Chapter 2
Global ETS Operation and Their Merits and Demerits

Since the Kyoto Protocol (KP) was signed in 1997, all parties to the KP have been actively exploring the path to transit to a low-carbon economy, and using market mechanism to cut Greenhouse Gas (GHG) emissions and save the cost for emission reduction. On January 1, 2005, European Union Emission Trading Scheme (EU ETS) was launched, which was followed by Regional Greenhouse Gas Initiative (RGGI), Midwestern Greenhouse Gas Reduction Accord (MGGRA), Western Climate Action Initiative (WCI), and California Cap-and-Trade. Australia achieved significant reduction results from the fixed-carbon emission reduction system. New Zealand Emission Trading Scheme (NZ ETS) has included agriculture, fishery, and forestry into governance, since agriculture is the country's pillar industry. Japan started VER since 1997 and has formed a cap-and-trade system at the municipal level.

In addition to the contracting parties to the UNFCCC (see Annex I), some non-contracting parties also pledged to join in this emission reduction campaign. For example, China defined seven provinces and municipalities to carry out the ETS pilot program, and then announced at the Paris Climate Conference in 2015 (COP21) to launch the nationwide carbon market in around 2017. Mexico set the targets and specific measures for emission reduction by 2020. South Korea started exercising the ETS since 2015. India has been making efforts in developing renewables and a market-oriented energy mechanism.

2.1 Construction and Operation of Global ETS

2.1.1 EU ETS

EU has all along been an initiator and forerunner in responding to climate change. From 1992 to 2008, the UK had promulgated 73 policies to deal with the challenges posed by climate change, and has achieved significant results [1]. After the KP took

D. Zhao et al., *A Brief Overview of China's ETS Pilots*,
https://doi.org/10.1007/978-981-13-1888-7_2

effective since 2005, EU launched the ETS—the largest GHG emission trading system in the world, for the purpose of helping member countries lower emission reduction cost. To date, EU ETS has been in operation for almost 10 years, and passed through the preliminary phase (2005–2007) of "learning-by-doing" and the interim phase (2008–2012) that is filled with drastic market fluctuations; it is now at the third phase (2013–2020) which is considered as a "post-KP period" that features adjustment of both market and institutions. The development of EU ETS is a process of sparse allowance management transfer to unified management and also a gradual improvement of the carbon market.

EU ETS, a strategic policy to cope with climate change, covered 50% of EU CO_2 emissions when launched. It scoped over 11,500 fixed emission installations from electricity generators, heat and steam production, mineral oil refineries, coke ovens, ferrous metals production and processing, cement, lime glass, bricks and ceramics, pulp and paper of 28 member countries. Six types of GHGs were emitted from these sectors (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) were covered [2]. From 2010, more than 4000 aviation operators were also scoped into EU ETS. The scope of EU ETS in Phase 3 has further extended to chemical, synthetic ammonia, nonferrous melting, and aluminum sectors. PFCs arising from electrolytic aluminum, and N_2O arising from chemistry, ammonia, aluminum, nitric acid, adipic acid, and glyoxylic acid were covered.

(1) Emission reduction targets

EU ETS set three phases to reach its emission targets. Phase 1 (2005–2007): to fulfill 45% of EU commitment target under KP. Phase 2 (2008–2012): each EU member state cuts average 6.5% emissions based on 2005 level. The total target of these two phases is in accord with the target of KP's first commitment period (2008–2012), which is by 2012, the total emissions of 15 European countries will decrease 8% compared to the emission level of 1990. In Phase 3 (2012–2020), EU emission reduction target will be formulated according to European "20/20/20" targets[1]; i.e., by 2020, European GHG emissions will be cut 20% based on 1990 level. In 2014, The European Council approved a more stringent emission reduction target for 2030, that: abatement of GHG emissions shall reach to at least 40% from 1990 level. In light of the overall emission reduction targets, EU ETS allowances allocated in the three phases will decrease gradually, i.e., Phase 1 preserves 2299 Mt CO_{2e}/a; Phase 2 preserves 2081 Mt CO_{2e}/a; Phase 3 cuts preserved allowances by 1.74% annually; and Phase 4 cuts preserved allowances by 2.2% annually.

[1]By 2020, European GHG emissions will decrease by 20% based on 1990 level; the share of renewables in European total energy consumption will to 20%; European energy-use efficiency will rise by 20%.

(2) Allowance allocation scheme

The allowance allocation of EU ETS in Phases 1 and 2 was based on National Allocation Plan (NAP). European Commission allocated allowances to each member country based on their reported historical CO_2 emissions, such allocation approach is called “Grandfathering”. In Phase 1, 95% of the allowances were allocated for free, and each member country was allowed to purchase no more than 5% of allowances through auction. In Phase 3, European Commission canceled NAP, but adopted “Benchmarking”, which means there was a benchmark for allocation based on CO_2 emissions per unit of production in different industrial sectors and production activities; the proportion of free allocation was gradually lowered, while the proportion of allocation auction would be increased.

(3) Flexible mechanisms

The surplus allowances in Phase 1 could be banked or Phase 2, with an aim to encourage emitters to cut more emissions according to their actual emission volume and allowance price, and maintain vigor and continuity of the secondary allowance market.

(4) Compliance

EU ETS imposes penalty on non-compliance companies. In Phase 1, one ton of excessive emission will be fined €40/CO_{2e}. In Phase 2, one ton of excessive emission will be fined €100/CO_{2e}. In Phase 3, the amount of fine will increase along with the European Consumer Price Index (CPI). The compliance ratio in 2005–2009 was above 98% and reached 100% in 2006–2008.

(5) Carbon market performance

EU carbon market has been developing rapidly. In 2010, the trading volumes in the EU carbon market accounted for 84% of the global total trading. EU carbon market is the largest market of this type to date. By 2012, the allowances traded in the EU carbon market reached 7.9 billion CO_{2e}, which was 17 times more than that in 2006. See Fig. 2.1 [3].

(6) Effectiveness assessment

In Phases 1 and 2, EU allocated all 3 years’ allowances for free. Allowances were based on historical emissions of member countries without considering the impact of economic fluctuations, and lack of allowance assessment and an adjustment mechanism. In 2008 when a global financial crisis broke out, the European industrial activities fell into a downturn, decreasing carbon emissions resulted in massive surplus allowances. Moreover, a large quantity of low-price carbon offset credits was used for commitment, which exacerbated allowance excess, and pulled down allowance prices further. At the end of Phase 2, the total allowances surplus of European companies were about 2100 Mt CO_{2e}, which equaled to an annual allowance volume of EU ETS, thus causing the allowance price to plunge again after a 2-year stable implement.

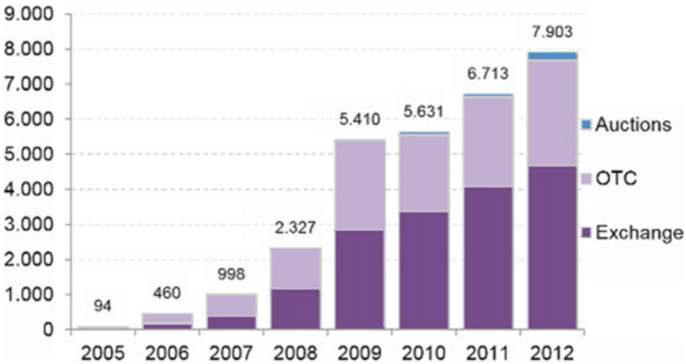

Fig. 2.1 EU ETS Phase 1 and Phase 2 Allowance Trading Volume (bln CO_2). *Source* "Evolution of the European carbon market", EU Emission Trading System, EU Action, Climate Action, European Commission official website. https://ec.europa.eu/clima/policies/ets/pre2013_en

In face of massive surplus allowances and gloomy market, EU was forced to reform the allowance allocation in Phase 3. First, EU adopted a unified allowance calculation to prevent unequal allocation among member countries. In order to reduce allowance inventory and cancel the "windfall profit" of the electricity sector, all of the allowances allocated to the electricity sector was subject to auction. In contrast, the industrial sectors facing international competition were receiving free allowances to safeguard their competitiveness and to prevent carbon leakage. For example, 85% of the allowances given to aviation operators were free of charge. However, the ratio of free allowances will decrease year on year, i.e., from 80% in 2013 to 30% in 2020 [4]. Second, EU postponed allowance auction. The 900 Mt CO_{2e} of allowances in Phase 3 are preserved for auction in 2019–2020, which, in turn, cuts the allowance auction in 2014, 2015, and 2016 by 400, 300, and 200 Mt, respectively. Consequently, the ratio of allowance auction has been increasing after entering Phase 3: exceeding 50% in 2013, reaching 70% in 2020, and 100% in 2027 [5]. Third, only the emissions based on Certification Emissions Reduction (CER)—from either the least developed countries or any country that has signed a bilateral agreement with EU—are accepted for compliance [6]. Last, EU plans to introduce an allowance reserve mechanism since 2018 for market stable to resolve excessive allowance allocation in the long run. Meanwhile, while considering the allowance supply and demand, EU will adjust the volume of allowance auction to regulate the supply–demand pattern, and strengthen the capacity of EU ETS to resist market impact [7].

