responsible for the success of China's ETSs in reducing emissions in buildings, which requires comparison between factors: some will play a greater part than others. To achieve the research aim, a factor-weighting approach was proposed. However, qualitative research methods such as interviews normally explore a subject rather than numbers, with the exception of Delphi research (Dobney, 2000).

6.1.2 Introduction to Delphi Interviews and Experts Selection

The Delphi method was originally developed to solve military issues in the US in 1953. Its aim was to obtain a reliable consensus from a group of military experts using a series of intensive questionnaires interspersed with controlled opinion feedback, with the results of each round fed into the next round (Linstone and Turoff, 1975). It is considered to be one of the most effective agreement-reaching qualitative methodologies (Jones, 1980). The following objectives can be achieved using Delphi techniques, as summarized by Delbecq, Van de Ven and Gustafson (1975).

1. *To determine or develop a range of possible alternatives;*
2. *To explore or expose underlying assumptions or information leading to different judgments;*
3. *To seek out information which may generate a consensus on the part of the respondent group;*
4. *To correlate informed judgments on a topic spanning a wide range of disciplines;*
5. *To educate the respondent group as to the diverse and interrelated aspects of the topic.*

In this research, certain parameters identified in the SFETS are assumed to influence the success of the trading scheme. The Delphi technique can be used to determine whether experts agree on given parameters, and whether any parameters are missing. Therefore, the experts' feedback was used to judge the usefulness of the SFETS. Another advantage of the Delphi technique is that the participating experts can reassess their initial judgments in each step (Hsu and Sandford, 2007). The research moves forward when the experts reach an agreement on parameters. The ultimate purpose of the Delphi interviews conducted in this study was to ask experts to rate selected parameters to identify factors responsible for the success of China's ETSs in reducing building emissions.

In line with the aim of the research, the following criteria were used to determine whether the participants' contribution of professional knowledge would be suitable for the study.

1) Participants work with and have extensive experience or knowledge of China's ETSs;
2) participants work in the building industry and manage emissions trading in their properties in Beijing, Shanghai or Shenzhen; and
3) participants have a detailed knowledge of China's ETSs..

The experts were deemed suitable if they met one or more of the above criteria. A list of the panel members and their demographic characteristics is provided in Table 6.3. The experts' names and organizations have been anonymized. The interview questions were primarily sent out by email, but some were delivered and collected in person.

Table 6.3 List of the Information of Experts for the Delphi Interview

Organization of experts/Type of work	**Number**
Government officers	4
Trading organization officers	4
Building managers	5
Third party consultants	6
Academic experts	5

6.2 FIRST ROUND OF INTERVIEWS

The purpose of the first round of interviews was to collect experts' opinions on the parameters, which represented potential factors in the success of the ETSs. Traditionally, the first round of the Delphi process begins with an open-ended questionnaire (Hsu and Sanford, 2007). Using the feedback obtained in the open-ended questionnaires, parameters are rearranged and made more focused.

In the first round of interviews, 24 experts were asked to select parameters that could be used to evaluate the success of the ETSs in the building sector. They were permitted either to choose from the 12 response activities in the SFETS or to suggest parameters of their own. Fewer parameters were suggested by the experts than selected from the SFETS, and their chosen parameters were more general. Therefore, it was necessary to remove redundant parameters from the SFETS and rebuild the evaluation framework to increase its accuracy and focus. Based on the feedback, five parameters were conclusively identified: 'volume of emissions reduction', 'compliance rate of the industry in reducing emissions', 'competitiveness of the industry in reducing emissions', 'quality of emissions reduction', and 'radical awareness of emissions reduction'. However, these five parameters did not reflect the concrete emissions reduction activities undertaken under the ETSs, which are summarized in the response column of the SFETS and in Table 3.9. Therefore, the next step was to link the five parameters with the 12 response activities in the SFETS and the 23 considerations listed in Table 3.9. Emissions trading activities and considerations are responses from society to inefficient emission mitigation. The process is to some extent causal. Next, the DSR framework was borrowed to link the parameters with emissions trading activities, as the driving forces may be either negative or positive. The model is presented in Table 6.4.

The five measurable parameters concluded by the experts were the changing states in the Indicator Assessment Model for ETSs (IAMETS). The weights of the parameters were then evaluated in the third round of the Delphi interviews. Each of the five parameters has relevant driving-force indicators and response indicators. The total 15 response indicators describe the effects on ETSs of the driving forces. The changing status of the five parameters can directly influence the success of the ETSs. For instance, the more emissions are reduced, the more efficient the trading scheme. However, when the maximum volume of emissions is reduced, the competitiveness of the industry must also be addressed. Therefore, the weights of the parameters need to be measured in each particular scenario to identify the success factors.

Table 6.4 The Indicator Assessment Model of The Emissions Trading Scheme

DRIVING FORCE	STATE (parameters)	RESPONSE (indicators)
Unconstrained resource/energy use, and pollution output	Volume of emissions	Carbon pricing scheme on emissions (tax or trade)
		Comprehensive emissions monitoring, reporting and verifying (MRV) system
Weak environmental monitoring and assessment		Identifying the emissions reduction scope (industry) and coverage (gas)
		'Green' technology guidance and promotion
Mono command and control emissions policy	Compliance rate of industry to reduce emissions	Financial assistance and CCER scheme
Low environmental tax and fines		Applying stringent fines for non-compliance
Cost of abatement	Competiveness of industry when reducing emissions	Incentives: subsidy or tax waiver
		Reward or labeling schemes
Open access to emissions reduction	Quality of emissions reduction	Transparent carbon price/CCER price
		Accurate verification system
Diverting emissions site or abatement cost		Integration and cooperation of carbon markets in China
		Supervision of cost delivery of carbon reduction
		Transform from free allowance to auctioned allowance
Intense regulation on emissions	Radical awareness of emissions reduction	Encourage voluntary reduction
High dependence on green technology		Improve production/operating pattern

6.3 SECOND ROUND OF INTERVIEWS

The second round of interviews involved sending out questionnaires and asking experts to review the IAMETS. Structured questionnaires were sent out to elicit the experts' responses, which were indicated by ticking relevant items and removing irrelevant ones. In the second round of interviews, a consensus was formed and the actual outcomes were identified from among the experts' responses (Jacobs, 1996). The experts reached an agreement on the IAMETS.

6.4 THIRD ROUND OF INTERVIEWS

The purpose of the third round of interviews was to obtain the experts' ratings of the parameters agreed in the IAMETS. As no disagreements occurred in the second round of interviews, it was not necessary to ask the experts to state the reasons for their disagreement. In the third round of interviews, the experts were invited to rate the importance of five state parameters to the success of ETS in the building sector. Numerical values were used to indicate the relative importance of the parameters, using a Likert scale. Details are shown in Table 6.5.

Table 6.5 Quantifying the Evaluation by Likert Scale

Level of importance	Ranking value
Extremely important	5
Important	4
Relatively important	3
Somewhat important	2
Not important	1

Judgment criteria	Quantify value (C_1)
Practice and experience	4
Theoretical study	3
Public information or peer discussion	2
Intuition	1

Level of experience	Quantify value (C_2)
Very experienced	4
Experienced	3
Relatively experienced	2
Less experienced	1
Not experienced	0

The first step in processing feedback is to analyze internal consistency and reliability using Cronbach's alpha. The higher the value of Cronbach's alpha, the more correlations there are between the parameters. Cronbach's alpha for the experts' ratings in this research was 0.834, which means that the credibility of the rating is very high and the data are extremely acceptable. In addition, the five selected parameters were all considered to influence the success of China's ETSs in reducing building emissions. None of the five parameters needed to be deleted or revised.

One of the most important elements of a Delphi interview is the level of soundness attributed to expert opinions. C_R is used to represent the experts' level of authority on the subject, using the following formula.

$$C_R = \frac{C_1 + C_2}{2}$$

In this study, 11 experts' opinions received authority level 4, and 9 were greater than or equal to 3. The lowest C_R value was 2. Overall, the experts displayed a fairly high level of authoritativeness.

The extent of the experts' positive response, k, is also a consideration. k is calculated by the ratio of the number of experts who rate parameter i, m_i, to the total number of experts, m. The formula is as follows.

$$k = \frac{m_i}{m}$$

In this study, all of the experts offered responses, so k was 100%.

After identifying the extent of the experts' authoritativeness and positive response, the coefficient of concordance between the experts needed to be tested. Kendall's coefficient of concordance, W, was used to measure the level of agreement between the raters. The formula is as follows:

$$W = \frac{12}{m^2(n^3 - n) - m\sum_{i=1}^{m} T_i} \sum_{i=1}^{n} d_i^2 ,$$

in which,

$$\sum_{i=1}^{n} d_i^2 = \sum_{i=1}^{n} (R_i - \overline{R})^2 .$$

The above formula is based on the assumption that m raters rate a total of n parameters in rank order from 1 to n. Let r_{ij} = the rating that rater j gives to the parameter i. Let

$$R_i = \sum_{i=1}^{m} r_{ij}$$

so R_i is the sum of the ratings given by the experts to parameter i, and $\overline{R}$ is the mean of R_i. d_i^2 is the square deviation. In addition,

$$T_i = \sum_{l=0}^{L} (t_l^3 - t_l)$$

L is the number of groups with the same parameter ratings given by experts j; t_l is the number of parameters with the same ratings in group L. W is 0.803, which indicates agreement among the experts. The p-value is 7.30E-16, which is < 0.01. Therefore, the null hypothesis that the experts do not agree can be rejected.

The advantage of Delphi interviews is that experts' authoritativeness is considered when calculating weighted arithmetical means, using the following formula.

$$\overline{C}_i = \frac{1}{m} \sum_{j=1}^{m} C_R C_{ij}$$

$\overline{C}_i$ is the weighted arithmetical mean of parameter i. The greater $\overline{C}_i$, the more important the parameter. C_{ij} is the rating given by expert j to parameter i. The frequency of full credit, k_i, is another criterion used to evaluate the importance of parameter i. The formula is as follows:

$$k_i = \frac{m_i^{'}}{m_i},$$

where $m_i^{'}$ is the number of experts who gave a full credit rating to parameter i, and m_i is the total number of experts rating parameters i. All of the experts rated all of the parameters in this study (k = 100%), so $m_i = m$. The higher the value of k_i is, the more important the parameter is. Lastly, the coefficient of variation, v_i, is used to indicate fluctuation in ratings, i.e. the variance in the experts' ratings of parameter i. The lower the value of v_i, the greater the concordance among the experts. The formula is as follows:

$$v_i = \frac{S_i}{C_i},$$

where S_i is the standard deviation of the parameters' rating:

$$S_i = \sqrt{\frac{\sum_{i=1}^{m_i}(C_{ij} - \overline{C}_i)^2}{m_i - 1}}.$$

The results of the Delphi interviews are summarized in Table 6.6. After normalizing

$\overline{C}_i$, the most important parameter was found to be 'volume of emissions reduction'.

Table 6.6 The Results of The Delphi Interview

	$\overline{C}_i$	k_i	R_i	S_i	v_i	***Normalization***
P_1	*14.896*	*0.375*	*104*	*0.56*	*0.376*	***0.249***
P_2	*12.333*	*0*	*86*	*0.50*	*0.041*	***0.206***
P_3	*10.042*	*0*	*70*	*0.65*	*0.065*	***0.168***
P_4	*13.604*	*0.125*	*95*	*0.55*	*0.040*	***0.228***
P_5	*8.917*	*0*	*62*	*0.65*	*0.073*	***0.149***

Table 6.7 The Parameters' Weight

Parameters	Weight
P_1: *volume of emissions*	*0.249*
P_2: *compliance rate of industry*	*0.206*
P_3: *competitiveness of industry*	*0.168*
P_4: *quality of emissions reduction*	*0.228*
P_5: *radical awareness*	*0.149*

6.5 IDENTIFICATION OF SUCCESS FACTORS

China's ETSs currently cover many industries, and it is important to understand which parameters influence its implementation and success in different scenarios. For instance, the parameters influencing the success of an ETS in the cement industry may differ from the parameters affecting its success in power plants. In this research, evolving the SFETS into the IAMETS was the preliminary step. The IAMETS was built into a DSR framework by Delphi interviews, and the experts reached a consensus on five parameters indicating the success of an ETS in the building sector. The parameters ‘volume of emissions reduction’ and ‘quality of emissions reduction’ were weighted as the two major factors in the success of the ETSs in reducing emissions in Chinese buildings. As the relationship between the state parameters and their corresponding response indicators is causal, weighting the response indicators can reflect whether the model is logical and the findings are precise. The next chapter reports on the distribution of questionnaires to weight the response indicators and thereby validate the success factors identified in this chapter. In addition, cases of buildings under the ETSs are selected and examined to explore the impact of the identified success factors in the real world.

