Chapter 5
Guangdong Pilot ETS Coverage Scope and Allowances

The ETS is comprised of seven components: coverage scope, allowances setting, allowance allocation, transaction management, legal framework, MRV rules, and linkage with external carbon markets. The coverage scope is the primary part, since its reasonable coverage, to a certain extent, decides the operational efficiency of the ETS. However, most of the Chinese current researches focus on total allowances calculation and allocation, instead of on industry coverage of the ETS. In fact, the number and ownership of the covered companies decide the allowances total amount and allocation standard of the ETS. Therefore, the research on the coverage scope shall be the fundamental work. The coverage scope of regional ETS is based on categories of GHGs and the covered industry selection. In light of the *IPCC Fourth Assessment Report: Climate Change 2007*, CO_2 is the predominant anthropogenic GHG, and also the main target in China's emissions reduction program [1]. This chapter elaborates on how to define the coverage scope appropriately for constructing ETS.

5.1 Overview the Coverage of Global ETS

The EU ETS is the world's largest GHG cap-and-trade system. It has developed all-round criteria for guiding industry selection. The EU ETS established two guiding principles for selecting the covered enterprises: First, making a narrow the coverage scope at the infancy of the ETS. Second, take the larger emitter into ETS [2]. The EU ETS had set the following five criteria for industry selection: (i) Environmental effectiveness; (ii) Economic efficiency; (iii) Impact on industrial competitiveness; (iv) Management feasibility; and (v) Substitution policy. Based on these criteria, such industrial sectors as electricity, steel, petroleum refining, glass (incl. ceramics and cement), and paper, with annual CO_2 emissions accounting for 42.6% of the total emissions of EU, were designated into the EU ETS Phase-1 regulation.

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The coverage scope of the Tokyo-ETS shall satisfy the following criteria: (i) All the buildings and installations within the administrative region of Tokyo are subject to CO_2 emissions regulation; (ii) All the buildings and installations within the administrative region of Tokyo, with annual consumption of fuels, heat, and electricity above 1500 kLOe, are involved in the ETS. The statistics show that the annual regulated CO_2 emissions account for 20% of Tokyo's total emissions [2].

The German ETS defines its coverage scope based on category and annual emissions of installations [3]. Through surveys of installations and their emissions of all companies, German Emissions Trading Authority defined that the installations (above 20 MW) as primary emitters, and they are obliged to set a cap on emissions and join in allowances trading as provided by law.

Whether the above global ETS experiences can be directly borrowed by China for building a nationwide ETS shall be first undergoing applicability analysis. A summary of the world prevailing ETS reveals that an ETS coverage scope usually satisfies the following criteria [4, 5]:

(1) Annual CO_2 emissions

The purpose for building an ETS is to fulfill regional emissions reduction goals at a lower cost. The existing ETS in all countries unanimously takes the amount of carbon emissions as a key criterion for defining regulation industries. Since "a small ship makes a good turn," the foreign countries start regulating the emitters with annual emissions taking up a small share of the regional total emissions, i.e., as small as 20–30% during Phase 1 regulation. Similarly, China shall also take account of such percentage while selecting regulation industries for the ETS. In reference to the foreign ETS experiences and the corresponding cost, while the ETS is still at its infancy, it is wise to control the percentage of regulated emissions in the country/region's total emissions at no more than 40%.

(2) Carbon leakage rate

In order to mitigate the impact of carbon trading on the domestic economy and carbon market, each country, when defining the ETS coverage scope, shall take account of the issue of carbon leakage.[1] The Kyoto Protocol targets at regulating emissions from the building; the EU ETS focuses on electric and industrial installations; the German ETS directs at industrial installations. The ETS designers at all levels shall pay special attention to carbon leakage, since it is much easier for inter-regional industry transfer. Some companies under the ETS framework may remove their high-emissions industrial production to other non-compliant areas, which may discourage the economic and industrial development of the areas of origin, and fail to fulfill the target of restricting carbon emissions. According to

[1]Carbon leakage under the Kyoto Protocol occurs when certain compliant countries transfer high-carbon industries to other noncompliant countries, thus increasing CO_2 emissions in the latter. Yet the "carbon leakage" herein occurs within one country, i.e., an area or province with a strict emissions regulation policy removes the local high-carbon industries to other areas, which may affect the economic development of the original area.