(7) Carbon Market Linkage

A global common mechanism for tackling climate change through negotiations is a long-term task, but EU has been attempting to link and cooperate with worldwide carbon markets, and help different countries establish the "cap-and-trade" system. EU believes that the market linkage shall meet the following conditions:

- Compatibility. Different trading systems shall have the same operational environment, e.g., 1 ton of CO_2 shall have the same equivalent value within different systems;
- Equivalent policy imperative;
- There is a cap on total emissions for each ETS scheme.

In light of the above requirements, EU and Australia used to negotiate on linking their ETS, but failed to reach any consensus, as Australia repealed its ETS in 2014 [8].

In order to encourage the development of global carbon market, at the time that the Paris Climate Conference was about to reach a new global climate change agreement, EU expects to define the rules for the international carbon market. EU holds that a new global carbon market mechanism shall be built, which is similar to the KP-based Clean Development Mechanism (CDM) and Joint Implementation (JI), in an aim to deepen international collaboration in emission reduction.

2.1.2 ETS in North America

Before the book was finalized, the US has not yet developed a nationwide cap-and-trade program, but several states have made their first move. Certain regional cap-and-trade programs, particularly the Regional Greenhouse Gas Initiative, Midwest Greenhouse Gas Reduction Accord, and Western Climate Initiative and California Air Resource Board, took shape one after another.

(1) Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI), which was officially launched in 2009, is the first mandatory market-based program in the US to reduce GHG emissions. The RGGI is a cooperative effort of nine Northeast and Mid-Atlantic US states—Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont—to regulate and reduce CO_2 emissions from 225 power plants (in operation of 500–600 generator units). For the first 3-year period (2009–2011), the cap for 10 states was 188 Mt. For the second 3-year period (2012–2014), the cap for the 9 RGGI states (New Jersey dropped out) was 165 Mt per year in 2012 and 2013. A self-assessment in early 2014 revealed that the reserved allowances were far more excessive than the actual emissions. Based on this result, several amendments were made to the RGGI Model Rule: the Emissions Cap in 2014 will be within 91 Mt. The Model Rule language maintains the original 2.5% per year reduction to the regional RGGI cap for the years 2015 through 2020 [9]. In the meantime, the RGGI will, based on the surplus allowances in the prior period, preserve a portion of allowances for macro regulation [10].

The RGGI was the world's first cap-and-trade program that allocated all emissions allowances through auctions. Regional auctions are held on a quarterly basis. They were initially conducted in a single round using sealed-bid or uniform price format, and later conducted in multiple rounds using ascending price formats. The unsold allowances in each auction will be transferred to the next auction. When entering into a new period, the RGGI will evaluate the current allowances' supply and demand, actual emissions and compliance performance of covered enterprises, and then decide to either revoke the undistributed allowances or transfer them for auction in the coming period. The first upset price in the 2009 auctions was set as $1.86/t, which was adjusted up in each auction after 2009 in reference to the CPI fluctuations. In addition to the upset price, the RGGI will bring in more allowances and price regulation mechanisms for easing fluctuations of allowances market. In light of the amended RGGI Model Rule, the unsold allowances left from 2012 and 2013 auctions will not be transferred into new auctions since 2014, and the Cost Containment Reserve (CCR) was introduced. The CCR would consist of a fixed quantity of allowances, in addition to the cap, that would be held in reserve, and are only to be made available for sale if allowance prices were to exceed predefined price levels.

In terms of complementary mechanisms, the RGGI covered enterprises, in addition to obtaining allowances through auctions, may purchase offset credits to deduct their emissions. Offset credits in the following five project categories may be eligible for use in the RGGI State regulations: (i) Landfill methane capture and destruction; (ii) Reduction in emissions of sulfur hexafluoride (SF_6) in the electric power sector; (iii) Sequestration of carbon due to the U.S. forest projects (reforestation, improved forest management, and avoided conversion) or afforestation (for CT and NY only); (iv) Reduction or avoidance of CO_2 emissions from natural gas, oil, or propane end-use combustion due to end-use energy efficiency in the building sector; (v) Avoided methane emissions from agricultural manure management operations.

All offset projects must be located within one of the RGGI States, or in any other state that agrees to implement the RGGI emissions reduction criteria; and commencement of these offset projects should be restricted in a certain period. Finally, the deduction proportion of CO_2 offset credits shall tie to the allowance auction prices [11].

(2) Midwest Greenhouse Gas Reduction Accord

The Midwest Greenhouse Gas Reduction Accord (MGGRA) is a regional agreement by six governors of states in the US Midwest (Minnesota, Wisconsin, Illinois, Iowa, Michigan, and Kansas) and the Canadian Province of Manitoba. It covered electricity generation and imports, industrial process sources, transportation fuels, and commercial sectors. The Accord envisions cutting GHG emissions 20% below 2005 levels by 2020, and 80% below 2005 levels by 2050.

The Accord has been inactive to date with allowance allocation not started, yet a special Advisory Group—constituted by the environmental division, industrial department and administrative department in all of the signatories to the Accord—has begun to provide recommendations regarding the implementation of the Accord. Allowance allocation is to be calculated in a uniform approach, granting the reward of allowances to the early starters, as well as taking account of emissions increase resulting from economic and population growth in any regulated state and province. Allowance allocation is first subject to an auction and free distribution, and gradually replaced by complete auction. The Accord allows for offset credits, which are no more than 20% of the allowance cap. The Accord shall be developed in a manner that facilitates linkage with other programs like RGGI, WCI, and EU ETS.

(3) Western Climate Initiative

The Western Climate Initiative (WCI) is a cooperative effort of seven U.S. states (Oregon, California, Washington, New Mexico, Arizona, Montana, and Utah) and four Canadian provinces (British Columbia, Manitoba, Ontario, and Quebec). The states of Alaska, Colorado, Idaho, Kansas, Nevada, and Wyoming participate as observers, as do the Canadian province of Saskatchewan and the Mexican border states of Baja California, Chihuahua, Coahuila, Nuevo Leon, Sonora, and Tamaulipas.

Western Climate Initiative funded a nonprofit corporation in 2011 to provide administrative and technical services to support the implementation of state and provincial GHG trading programs.

Beginning in 2012, the initial compliance period , the program will cover 90% emissions of involved states with an overall emissions reduction objective of lowering 2020 emissions by 15% from 2005 levels. The scoped sectors include electricity, including electricity imports; fossil fuel combustion at large sources; and industrial process emissions. The second compliance period would begin in 2015, the program would expand to cover the combustion of natural gas and diesel oil at transportation sector, fossil fuels used for residents, and commerce, as well as other industrial fuels.

Generally, allowance distribution will be done independently by each WCI Partner jurisdiction. For the first compliance period, the WCI Partner jurisdictions will auction a minimum of 10% of the allowance budget, and to increase the minimum percentage to reach 25% in 2020.

In order to encourage early initiators prior to the start of the program, WCI considering to issue “Early Reduction Allowances” as a reward to provide incentives for emission reduction. Each Partner will have the discretion to bank allowances to the next phase.