CHAPTER 7 VALIDATION AND EXAMINATION OF THE SUCCESS FACTORS

In this chapter, the results of the Delphi interviews are validated by comparison with the findings of another independent questionnaire survey. Twenty-four experts were selected for the Delphi interviews by purposive sampling, as explained in the previous chapter. A snowballing practice was used to select the target group for the questionnaire survey: each expert was asked to distribute five questionnaires to their colleague to weight the response indicators in the IAMETS. Principal component analysis (PCA) was used to process the weightings of the response indicators. The purpose of the questionnaires was to ensure the reliability and increase the accuracy of the weighting, and to verify the consistency of the model. For instance, the most frequently observed parameter in the Delphi interviews was the ‘volume of emissions reduction’, which can be verified by adding up the weights of its corresponding indicators – ‘carbon pricing scheme on emissions’, ‘comprehensive MRV system’, ‘identifying emissions reduction scope and coverage’, and ‘green technology promotion and guidance’. If the results are consistent, the weighting was considered to be reliable and the structure of the IAMETS logically supported. Otherwise, the model or data-collection procedure needed to be revised. Another validation process involved reviewing published reports in the same field and comparing their findings with the success factors identified in the present research.

7.1 VALIDATION BY QUESTIONNAIRES

7.1.1 Design of Questionnaires

The purpose of the questionnaires was to rate the 15 indicators. The experts selected for the Delphi interviews distributed 120 questionnaires: each expert was asked to send five questionnaires to their colleagues, who are assumed to be able to provide valuable feedback. The quantified importance of the indicators was the same as that in the first chart in Table 6.5. We obtained 103 completed questionnaires.

7.1.2 Questionnaire Data Analysis

Both the reliability and the consistency of the questionnaire data had to be tested at the beginning to ensure their availability for further analysis. Cronbach's alpha for the 15 indicators was 0.865, which indicated that the rating was highly reliable. Kendall's W was 0.660, with a p-value of 3.36E-194 < 0.01, which means agreement was reached by the raters, and these data could be processed for further analysis.

The technique used to analyze the weighted data was based on PCA, a process of deducting variables and reducing dimensions but also maintaining the original information as must as possible. First, the Kaiser-Meyer-Olkin (KMO) measure was used to determine whether the data could be analyzed by PCA. The result is shown in Figure 7.1. A KMO value > 0.7 indicates that the questionnaire data can be examined by PCA.

Figure 7.1 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.799
	Approx. Chi-Square	721.590
Bartlett's Test of Sphericity	df	105
	Sig.	.000

Many principles can be used to select components. The most common criteria are that the components' cumulative variance contribution rate is more than 80%, and that eigenvalues are greater than 1; however, these criteria must sometimes be adjusted in practice. After processing the data by SPSS, five components were extracted with eigenvalues greater than 1, which also represented 75.391% of the information conveyed in the original 15 indicators. The cumulative variance contribution rate was 75.391%, which is < 80%. As 15 indicators were weighted by 103 raters, and the decrease slowed after the first five components (see Figure 7.2), the cumulative variance contribution rate was reasonable and acceptable in practice. Details are provided in Table 7.1.

Figure 7.2 The Scree Plot in PCA

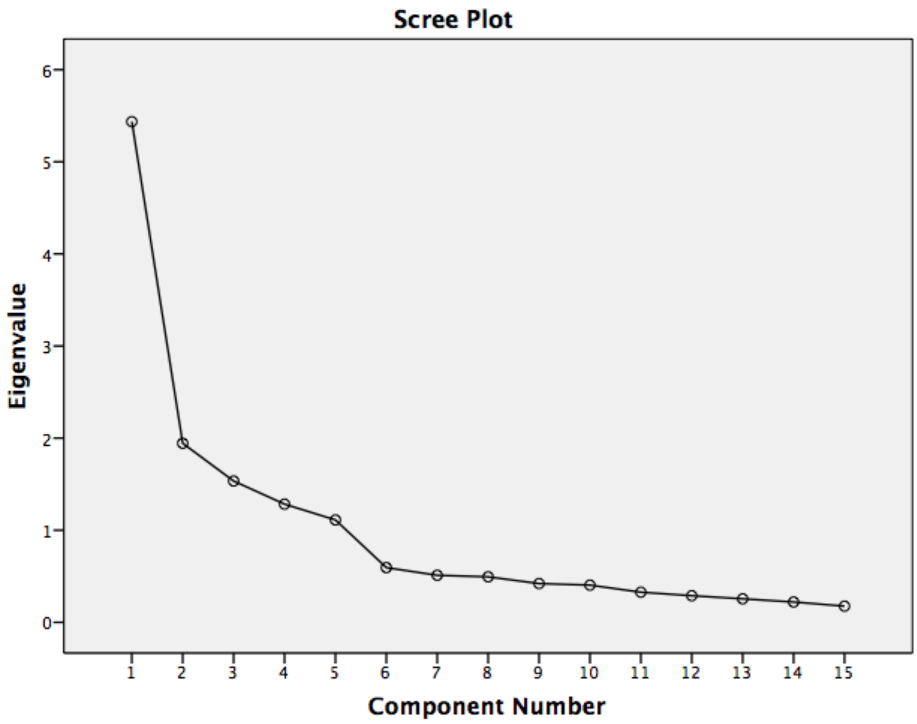


Table 7.1 Component Extracted by PCA

Component	Initial Eigenvalues		
	Total E_i	% of Variance V_i	Cumulative %
1	5.436	36.238	36.238
2	1.944	12.960	49.197
3	1.534	10.228	59.425
4	1.283	8.555	67.980
5	1.112	7.411	75.391

Table 7.2 Component Matrix

Indicator	Component X_{ij}				
	1	2	3	4	5
$\mathbf{I_1}$	.407	.725	-.144	.068	.035
$\mathbf{I_2}$	.567	.098	-.072	.552	.319
$\mathbf{I_3}$	.505	-.258	.261	.640	.225
$\mathbf{I_4}$	.154	.698	.441	.163	.000
$\mathbf{I_5}$	.634	.131	.112	-.457	.426
$\mathbf{I_6}$	.732	-.311	.226	-.139	.121
$\mathbf{I_7}$	.688	-.033	.001	-.458	.298
$\mathbf{I_8}$	.838	-.108	-.161	-.133	-.029
$\mathbf{I_9}$	.655	.153	-.201	.069	-.526
$\mathbf{I_{10}}$	.658	.518	.187	.019	.034
$\mathbf{I_{11}}$	.708	.063	.149	-.132	-.407
$\mathbf{I_{12}}$	.540	-.262	.445	-.035	-.458
$\mathbf{I_{13}}$	.562	-.571	.248	.161	.042
$\mathbf{I_{14}}$	.569	-.193	-.588	.003	.073
$\mathbf{I_{15}}$	.512	.032	-.674	.179	-.110

Extraction Method: Principal Component Analysis.

Table 7.2 lists the indicators' loading for the five extracted components. With the indicator loadings given as X_{ij} in Table 7.2 and the components' eigenvalues given as E_i in Table 7.1, the linear combinations of indicators were generated by regression coefficient B_{ij}, where i represents the number of components extracted and j represents the number of indicators. For instance, 0.407 is the loading of **I1** for the first extracted principal component, which can be represented as X_{11}. The regression coefficient B_{ij} is calculated as follows.

$$B_{ij} = \frac{X_{ij}}{\sqrt{E_i}}$$

The results for the regression coefficient B_{ij} of each indicator in the five extracted components are calculated using Excel and listed in Table 7.3.

Table 7.3 Results of Regression Coefficient

INDICATORS	B_{1j} in F_1	B_{2j} in F_2	B_{3j} in F_3	B_{4j} in F_4	B_{5j} in F_5
I_1	0.175	0.520	-0.116	0.060	0.033
I_2	0.243	0.070	-0.058	0.487	0.302
I_3	0.217	-0.185	0.211	0.565	0.213
I_4	0.066	0.501	0.356	0.144	0
I_5	0.272	0.093	0.090	-0.403	0.404
I_6	0.314	-0.223	0.182	-0.123	0.115
I_7	0.295	-0.024	0.001	-0.404	0.283
I_8	0.359	-0.077	-0.130	-0.117	-0.028
I_9	0.281	0.120	-0.162	0.061	-0.499
I_{10}	0.282	0.372	0.151	0.017	0.032
I_{11}	0.304	0.045	0.120	-0.117	-0.386
I_{12}	0.232	-0.188	0.359	-0.031	-0.434
I_{13}	0.241	-0.410	0.200	0.142	0.040
I_{14}	0.244	-0.138	-0.475	0.003	0.069
I_{15}	0.220	0.023	-0.544	0.158	-0.104

Therefore, the linear combination of the first principal component, F_1 and the second principal component up to the fifth principal component is listed below.

$$\begin{aligned}
F_1 &= 0.175 * I_1 + 0.243 * I_2 + 0.217 * I_3 + ... + 0.220 * I_{15} \\
F_2 &= 0.520 * I_1 + 0.070 * I_2 - 0.185 * I_3 + ... + 0.023 * I_{15} \\
&... \\
F_5 &= 0.033 * I_1 + 0.302 * I_2 + 0.213 * I_3 + ... - 0.104 * I_{15}
\end{aligned}$$

In Table 7.1, '% of Variance' indicates the variance contribution rate for each principal component. The higher the value of V_i is, the more important the principal component is. So V_i can be used to weight the principal components. The purpose of the questionnaire was to weight the indicators I_j, using the following formula.

$$I_j = \frac{\sum_{i=1}^{5} B_{ij} V_i}{\sum_{i=1}^{5} V_i}$$

The weight of each indicator is presented in Table 7.4.

Table 7.4 The Weight of the Indicators

Indicator	Coefficient of Weight	Normalization
I_1	0.168	0.085
I_2	0.206	0.105
I_3	0.186	0.095
I_4	0.182	0.093
I_5	0.153	0.078
I_6	0.135	0.069
I_7	0.120	0.061
I_8	0.126	0.064
I_9	0.092	0.047
I_{10}	0.225	0.114
I_{11}	0.119	0.060
I_{12}	0.082	0.042
I_{13}	0.093	0.047
I_{14}	0.036	0.018
I_{15}	0.044	0.022

7.1.3 Comparing the Results of Delphi Interviews and Questionnaires

Two independent data collection processes – Delphi interview and questionnaire surveys – were conducted for two reasons. The first was to examine the structural consistency and reliability of the IAMETS. The IAMETS is built based on the causality of the DSR framework, but whether the response indicators positively affect the corresponding state is still uncertain. The use of two independent data collection methods can overcome this uncertainty and verify their relationship. The second purpose is to combine the subjective weighting of parameters and indicators with objective analysis of the feedback by PCA. Delphi interviews and questionnaire surveys reflect experts' subjective opinions on the importance of different parameters and indicators for implementing ETSs in buildings. Meanwhile, analyzing the questionnaires by PCA, which is an objective data processing method, increases the credibility of the research. Ultimately, the success factors identified are validated.

In the IAMETS, indicator 1 to indicator 4 (I_1 to I_4) correspond to parameter 1 (P_1), and I_5 and I_6 are categorized as P_2 (see Table 7.5). Summing the weighting of the indicators for the five groups generates five group weightings: G_1 to G_5. Comparison of the P and G values reveals that 'volume of emissions reduction' and 'quality of emissions reduction' are the most important and second most important parameters, respectively, used to assess the success of China's ETSs in buildings.

In terms of the indicators' weighting, indicator 10 (I_{10}) and indicator 2 (I_2) – 'accurate verification system' and 'comprehensive emissions monitoring, reporting and verifying (MRV) system' – are the two most important indicators of the success of ETSs in reducing emissions in buildings. The structure of the IAMETS is proven to be consistent, allowing us to evaluate the importance of different indicators in different scenarios.