China's "12th Five-Year Plan" (2011–2015), all provinces and cities shall reduce carbon emissions, yet their reduction targets varied. Different regions were either strict or relaxed at the control of carbon emissions, which created objective conditions for carbon leakage. Therefore, the areas that set higher emissions reduction targets shall pay special attention to this issue.

(3) Management feasibility

Among the five criteria for selecting industries for the ETS regulation, "management feasibility" is especially important, since it relates to manageability of industry nature, feasibility of monitoring measures, and acceptability of management cost. These factors vary greatly among the Chinese industries, because of weak data foundation of carbon emissions and imperfect legal system about CO_2 emission. Therefore, management feasibility is a particularly important criterion for China to select ETS regulation industries.

All the ETS regulation industries in the EU, German, and Japan satisfy one common criterion: the high-emissions sources are covered to fulfill national/regional emissions reduction targets, lower average management cost, which meets the requirements for the ETS trial operation. Therefore, when selecting regulation industries for the ETS, the priority shall be given to the high-emissions sources.

5.2 ETS Coverage Selection Model Building

While designing a coverage selection mechanism of ETS, those elements of the national/regional carbon emissions structure, economic development plans, and emissions reduction targets shall all be taken into account.

5.2.1 Principles of Model Constructing

The following principles shall be followed for building an indicator system for industry selection:

(1) Integration of universality and comparability

The modules and elements in the indicator system shall be understood and accepted by all stakeholders, and able to reflect the ETS characteristics and regional differences, i.e., the selected indicators shall be of versatility and compatibility. The comparable indicators shall be selected to ensure both space–time comparison and vertical–longitudinal comparison.

(2) Scientificity and operability

When building the indicators for both element layer and base layer, the representation indicators that are scientific and able to reflect the ETS connotation and industry requirements shall be selected. Moreover, the indicators shall be easier to be collected, with authoritative and reliable data sources.

(3) Completeness and independence

The cap on regional total emission allowances trading, allowances allocation approach, and MRV design are essential contents of the ETS, thus calling for complete industry information. The indicators that are capable of satisfying the three requirements shall be selected. Besides, each indicator shall reflect unique and significant information, rather than different indicators reflecting the same fact, so as to ensure a small number of indicators reflecting the overall information of the ETS.

5.2.2 Model Construction

In light of the principles for selecting indicators, Guangdong Province designed an indicator system for the "regional ETS coverage Selection", which consists of the indicators at four levels of system layer, module layer, elements layer, and base layer for identifying the industries accessible to the ETS. This indicator system involves one Tier-1 indicator, 4 Tier-2 indicators, 10 Tier-3 indicators, and 26 Tier-4 indicators. The former three indicators are synthetic and indirect indicators, the Tier-4 indicators are objective, direct, and measurable indicators that should occupy a basic position in the indicator system.

(1) Build an indicator system for the regional ETS coverage scope

Tier-1 indicator, the only one indicator at system layer, refers to the regional industries joining in the ETS. It is a comprehensive and systematic indicator for defining the scope of ETS-regulated industries. Tier-2 indicators, which are in the module layer (below system layer), consist of four representation indicators, i.e., physical quantity, technicality, economy, and quality. Tier-3 indicators, which are an element layer, consist of 10 elements as industrial carbon emissions, emissions reduction space, emissions reduction cost, the operability of emissions administration, industrial development prospect, carbon leakage rate, trading willing, relevant policies, technical advancement, and economic efficiency. Tier-4 indicators, which are in a base layer, are made up of 26 directly measurable indicators, which mark the operability of the indicators for selecting the ETS-regulated industries.

(i) Preconditions:

Manageability of carbon emissions data is precondition or threshold for industries to join in carbon trading. It is the industries with C_3 score above 0.65 that are

covered in the indicator system (this precondition is numbered as B_2, since it essentially attached to B_2).