The WCI Partner jurisdiction will limit the use of all offset credits. The proportion would be no more than 49% of the total cap during 2012–2020. Each WCI Partner jurisdiction will have the discretion to set more stringent rules for abatement.

Through a review of the WCI operation, it is only California and Quebec that have implemented the cap-and-trade mechanism (with the former becoming a separate executor with the “California Air Resource Board”), and jointly organized allowance auctions. Other states and provinces are yet to publish any substantial progress in cutting emissions.

(4) California Air Resource Board

California Air Resource Board (CARB), which was created in 1967 to aggressively address the serious issue of air pollution in the state, saw its role expanded by the Global Warming Solutions Act of 2006 (Assembly Bill 32 or "AB 32") to development and oversight of California's main GHG reduction programs.

The CARB regulates 85% of California GHG emissions generated from about 600 emitters with annual emissions above 25,000 tons. They are industrial companies; electric power generators, transmitters, and distributors; fuel producers, suppliers, and importers; residential and commercial natural gas distributors; LPG producers; producers and suppliers of transportation fuels and biomass fuels. The CARB regulation also extends to the six KP-restricted GHGs (CO_2, CH_4, N_2O, HFC_S, PFC_S, and SF6) and NF_3.

California has set the target to roll back carbon emissions to 1990 levels by 2020, marking an emission drop of around 9% from 2005 levels.

Transportation accounts for 37% of GHG emissions in California. Reducing GHG emissions from this source category is vital in achieving the goals of AB 32. Understanding this challenge, the state government exercises emission regulation over the fuel stations that import fuels to California, i.e., to exert pressure upon the supply end [12]. Besides, with 31% of the state electricity demand satisfied by outbound sources, the CARB has to impose more cost on electricity importers to curtail GHG emissions.

The CARB involves three phases: in Phase 1 (2013), the total allowances were 98% of the emissions of the covered enterprises in 2012. In Phase 2 (2014), the allowances dropped 3% from 2013 levels. In Phase 3 (2015–2020), the allowances will drop 3% year on year from 2013 levels.

The CARB allowance auction is based on a quarterly basis. Free allowances are granted to the industrial installations that are prone to industry transfer under the cost pressure from the cap-and-trade mechanism (a latent danger for carbon leakage). The amount of free allowances is calculated on basis of carbon intensity baseline, so the companies with lower carbon intensity will have access to more free allowances. The baseline is constantly updated in light of the carbon intensity reported by companies, so as to encourage the low-carbon development of California-based companies [12]. In contrast, the free allowances granted to electricity producers and distributors are merely 24% of their total demand for allowances in 2013–2020. For other industries, the percentage of free allowances range from 30 to 100% in light of their carbon leakage. In the meantime, in order to guard against drastic price fluctuations in allowance auctions, California sets the upset price at \$10 t/CO_2, and reserves 5% of the total allowances for market regulation, i.e., setting the price for reserved allowances is a means to control price ceiling in auctions.

California allows offset credits of nonlocal projects to offset the local emissions. Companies may use the offset credits to meet up to 8% of their compliance obligations. Yet there are also strict rules on the operation time and location of the offset projects. The Climate Action Reserve (CAR) only approves the offset credits from four categories of projects that are about forestation, urban forestry, livestock breeding, and ozone depletion. The offset credits from the projects in developing countries may not be above 25% of the total allowances in 2013; and such percentage may not be above 50% through 2014–2020. California also accepts the offsets from the Reducing Emissions from Deforestation and Forest Degradation (REDD) in developing countries. The offset credits approval based on the CAR methodology is about 8.70 Mt, which is estimated at 125 Mt in 2013–2020, i.e., equal to about 4% of the total emissions during this period.

In terms of the allowance allocation approaches, several US carbon emission trading mechanisms adopt allowance auction, which takes account of the emissions reduction cost and actual allowance demand of covered enterprises, and keeps from excessive allocation. However, the RGGI operation experience shows the Phase 2 allowance allocation was excessive, because of too many allowances placed in the auction and extensively sold at lower prices. Such experience tells that allowance allocation, even by means of an auction, shall be adjusted amid economic fluctuations and abiding by strict allocation principles, instead of setting any unrealistic lower upset prices.

The US initiated SO_2 and NOx emissions trading as early as in the 1990s, the mature experiences therefrom have laid a solid foundation for each state to develop their own cap-and-trade system. Local governments have been actively playing a lead role in caring out carbon emissions reduction programs and mapping out trading rules. Although a nationwide GHG emissions reduction campaign is still in absence in the US, the regional emissions reduction endeavors have formed a bottom-up driving force and good example, which will stimulate the promulgation of a nationwide emissions reduction policy. In contrast to a nationwide carbon market, regional cap-and-trade mechanisms—though help to fulfill regional emissions reduction targets—have certain limitations since they are separate from each other, the varied allowance prices and different marginal reduction cost may hold back effective allowance allocation and lower reduction efficiency [13].

2.1.3 ETS in Australia

Australia carbon emission trading is carried out in several phases, and each phase takes on different characteristics. Phase 1 (July 2012–July 2015) was actually a phase featuring fixed pricing, rather than the typical "cap-and-trade". During this period, the government sold allowances to covered enterprises at a fixed price. In Phase 2 (July 2015–July 2018), fixed pricing is replaced by float pricing, and "cap-and-trade" is truly carried out.

During the fixed-pricing period, the carbon emissions regulated by AU ETS accounted for two-thirds of Australian total emissions. About 300 covered enterprises—each with annual CO_2 emissions above 25,000 tons—are mostly distributed in the sectors of stationary energy, industrial process, volatiles, and waste. Natural gas retailers are also included, and they are allowed to transfer their

Table 2.1 Categories of companies that receive free allowances

Levels of emission intensity	Intensity	Percentage of free allocation (%)	Compliance companies
$\geq$ 2000 tCO_{2e}/mln AUD	High	94.5	Glass, methanol, aluminum smelting
1999–1000 tCO_{2e}/mln AUD	Medium	66	Lead–zinc, high-purity ethyl alcohol, polyethylene, urea
$\leq$ 1000 tCO_{2e}/mln AUD	Low	0	Aluminium oxide, coal mine, lime, LNG, gasoline, paper, ethylene

emissions obligation to large-scale natural gas users based on the "Obligation Transfer Numbers" (OTN). The Australian government has been levying liquefied fuel tax upon the users. The large-scale liquefied fuel users may join in the ETS by means of joining in emissions pricing mechanism or paying for liquefied fuel tax.

During the fixed-pricing period, the Australian government divided the covered enterprises into three categories based on their carbon intensity (CO_2 emissions/monthly business income), and allocated allowances based on the benchmark of varies industries. See company categories and their allowances in Table 2.1.

During the float-pricing period, the companies with high-carbon intensity and cost hard to pass on to end users will continue receiving free allowances, yet the specific allocation method is yet decided. The paid allowances will be allocated through auctions.

The fixed price was initially set as A$23 t/$CO_2$, which will go up 2.5% year on year by taking account of the inflation rate. The Australian government sets a ceiling price that it should not be higher than global prices by A$20 t/$CO_2$. During the float-pricing period, the government sets a floor price at A$15 t/$CO_2$ in 2015–2016 to guard against drastic price fluctuations, such price will rise 4% year on year afterward.

The Australian government has unveiled a slew of supplementary measures to ease the adverse impact of the ETS on socioeconomic growth. First, extending vigorous support to the export-oriented and emissions-intensive industries during the fixed-pricing phase. Second, supporting electric power sector (including the clean energy-based power grid), subsidizing to close outmoded power plants, and allocating free allowances to the large-sized power plants that may be affected. Moreover, in order to mitigate the impact upon electricity consumers, at least 50% of the allowances revenue shall be used for subsiding households, and the amount of subsidy will gradually increase.

In August 2012, Australia and EU announced to link their carbon markets, and achieve complete bidirectional linkage by 2018. At that time, the Australian companies may purchase allowances from EU; the Australian government shall adjust the current carbon pricing policy; calling off the floor price; and updating the offset rules. The coverage of linkage involves the MRV, market supervision, and support to the industrial sectors that are prone to be affected by carbon leakage.