Table 7.5 The Comparison of Parameters' Weighting and Indicators' Weighting

Parameters' Weighting by Delphi interview	Indicators' Weighting by PCA	
P_1: 0.249	**I_1**: 0.085 **I_2**: 0.105 **I_3**: 0.095 **I_4**: 0.093	**G_1**: 0.378
P_2: 0.206	**I_5**: 0.078 **I_6**: 0.069	**G_2**: 0.147
P_3: 0.168	**I_7**: 0.061 **I_8**: 0.064	**G_3**: 0.125
P_4: 0.228	**I_9**: 0.047 **I_{10}**: 0.114 **I_{11}**: 0.060 **I_{12}**: 0.042 **I_{13}**: 0.047	**G_4**: 0.31
P_5: 0.149	**I_{14}**: 0.018 **I_{15}**: 0.022	**G_5**: 0.04

7.2 USE OF RESEARCH FINDINGS TO VALIDATE SUCCESS FACTORS OF ETS IN BUILDING SECTOR

In Beijing, Shanghai and Shenzhen, buildings' emissions are constrained by the ETSs: public buildings emitting more than 10,000 tonnes of emissions a year are included in the ETS in Beijing and Shanghai; and public buildings whose area exceeds 20,000 square meters, government buildings whose area exceeds 10,000 square meters, and buildings emitting more than 5000 tonnes of emissions annually are included in Shenzhen's ETS (details presented in Table 4.1). In the last three compliance years, all of the buildings subject to the scheme have fulfilled their duties under the ETSs. However, despite this perfect compliance rate, problems with the implementation of the ETSs in buildings remain unsolved.

An accurate and comprehensive MRV system was found to be a factor in the success of China's ETSs in reducing emissions in buildings, which indicates that the current system has limitations. Indeed, the limitations of MRV systems in China's ETSs have been emphasized in many studies (Bo et al., 2014; Wang, 2012; Sino Carbon, 2014). The conclusion to Chapter 4 of this study also highlights that the deficiencies of China's MRV systems. More specific difficulties arise in the building sector: first, the amount of energy saved in a single building is much lower than the equivalent figures for emissions-reduction projects in other industries, such as in power plants or the cement industry. This suggests that the financial incentive to save energy or reduce emissions is too limited to be attractive (Mo, 2016; Zhou and Duan, 2014). Second, energy usage is significantly influenced by humans' lack of energy awareness, which can increase energy usage by up to a third (Nguyen and Aiello, 2012) – for example, a lot of energy can be consumed even in a green building if inappropriate energy-consuming behavior takes place. Third, an energy efficiency building project is generated through cooperation and coordination between departments, which can increase transaction costs and may create conflicts regarding benefit distribution within an ETS (Zhou and Duan, 2014). Lastly, a building's energy saving performance can be affected by external factors such as weather, building function and occupancy rate, making it difficult to accurately audit energy saving across buildings (Deng et al., 2013).

China's Ministry of Housing and Urban-Rural Development (MOHURD) has funded research on emissions calculation methods for Chinese buildings since 2002; however, the emission baseline was not included in this research, due to the complexity involved (Hu, 2013). In an ETS, the baseline for emissions determines how much allowance can be distributed to the participants. The emissions reduction will not be credible if the emissions baseline is not accurate. In another technical report published by MOHURD in 2013, it is noted that data on building energy consumption and GHG emissions are very limited, which is the biggest challenge to the inclusion of buildings in China's pilot ETSs (MOHURD, 2013). The report also mentioned that lots of effort will be needed to develop and improve the MRV system in the pilot ETSs (ibid.). An evaluation report published by the Shenzhen Institute of Building Research in 2014 concludes that current building emission quantifying methods and verification guidance are not comprehensive enough to identify emissions boundaries in building operation, leaving the performance of emissions reduction uncertain (Ye et al., 2014). In addition, research on green building standards is progressing slowly in China (Mo, 2016). A mature and credible set of building energy evaluation standards will provide strong support for the smooth integration of buildings into the ETSs (Yuan et al., 2015).

Limited precedents are available, as the building sector is included in few of the cap and trade schemes, except for the Tokyo cap and trade program. The Tokyo program, which entered preparation in 2000 and took effect in the fiscal year of 2010, is the first cap and trade scheme in the world to cover facilities in the building sector, due to a significant growth in CO2 emissions in the commercial and residential sectors between 1990 and 2006 in Tokyo (Bureau of the Environment TMG, 2010). The first compliance period came to an end in December 2014, and city officials declared the system a success, as many businesses had slashed emissions on their own (Kaneko, 2014). Over 90% of the facilities covered surpassed their reduction targets, and 69% exceeded their second compliance period targets; more than 100 facilities left the cap and trade program, having reduced their emissions below the threshold (Afriat et al., 2015). The Tokyo program has a strict and accurate third party verification process, as all emissions data from mandated reduction facilities are accumulated to calculate total emissions, which is of great reference value to building collaboration between the city government and the private sector (Friedlander, 2016). Although buildings are the main entities covered in the Tokyo cap and trade scheme, the difficulties involved in integrating buildings into the ETS due to the nature of the building sector have seldom been discussed in relation to the Tokyo program. The design of the MRV system is one of the reasons why the Tokyo cap and trade program has been effective in measuring building emissions (Center for Public Impact, 2016). Generally, the monitoring and reporting mechanism for the Tokyo program is similar to that of other cap and trade schemes: participants submit an annual report on the previous fiscal year's emissions and a registered independent verification agency issues a verification report; the governor checks the final compliance status at the end of the compliance period. Tracking the design and planning of the Tokyo program reveals that the Tokyo Carbon Reduction Reporting Program (TCRRP) established by the Tokyo Metropolitan Government (TMG) in 2008 significantly motivated the later cap and trade program (Nishida and Hua, 2016). The TCRRP not only gathered substantial emissions reports every year, but also encouraged around 30,000 small to medium-sized facilities to reduce their emissions (Afriat et al., 2015; Nishida and Hua, 2016). The Green Building Program (GBP) introduced in 2002 and the Green Labeling Program for Condominiums and the Energy Certificate Program pioneered the creation of a rating and reporting system to measure the environmental performance of buildings (Afriat et al., 2015). Furthermore, as Tokyo Electric Power Company supplies almost all of the electricity consumed within the jurisdiction of the TMG, the TMG can forcefully execute measures of emissions calculation on the energy demand side, as well as asking energy suppliers to decrease emissions (Bureau of the Environment TMG, 2010).

The Tokyo cap and trade program can be deemed successful, because authorities provided extensive data on their success in meeting the ambitious emissions reduction targets (Nishida and Hua, 2016), which was achieved by the use of a proper MRV system and its antecedents, such as the TCRRP and GBP. Meanwhile, the disadvantages of buildings as ETS participants are minimized in the Tokyo cap and trade program. First, the TCRRP and the GBP increased awareness of the need to reduce emissions in the building sector with limited economic incentives before the launch of the Tokyo program. Second, stakeholder engagement since the TCRRP period gave the TMG the chance to tailor the ETS to individual companies' needs (Center for Public Impact, 2016), which encouraged the increasing application of efficient lighting systems in 2010, as emissions from off-work lighting in commercial buildings were avoidable (Friedlander, 2016). The influence of humans' energy-unaware behavior was thereby reduced. Third, as the only electricity supplier, close cooperation between the Tokyo Electric Power Company, the verification agency, and the TMG ensured a strict and accurate verification result, lowering transaction costs and reducing conflict between parties. The Tokyo cap and trade scheme demonstrates that a proper MRV system can not only overcome difficulties in including buildings in an ETS but also encourage participants to engage actively in reducing emissions.

7.3 VALIDATION PROCESS: CONCLUSION

The success factors identified in the previous chapter were validated by processing the feedback data obtained in the 105 questionnaires by PCA. ‘Accurate verification system’ and ‘comprehensive MRV system’ were highlighted as the two most important factors influencing the success of the ETSs in the building sector. The IAMETS was proven to be a reasonable indicator evaluation model. Next, several reports indicating the limitations of the MRV system in China’s buildings were summarized. Analysis of the Tokyo cap and trade program revealed that the success of the Tokyo ETS depended in part on its MRV system and an earlier reporting program.

CHAPTER 8 RECOMMENDATION FOR IMPROVING THE SUCCESS FACTORS

In the previous chapter, an accurate verification system and MRV system are identified as the success factors of the ETS in reducing emissions in China's buildings. It becomes important to examine buildings' energy efficiency and the emission verification system in operation in China. This chapter starts with background research, namely expert interviews and desk research, to explain why these two factors are important. The experts were from authorized verification organization in Beijing, Shanghai and Shenzhen. The desk research focused on energy-efficiency standards and regulations. The purpose of this chapter is to make recommendations to improve on these success factors to maximize the functioning of ETSs in China's buildings.

8.1 BACKGROUND TO BUILDING ENERGY EFFICIENCY AND EMISSIONS VERIFICATION SYSTEM

The verification system for China's ETSs is approved by the NDRC and applied by verification organizations to calculate the actual emissions emitted by the entities subject to the scheme. The MRV system requires these entities to monitor their emissions, report their emissions to related authorities, and seek verification from assigned organizations. The MRV system is important not only because it provides a common framework for ensuring the accountability and credibility of ETS governance, but also because it builds trust among parties and shows how they can effectively meet their respective obligations (Wemaere, 2009). In these processes, the verification system determines the methodologies adopted by verification organizations to validate their emissions reduction, as well as the monitoring and reporting method used by the building sectors covered. Without an accurate emissions verification system, it will be difficult to improve the MRV system and ensure the effectiveness and moreover the success of the ETSs in China's buildings. Emission verification systems for building are usually discussed in relation to building energy efficiency verification. To effectively examine the success factors, a background to the system for verifying building energy efficiency and emissions reduction in China must be provided.

China's building industry was highlighted in the 12^{th} Five Year Plan as the key target of energy saving and emissions reduction. To achieve this aim, the government designed regulations and promoted market mechanisms other than ETSs, such as financial rewards for building energy retrofitting, building energy performance contracting, building energy efficiency trading, a building energy evaluation and labeling scheme, and a building energy efficiency financing scheme. The success of these schemes is based on the accurate audition and evaluation of emissions reduction for each project. Currently, the system used to quantify, monitor, report and verify emissions reduction under China's ETSs is ISO 14064, which is an international standard for environmental management. ISO 14064 is a typical verification system comprising a series of tools and programs for quantifying, monitoring and verifying emissions. Nevertheless, ISO 14064 is generally applied to all kinds of projects without specific consideration of buildings' characteristics, which is based on off-site calculations of energy saving and emissions reduction. Similar to ISO 14064, the CWM methodologies constitute another popular verification system (discussed in the literature review), which provides a normalized process and transparent obligations and rights for a range of participants. But the CDM verification methodologies are not adapted to building energy efficiency either. The CDM methodologies are effective in verifying energy saving in the context of a big industry or large project. The verification of building energy saving entails complex procedures, such as identifying the building's position in its life cycle, clarifying the energy demand side or use side, and investing in monitoring devices, whose costs usually outweigh the benefits of building energy saving.

For this reason, a verification system specifically designed for buildings is needed. The International Performance Measurement and Verification Protocol (IPMVP) produced by the Efficiency Valuation Organization is currently the most recognized and experienced building verification system. Countries such as the UK, China and Spain have all signed an agreement on the application of the IPMVP. The Federal Energy Management Program's Measurement and Verification Guidelines (FEMP M&V) and ASHRAE standards and guidelines are also important valuation systems suitable for the building sector.

No specific verification system considering the characteristics of buildings in China's ETSs has been developed; only some guidelines and standards for building energy efficiency. Key related standards are as follows: Technical Code for the Retrofitting of Public Buildings for Energy Efficiency (Building Standard 1), Standard for Building Energy Performance Certification (Building Standard 2), Guidelines for Energy Auditing in Government Building and Large Scale Public Buildings (Building Standard 3), Technical Guidelines for Measurement and Verification of Energy Saving (Auditing Guidelines 1), and the Auditing Guidelines for Energy Saving to Build Energy Saving Project (Auditing Guidelines 2). Some of these standards borrow experience from internationally recognized international verification systems, and their development took into consideration the characteristics of the Chinese setting (Liu et al., 2013). The IPMVP, FEMP M&V and ASHRAE are worth exploring, but cannot be simply replicated in China's ETS context. China's own standards may be defective, but there are still strengths to be maintained. Through examination and comparison of verification systems and standards in China, a suggested emissions verification system for China's buildings is built in the next section. On the basis of the verification system, how can the mentioned standards and guidelines contribute to the system in the context of China's ETSs is discussed. The standards and guidelines that can best cooperated with the verification system is concluded and validated by experts.