(ii) Module of physical characterization

This module is made up of two elements: emissions amount and possible carbon leakage. The coverage of large emitters in the ETS help fulfill regional emissions reduction targets, and activate carbon trading market. Carbon leakage concerns the sustainable development of regional economy. If there was a cap on total emissions of an industry, which is fairly mobile and less dependent on resources, there would be capital flight, thus exerting a negative impact on local economy and employment, and hurt stability of the ETS operation.

(iii) Module of technical advancement

"Emissions reduction space" measures the possibility of emissions reduction through technical improvement, so as to manifest the emissions reduction potentials of the industry. "Technical advancement" represents the overall technical conditions of an industry, judge the position of the industry in the carbon market, i.e., buyer or vendor.

(iv) Module of economy

"Emissions reduction cost" measures the expenses spent for cutting emissions. Economically, a company will not adopt any costly technology even though it is able to cut CO_2 emissions. Such potential for emissions reduction is theoretical, instead of operable. "Industry prosperity" is able to differentiate sunset industries from emerging industries.

(v) Module of quality advancement

Such indicators are used to express and deal with the fairly important information that is hard to be conveyed with visual data. "Trading will" and "relevant policies", mainly through interpretation of regional emissions reduction policies and basic industrial conditions, are used to judge the attitude of stakeholders, and the obstacles for the industries to join in carbon trading.

(vi) Explanations of indicators

There are three categories of indicators in Table 5.1, quantitative indicators, nominal indicators, and sequencing indicators. D_7, D_8, D_{23}, D_{24}, and D_{25} are nominal indicators; their value only differs in categorical attributes, and means equal or unequal; if the value of D_7, D_8, $D_{24,}$ and D_{25} is set at "1 or 0" which, respectively, represents "Yes or None" or "Concentrated or Scattered". The value of D_{23} is −1 (very high: fully competitive market), −0.6 (high: monopolistic competition market), −0.3 (relatively low: oligopoly market), and −0 (low: administrative regulation).

Table 5.1 Comprehensive assessment indicators for ETS-regulated industries

Tier-1	Tier-2	Weight	Tier-3	Weight	Tier-4		Total weight
					Name	Weight	
Precondition P		***1***	***C_3 Manageability***	***1***	***D_7 Emissions monitoring and verification***	***0.40***	***0.40***
					D_8 Distribution of emissions sources	**0.60**	**0.60**
Industry accessibility A	Physical B_1	0.25	C_1 Carbon emissions	0.7	D_1 Amount of emissions	0.48	0.084
					D_2 Percentage of emissions from energy and technical process	0.21	0.037
					D_3 Percentage of regulated emissions in regional total emissions	0.21	0.037
					D_4 Unit carbon intensity	0.10	0.018
			C_2 Carbon leakage	0.3	D_5 Resource dependence	0.42	0.032
					D_6 Fixed-asset lock-in rate	0.58	0.043
	Technical B_2	0.25	C_4 Emissions reduction space	0.6	D_9 Emissions reduction potentials in production process	0.41	0.062
					D_{10} Potentials in energy consumption	0.41	0.062
					D_{11} Ranking of industrial emissions reduction space in the region	0.18	0.027
			C_5 Technical advancement	0.4	D_{12} Number of companies using low-carbon technologies	0.46	0.046
					D_{13} Maximum difference value of unit carbon intensity inside the industry	0.19	0.019
					D_{14} Ranking of industrial average carbon intensity among the national same industries	0.35	0.035

(continued)

Table 5.1 (continued)