2.1.4 ETS in Japan

Japan took an early start in carbon emissions reduction action. To date, Japan has developed diverse GHG emissions reduction programs. After the KP was concluded, Japan—one of the Annex I Parties—sets an overall reduction target to lower 2012 emissions by 6% from 1990 levels. Japan did not build a cap-and-trade system, but embarked on voluntary reduction.

(1) Keidanren Voluntary Emissions Action Plan (KVAP)

In 1997, Keidanren—the most important and influential business federation in Japan—kicked off the Keidanren Voluntary Emissions Action Plan (KVAP), which regulates massive companies in fields such as manufacturing, energy, transportation, construction, and foreign trade. The scope of regulation extended from the preliminary 38 industrial sectors to 50 industry associations, 1 conglomerate, and 7 railroad companies in 2007. Each industrial sector and company defines the emission reduction and energy saving objectives on their own. The KVAP does not include allowance allocation and trading, it is a voluntary action initiated by companies.

Through a self-assessment, Keidanren acknowledged the accomplishments of the KVAP in lowering carbon emissions and energy intensity and promoting low-carbon energy use. The covered enterprises are on the way of cutting emissions, and some of them have effectively lowered their emissions from 1990 levels. Yet, some nonprofit environmental organizations are skeptical about the reduction effect of the KVAP, because the KP requires the Japanese industrial sectors to cut the 2008–2012 emissions by 8.3% from 1990 levels, while the KVAP target is to cut 2008–2012 emissions to 1990 levels, which is far lower than the KP targets.

(2) Japan Verified Emission Trading Scheme (J-VETS)

In 2005, the Japanese Ministry of the Environment launched the Japan Verified Emissions Trading Scheme (J-VETS) with the jurisdiction over the small-to-medium sized companies that are not covered by the KVAP. The government encouraged companies to send applications, and then picked out the eligible ones based on their reduction cost proposals. The selected companies would receive certain subsidies for installing emissions reduction equipment; meanwhile, they shall bear emissions reduction obligations and fulfill reduction goals through allowance trading. There were altogether 303 companies joining in this program in 2006–2010, their allowances were allocated after their 2002–2004 annual average emissions were calculated and verified.

After the J-VETS was carried out, the annual allowance trading was only at 10,000 tons level on average, i.e., 82,624 t/CO_2 in 2006, 54,643 t/CO_2 in 2007 and 34,227 t/CO_2 in 2008. In contrast, the covered enterprises outperformed their annual reduction targets: they cut 29% of their emissions in 2006 (base year) despite of the target at 21%; they cut 25% in 2007, higher than the target at 19%;

they cut 23% in 2008, far above the target at 8.2%. The operation of J-VETS shows that small companies have great potentials in emissions reduction.

(3) Tokyo Cap-and-Trade Program

In 2010, the Tokyo cap-and-trade program was officially launched, thus becoming the world first cap-and-trade program designed for commercial operation, and the first city-level cap-and-trade program. The program regulates about 1100 industrial and commercial installations, whose emissions accounted for about 40% of Tokyo's total emission. The main objects of regulation are large installations with fuel, heat, and electricity consumption of at least 1500 ton annually. The Tokyo Cap-and-Trade program has extended its emissions reduction target from the KP objectives: to cut the 2020 emissions by 25% from 2000 levels. This overall target is to be fulfilled through two phases. In Phase 1 (2010–2014): to cut annual emissions by 6% from the base year (the average emissions of 3 consecutive years in 2002–2007). In Phase 2 (2015–2019): to cut annual emissions by 17% from the base year. In light of the grandfathering principle, the allowances given to the covered enterprises are calculated based on the emissions in base year and the compliance factors set by the government (the allowances for two phases are calculated at one time), and allocated to the companies at the start of each compliance period for free (Fig. 2.2).

According to the annual summary report released by the Bureau of Environment of Tokyo, the cap-and-trade program has attained significant results: Tokyo cut 2010 emissions by 13% from the base year. Among the total regulated installations, 64% of them overfilled their 2010 reduction targets (the commercial and industrial installations, respectively, cut emissions by more than 8 and 6%); 26% of them cut emissions by more than 17% which was the Phase 2 reduction target; 71% of them were able to fulfill the reduction target on their own, indicating that the remaining 29% had to purchase allowances. Tokyo adjusted up the 2012–2013 reduction targets to 22%. In 2014, only 10% of the installations failed to achieve their intended targets.

(4) Integrated emissions trading market

The KVAP and J-VETS have been developing side by side and complement each other.

The covered enterprises regulated by different emissions reduction systems may carry out additional emissions reduction projects to obtain VER, and the VER would be valid for trading in Japan's integrated emissions trading market that started operating since 2008. In addition, the domestic VER that is developed on basis of the Japan Verified Emissions Reduction (J-VER) could also be traded in this market, so does the VER based on the KP-recognized CDM. In short, the Japanese allowance market has a large capacity and extensive scope.

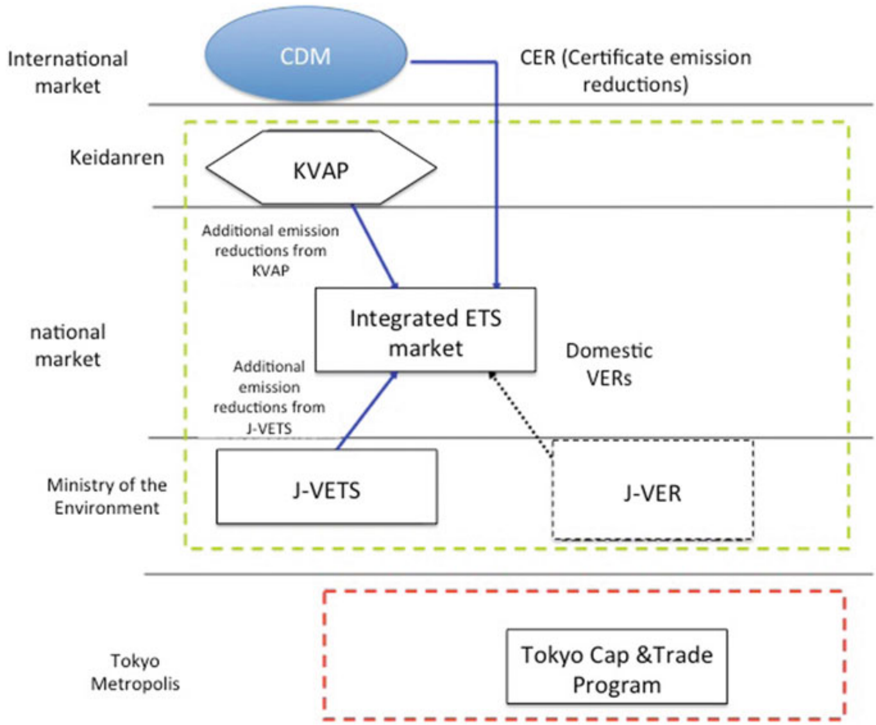

Fig. 2.2 Relations among the Japanese carbon emissions programs

2.1.5 ETS in Other Countries

(1) Korea Emissions Trading Scheme (KETS)

The Korean Government came up with the "low-carbon green growth" strategy in 2008, and promulgated the Green Development Law in 2010 which states to fulfill the GHG emissions reduction target in 2020 (emissions decrease 4% from 2005 levels), which has laid a legal basis for carrying out the cap-and-trade system. In January 2015, the Korea Emissions Trading Scheme (KETS) was launched to regulate 68% of the national total emissions, and cut emissions by 37% until 2030, which is equivalent to emission decreasing by 22% based on 2012 level.

There are 525 companies (including 5 domestic aviation companies), which are distributed in the sectors like steel, cement, petrochemical, oil refining, electric power, building, waste, and aviation, under the regulation of the KETS. Six GHGs prescribed in the KP and the indirect emissions from electricity consumption are involved in the KETS.