8.2 EXAMINATION OF CHINA'S EMISSIONS VERIFICATION SYSTEM AND STANDARDS

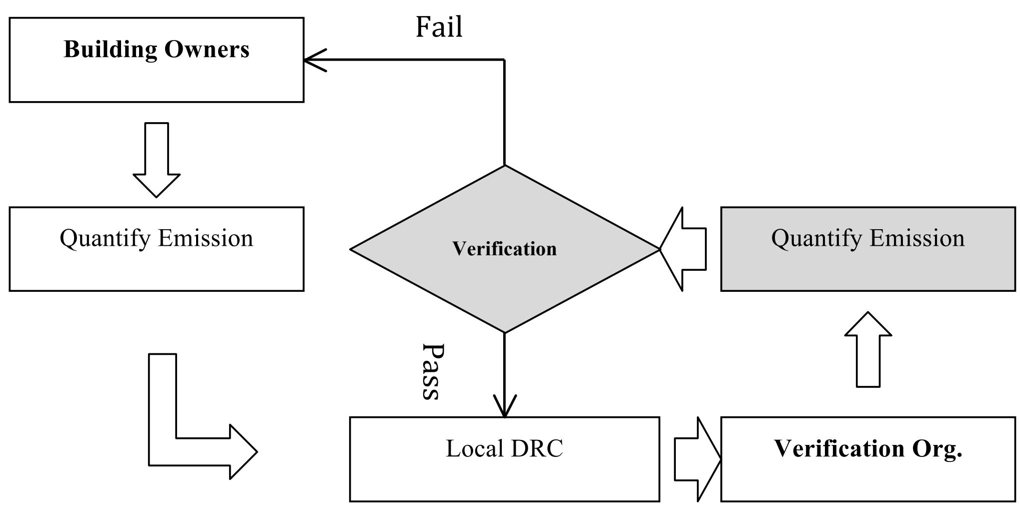
8.2.1 Emissions Verification Procedure for China's ETSs

In China's ETS, there are two types of participant in the building emissions verification process: the building owner/management company and the assigned verification organization (see Figure 8.1). As shown in the left side of the figure, the building owners calculate the emissions and submit the results to the local DRC. Next, the local DRC assigns a verification organization (on the right side) to quantify the building's emissions and verify whether the report made by the building owner is true. If the verified result matches the building owner's report, the building passes the verification process. Otherwise, building owners have to recalculate and submit their emissions reduction reports until they are accepted by the verification organization.

The verification system mentioned in this study is the method used to calculate and verify emissions reduction by the verification organization (the grey box in Figure 8.1). Currently, the system applied to China's ETSs in the building sector is ISO 14064. A typical GHG reduction project cycle and the actions required in ISO 14064-2 are presented in Figure 8.2. Before the implementation of each emissions reduction project, the ISO system required a proposal to introduce how to process the monitoring, quantification and reporting of GHG emissions, as well as how to validate the emissions. Verifying emissions in the ISO system is not a linear process. The identification of project type and baseline, along with monitoring and validation activities, can be repeated again and again until the final GHG emissions level is certified. ISO 14064 has been updated to the third version (ISO 14064-3), targeting all

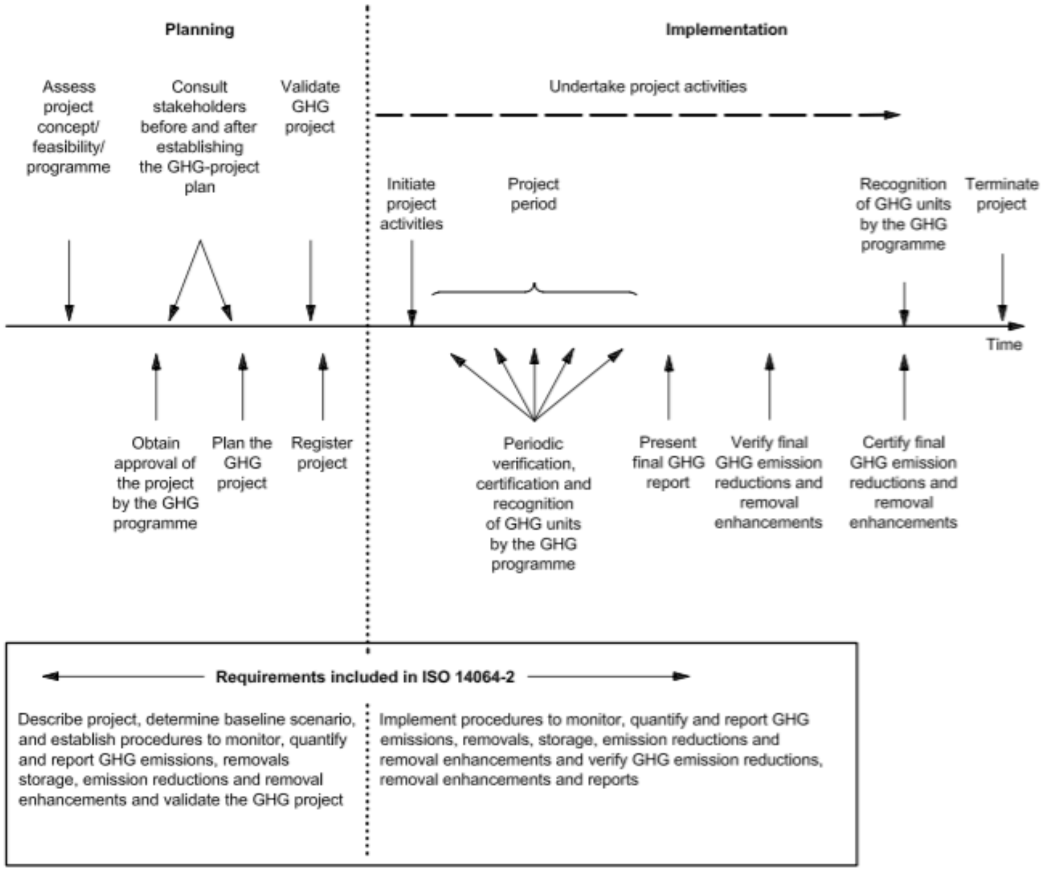
GHG emissions reduction projects with strict regulated procedures and principles. However, as no evaluation or quantification methods are specified for buildings, the outcomes of building energy saving and emissions reduction cannot be accurately measured.

Figure 8.1 China's Building Emission Verification Procedure in ETS



Based on the ISO standards, a simplified flowchart of the verification system for building energy efficiency and emissions reduction is presented in Figure 8.3. Building owners normally use the same method used by the verification organization to monitor and quantify their emissions and submit them in a report to the local DRC. Therefore, the verification system will only be studied from the perspective of verification organizations.

Figure 8.2 A Typical GHG Project Cycle

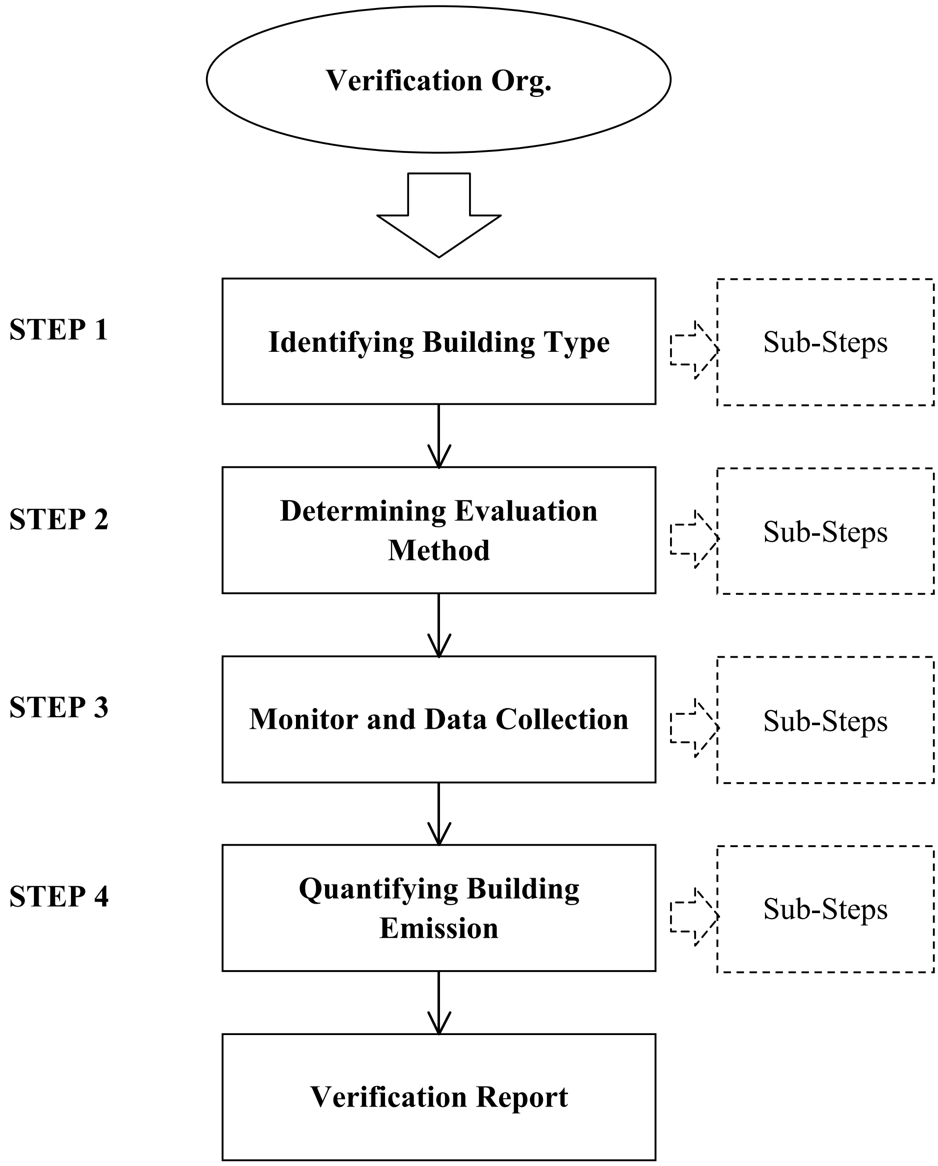


NOTE 1 Not all GHG programmes will require all the elements included in this figure.

NOTE 2 A GHG unit is a unit used for GHG accounting. Common GHG units for GHG projects are certified emission reduction units (CER), emission reduction units (ERU), credits and offsets. GHG units are usually expressed in tonnes of CO_2e.

Source: ISO 14064-2-2006. 2006.

Figure 8.3 Flowchart of Current Emissions Verification System in Buildings



8.2.2 Representative Verification Methods and Standards in China and Globally

The four steps in the verification system are identified in Figure 8.3. As ISO 14064 does not include methods for the building sector, the sub-steps need to be completed through examination of China's verification methods and standards, as mentioned in the previous section. Technical Code for the Retrofitting of Public Buildings for Energy Efficiency (Building Standard 1), Standard for Building Energy Performance Certification (Building Standard 2), and Guidelines for Energy Auditing of Government Buildings and Large Scale Public Buildings (Building Standard 3) all focus on the building energy efficiency domain; Technical Guidelines for Measurement and Verification of Energy Saving (Auditing Guidelines 1) and Auditing Guidelines for Energy Saving in Building Energy Saving Project (Auditing Guidelines 2) are used for the energy efficiency project. These standards and guidelines target buildings of different scales and with slightly different purposes (see Table 8.1). Following Liu et al. (2013), the methods of evaluating and quantifying building emissions are summarized in Table 8.2. Building Standard 1 and Auditing Guidelines 1 apply an internationally recognized evaluation method. For instance, the Method of Measurement, Method of Bill Analysis and Calibration Method are the same as IPMVP, FEMP M&V and ASHREA. However, the equivalent quantification methods are not feasible. Building Standard 1 does not consider the conditions of China, for which there are very limited historical data on building energy consumption, and thus no information on energy consumption for the baseline period. Auditing Guidelines 1 does not require historical data, but the measurement of parameters on site before and after the retrofits, which is required for the calibration, is much more complicated in buildings than in other industries.

Table 8.1 Scope and Purpose of The Standards and Guidelines

(Adapted from Liu, et.al., 2013)

Title	Scope	Purpose
Building Standard 1	Public Building	Energy Efficiency Retrofit (EEF)
Building Standard 2	New Civil Building Old Civil Building Old Civil Building with EEF	Labeling
Building Standard 3	Government Building Large Scale Building	Auditing Real Energy Consumption
Auditing Guideline 1	First Industry Building Industry	Auditing and Verifying Techniques
Auditing Guideline 2	Energy Efficiency Project	Monitor and Quantify Methods

The evaluation method outlined in Building Standard 2 is quite different from internationally recognized methods, but easy to operate. The relative energy saving rate is the calculation of energy consumption through conversion to the usage of coal, except for electricity use. It also identifies variables such as building usage and weather, which is important to establish a fair baseline for building energy efficiency that takes the conditions of the natural environment into consideration. On the contrary, Building Standard 3 does not consider external factors that may influence building energy efficiency. The measurement of energy-saving performance may thus be inaccurate. Nevertheless, it is very easy to analyze the record of energy usage and energy bills using Building Standard 3. Lastly, Auditing Guidelines 2 are better adapted to the process of industrial production than to the building industry. Through the examination of Auditing Guidelines 2, the requirements of data quality management are raised, which is considered to be an important step in verifying building energy saving and emission reduction. The implementation procedures for the three standards and two sets of guidelines are reviewed and organized in Table 8.3.