Tier-1	Tier-2	Weight	Tier-3	Weight	Tier-4		Total weight
					Name	Weight	
	Economic B_3	0.25	C_6 Emissions reduction cost	0.4	D_{15} Average emissions reduction cost	0.63	0.063
					D_{16} Marginal emissions reduction cost	0.37	0.037
			C_7 Economic efficiency	0.1	D_{17} Total factor productivity	0.42	0.011
					D_{18} Carbon productivity	0.58	0.014
			C_8 Industrial prospect	0.4	D_{19} Industry prospect	0.22	0.022
					D_{20} Percentage of newly added capacity in industrial plan	0.63	0.063
					D_{21} Percentage of industrial GDP in regional total GDP	0.15	0.015
	Quality B_4	0.25	C_9 Trading will	0.7	D_{22} Mandatory emissions reduction	0.46	0.081
					D_{23} Marketization degree	0.28	0.049
					D_{24} Experiences in CDM	0.26	0.045
			C_{10} Relevant policies	0.3	D_{25} Substitution policy	0.32	0.002
					D_{26} Percentage of eliminated technologies/ companies	0.68	0.051

Both D_{11} and D_{19} are sequencing indicators, D_{11} could be ranked in a top-down order after calculation with Formula 5.1. D_{19} could be directly traced back to the statistical yearbooks.

$$\text{Emissions reduction space} = \frac{\text{BAU - based emissions} - \text{ETS - based emissions}}{\text{BAU - based emissions}} \tag{5.1}$$

Other indicators are quantitative indicators that are available from statistical yearbooks, industry development plans, study reports, and other public channels.

(2) Model for industry selection

After the assessment indicator system is built, we shall build an industry selection model in the following three steps:

Step 1: Based on the fuzzy membership function model [6, 7], nondimensionalize the B_1–B_4 indicators. Quantify positive indicators with the upwards semi-trapezoid fuzzy membership function model (Formula 5.2). Quantify contrary indicators with the lower semi-trapezoid fuzzy membership function model (Formula 5.3).[2]

$$C(X_i) = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} = \begin{cases} 1 & X_i \geq X_{\max} \\ \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} & X_{\min} \leq X_i \leq X_{\max} \\ 0 & X_i \leq X_{\min} \end{cases} \tag{5.2}$$

$$C(X_i) = \frac{X_{\max} - X_i}{X_{\max} - X_{\min}} = \begin{cases} 1 & X_i \leq X_{\min} \\ \frac{X_{\max} - X_i}{X_{\max} - X_{\min}} & X_{\min} \leq X_i \leq X_{\max} \\ 0 & X_i \geq X_{\min} \end{cases} \tag{5.3}$$

In Formulas 5.2 and 5.3, $C(X_i)$ is the membership value of the actual value, $X_{\max}$ and $X_{\min}$ are, respectively, the maximum and minimum value of D_i; the impact of a dimension could be eliminated with the fuzzy membership function model, and then subject to mathematical calculation.

Step 2: The Delphi Technique and the Analytic Hierarchy Process are used to evaluate the weight of indicators. The weight of indicator P is 1, and the weight of B_1–B_4 is the same at 1/4 (due to basically the same importance degree) based on the average weighting method.

Step 3: In terms of the industries with the weight of P above 0.65, the weight of B_1–B_4 is calculated with Formulas 5.4, 5.5, and 5.6.

[2]Positive indicator is the indicator whose higher score means better assessment result. The contrary indicator is the indicator whose lower score means better assessment result, like cost indicator.

$$T = \sum_{i=1}^{4} \sum_{j=1}^{9} \sum_{k=1}^{24} X_{ijk} W_{ijk} \tag{5.4}$$

$$Y_i = \sum_{j=1}^{9} \sum_{k=1}^{24} X_{ijk} W_{ijk} \tag{5.5}$$

$$Z_j = \sum_{k=1}^{24} X_{ijk} W_{ijk} \tag{5.6}$$

In Formulas 5.4, 5.5, and 5.6, "T" is the integrated score of the four modules (B_1–B_4), Y_i is the score of Module i, Z_j is the score of Element j, X_{ijk} is the weight of Base Indicator k (Element j of Module i) after nondimensionalization. Element C_3 and Base Indicators D_7 and D_8 are separately listed as preconditions, rather than covered in these formulas. Through the above calculations, the "T" value, i.e., the score marking the "industry accessibility", of each industry is finally obtained.