KETS contains three phases. In Phase 1 (2015–2017), 100% of the allowances are allocated for free, and the quantity of allowances is defined on basis of the companies' average emissions in 2011–2013. The allowances for the cement clinker, oil refining, and aviation sectors are based on benchmarking and the companies' activities in 2011–2013. The government reserves about 5% of the allowances for stabilizing the allowance market and newly operated projects. In Phase 2 (2018–2020), 97% of the allowances will be allocated for free, 3% is left for auctions. In Phase 3 (2021–2025), the free allowances will be no more than 90%, over 10% will be sold in auctions.

The KETS allows for cross-phase allowance banking, yet the allowances are only available for borrowing within the same phase, the amount of lending is no more than 10% of the allowances allocated to the covered enterprises.

During Phases 1 and 2, only the domestic offset credits are allowed for use which are no more than 10% of the total emissions of the covered enterprises. In Phase 2, the projects in other countries may contribute 5% of the offsets. According to the KETS rules, the emissions reduction projects started after April 14, 2010 are compliance projects, and the project owners are noncompliance companies, e.g., the CDM, carbon capturing and storage projects within South Korea. The over-emission companies will be fined three times more than the allowance price.

In order to effectively manage the carbon emissions trading market, the Korean government put into effect the allowance price management mechanism which applies to the following three circumstances [14]:

(i) When allowance prices are three times more than the average prices in past the 2 years for 6 months in a row;
(ii) When allowance prices are two times more than the average prices in the past 2 years for 2 months in a row, and the average trading volume is two times more than the average volume in the same month in the past 2 years;
(iii) When the average allowance prices in any month is 40% lower than the average prices in the past 2 years.

The allowance price management mechanism includes the following measures:

(i) Increase the percentage of reserved allowances up to 25% of the total allowances;
(ii) Develop an allowance regulatory mechanism: no less than 70% and no more than 150% of the total allowances;
(iii) Increase or decrease the ceiling of allowance borrowing;
(iv) Increase or decrease the limit on offset credits;
(v) Set a short-term price ceiling and price floor. The government reserves no more than 25% of the allowances to the new participants.

(2) New Zealand Emissions Trading Scheme (NZ ETS)

In September 2008, New Zealand Parliament adopted the Climate Change Act, which provides for a series of measures to achieve the 10–20% emissions reduction by 2020, and states to establish the New Zealand Emissions Trading Scheme (NZ ETS). In addition to the industrial sector, the NZ ETS also regulates agriculture, fishery, and forestry, but does not set any cap on emissions during the transitory stage. The quantity of allowances is calculated on basis of the companies' industrial output and emissions intensity, and the percentage of free allowances is based on the emissions intensity of companies. The fishery and forestry sectors that are prone to be affected by allowance cost will receive a higher percentage of free allowances. The agricultural sector of New Zealand features high emission and export orientation, so the agricultural companies are also accessible to free allowances. Some of the NZ ETS rules which were effective during the transitory period (from July 2010 to December 2013) still prevail, e.g., the allowances are sold at a fixed price of NZ \$25/t CO_2. The stationary energy, liquefied fossil fuel, and industrial processing sectors are entitled to emit 2 tons of CO_2 with 1 ton of allowance.

During the KP first commitment period (2008–2012), the NZ ETS permit to use offset credits from KP, in order to make the NZ ETS allowance prices synchronize with the global prices.

Some studies show that the emissions reduction cost generated from the NZ ETS may push up electricity and fuel prices, which will, in an indirect manner, raise companies' production cost and household consumption cost. Since the NZ ETS is still implemented in a short time, its impact on cutting GHG emissions is hard to be precisely estimated.

(3) Mexico Emissions Trading Scheme (MX ETS)

In April 2012, the Climate Change Act of Mexico was adopted, which states to cut emissions by 30% until 2020 compared to the Business as Usual (BAU) scenario. Mexican Government was empowered to work on an emissions reduction program, including the building of Mexico Emissions Trading Scheme (MEX ETS). The MEX ETS is made up of two phases: capacity construction and emissions reduction. It was proposed to cover energy production and consumption, transportation, agriculture, forestry, land use, waste disposal, and industrial processing.

(4) India Emissions Trading Scheme (IND ETS)

In 2008, the Indian Government announced the National Action Plan on Climate Change (NAPCC), which states to cut GHG emissions by 20–25% from 2005 levels until 2020. The Indian Government, in addition, to vigorously promote renewables in lieu of traditional energy and raise energy-use efficiency, started operating the energy-related market mechanism, i.e., "Perform, Achieve and Trade" (PAT) and "Renewable Energy Certificate" (REC).

2.2 Gains and Losses of Mainstream Emissions Trading Schemes

The ETS is recognized as an effective mechanism for promoting GHG emissions reduction, lowering emissions reduction cost, and responding to climate change. To date, there are 14 countries either operating or planning for developing the ETS.

The experiences of the states and regions that took the lead in launching the ETS, emissions trading not only motivates emissions reduction, but also generates multiple negative impacts, e.g., carbon leakage and worldwide competitiveness of enterprises. Moreover, the varied design elements of the ETS may generate different effects on the fulfillment of the emissions reduction targets. In order to obtain anticipated effect and weaken the negative effect, it is necessary to analyze the gains and losses of the ETS, conduct assessment of the entire process of the ETS and adjust the mechanism.

The ETS is a market-based environmental policy with one of the aims to promote GHG emissions reduction in countries and regions, with the basic premise of achieving low-cost emissions reduction. Therefore, when assessing the ETS implementation effect, the priority is to discuss whether the compliance entities could deliver abatement and how does the abatement effectiveness; second, whether the abatement cost is relatively lower.

To date, EU ETS is with the longest performance period; the assessments and analyses about this mechanism are the most fruitful. This section will introduce and demonstrate the gains and losses of ETS by quoting relevant literature on the evaluation of operation of EU ETS.

2.2.1 Evaluation of Abatement Effectiveness

ETS is an environmental policy that parallels with other eco-economic policies. The economic development, climate change, production decisions, and non-ETS-driven emissions reduction endeavors may affect the levels of GHG emissions. ETS may overlap with other policies to have abatement effects. For example, energy prices adjustment, subsidizing renewables, and other relevant policies are also have abatement effectiveness. The difficulty faced by researchers is isolating the effect of the EU ETS from other dominant factors. Yet, it is still an arduous task to do so for lack of reliable situational data for comparing with the actual emissions [15].

After reviewing related literature, we find out that the ex-ante analysis method is widely used for calculating the ETS-enabled emissions reduction. Through simulation of scenarios, we can calculate the differences between the emissions reduction under the ETS and BAU.

When making an assessment of the EU ETS emissions abatement effects, Ellerman et al. [16] took account of the historical GDP growth and emissions reduction of the covered enterprises. Through data modeling of 2004 emissions, they made an estimation of the 2005 and 2006 emissions and found out that the emissions reduction of the European 23 countries were about 50 Mt (down 2.4% from 2004); and the cumulative emissions reduction by 2006 was around 100 Mt (down 4.7% from 2004). Moreover, this study compared the prices for carbon, fuel, and gas in Phase 1 and Phase 2 of the EU ETS, and found out that the European electric power generation companies, after shifting from coal-fired power generation to gas-fired power generation, have become a major driver of emissions reduction. In light of the 2004 emissions of the EU members published by the UNFCCC, Ellerman et al. [17] estimated the BAU-based emissions, which show that the EU ETS Phase 1 emissions reduction was about 210 Mt (down 3.5% from 2004). Anderson et al. [18] imported the historical emissions data from the European Statistics Agency into the Dynamic Panel Data Model, adopted energy prices, level of industrial economic activity and climate factor as main conditions, built a model that manifests the relations between various factors and carbon emissions, then estimated the EU ETS BAU-based emissions in 2005–2006. The result shows the EU ETS Phase 1 emissions are around 247 Mt. The comparison between the modeling calculation and the EU ETS verified actual emissions shows that the BAU-based results are overestimated, they shall be around 174 Mt (down 2.8% from 2004). Based on the conclusions made by Ellerman et al. Egenhofer et al. [19] modified the assumptions for the economic activities in order to accord with the actual situations in the EU ETS Phase 2, quantified the emissions in the prior 2 years in Phase 2, and found that contribution ratio of the EU ETS to emissions reduction rose from 1% annually in 2006–2007 to 3.35% annually in 2008–2009.