Table 8.2 Methods of Evaluation and Quantify Building Emission

(Adapted from Liu, et.al., 2013)

Title	Evaluation Method	Quantify Method
Building Standard 1	1) Method of Measurement (include Key Parameter Measurement, All Parameter Measurement, and Direct Comparison) 2) Method of Bill Analysis 3) Calibration Method	Energy Consumption in Baseline Period -Energy Consumption after Retrofit ±Adjusting
Building Standard 2	Simulation Assessment: 1) Basic Item: Relative Energy Saving Rate and 2) Regulated Item: Building Usage Type and 3) Option Item: Weather	Energy Consumption in Reporting Period – Calibrated Energy Consumption
Building Standard 3	Record of Energy Usage or Energy Bill (Bill Analysis)	Convert to Coal Use
Auditing Guideline 1	1) 'Energy Consumption in Baseline Period – Influence factor' Modeling 2) Method of Direct Comparison 3) Simulation Method	Energy Consumption in Reporting Period – Calibrated Energy Consumption
Auditing Guideline 2	Meter Monitoring	Σ(Energy Consumption of each Product before Energy Saving – Energy Consumption of each Product after Energy Saving) * Number of Products
IPMVP	1) Method of Key Parameter Measurement 2) Method of All Parameters Measurement 3) All Energy Consumption Facility Measurement 4) Calibration Method	(Energy Consumption in Baseline Period – Energy Consumption in Reporting Period) ±Adjusting
FEMP M&V	1) Method of Key Parameter Measurement 2) Method of All Parameters Measurement	(Energy Consumption in Baseline Period – Energy Consumption in Reporting Period) ±Regular

	3） All Energy Consumption Facility Measurement 4） Calibration Method	Adjusting ± Irregular Adjusting
ASHREA	1） Whole Building Energy Consumption Assessment (Metering) 2） Independent Facility Assessment 3） Whole Building Calibration Method (Actually the Methods are the Same as IPMVP and FEMP M&V, but Different in the Way of Categorization)	The Mapping of the Energy Consumption Baseline on Reporting Period – Actual Energy Consumption after Retrofit

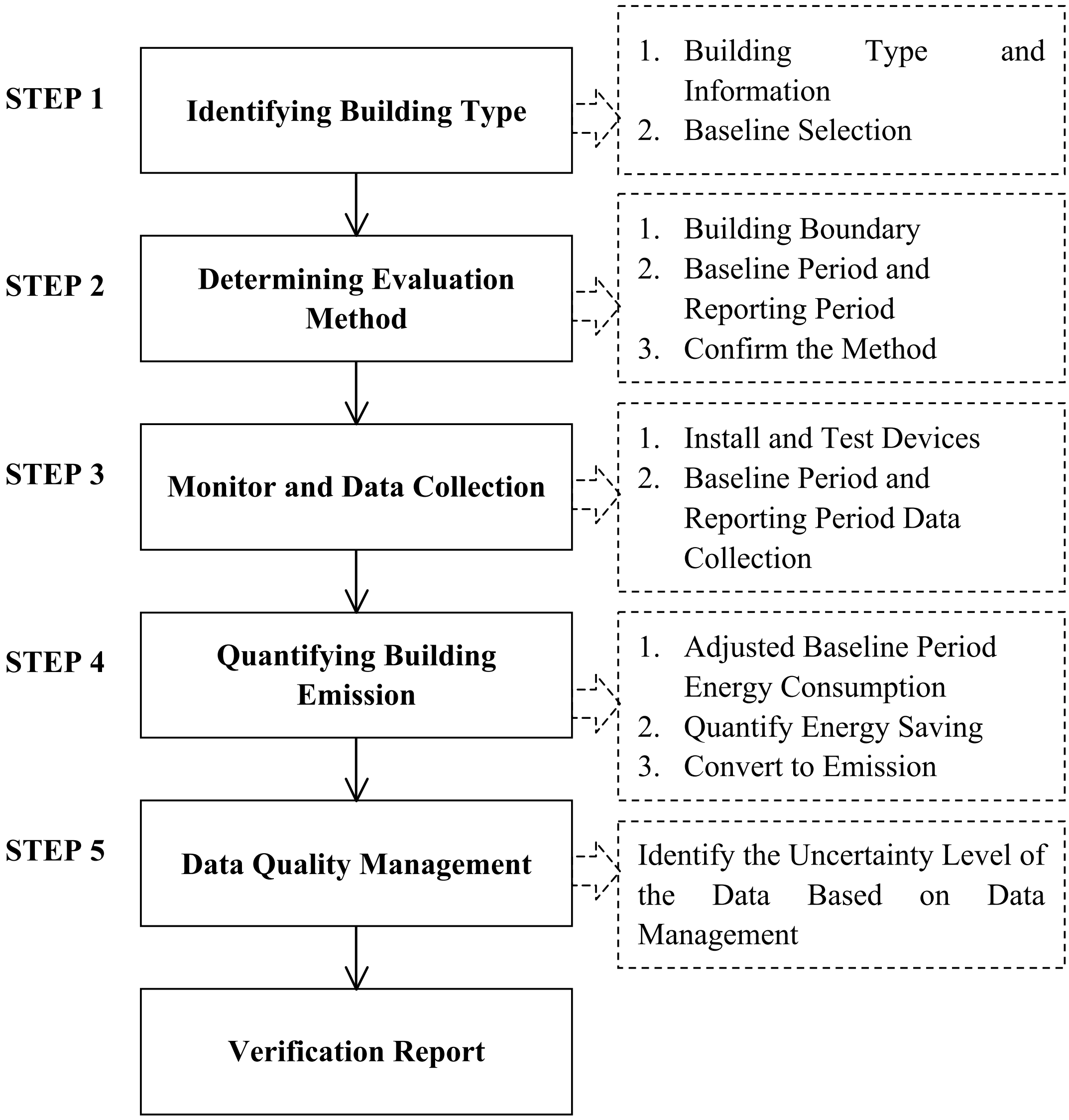
Table 8.3 Flowchart of the Standards and Guidelines

Building Standard 1	Building Standard 2	Building Standard 3	Auditing Guideline 1	Auditing Guideline 2
		1. Select the Auditing Building		1. Preparation
		2. Basic Information of Building		2. Basic Information
		3. Identify the Auditing Target		
			1. Identify the Boundary	
	1. Apply and Obtain Theoretical Baseline		2. Identify the Baseline Period and Reporting Period	3. On site Audit Energy Consumption in the Baseline Period
			3. Choose Evaluation Method	
1.Identify the Plan			4. Confirm the Plan	
			5. Design, Install and Test the Devices	
2. Collect the Data of Energy Consumption before and after Retrofit	2. Collect the Measurement Data in Project	4. On site Data Collection and Test	6. Collect and Measure Energy Consuming Data and Analyze	4. On Site Measure Energy Consumption after Retrofit
3. Quantify the Energy Saving			7. Quantify and Validate the Energy Saving, Identify the Uncertainty	
4. Finish the Report	3. Get the Label	5. Auditing Report	8. Verify the Energy Saving	5. Verify the Quality

8.3 RECOMMENDATIONS FOR BUILDING EMISSIONS VERIFICATION SYSTEM IN CHINA

The review in Section 8.2.2 provides valuable information on the sub-steps in Figure 8.3. The recommended building emissions verification system for China's ETS is presented in Figure 8.4

Figure 8.4 Flowchart of Recommended Building Emissions Verification System in China's ETS



As the verification system is proposed for the buildings covered by China's ETSs, some of the sub-steps are determined from the outset. For instance, building type and information and the baseline selection (see in Table 8.4) are already regulated by the government. Currently, the majority of the buildings subject to the scheme are large-scale public buildings and government buildings, falling within the scope of Building Standard 3. Therefore, Building Standard 3 is better adapted to determining the project boundary. The baseline period and reporting period have also been defined by the local DRC at the beginning of each pilot scheme. In China's ETSs, no devices are currently used to monitor energy usage. Energy usage data in the reporting period are collected by verification organizations solely from the records of energy usage and energy bills, through bill analysis. Next, given the limitations on historical energy use data, the data collected are compared with the records for the year before (under the Beijing and Shanghai pilot schemes) or with the baseline decided by peers through game theory (in the Shenzhen pilot). This method is similar to the evaluation method for Building Standard 3. Energy saving is then quantified and converted to emissions reduction without considering the need for adjustment.

Table 8.4 Building Coverage in China's ETS

Pilot	Coverage
Beijing	Service industry building emit ≥ 10000 tons of CO_2 per year
Shanghai	Commerce, hotels and financial enterprises emit ≥10000 tons of CO_2 per year
Shenzhen	Public building ≥ 20000 m^2; governmental offices ≥10000 m^2

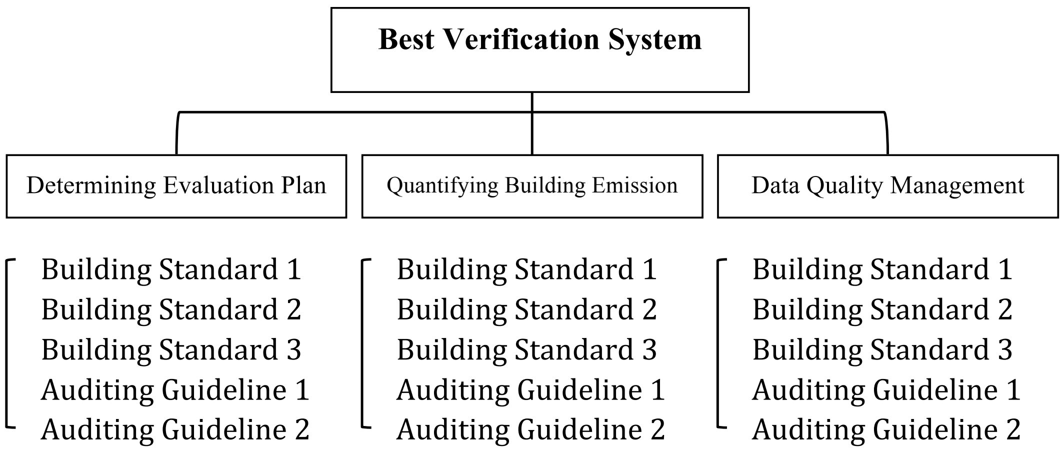
Adjustment takes into account external factors such as the weather when quantifying emissions. ISO 14064 does not include a method of quantifying building emissions. Therefore, there is no adjusted baseline for energy consumption in China's ETSs in the building sector. Here, the proposal is made to use the quantification method in Building Standard 1 and Auditing Guidelines 1. Despite the limited historical data, it is still possible to use the calibrated method to identify energy-saving capacity. This method will require investment in monitoring devices.

Lastly, no data quality management scheme has been created for the ETSs. The ISO 14064 system has clarified the requirements for auditor qualifications. The verification reports submitted by the verification organizations are considered to be fair and accurate. Data quality management can also be carried out by the methods used in Auditing Guidelines 2. Building Standard 3 is the most commonly used to accompany the suggested verification system for buildings in the context of China's ETSs; the simulated calibration methods of Building Standards 1 and Auditing Guideline 1 are worth learning and adapting to the suggested verification system, and this method also includes consideration of external factors such as weather, which are not evaluated in the current verification process. The ISO 14064 system ensures the qualifications of auditor, and the quality of the data can also be measured based on Auditing Guidelines 1, although these are more feasible for the manufacturing industry.

8.4 VALIDATION OF RECOMMENDED BUILDING EMISSIONS VERIFICATION SYSTEM

Based on the examination and analysis reported in Section 8.2, the following processes should be improved to ensure the accuracy of building emissions verification for China's ETSs: 'determination of evaluation method', 'monitoring and data collection', 'quantifying method of emission' and 'data quality management'. The evaluation plan in Building Standards 3 is found to be the most suitable, and the others can be applied with adjustment. To validate this finding, experts were asked to select the best of the three standards and two sets of guidelines, for buildings emissions verification in China's ETSs. The framework is presented in Figure 8.5. As the process of 'monitoring and data collection' is decided by the evaluation method, 'determining evaluation method' and 'monitoring and data collection' are grouped together.

Figure 8.5 Options to Achieve Best Building Emissions Verification System in China's ETSs



The validation process involved asking experts to choose from the five options for each of the three steps to construct the best building emissions verification system. Saaty and Vargas (1984) concluded that the analytical hierarchy process (AHP) can facilitate the choice of best policy alternatives. Therefore, the validation was conducted by AHP. Figure 8.5 shows the corresponding hierarchical structure. The three steps make up the first hierarchy, and the three standards and two guidelines make up the second hierarchy; they are also known as alternatives. Quantitative analysis is conducted through pairwise comparison of the qualitative information. The first step in the AHP is selecting the experts.