(3) Industry selection principles

With reference to the calculation results, we ranked the pool of industries in a top-down order based on their scores. Higher score indicates the industry is more appropriate for joining in the ETS. The global ETS experiences show that in its infancy, there should be not many regulation industries. While taking account of the fact that the Chinese overall economic development level is not high, and there is uneven economic growth among regions, it is better for the ETS to cover 2–4 industries during the trial run. In the areas that are fairly marketized and having set higher emissions reduction targets, 3–4 industries may be involved.

5.3 Methods to Define the Coverage of Guangdong Pilot ETS

5.3.1 Industry Alternatives Pool Construction

In 2010, Guangdong's gross energy consumption in all industrial sectors was 271.98 million tons (Mt) of coal equivalent; of that, 85.5% was occupied by such sectors as manufacturing, electricity, and transportation [8]. They are an epitome of all industrial sectors that use different technologies. Theoretically, all industries should be separately tested based on the above industry selection model. However, while considering data availability and cost efficiency, we streamlined the scope of sectors in this article based on the criterion that the annual energy consumption of

the sector shall exceed 2% of Guangdong's total [9]; then nine sectors have won out, their combined energy consumption holds 55% of Guangdong's total (see Table 5.2).

5.3.2 To Sort out the Qualified Sectors

By referring to the metrics in Table 5.1, we assembled, collated, and calculated the data about these nine sectors, and found out that only five of them meet the preconditions, i.e., electricity, textile, petrochemistry, cement, and steel. Yet their accessibility to the ETS is subject to further assessment (see Table 5.3).

In light of Guangdong's *Plan for Adjustment and Revitalization of Petrochemical Sector*, and the layout program for key industries during the 12th Five-Year-Plan period (2011–2015), the province will quadruple the production capacity of its petrochemical sector, and place the sector at the core of industrial restructuring in the coming five years since 2011. Guangdong has great potentials to reduce carbon emissions with a large cardinal number of emissions volume. The province's petrochemical sector mostly out-purchases raw materials, but in essence, it is a highly resource-dependent sector, coupled with high percentage of occupancy for fixed assets, so it is less likely to cause carbon leakage.

Likewise, the electricity sector, with a high percentage of occupancy for fixed assets, is neither likely to cause carbon leakage. And, this sector also has great potentials to reduce carbon emissions, which is attributed to its low-carbon energy consumption mix, application of CCS and similar technologies, relatively high economic efficiency and Industry Climate Index (ICI).

In case of textile sector, it is at risk of carbon leakage if a cap was placed on its emissions volume which is too small to allow for massive reduction; moreover, it has a low ICI and small motive power to join in the ETS, which explains its lowest score among the five sectors that meet the preconditions.

In light of Guangdong's *12th Five-Year Plan for Development of Cement Sector*, its cement sector shall expedite industrial restructuring in 2011–2015. In such context, quite a number of the cement enterprises with backward capacity eliminated are able to sell the permits to emit carbon, and those holding newly operated capacity will become the buyer. In a word, the cement sector will play an active role in Guangdong ETS.

Steel sector ranks itself at a low-to-mid place in the scores of five metrics, while there are altogether nine metrics; yet the discrepancy between other sectors is still moderate, indicating that steel sector may be embraced by Guangdong ETS if its scope is extended.

Table 5.2 Sectors with separate energy consumption in 2010 holding above 2% of Guangdong's total (Unit: %)

Sector	Electricity	Textile	Paper	Petrochemical	Transportation	Cement	Construction	Steel	Livelihood	Subtotal
Percentage	7.45	3.15	3.19	8.6	10.3	4.68	2.37	4.67	11.2	55.6

Source Guangdong Bureau of Statistics. Guangdong Statistical Yearbook 2011 [M] Beijing: China Statistics Press, 2012