Based on the econometric model, Murray et al. [20] studied the emissions reduction effect of the RGGI, and found out that the contribution ratio of economic recession to emissions reduction is merely 1%, while the one-third emissions cut of the natural gas market is attributed to the transition from coal-fired power generation to mixed fuels-based power generation. Once the aforesaid variable elements are controlled, the RGGI becomes the major driver of emissions reduction, yet it is still hard for further quantization resolution of the RGGI allowance prices and auction procedures, etc., the accurate research result calls for further studies.

The post evaluation of the ETS effects is based on the micro-data from the companies, yet it is hard to directly gather the corporate data and information, but resorting to the ETS registration system and competent administrations. Wagner et al. [21] by consulting with to the energy and fuel consumption data of each ETS regulated company, calculated the CO_2 emissions from the covered enterprises and found out their emissions were 26% lower than those nonregulated emitters in 2007–2010.

2.2.2 *Evaluation of Reducing the Abatement Cost*

It is a necessity to evaluate the ETS cost-effectiveness, i.e., whether it is able to fulfill the emissions reduction targets at a lower cost. An analytical thinking goes like this, adopting a pre-analysis method, simulating both ETS- and BAU-based scenarios, and comparing their marginal costs for fulfilling the same emissions reduction targets. Whether the ETS is able to realize low-cost emissions reduction is a focal point to be considered and evaluated by the government before the program is launched.

Capros and Mantzos [22] built a PRIMES for the European energy market to compare with the KP-based emissions reduction costs, and observe the changes on the overall emissions reduction cost along with expanding the scope of covered enterprises. The comparison shows that a wider transaction scope could save the expenses on emissions reduction. In case of an ETS-free scenario, the emissions reduction cost holds 0.095% of EU's GDP; such proportion drops to 0.06% in the ETS-based scenario; and it will be as low as 0.025% in a globally industry-wide trading.

The Institute for Prospective Technological Studies (IPTS), one of the seven joint research centers under the European Commission, built a POLES[2] model to compare the emissions reduction costs among all EU countries [23]. The study result shows that the Northern European countries bear more cost for emissions reduction, which is about 0.48% of their GDP; such proportion in other states, like Italy, is generally no more than 0.17%. Although the KP-based emissions reduction targets have increased expenses in this regard, the ETS scenario does bring more benefits to almost all EU countries than the BAU scenario, e.g., the Southern European countries cut their emissions reduction cost by 62%, particularly Germany (50%) and Italy (20%).

The actual carbon market is influenced by supply and demand of emissions allowances (allowances allocation in primary market and allowances trade in the secondary market), competition among traders and asymmetric information. The actual carbon market is not as efficient as the hypothetical market, and the actual carbon prices differ from the theoretically calculated emissions reduction cost, which complicates the post evaluation of the ETS role in cutting emissions. The carbon price is generally affected by fuel price, air temperature, and hydroelectric power generation that impact the marginal cost for emissions reduction. However, Hintermann [24] believes that the carbon price at the initial phase of EU ETS may be affected by the large-scale industrial companies (owner of more free allowances), market expectations of the speculators that opt for market hedging, which causes carbon price to deviate from the marginal cost and results in market bubbles. However, it is fairly difficult to quantify such adverse impacts on the role of the EU ETS in emissions reduction.

According to the Porter Hypothesis, strict environmental regulations can induce efficiency and encourage innovations that help to improve commercial competitiveness. In a long-term view, the ETS is able to motivate the high-emission companies to join in technical innovation and put in place new measures for emissions reduction, so as to mitigate the higher opportunity cost arising from inaction. However, the evaluation from the above perspective is neither an easy job, due to lack of public data about the corporate investment into low-carbon assets and low-carbon public welfare activities. Some researchers are forced to shift to qualitative research to lock up the relevant information. Herve-Mignucci et al. [25] investigated the operational performance of the Germany-based companies under

[2]"POLES" is short for Prospective Outlook on Long-term Energy Systems.

the EU ETS regulation, and found out that most of them realized emissions reduction through funding technical upgrading or improving the production process. Yet the emissions reduction is proved to be a by-product instead of their foremost objectives. Martin et al. made a survey of more than 800 manufacturing companies in six European countries, and learned that after joining in the EU ETS, the large-sized companies called off the investment into high-emission power generation plants, but diverted their funds into the Carbon Capture and Storage (CCS) projects, and turn to supporting more small-scale projects with fewer installments.

Löschel et al., in a qualitative approach, studied the investment of Germany's cross-industry companies that are under the EU ETS regulation in the context of fluctuating allowance prices. The study shows that 77% of these companies have invested or improved the production process that favors emissions reduction; 64% of these companies made investment decisions in 2008–2012. However, most companies (89%) admitted that their original intention was to raise efficiency and reduce energy-induced cost, rather than lowering the cost of compliance. Most of the investigated companies, particularly small-sized ones, have been storing allowances for later. The allowances stored by electricity companies are less than those stored by industrial companies, indicating that industrial sectors—one of the external factors—may drive up the demand for emission allowances.

2.2.3 Other Impacts Evaluation

(1) Value redistribution and "windfall profits"

The economic cost arising from the ETS occupies a small share in the GDP, and free from exerting a significant negative impact on the overall economic performance, shown by massive studies. However, the ETS rules and allowances circulation have resulted in the redistribution of emission rights among different countries, industries, and income earners, and divided value distribution. Any incompliance of the allowance allocation principles may lead to uneven distribution of emission rights among countries and "windfall profits" of certain industries, and widen wealth gap. As a result, the efficiency of the ETS has become a widely debated issue across the world.

Take the EU ETS for instance. Owing to the disparity in economic development, different EU countries have varied demand for emission allowances, thus causing frequent allowance circulation and massive transfer of allowance value among these countries. In its Phase 1 implementation, the EU ETS traded about €505 million of allowances [26]. The volume of transferred allowances (from the surplus countries to the deficit countries) reached 650 Mt, which was 11% of the EU's total allowances and worth of €5200 million. The total import-and-export allowances were about 218 Mt, worth of €9.41 billion, mainly flowing from Poland, France, the Czech Republic, and the Netherlands to such importers as the UK, Spain, Italy, and

Germany. The allowance sufficiency also varied among industries. Trotignon and Delbosc [26] revealed that the EU electricity sector was short of 6.1% of allowances, while other sectors were in surplus, e.g., the surplus proportion of cement and paper sectors was 4 and 20%, respectively.

The EU ETS was abiding by free allowance allocation during the prior two phases of implementation, it means that when some industries are short of allowances, they may transfer the allowance cost to obtain windfall profit. The occurrence of windfall profit is a negative outcome of the value distribution of ETS. Several studies have shown that the European electricity sector has passed the allowance cost on to consumers by raising electricity price.

Some studies have shown that the ETS may widen the gap between the rich and the poor. Terry Dinan and Diane Lim Rogers argue that both the auction-based ETS and carbon tax will drive up carbon prices and generate income distribution effect. Feng et al. [27] compared the wealth gap, respectively, induced by the carbon tax and ETS, and concluded that the cost from carbon tax held 6% of the gains of the lowest income earners and 2.4% of the gains of the high-income earners. In case of the ETS-induced cost, it was 4.3% of the gains of the lowest income earners and 1.7% of the gains of the high-income earners.

The transnational allowance circulation and allocation, which directly reveals the fact the industrial sectors in different countries have varied demand for allowances, enables efficient distribution of allowances. However, free allowance allocation fails to fully reflect the real supply–demand pattern of allowances, and may affect the efficiency of allowance allocation. Moreover, different income earners have paid great attention to the increasing cost of carbon emissions, which creates an important basis for adjusting the ETS.