Experts were asked to choose the best standards for building energy and emissions verification for China's ETSs. To ensure professional and credible results, experts in the building energy saving area in China were preferred. Experts working on verifying building emissions reduction in China's ETSs were also selected. Four professionals were invited to join the AHP process. The backgrounds of the interviewees are listed in Figure 8.6. Their affiliations are provided with their permission.

Figure 8.6 Backgrounds of the Interviewees

	Affiliation	Working Experience
Expert 1	Institute of Building Environment and Energy, China Academy of Building Research	More than 10 years
Expert 2	Institute of Building Environment and Energy, China Academy of Building Research	7 years
Expert 3	China Electronics Standardization Institute (Verification Organization Assigned by Beijing DRC)	More than 10 years
Expert 4	China Electronics Standardization Institute (Verification Organization Assigned by Beijing DRC)	5 years

However, the selection of experts had shortcomings. Experts 1 and 2 had abundant experience of building energy efficiency research, although knowledge of the building emissions verification in China's ETSs is limited. In contrast, experts 3 and 4 were proficient in the area of building emission verification, but were less familiar with the standards and guidelines selected in the research. To overcome these shortcomings, the four interviews were conducted face to face. This allowed the interviewer to provide a necessary introduction and explanation when interviewees had uncertainties during the selection. Table 8.2 was also provided to assist their choosing. The 1-9 scale suggested by Dr. Saaty (1980) for pairwise comparison was used (see Figure 8.7).

Figure 8.7 The 9 Scales for Pairwise Comparison

Scale	Verbal Expression	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one over another
5	Strong Importance	Experience and judgment strongly favor one over another
7	Very Strong Importance	An activity is favored very strongly over another
9	Extreme Importance	The evidence favoring one activity over another is off the highest possible order of affirmation
2,4,6,8	Intermediate Values	When compromise is needed

The first pairwise comparison is conducted among the three items: determining evaluation plan, quantify building emission and data quality management. The comparison is based on the question that which step is more important to a building emissions verification system. Table 8.5 is the result of the first comparison from experts. After the calculation, the eigenvector in the first hierarchy, which is named as relative value vector (RVV) of the three steps are 0.5862, 0.3334, and 0.0804. 0.5862 means that the determination of evaluation plan is the most concerned issue among the experts when to design a building emissions verification system in China's ETSs.

Table 8.5 Results of the Pairwise Comparison of the 3 Steps

	Determining evaluation plan (A_{1j})	Quantifying Building Emission (A_{2j})	Data Quality Management (A_{3j})
Determining evaluation plan (A_{i1})	1	2.3333	5.5
Quantifying Building Emission (A_{i2})	0.4286	1	5.5
Data Quality Management (A_{i3})	0.1818	0.1818	1
RVV (R_i)	**0.5862** R_1	**0.3334** R_2	**0.0804** R_3

The consistency ratio (CR) is required to calculate in each AHP, to measure how consistent the judgments have been relative to large samples of purely random judgments (Coyle, 2004). CR is calculated using the following formula.

$$CR = \frac{CI}{RI}$$

In which, CI is the consistency index and RI is the random index. The value of RI will increase if the matrices increase. The RI value has been concluded by Saaty (1980): there are three elements in the pairwise comparison, $n = 3$ and the corresponding RI value is 0.58. Therefore, only the value of CI remains to be determined by the following formula:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

where

$$\lambda_{\max} = \frac{C_1 + C_2 + C_3}{3}$$

and

$$C_j = \frac{\sum_{i=1}^{3} A_{ij} R_i}{R_i} \qquad j = 1,2,3$$

Based on this calculation, C_1 = 3.0823, C_2 = 3.0798, and C_3 = 3.0796. Therefore, the value of $\lambda_{\max}$ is 3.0806. Lastly, the CI value in the first pairwise comparison is 0.0403 and the CR is 0.0694, which are both < 0.1. This result indicates that the comparison is consistent and the result is acceptable.

The second round of pairwise comparisons is managed among the three standards and two guidelines, judging their contributions separately to the three steps. The scale used is the same as Figure 8.7. In determining the evaluation plan, the eigenvector of Building Standard 3 is larger than the others, which indicates experts prefer to borrow the evaluation plan in Building Standard 3 to apply in buildings under China's ETSs. The consistency is required to test in each comparison matrix. The method of calculating CR is the same as previous section; only the RI value should be changed to 1.12 as there are 5 elements compared in this section. Both CI and CR are less than 0.1, which indicate that the results are reliable. Table 8.6, Table 8.7 and Table 8.8 are the results of pairwise comparisons in the second hierarchy.

Table 8.6 Results of the Pairwise Comparison in Determining Evaluation Plan

	Building Standard 1	Building Standard 2	Building Standard 3	Auditing Guideline 1	Auditing Guideline 2
Building Standard 1	1	3	0.3	1	5
Building Standard 2	0.3333	1	0.2	0.3333	4
Building Standard 3	3.3333	5	1	5	5
Auditing Guideline 1	1	3	0.2	1	5
Auditing Guideline 2	0.2	0.25	0.2	0.2	1
Eigenvector	**0.1874**	**0.0910**	**0.4990**	**0.1781**	**0.0445**
CI **= 0.0985 <0.1** CR **= 0.0082 <0.1**					

Table 8.7 Results of Pairwise Comparison in Quantifying Building Emission

	Building Standard 1	Building Standard 2	Building Standard 3	Auditing Guideline 1	Auditing Guideline 2
Building Standard 1	1	1.8333	1.1667	1.8333	6
Building Standard 2	0.5455	1	0.6667	1	5
Building Standard 3	0.8571	1.5	1	1.8333	5
Auditing Guideline 1	0.5455	1	0.5455	1	5
Auditing Guideline 2	0.1667	0.2	0.2	0.2	1
Eigenvector	**0.3129**	**0.1876**	**0.2737**	**0.1811**	**0.0447**
CI **= 0.00963 <0.1** CR **= 0.0086 <0.1**					

Table 8.8 Results of Pairwise Comparison in Data Quality Management

	Building Standard 1	Building Standard 2	Building Standard 3	Auditing Guideline 1	Auditing Guideline 2
Building Standard 1	1	1	1	1	0.3333
Building Standard 2	1	1	1	1	0.3333
Building Standard 3	1	1	1	1	0.3
Auditing Guideline 1	1	1	1	1	0.3333
Auditing Guideline 2	3	3	3.333	3	1
Eigenvector	**0.1419**	**0.1419**	**0.1392**	**0.1419**	**0.4351**
CI = **0.00029 <0.1** CR = **0.00025 <0.1**					

Different with the choice in determining evaluation plan, experts consider Building Standards 1 is the best alternatives to quantify building emissions, and the second choice is Building Standards 3. In the aspect of data quality management, Auditing Guideline 2 is chosen to be the best alternatives as it is the only one suggesting particular procedure for data quality management. Table 8.9 organizes the results of the three sets of pairwise comparison into an option performance metric. Combining the result of R_i in the comparison of the first hierarchy, the overall weightings are calculated and the results are listed in Table 8.10. Experts consider Building Standard 3 as the most adapted one to borrow in building emissions verification in China's ETSs. Auditing Guideline 2 is the most unsuitable one.

Table 8.9 The Option Performance Matric

	Determining evaluation plan V_{1i}	Quantifying Building Emission V_{2i}	Data Quality Management V_{3i}
Building Standard 1	0.1874	0.3129	0.1419
Building Standard 2	0.0910	0.1876	0.1419
Building Standard 3	0.4990	0.2737	0.1392
Auditing Guideline 1	0.1781	0.1811	0.1419
Auditing Guideline 2	0.0445	0.0447	0.4351

Table 8.10 Results of the AHP

Title	**Score** W_i
Building Standard 1	0.2256
Building Standard 2	0.1273
Building Standard 3	0.3949
Auditing Guideline 1	0.1762
Auditing Guideline 2	0.0760

8.5 RECOMMENDED BUILDINGS EMISSIONS VERIFICATION SYSTEM: CONCLUSION

The factors responsible for the success of ETSs in reducing emissions in buildings in China were identified as ‘accurate verification system’ and ‘comprehensive monitoring, reporting and verifying system’. Examination of the emissions verification system in the buildings covered by China’s ETSs revealed that although the ISO-14064 verification system is sophisticated; there are no specific standards or guidelines for the building industry. Therefore, the verification results may be biased. For this reason, a novel building emissions verification system adapted to the context of China’ ETSs is proposed. Representative standards and guidelines on building emissions auditing are analyzed. Based on the validation of experts, it is concluded that Building Standard 3, Guidelines for Energy Auditing of Government Buildings and Large Scale Public Buildings, is the most appropriate to accompany the building emissions verification system for China’s ETSs, as energy record and energy bill analysis is the most feasible measurement method currently used in China. Meanwhile, as there are very limited historical data on building energy consumption, a simulated calibration model will be difficult to apply. Other measurements, such as installing devices to monitor energy consumption, are too expensive, and this method will be very challenging in an ETS, as deciding who should bear the cost is already a critical task. Nevertheless, experts prefer to apply the quantifying method in Building Standard 1, Technical Code for the Retrofitting of Public Buildings for Energy Efficiency, because Building Standard 1 includes the calculation of external factors influencing building energy consumption, which increases the accuracy of auditing results. The suggested building emissions verification system includes the step of data quality management. Experts agree on the need to learn from Auditing Guidelines 2, Auditing Guidelines for Energy Saving in Building Energy Saving Project, although data quality management is not yet perceived as a major step in the building emissions verification system in the context of China's ETSs. An accurate building emissions verification system should incorporate energy record and bill analysis with the use of a simulated calibration method that includes the assessment of external factors such as weather in the context of China's ETSs.

CHAPTER 9 CONCLUSION

9.1 OVERVIEW OF THE STUDY

ETSs have been implemented in many regions and countries around the world, and the scope of their application continues to expand alongside that of another major carbon-pricing instrument and market-based mechanism, carbon taxation. Compared with a traditional command and control mechanism, an ETS is theoretically a more flexible means for industry to reduce emissions while maintaining economic competitiveness. From the environmental-economics perspective, ETSs are expected to serve as an effective policy instrument for sustainable development. However, the EU ETS, the world's most influential and representative ETS, has been criticized and challenged since its commencement. Clearly, no scheme introduced to deal with emissions pollution is favored by both policy makers and industry. With periods of revision, the EU ETS has changed and adapted over time, and together with the California cap and trade program, the Tokyo cap and trade program and many other ETSs around the world, has given policy makers increasing confidence in promoting the ETS mechanism.

China has positioned the ETS as an important instrument to deal with emissions pollution. Seven pilot regions have been selected for the implementation of the cap and trading scheme since 2013. China's building industry has in recent decades become a major emissions polluter, due to a significant increase in construction. For this reason, some buildings with high emissions are included in the Beijing, Shanghai and Shenzhen pilots. The aim of the present research was thus to identify the factors responsible for the success of these ETSs in reducing emissions in China's buildings.

To achieve this aim, first, a sophisticated understanding and conceptualization of China's ETSs was needed. This entailed an examination of the theories underpinning the ETS, the debate around ETSs, and a range of ETS practices. Next, a case study of China's ETSs was conducted, enabling examination of key issues around the conceptual framework of ETS concluded in the theoretical discussion. The strengths and limitations of China's ETSs thus became clear. With this knowledge, the DPSIR model was applied to build a sustainability framework for the ETS (SFETS), which was used to identify its success factors. Delphi interviews were conducted in three rounds, and the originally developed SFETS was revised to give a more accurate and specific Indicator Assessment Model of the ETS (IAMETS). Success factors were then identified by experts weighting the parameters in the IAMETS. A questionnaire survey was conducted and the feedback was processed by principal component analysis (PCA). Comparison of the results of the Delphi interviews and questionnaires confirmed that an accurate verification system and MRV system are the two main factors determining the success of ETSs in reducing emissions in China's buildings. The findings of reviewing the Tokyo cap and trade scheme also confirmed that MRV systems influence the success of ETSs in the building sector. In addition, the verification system in China's buildings was examined and recommendations for improving the current system were made.