Table 5.3 Candidate sectors of Guangdong ETS

Sector	Preconditions C_3	Emissions C_1	Leakage C_2	Emissions reduction C_4	Technology C_5	Cost C_6	Efficiency C_7	ICI C_8	Intention C_9	Policy C_{10}	Synthetic score T
Electricity	0.984	0.101	0.042	0.028	0.039	0.053	0.035	0.064	0.014	0.035	0.411
Textile	0.689	0.015	0.021	0.052	0.013	0.044	0.024	0.017	0.012	0.027	0.225
Paper	0.604	–	–	–	–	–	–	–	–	–	–
Petrochemistry	0.989	0.124	0.051	0.089	0.045	0.062	0.027	0.069	0.052	0.015	0.534
Transportation	0.096	–	–	–	–	–	–	–	–	–	–
Cement	0.953	0.046	0.027	0.012	0.031	0.046	0.039	0.058	0.047	0.054	0.361
Construction	0.565	–	–	–	–	–	–	–	–	–	–
Livelihood	0	–	–	–	–	–	–	–	–	–	–
Steel	0.815	0.048	0.039	0.053	0.028	0.021	0.040	0.012	0.025	0.049	0.315

Note "–" indicates the concerned sector does not meet the preconditions, so they are free from further calculation

5.3.3 Result and Conclusion

The industry alternatives pool for the ETS will play a crucial role in Guangdong's energy saving and carbon emissions reduction in the future, yet the above analysis reveals that not all sectors with high-carbon emissions are eligible to be covered by the ETS. Only five of them meet the preconditions, i.e., petrochemistry, electricity, cement, steel and textile, which are herein placed in a descending order of their synthetic scores (see Table 5.3). Being one of China's low-carbon pilot provinces, Guangdong boasts favorable economic conditions and industry environment to implement the ETS. We hereby suggest that Guangdong ETS shall involve electricity, petrochemical, and cement sectors for the following reasons:

First, the combined energy consumption of the three sectors accounted for 20.7% of Guangdong's total in 2010, similar to the percentage within the Tokyo Protocol and qualified for the trial run of the ETS.

Second, petrochemical, electricity, and cement sectors are able to constitute a self-run carbon emissions trading market, where petrochemical sector buys the permits to emit carbon, while cement sector can sell the permits, it seems that they are able to go through the complete process of the ETS, and;

Last, Guangdong's electricity and petrochemical sectors are dominated by a small number of large-sized enterprises. In contrast, the cement enterprises are in a large number, yet they only rely on four types of cement-making kilns, which are easier for ETS administration.

Carbon emissions mainly stem from two sources: energy consumption and production process. When making a model calculation based on energy consumption, the result thereof may be somewhat deviated from the calculation based on carbon emissions volume, and the difference exists in two basic metrics as the potential for carbon emissions reduction and emissions volume, yet such deviation is of little impact on the overall calculation result.

5.4 Guangdong Total Carbon Emissions Allowances

The carbon trading competent department will, by taking account of several elements like local GHG emissions reduction targets, historical emissions of the regulation industries, and emissions reduction space of covered enterprises, set an upper limit on the emissions allowances of covered enterprises at certain point, and finally total up all upper limits on the emissions, which will be the total carbon emissions allowances. A reasonable design of total carbon emissions allowances is one of the essential elements for safeguarding ETS smooth operation.

In light of the *Notice on Carrying out the Work of Carbon Emission Trading Pilot Program in China*, and the *Program for Carrying out the Carbon Emissions Trading Pilot Work in Guangdong Province*, Guangdong ETS shall undergo a pilot period from 2013 to 2015. In order to comply with its emissions reduction

obligation required by the "12th Five-Year Plan" (2011–2015), an estimation of the ETS-based total emissions allowances shall be made, then integrated with different economic growth rate estimated in scenario setting, and finally evaluate whether the ETS-regulated industries are able to fulfill the total emissions allowances of Guangdong Province.