(2) Carbon leakage effect

Carbon leakage occurs when there is an increase in CO_2 emissions outside the country which is under a strict climate policy. In light of the *IPCC Fourth Assessment Report: Climate Change 2007*, integrated carbon leakage rate of one region or country equals to the proportion of CO_2 emissions increase outside the region or country to CO_2 abatement inside the region or country. The two parties shall have trading contacts, resource/energy import or export, or geographic proximity. Leakage can occur through three channels, including: (i) Carbon leakage results from transnational/trans-regional trade. Since the local compliance industries have all along been bearing high-emissions cost, disadvantageous market occupancy, and profit margin, the regulation areas may reduce production and export of emissions-intensive products in the short run, but an increase in the import of these products from nonregulation countries, which consequently transfers the production of such products to the export countries and increases their emissions, instead of altering the global total emissions, carbon leakage is thereby caused. (ii) An increase in local fossil fuel prices resulting, for example, from mitigation policies may lead to the reallocation of production to regions with less stringent mitigation rules (or with no rules at all), leading to higher emissions in those regions and, therefore, to carbon leakage. (iii) Carbon leakage may also arise from technical spillover—cross-regional technical development and promotion, yet such portion of carbon leakage is hard to quantify for unavailable direct data and information.

With Gemini-E3 CGE Model, Bernard and Vielle [28] calculated the integrate carbon leakage rate within the EU ETS framework at about 7%, of which 2.3% is through trans-regional trading. With GTAP-E Model (comparative-static CGE Model) and considering the impacts from the Border Adjustment Measures, Kuik and Hofkes [29] estimated the integrated carbon leakage rate of within the EU ETS framework at about 8.2–10.2%. The carbon leakage rate of the steel sector drops the most vigorously owing to these measures, i.e., dropping from 35 to 29% based on national unified policy; and falls even further to 2% based on the national differentiated policy. FitzGerald et al. [30] ranked the pricing power of different industries in a top-down order, and took account of the impacts from energy price and carbon tax, and finally concluded that the European steel sector is the most vulnerable to have carbon leakage.

(3) Impact on industrial competitiveness

The covered enterprises of each country's ETS are mainly distributed in energy- and carbon-intensive industries. Generally, the companies with low unit production cost, high-profit margin, and a large market occupancy will be more competitive in markets. Under the framework of the ETS, the companies with unit emissions higher than a defined amount of emissions allowances have to pay the additional environmental cost, which increases the production cost of these companies and alters their competitive strength. Moreover, owing to different percentages of free allowances and allowance allocation approaches, the regulation companies will have varied competitive edge in emissions pace and environmental cost.

Based on a scenario of 100% of allowances allocation, if 15 British industries would not cut carbon emissions in the short term, Hourcade et al. [31] then calculated the percentage of emissions cost in their industrial added value (IAV). Through comparison, he found out that both cement and steel sectors have the highest percentage of emissions cost. The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU) organized similar studies of the domestic industries, and concluded that the cement, lime, chemical fertilizer, and steel sectors bear the highest emissions cost.

Based on a scenario of free allowances allocation, Quirion and Demaily [32] developed the CEMSIM Model[3] and GEO Model[4] for analyzing the impact of grandfathering allocation and benchmarking allocation on the European cement output and profit. Based on grandfathering allocation, even if the allowances are 50% of the historical emissions, the cement sector is still profitable as usual, the

[3]The CEMSIM Model is developed to assess the energy and technical development trends of the European cement industry.

[4]The GEO Model is developed to assess the effect of carbon emissions trading.

cement output declines remarkably accompanied with serious carbon leakage. In contrast, based on benchmarking allocation, the allowances are no more than 75% of the historical emissions, the cement sector is moderately affected with both output and profit dropping more than 5%.

Through analyzing the differentiated impact of the EU ETS on the marginal production cost of the British different industries, Oxera finds out that the industrial marginal production cost will increase along with rising emission allowances prices, there is also value appreciation of the free allowances granted to the industry at the same time, which may make up for the loss incurring from rising marginal production cost. Thus, the selection of allowance allocation approach is fairly important.

2.2.4 Conclusion and Adjustment to ETS

The ETS is of great significance in helping a society achieving the carbon emissions reduction targets, and effectively lowering the emissions reduction cost. A review of the EU ETS operation experiences shows that the prior two phases of operation generated 50–100 Mt of emissions reduction annually. In order to avert from any excessive allowances allocation as in Phase 1, more allowances were auctioned in Phase 2. In contrast to the BAU-based emissions reduction, the ETS motivates covered enterprises to fulfill emissions reduction target at a lower cost. Meanwhile, the investigations of the EU companies reveal that the ETS triggers the high-emissions companies to update emissions reduction technologies, adopt measures and work out investment plans that favor emissions reduction, in an aim to lower the potential high opportunity cost arising from inaction in the future.

The impact of the ETS on a society varies among different regions and industries. In reference to the EU ETS experiences, most of Phase 1 and 2 allowances were subject to free allocation; the electricity sector passed on the allowance costs and other costs onto the consumers, which widened the wealth gap and garnered windfall profit. The integrated carbon leakage rate arising from the EU ETS is about 7–10%. The steel and aluminum sectors are less competitive and the most vulnerable to the foreign rival companies; the cement sector is fairly competitive and free from serious impact from the ETS.

In order to tackle the above problems arising from the EU ETS operation, the EU plans to adjust and reform the scheme during Phase 3, in an aim to revitalize the weak emissions trading and prevent from excessive allowance allocation within the EU.

In addition to helping an area achieve low-cost emissions reduction, the ETS is, in fact, using allowances prices as a signal to call for companies to divert investment into low-carbon technologies, and guard against the "lock-in effects" [33] from continuous funding high-carbon technologies—the great expectation of the

Table 2.2 Strength and weakness of three allowances supply management mechanisms

Type of mechanism	Description	Strength	Weakness
Economic activity-based	Regulate allowances supply in light of the changes in the macroeconomic indicators, like GDP, primary energy consumption, petroleum price, and relevant financial market indicators that reflect commodity market development	The economic indicators are usually public and available data, and they are objective enough to prevent SMM from affected by subjective policies and decisions. The economic indicators also exhibit the direct correlation between commodity market and allowances market, thus making participants make more accurate judgment about carbon market	The macroeconomic indicators only represent the overall social economic activities, rather than the actual economic performance of the ETS covered enterprises. The data incompleteness, lagged updating, or inconsistency may affect the implementation effect of SMM
Allowances surplus-based	Regulate supply of the allowances surplus (verified yet not auctioned). Set a lower threshold for the allowances surplus, if it is above the threshold, then withdraw the allocated allowances from the carbon trading market	Such regulation, which is transparent, simplified, and comprehensible, enables the ETS to flexibly cope with the emergent economic shocks and inrush of international VERs	The transaction behavior of the ETS-based market players is guided by the future allowances policy; therefore, it is difficult to define the instant lower threshold for the allowances surplus, which, in turn, affects implementation effect of SMM
Allowances price-based	Regulate allowances supply in light of carbon price. Set lower threshold for carbon price, if it is above the threshold, then withdraw the allocated allowances from the carbon trading market	Develop an explicit and definite price signal, based on which the companies will limit their compliance cost within a designated price range, and explore low-carbon technologies at the lowest cost, which is favorable for companies to making investment decisions. Open and transparent data about carbon prices, basis for SMM, provide market players with more clear-cut bases for decision-making	The price-based allowances supply mechanism is deemed as distorting the connotation of carbon prices reflecting emissions reduction cost, and affecting the price discovery principle, which may lead to carbon price fluctuations between price ceiling and price floor, and make SMM like a dynamic carbon tax system. The varied price ranges will hold up the linkage between different trading mechanism

EU placed on the ETS. Therefore, in case of any extreme situations taking place on the carbon market, it is necessary to extend interventions to maintain carbon prices at a reasonable level which is favorable for the fulfillment of the emission reduction targets.

Kollenberg and Taschini [34] holds that the current EU ETS policy measures are incapable of market feedback, so the changing EU economic environment will lead to extreme uneven allowances allocation, yet the ETS itself fails to draw any effective market feedback. Although the European governments decided not to allocate the verified 900 Mt allowances before 2020, it could only resolve the superficial problem as low carbon prices in the short term, rather than essentially enabling the ETS to be more capable of market feedback. Such one-off measure is neither able to handle the increasingly complicated economic fluctuations in the future, nor alter the corporate expectations for carbon price decline. Besides, the repeated raising or lowering of the percentage of the allowances allocation is unworkable within the EU policy framework. The amount of allowances should not be decided by the governments on their own, but through gaming and consultation among multiple stakeholders.