9.2 SUMMARY OF MAJOR RESEARCH OUTPUT

9.2.1. Considerations for ETS Sustainability and Conceptual Framework

The ETS was designed as an environmental conservation solution tailored to the needs of modern societies accustomed to prioritizing economic growth but still concerned about social issues such as justice and poverty. It can be concluded, therefore, that the ultimate purpose of an ETS is to ensure that society develops sustainably. A literature review of the theories underpinning the debate on ETSs links ETSs with sustainable development: each procedure undertaken as part of an ETS corresponds to a sustainability target (see Table 3.9). An ideal ETS is considered to balance the demands of the natural environment, the economy and society. Previous research on ETS practice was used to conceptualize ETSs in a procedure flowchart (Figure 3.10) and sectoral-duty framework (Figure 3.11). This output provides sound knowledge of the ETS and preparation for further exploration of China's ETSs.

9.2.2. China's ETS Practices

The abovementioned procedure flowchart and sectoral-duty framework was used to investigate China's ETSs. The analysis revealed that China's ETS pilots were designed in line with regional characteristics, with a different coverage and cap and different emissions reduction targets for each pilot. China's pilot ETSs have been operational for two years. Some deficiencies have emerged in practice. The data obtained during field visits indicate that although the industry compliance rate is quite high, a lack of awareness of carbon-asset management and insufficient enthusiasm for emissions reduction are prevalent. In addition, the progress of China's ETSs is impeded by a lack of specialist training and a poor MRV system. China's CCER market, as a national voluntary carbon market, does provide experience useful to the forthcoming national cap and trade scheme. However, most CCER projects are based on pre-CDM projects, so the CCER market may not yet be able to encourage sufficient voluntary public participation. The CCER market will also need more government supervision, as both non-transparent CCER prices and an excessive number of carbon-derivative businesses represent potential crises in the voluntary market, which may lead the CCER market astray from its original purpose. China's carbon tax is currently being investigated by the government, with a view to integrating it with a national ETS to pursue emissions reduction. The main difficulties ahead relate to cooperation and negotiation between parties. From the government's perspective, the carbon tax has to be effective in reducing emissions; from the industry's perspective, the carbon tax cannot overlap with existing energy or environmental taxes, as these will become a burden. China's national ETS was previously scheduled to be established in 2016. Unifying the seven pilot schemes, which are considered to benefit from consideration of local economic patterns, is another challenge ahead.

9.2.3. SFETS

Based on a literature review and case study of China's ETSs, a sustainability framework of the ETS was built using the DPSIR model (see Table 5.4). This framework describes how certain observable tendencies bring about changes in the natural environment, economic activities, and social and political development. These changes bring stress in the form of emissions, such as unconstrained resource use. The natural environment is affected, resulting in climate change and increasing energy prices. As this changing environmental status impacts on society, society has begun to seek solutions. ETSs represent one of the solutions proposed for emissions reduction. The sustainability framework is based on the causal relationships linking an ETS with the factors it affects, and defines the considerations that should be taken to ensure a successful ETS. In practice, however, an ETS is hardly able to achieve all of its potential positive effects. In different scenarios, the scheme must have different emphases to maximize its positive results. To identify the factors responsible for the successful reduction of building emissions, the SFETS was situated in the building sector covered by China's ETSs.

9.2.4. IAMETS

One of the most effective methods of identifying success factors is to seek experts' agreement on certain subjects. Therefore, Delphi interviews were conducted. The first round of interviews comprised solely open-ended questions, inviting experts to propose their own success factors and compare them with the ETS measures in the response column of the SFETS. The results showed that the SFETS was too abstract and covered too many aspects. A model with more straightforward factors was needed. To revise the SFETS to give a more specific and accurate model without changing the causality relationships, the driving force–state–response framework was adopted to generate an IAMETS (see Table 6.4). The experts agreed on the parameters identified as influencing the success of ETS in buildings. In this model, "state" comprised changing parameters in the natural environment, such as the volume of emissions reduction; changing parameters in the economic environment, such as industry compliance rate in reducing emissions and industry competitiveness in reducing emissions; and changing parameters in the social environment, such as quality of emissions reduction and social awareness of emissions reduction. In the causal framework, the steps in the ETS – conclusively identified as the indicators in the response column – represent the solutions to negative changes in state resulting from the above pressures. The last step in the Delphi interviews was to invite the experts to rank the five parameters, selecting the one with the greatest influence on the success of ETS in buildings. The results showed that volume of emissions reduction and quality of emissions reduction are the most important and second most important parameters, respectively, determining the success of ETSs in the building industry.

Meanwhile, based on the IAMETS agreed by the Delphi experts, the indicators in the response column were ranked in another independent study by distributing questionnaires and rating the importance of the indicators. Each Delphi expert assigned questionnaires to their colleagues, and 103 responses were received. PCA was used to process the feedback. The results validated the findings of the Delphi interviews, indicating that an accurate verification system and a comprehensive MRV system are the most important factors responsible for the success of ETSs in reducing building emissions. Comparison of this finding with the results of the Delphi interviews confirmed the consistency of the IAMETS and validated the success factors. Another validation exercise was conducted by reviewing research on the ETSs in China's building sector and the case of the Tokyo cap and trade program, which is the only such program to include buildings. The limitations of China's current MRV system and the importance of a properly designed MRV system were confirmed by the literature review. In the case study of China's ETSs, an inadequate MRV system was also found to compromise the success of the program, which validates the findings reported in this section.

9.2.5. Recommendations for Building Emissions MRV System

In the final stage of the research, it was necessary to examine why the abovementioned success factors were highlighted in practice. China's current ETS verification system is ISO 14064, which is sophisticated; however, no specific standards or guidelines are available for building-emissions evaluation or verification. Therefore, a verification system is proposed here. Reviews of building energy saving and emissions reduction auditing standards in China were conducted, and representative verification systems around the world were studied. The results indicated that systems in other countries are not suitable for application in China, due to deficiencies such as China's limited historical building energy record. It is recommended that some of the methods used in China's building-energy standards or auditing guidelines for energy-efficiency projects be adopted.

The suggested verification system for building emissions auditing consisted of three steps: determining evaluation plan, quantifying building emissions, and data quality management. The recommended evaluation method can be found in ‘Guidelines for Energy Auditing of Government Buildings and Large-Scale Public Buildings’, as this standard does not require a historical energy record or bill analysis, and thus offers the most feasible and convenient approach. It is recommended that the quantification method be drawn from ‘Technical Code for the Retrofitting of Public Buildings for Energy Efficiency’, because external factors such as weather should be calculated to ensure an accurate result. The recommended method of data quality management follows the process in ‘Auditing Guidelines for Energy Saving in Building Energy Saving Project’. Although this may not currently be a critical process in the context of China’s ETSs, it is expected to contribute to a thorough building verification system in the future. Generally, determining the evaluation plan is the most important step in the suggested verification system. Four experts were invited to validate the results by AHP at the end of the study.

9.3 SIGNIFICANCE AND CONTRIBUTIONS OF RESEARCH

The first contribution of the research to existing knowledge lies in conceptualizing the ETS as a procedure flowchart and sectoral framework. Although the topics of ETSs cover many practical issues around policy, economy and society, theories and concepts of ETSs have seldom been examined and organized. The conceptual ETS framework generated through the comprehensive review yields an ideal ETS, which was originally designed to implement sustainable development and can also be used to judge the difference between design and implementation.

The second contribution of the research lies in the connection made analytically between sustainable development and ETSs via the establishment of the SFETS and the IAMETS, based on the notion of causality. The SFETS links ETSs with influential factors in the natural environment, economic environment and social environment, and all of the changes are observable and calculable. However, the SFETS would be most appropriately used to assess changes in a city or region before and after applying an ETS, whereas the IAMETS is more focused, with accurate parameters and indicators. The second model was found to be successful in identifying the factors responsible for the success of an ETS for reducing emissions in the building sector. Feedback from Delphi interviews and questionnaires proved the consistency of the IAMETS, and the results were found to be reliable. The SFETS and IAMETS can also be used to assess the importance of different parameters or indicators in any other scenarios, not only in the building sector.

The final contribution of this research is to show why a verification system has the potential to determine the success of ETSs in China's buildings, and to propose a verification system adapted to China's current ETSs. Many studies have been conducted on building-energy efficiency, from both policy and technical perspectives. In addition, many assessments have been made of building energy saving standards or systems, in China and around the world. However, when buildings are included in an ETS, the verification system for energy saving should be adjusted, as the ETS constrains building type, building usage and project boundary in advance. For these reasons, a verification system for buildings in the context of ETSs should be more closely directed towards determining an evaluation plan and quantifying emissions. In China's context, the most feasible method is to analyze energy records and combine some existing simulated calibration methods. The proposed system will also enable policy makers to understand what aspects of current building energy saving standards need to be improved. With the improvement of standards and evaluation methods in the future, the inadequate MRV system currently in place in China's ETSs can also be improved.

9.4 LIMITATIONS OF THE STUDY

First, the recommendations for improving the current MRV system avoid technical details, instead offering a comparison of current standards and guidelines; however, these standards and guidelines may not be sufficient to verify emissions today. Examination of China's building energy efficiency standards reveals many issues of concern in the verification system. To clearly organize the standards and guidelines, certain criteria are used to simplify the classification. For instance, the criteria used to compare the standards are whether they include the calculation of external factors and other biased factors. In this way, they are categorized simply by group: including external factors and not including external factors. Meanwhile, the quantification methods are not explored in sufficient depth; much work remains to be done to build a sophisticated understanding of China's building verification system.

Second, as with most other interview-based methods, subjectivity may be a limitation. In the phase of validating success factors, PCA was conducted to compensate to some extent for the subjective findings of the Delphi interviews, as PCA is an objective analytical method. However, the sample subjected to PCA was not big enough. Increasing sample size will reduce errors and increase the reliability of the findings. In addition, only four experts were invited to validate the suggested verification system, because it is not easy to find professionals who are familiar with both building energy efficiency standards and China's ETSs. Conducting AHP with just four interviewees is insufficient to ensure credibility, which is another limitation of the study.

Last but not least, the IAMETS was established against the backdrop of China's ETSs, with particular reference to buildings. It is unclear, however, whether the IAMETS can be applied to other industries or in other countries, as the establishment of the IAMETS and the identification of the success factors were based on empirical findings obtained in a certain context. The IAMETS was shown to be a logical and consistent evaluation model, but it may be invalid in other contexts.

9.5 FUTURE RESEARCH DIRECTIONS

Further research could be conducted to further explore China's building energy efficiency verification system and propose a more sophisticated system for China's ETS with specific instructions rather than merely referencing current standards and guidelines. Current building energy evaluation standards should also be further explored and refined: although green buildings and Building Information Modeling techniques are becoming more and more popular, the related standards are still underdeveloped in China.

The SFETS could be used to observe the changes before and after the implementation of an ETS in a city scenario to evaluate the effects of the ETS. The SFETS links the ETS with events happening in cities, whether in the natural environment or the economic or social environment. As the parameters identified in the final SFETS are all measurable, the changes resulting from the ETS can be monitored. In further research, the SFETS could be developed to give a policy tool for assessing the changes before and after certain government actions.

Lastly, the factors responsible for the success of ETSs in reducing emissions in other sectors, such as the transportation sector or the aviation industry, which are also included in some of China's ETSs, could be identified by following the research flow of the present study. As the ETSs will cover more and more industries over time, it is important to understand the difficulties and limitations in each scenario to maximize the positive effect of each ETS.

APPENDIX 1: Interview Questions in the Case Study of China's ETSs

1. The current China's ETS pilots seem to be strictly managed by authorities, which is more similar to the command and control instrument. Is the market mechanism stepping in the near future? Will it be the main instrument to promote and maintain the market, as ETS promote?
2. How NDRC and DRC ensure the compliance of industry to reduce emission? More regulation or incentives?
3. In the aspect of verification institutions, what are the requirements of these institutions? Are they private organization or affiliated to government?
4. So far, is the emission reduction verification measure accurate? As we know, the identification of emission boundary is still controversial.
5. How to maintain the competiveness of obliged industries? And how to ensure the economic equity of different industries?
6. What are the difficulties to promote ETS in China so far?
7. Is carbon tax expected to work with ETS? Positive or negative?

APPENDIX 2: The First Round of Delphi Questionnaire Survey on Criteria to Evaluate the Success of ETSs

Guidance on completion:

Thank you very much for participating in the survey. The purpose of this survey is trying to identify criteria, which can be used to evaluate whether an ETS is sustainable, or success to reduce emission. Here, I also have attached my conclusion through literature review for you reference, as chart below. You can suggest criteria by the best use of your expertise, as well as choosing from my conclusion.

1. Giving price to emission
2. Setting allowance to emission
3.Energy technology research and promotion
4.Monitoring, reporting and verifying scheme
5. Co-work of carbon tax and ETS
6. Subsidy to emission reduction
7. Stringent fine and punish to failed reduction
8. Foster voluntary emission reduction, encouraging offset scheme
9. Transforming from free allowance to auction
10. Efficient level of carbon tax
11. Integration of the carbon market
12. Price supervision of ‘green product’

Please list criteria that can influence the success or effect of ETS, in the thinking of sustainable development in the following chart.