5.4.1 Economic Growth, Energy Consumption, and Carbon Emissions

Guangdong—a fairly developed province in east China—has been a bellwether of China's reform and opening-up endeavor. With continuous economic growth, the province witnessed its 2010 GDP aggregate exceed 4.5 trillion yuan, which accounted for 1/9 of China's total, thus ranking first in the whole country. Moreover, Guangdong has kept optimizing its industrial structure, with the output value of the primary, secondary and tertiary industry holding 5.52, 51.55, and 42.93%, respectively, of its 2008 GDP, such percentage became 5.0, 50.4, and 44.6% in 2010. The ratio of the primary industry kept falling, while that of the tertiary industry was steadily going up; highlighting the predominant role of both industrial and service sectors. Guangdong attempted to control the permanent resident population at no more than 97.30 million in 2010. The province will make a continuous effort in pressing ahead with industrialization and urbanization, and sustaining economic growth. The GDP aggregate of Guangdong is estimated to reach 8.73 trillion yuan by 2020 (calculated at 2005 constant prices). At that time, the urbanization rate of registered population will reach 65%, and that of the permanent resident population will reach 74%.

In 2010, Guangdong total energy consumption reached 268 Mtce, with per unit GDP energy consumption at 0.66 tce/10,000 yuan, marking a level of energy efficiency among the front rank in China, and fulfilling the provincial overall target for energy saving and consumption reduction during the 11th Five-Year-Plan period (2006–2010). Guangdong has been insisting on developing new energy and renewables, the provincial nuclear power sector is about to release production capacity. Guangdong ranks first with a grand scale of nuclear power installed capacity: 5 GW was already completed, and 11 GW is still being built. The province is ready to vigorously develop hydropower generation projects and absorb more electricity transmitted from West China. Of the provincial primary energy consumption in 2010, raw coal, petroleum and natural gas, respectively, accounted for 48.1, 29.1 and 3.7%. Of the provincial final energy consumption, raw coal, petroleum, and natural gas, respectively, made up 11.4, 18.9, and 47%; while other types of energy held 22.7%.

Continuous industrialization and urbanization will improve the level of energy consumption of Guangdong. The industrialized characteristics of urbanization are an outcome of the rapid development of highly energy-consuming industries. The

urbanization process promotes massive construction of urban infrastructure and housing, and drives up both per capita energy consumption and energy intensity. Urbanization gives rise to rigid growth in energy demand, and the emissions from increasing energy consumption have become a crucial challenge against Guangdong emissions reduction endeavor.

In light of the general arrangement of the *Program for Carrying out the Carbon Emissions Trading Pilot Work in Guangdong Province*, during the pilot period (2013–2015), Guangdong will carry out the emission allowances regulation over the companies (with annual CO_2 emissions above 20,000 tons) distributed in electricity, steel, petrochemical and cement sectors. Through verification of the companies' historical emissions and in reference to *Guangdong Statistical Yearbook 2011*, the above four industrial sectors emitted a total of about 340 Mt of CO_2 in 2010. As for the 202 ETS-regulated companies (including 62 electricity companies, 63 steel companies, 9 petrochemical companies, and 68 cement companies), their combined emissions held 80% of the total emissions of the four industrial sectors, and accounted for around 54% of Guangdong's total emissions.

5.4.2 Approach for Calculating Total Quantity of Allowances

The ETS is essentially an emission allowances trading mechanism with a cap on total emissions; thus, a reasonable estimation of total allowances is of great importance. An overly large total quantity is unable to constrain the emissions of covered enterprises, which offsets the effect of the ETS. Yet the total quantity should not be too small, otherwise, it may impede the normal production and operation of covered enterprises. The operational experiences of the ETS both home and abroad demonstrate that the total emission allowances shall be calculated with both "top-down" and "bottom-up" approaches.

Thinking of the "bottom-up" approach: verify the production and emission statistics of the covered enterprises, in order to learn about their quantity of emissions, potentials for emission reductions with the current technologies and the best accessible technologies; set different scenarios, calculate the emission reduction space of different companies distributed in all compliance industries, and add up to a total amount of allowances; evaluate the feasibility of the total amount of allowances under all scenarios (varied costs and technologies), and rehearse the allowance allocation; pay visit to industry associations and corporate representatives, discuss with them, and finally define the total quantity of allowances that are cost-effective and technically feasible.

Conduct a cross-comparison between the total emission allowances, respectively, based on "top-down" and "bottom-up" estimation approaches, take account of the emission demand and reduction potentials of the currently covered enterprises, and reserve a portion of allowances for newly operated projects and for

government regulation. Through discussions among all stakeholders, a total amount of allowances will be finalized. And, the sum should be divided into two portions by their use: one is left for the covered enterprises, and the other is reserved for new projects and government regulation.