The building of an ETS feedback mechanism is, therefore, a necessity. Its essential role is to alter the corporate intrinsic pessimistic expectation of carbon prices, and turn to adjusting allowances supply flexibly in light of economic environment, and guide market players to keep a close watch on carbon price trend, make corresponding strategies and finally develop a virtuous cycle. A feedback mechanism is able to encourage regulation companies to store up allowances in case of low carbon prices to boost up the prices; and sell out allowances in case of high carbon prices to adjust down the prices.

An allowances supply management mechanism shall have the following core functions:

(1) Increase elasticity of the ETS to deal with external shocks or extreme events, and improve the policies to be more adaptable to time dimension and desired effect;
(2) Improve the accuracy of the allowances supply adjustment plan, e.g., explicitly prescribe when and how the adjustment shall be made;
(3) Exempt from any policy discretionary power in addition to market rules so as to avert from possible policy intervention.

Currently, there are three allowances supply management mechanisms: economic activity-based mechanism, allowances surplus-based mechanism, and allowances price-based mechanism. Each mechanism has its own strength and weakness, and capable of managing allowances supply in light of real supply and demand. Their comparison is shown in Table 2.2.

References

1. Wenjun Wang. UK's Climate Change Policy and Its Lessons [J]. Contemporary International Relations, 2009 (09): 29-35.
2. Commission Stuff Working Paper-Impact Assessment[R]. SWD (2012) 177 final, Brussels: European Commission, 2012.
3. Minsi Zhang, Di Fan, Yong Dou. Analysis of EU ETS Operation Progress and Enlightenment on China [EB/OL]. (2014-02-12). http://www.ncsc.org.cn/article/yxcg/yjgd/201404/20140400000848.shtml.
4. European Commission Decision of 29.3.2011 [S]. C (2011)1983 final.
5. Commission Regulation (EU) NO. 176/2014 of 25 February 2014 [J]. Official Journal of the European Union, 2014 (NO. 176/2014).
6. COMMISSION REGULATION (EU) No 5502011 of 7 June 2011 [J]. Official Journal of the European Union, 2011 (No. 550/2011).
7. Commission Staff Working Document Exclusive Summary of the Impact Assessment [R]. SWD (2015) 136 final, Brussels: European Commission, 2015.
8. Customs Tariff Amendment (Carbon Tax Repeal) Bill 2014 [S].
9. RGGI 2012 Program Review: Summary of Recommendations to Accompany Model Rule Amendments [R]. Final Program Review Materials, U.S: RGGI Inc, 2013.
10. Second Control Period Interim Adjustment for Banked Allowances Announcement [R]. General Documents, RGGI Inc, 2014.
11. Regional Greenhouse Gas Initiative Memorandum of Understanding [J]. 2005.
12. Final Regulation Order [S].
13. Yan Wen, Changsong Liu, Yong Luo. Review and Analysis on U. S. Carbon Emissions Trading System [J]. Advances in Climate Change Research, 2013, 9 (2): 144–149.
14. Korea Emissions Trading Scheme [R]. International Carbon Action Partnership, 2016.
15. LAING T, SATO M, GRUBB M, et. al. The effects and side-effects of the EU emissions trading scheme: The effects and side-effects of the EUETS [J]. Wiley Interdisciplinary Reviews: Climate Change, 2014, 5(4): 509–519.
16. ELLERMAN A D, BUCHNER B K. Over-Allocation or Abatement? A Preliminary Analysis of the EU ETS Based on the 2005–06 Emissions Data [J]. Environmental and Resource Economics, 2008, 41 (2): 267–287.
17. ELLERMAN A D, CONVERY F J, DE PERTHUIS C. Pricing Carbon [M]. The United States of America by Cambridge University Press, New York, 2010.
18. ANDERSON B, DI MARIA C. Abatement and Allocation in the Pilot Phase of the EU ETS [J]. Environmental and Resource Economics, 2011, 48 (1): 83–103.
19. EGENHOFER C, ALESSI M, GEORGIEV A, et al. The EU Emissions Trading System and Climate Policy Towards 2050-Real Incentives to Reduce Emissions and Drive Innovation [R]. Brussels: Centre for European Policy Studies (CEPS) Brussels, 2011.
20. BRIAN C. MURRAY, PETER T, MANILOFF, EVAN M. MURRAY. Why have GHG in RGGI States Declined-An Econometric Attribution to Economic, Energy Market, and Policy Factors [R]. Working Paper EE 14-01, U.S: Nicholas Institute for Environment Policy Solutions, Duke University & Colorado School of Mines & Trinity College of Arts and Sciences, Duke University.
21. MARTIN R, MUÛLS M, WAGNER U J. The Impact of the EU ETS on Regulated Firms: What is the Evidence After Eight Years? [J]. Available at Social Science Research Network 2344376, 2014 (31).
22. European Union energy outlook to 2020 [M]. CAPROS P, ETHNIKON METSOBION POLYTECHNEION. Ms completed on 30 September 1999. Luxembourg: Off. for Off. Publ. of the Europ. Communities, 1999.
23. Preliminary Analysis of the Implementation of an EU-wide Permit Trading Scheme on CO2 Emissions Abatement Costs [R]. Institute for Prospective Technological Studies (IPTS), 2000.

24. RALT MARTIN, MIRABELLE MUÛLS, ULRICH WAGNER. An Evidence Review of the EU Emissions Trading System, Focusing on Effectiveness of the System in Driving Industrial Abatement [R]. United Kingdom: Department of Energy & Climate Change of UK, 2012.
25. ANDREAS LÖSCHEL, BODO STURM, REINHARD UEHLEKE. Revealed Preferences for Climate Protection when the Purely Individual Perspective is Relaxed-Evidence from a Framed Field Experiment [R]. Discussion Paper No. 13-006, Centre for European Economic Research (ZEW), Mannheim, 2013.
26. RAPHAEL TROTIGNON, ANAIS DELBOSC. Allowance Trading Patterns During the EU ETS Trial Period: What Does the CITL Reveal? [R]. Climate Report No 13, Mission Climate of Caisse des Dépôts, 2008.
27. FENG K, HUBACEK K, GUAN D, et al. Distributional Effects of Climate Change Taxation: The Case of the UK [J]. Environmental Science & Technology, 2010, 44 (10): 3670–3676.
28. BERNARD A, VIELLE M. Assessment of European Union Transition Scenarios with a Special Focus on the Issue of Carbon Leakage[J]. Energy Economics, 2009, 31: S274–S284.
29. KUIK O, HOFKES M. Border Adjustment for European Emissions Trading: Competitiveness and Carbon Leakage [J]. Energy Policy, 2010, 38(4): 1741–1748.
30. FITZGERALD J, KEENEY M, SCOTT S. Assessing Vulnerability of Selected Sectors Under Environmental Tax Reform: the Issue of Pricing Power [J]. Journal of Environmental Planning and Management, 2009, 52 (3): 413–433.
31. HOURCADE J-C, DEMAILLY D, NEUHOFF K, et al. Climate Strategies Report: Differentiation and Dynamics of EU ETS Industrial Competitiveness Impacts [R]. Climate Strategies, 2007.
32. DEMAILLY D, QUIRION P. CO2 Abatement, Competitiveness and Leakage in the European Cement Industry Under the EU ETS: Grandfathering Versus Output-based Allocation [J]. Climate Policy, 2006, 6 (1): 93–113.
33. RALF MARTIN, MIRABELLE MUÛLS, ULRICH WAGNER. Climate Change-Investment and Carbon Markets and Prices-Evidence from Manager Interviews [R]. Climate Policy Initiative, 2011.
34. SASCHA KOLLENBERG, LUCA TASCHINI. The European Union Emissions Trading System and the Market Stability Reserve-Optimal Dynamic Supply Adjustment [R]. University of Duisburg-Essen & Grantham Research Institute of London School of Economics, 2015.