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Please add here if there are more than 10 items:

Thank you very much for the contribution.

APPENDIX 3: The Second Round of Delphi Interview on Agreement of the Criteria

Guidance on completion:

Thank you very much for participating in the second round of Delphi survey. After the arrangement of the first round feedbacks, criteria on evaluating the success of ETS to reduce emission are rearranged as the following chart. The PSR model is borrowed to organize the criteria. The parameters in the state column are the main criteria identified through the first round survey, the indicators in the response column are corresponding sub criteria. The purpose of this survey is asking whether you agree on the five parameters in the state column used to evaluate the success of ETS.

☐ Agree

☐ Disagree

Comments:

DRIVING FORCE	STATE (parameters)	RESPONSE (indicators)
Unconstrained resource/energy use, and pollution output	Volume of emissions	Carbon pricing scheme on emissions (tax or trade)
		Comprehensive emissions monitoring, reporting and verifying (MRV)
Weak environmental monitoring and assessment		Identifying the emissions reduction scope (industry) and coverage (gas)
		‘Green’ technology guidance and promotion
Mono command and control emissions policy	Compliance rate of industry to reduce emissions	Financial assistance and CCER scheme
Low environmental tax and fines		Applying stringent fines for non-compliance
Cost of abatement	Competiveness of industry when reducing emissions	Incentives: subsidy or tax waiver
		Reward or labeling schemes
Open access to emissions reduction	Quality of emissions reduction	Transparent carbon price/CCER price
		Accurate verification system
Diverting emissions site or abatement cost		Integration and cooperation of carbon markets in China
		Supervision of cost delivery of carbon reduction
		Transform from free allowance to auctioned allowance
Intense regulation on emissions	Radical awareness of emissions reduction	Encourage voluntary reduction
High dependence on green technology		Improve production/operating pattern

APPENDIX 4: The Third Round of Delphi Interview on Ranking the Parameters

Guidance on completion:

Thank you very much for participating in the third round of Delphi survey. After the first two rounds of survey, there are agreements achieved on the 5 parameters, which can be used to evaluate the success of ETS to reduce emission. The purpose of this survey is to ranking these 5 parameters, identifying the most important one to reduce emission in buildings. Likert scale is used to quantify the evaluation, as the flowing chart:

Level of importance	Ranking value
Extremely important	5
Important	4
Relatively important	3
Somewhat important	2
Not important	1

Judgment criteria	Quantify value (C_1)
Practice and experience	4
Theoretical study	3
Public information or peer discussion	2
Intuition	1

Level of experience	**Quantify value (C_2)**
Very experienced	4
Experienced	3
Relatively experienced	2
Less experienced	1
Not experienced	0

Please give the corresponding value to the five parameters:

Parameters	Level of importance	Judgment Criteria	Level of experience
Volume of Emission Reduction			
Compliance rate of industry to reduce emission			
Competiveness of industry when reduce emission			
Quality of emission reduction			
Radical awareness of emission reduction			

Comments, if any:

Thank you very much for the contribution.

APPENDIX 5: Questionnaires of Ranking the Indicators

Guidance on completion:

Thank you very much for participating in the questionnaire survey. The purpose of this questionnaire is ranking the 15 indicators, which is used to evaluate the success of ETS to reduce emission in buildings. The quantifying value is as followed:

Level of importance	Ranking value
Extremely important	5
Important	4
Relatively important	3
Somewhat important	2
Not important	1

Please rank the 15 indicators in the following chart:

Indicators	**Level of importance**
Carbon pricing scheme on emission(tax or trade)	
Comprehensive emission monitoring, reporting and verifying (MRV)	
Identifying the emission reduction scope (industry) and coverage (gas type)	
Green technology guidance and promotion	
Financial assistance and CCER scheme	
Applying stringent fine on non-compliance	
Incentives: subsidy or tax waive	
Reward or labeling scheme	
Transparent carbon price/CCER price	
Accurate verification system	
Integration and cooperation of carbon markets in China	
Supervision on cost delivery of carbon reduction	
Transform from free allowance to auction allowance	
Encourage voluntary reduction	
Improve of production/.operating pattern	

Comments, if any:

Thank you very much for the contribution.

APPENDIX 6: Validating the Suggested Building Energy Verification System by AHP

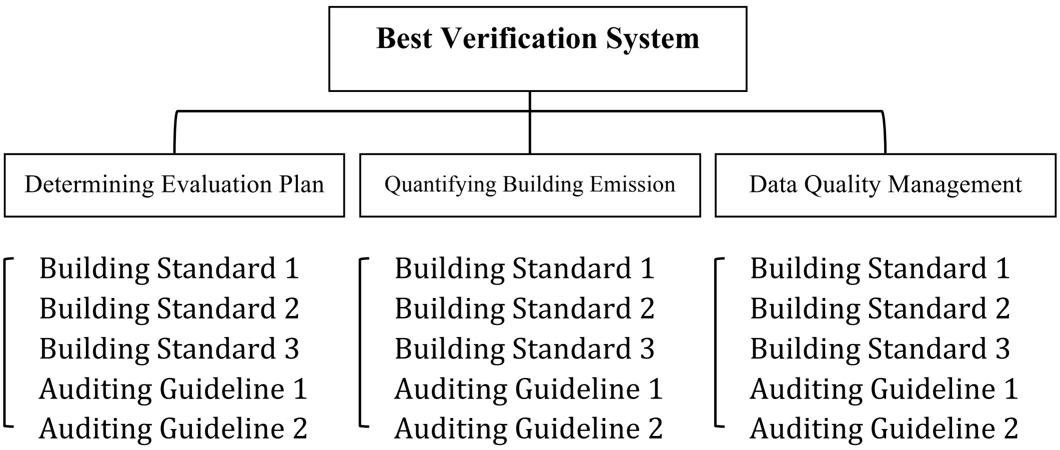
Guidance on completion:

Thank you very much for participating in the survey. The purpose of this survey is selecting from options to achieve the best verification system in buildings under China's ETS. There are total 5 options provided, and their characteristics are summarized in the following char

Title	Evaluation Method	Quantify Method
Building Standard 1	1) Method of Measurement (include Key Parameter Measurement, All Parameter Measurement, and Direct Comparison) 2) Method of Bill Analysis 3) Calibration Method	Energy Consumption in Baseline Period -Energy Consumption after Retrofit ±Adjusting
Building Standard 2	Simulation Assessment: 4) Basic Item: Relative Energy Saving Rate and 5) Regulated Item: Building Usage Type and 6) Option Item: Weather	Energy Consumption in Reporting Period – Calibrated Energy Consumption
Building Standard 3	Record of Energy Usage or Energy Bill (Bill Analysis)	Convert to Coal Use
Auditing Guideline 1	1) 'Energy Consumption in Baseline Period – Influence factor' Modeling 2) Method of Direct Comparison 3) Simulation Method	Energy Consumption in Reporting Period – Calibrated Energy Consumption
Auditing Guideline 2	Meter Monitoring	Σ(Energy Consumption of each Product before Energy

		Saving – Energy Consumption of each Product after Energy Saving) * Number of Products

There are three aspects need to be concerned when design a verification system on buildings: determining the evaluation plan; quantifying building emission; and data quality management. The hierarchy is showed as:



And there are 9 scales provided to the pairwise comparison:

Scale	Verbal Expression	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one over another
5	Strong Importance	Experience and judgment strongly favor one over another
7	Very Strong Importance	An activity is favored very strongly over another
9	Extreme Importance	The evidence favoring one activity over another is off the highest possible order of affirmation
2,4,6,8	Intermediate Values	When compromise is needed

Please provide your comparison value in the following chart:

	Determining evaluation plan	Quantifying Building Emission	Data Quality Management
Determining evaluation plan			
Quantifying Building Emission			
Data Quality Management			

In the aspect of determining evaluation plan:

	Building Standard 1	Building Standard 2	Building Standard 3	Auditing Guideline 1	Auditing Guideline 2
Building Standard 1					
Building Standard 2					
Building Standard 3					
Auditing Guideline 1					
Auditing Guideline 2					

In the aspect of quantifying building emission:

	Building Standard 1	Building Standard 2	Building Standard 3	Auditing Guideline 1	Auditing Guideline 2
Building Standard 1					
Building Standard 2					
Building Standard 3					
Auditing Guideline 1					
Auditing Guideline 2					

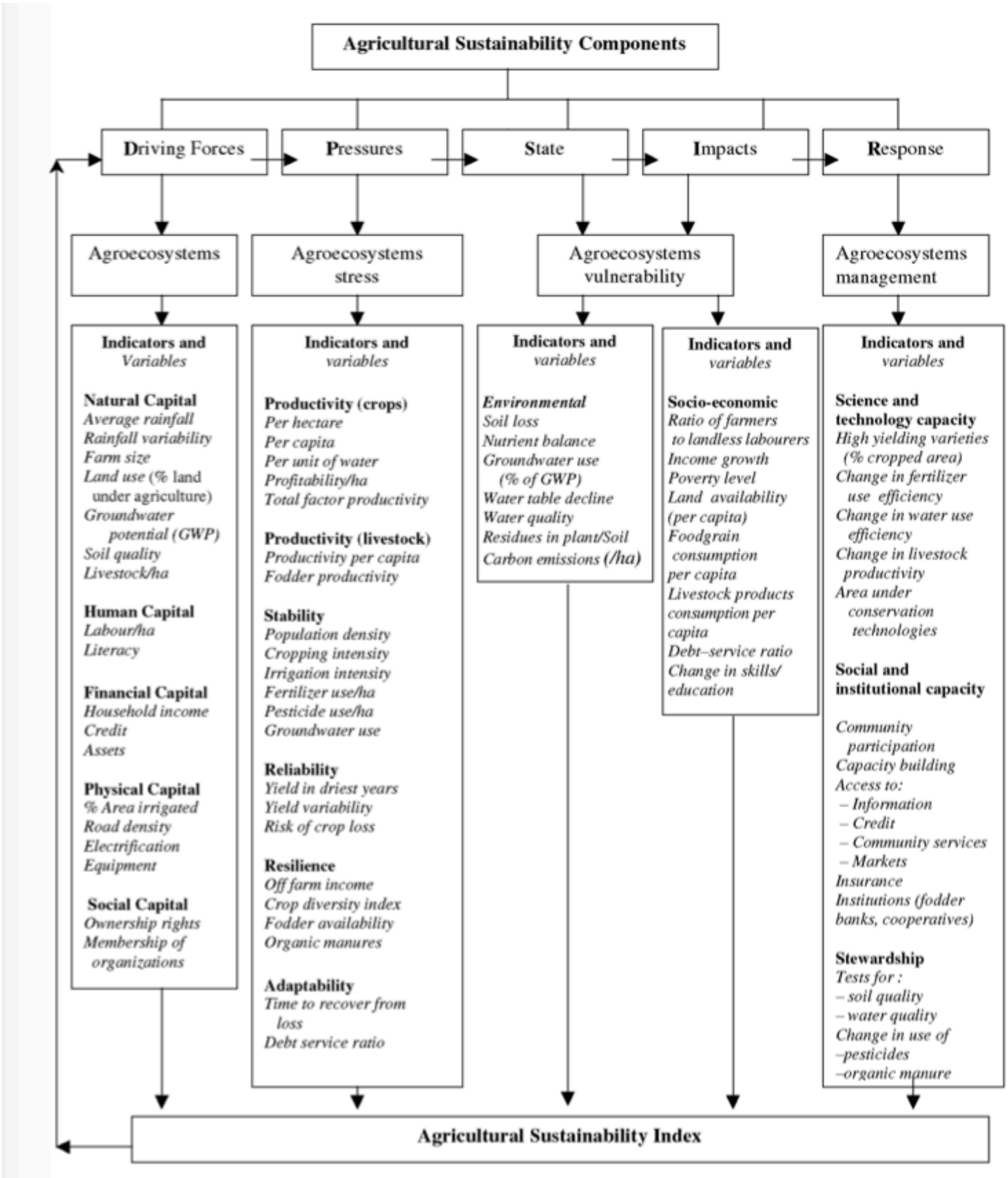
In the aspect of data quality management:

	Building Standard 1	Building Standard 2	Building Standard 3	Auditing Guideline 1	Auditing Guideline 2
Building Standard 1					
Building Standard 2					
Building Standard 3					
Auditing Guideline 1					
Auditing Guideline 2					

Comments, if any:

Thank you very much for the contribution.

APPENDIX 7: DPSIR Structure from Rao and Rogers



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