Calculation of the total amount of allowances shall abide by the following principles:

- Define the total quantity of allowances for compliance industries under the framework of fulfilling the emission reduction targets of Guangdong;
- The emission reductions of the regulated industries should not be lower than Guangdong's targets for emission reduction (a drop of 19.5%);
- Set a cap, respectively, on the emission allowances for covered enterprises and newly operated projects;
- Double counting of emissions from power generation (based on different power sources) is allowed, owing to data accessibility, and;
- Take account of the emission reduction potentials of each industry, the total quantity of allowances may not obstruct the normal operation of covered enterprises.

Overall, Guangdong ETS shall combine both "top-down" and "bottom-up" approaches for calculating the total quantity of allowances, and set a reasonable range for the total quantity.

5.4.3 Calculation Process and Result of Total Quantity of Allowances

(1) For the currently covered enterprises (top-down calculation)

Assumption: By 2015, the share of the emissions of the regulated industries in Guangdong's total emissions will remain unchanged from 2010, and Guangdong's total emissions will drop by 19.5% from 2010 levels.

Based on the above assumption and several scenarios with different GDP growth rate, we calculated the upper limit of the emissions of the currently covered enterprises by 2015. The result shows that the emission space of these companies varies greatly. With an average GDP growth rate at 8–10%, the provincial total emission allowances should be 640–660 Mtce in 2015.

Scenario A (GDP growth rate at around 8%): the total allowances of the covered enterprises will be 342 Mtce by 2015 based on their constant share in Guangdong's total emissions.
Scenario B (GDP growth rate at 10%): the total allowances of the covered enterprises will be 353 Mtce by 2015 based on their constant share in Guangdong's total emissions.

(2) For the currently covered enterprises (bottom-up calculation)

First, verify the historical carbon emissions of the covered enterprises of Guangdong ETS, process and analyze their emission data, and figure out their average emissions in past years. Second, screen the four industrial sectors involved in Guangdong ETS, and define the typical companies; investigate the production and technologies of different covered enterprises, draw up a conclusion about their BATs[3] for emissions reduction and capacity.

Third, in light of the national plan for lowering emissions by 2020, the State Council's *Work Plan for Greenhouse Gas Emissions Control during the 12th Five-Year Plan Period*, and *Guangdong Province to Carry out the National Low-carbon Province Pilot Implementation Plan*, three scenarios are set to estimate the emissions space of the covered enterprises, and add up to total allowances; with respect to cost and technical conditions, analyze the ability of these companies to handle such quantity of allowances in three scenarios. Through visits and exchanges with industry associations and corporate representatives, rehearsal and adjustment of total allowances, finalize the allowance budget that is cost-effective and technically feasible.

(3) Guangdong ETS allowance budget in 2013–2015

In light of Guangdong's plan for new installations during the 12th Five-Year Plan period, and in reference to the criteria for allocating allowances to the industries where these installations are distributed, the total emissions of these new installations by 2015 could be figured out.

Here is a formula: Guangdong ETS allowance budget = allowances to covered enterprises + allowance reserve for new installations + allowance reserve for government regulation.

The quantity of the allowance reserve for government regulation is determined by the emission reduction potentials of covered enterprises and the overall reduction targets of the ETS. Table 5.4 shows Guangdong ETS allowance budget and composition during the pilot period (2013–2015).

[3]"BAT": best available technology

Table 5.4 Guangdong ETS allowance budget in 2013–2016 (Unit: Mt)

Timeframe	Trading period	Allowance budget	Compliance companies	Allowance reserve	
				New installations	Government
Pilot period	2013	388	350	20	18
	2014	408	370	38	
	2015	408	370	38	
Transitional period	2016	386	365	21	

Source Guangdong Provincial Development and Reform Commission, *Notice of the First Allowance Allocation Plan in Guangdong ETS*. 2013.11.25 [10]

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