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Are Emission Trading Systems Effective?

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Abstract:

An emission trading scheme (ETS) has been promoted based on the premise that it is one of the most promising options to control greenhouse gas emissions in a cost-effective way. However, these theoretical arguments have rarely been tested against the records in the real world. By reviewing implementation and outcomes of the cap and trade systems, which represent one of the ETS systems and have been applied for several air pollutants in the U.S. and Europe, we can draw some lessons of ETS to be applied for climate change mitigation. This paper examined recent literatures reviewing three ETS implementation experiences, the U.S. Acid Rain Program, the NO_x Budget Program, and the EU ETS. Our observations are the followings. A) Although we have seen substantial emission reductions under the regimes in all the three cases, similar or even better outcomes were obtained in other countries by conventional command and control approaches. B) Cost savings from emissions trading may not be as large as originally expected. C) ETS does not accelerate facility renewal as expected. D) The ETS administration costs seemed to be larger than originally expected. E) Coverage of the ETS in reality tends to be limited in specific sectors and large emitters. F) ETS tends to stimulate diffusion of existing technologies but not necessarily to encourage technology innovation. Based on these experiences, it would be prudent to examine benefits and costs of ETS and to compare them with those of alternative regulatory schemes before introducing an ETS to climate change abatement regulations.

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1. Introduction

The Kyoto Protocol, adopted in 1997 as shown in Fig. 1, includes emission trading as one of the flexible mechanisms for developed countries to achieve their emission reduction targets. At the time of adoption, the U.S. insisted on introduction of emission trading while European counties were negative about it.

Situation changed drastically as the decade of 2000s started. In 2001 the U.S. withdrew from the Kyoto Protocol. On the other hand, European countries, which were negative at first, became positive about utilization of emission trading schemes, and in 2005 started implementing EU ETS, an emission trading scheme covering the whole EU.

1997	Kyoto Protocol adopted	U.S. insisted on, but EU opposed.
2001	Denmark introduced domestic emission trading scheme. (Continued until 2004)	
2002	U.K. introduced domestic emission trading scheme (UK ETS). (Continued until 2006)	
2005	EU introduced ETS.	EU introduced.
2005	U.S. eastern 7 states agreed on Regional Greenhouse Gas Initiative (RGGI).	
2007-	Evaluation of EU ETS started.	

Fig. 1 Historical facts concerning emission trading schemes for climate change mitigation

In this context, more people began to think as though ETS was a trump card for climate change mitigation, namely one of the most promising options to control greenhouse gas emissions in a cost-effective way. However, these arguments were merely focused on pre-evaluation based on theory, and not necessarily proven.

This paper discusses whether theoretical advantages of emission trading schemes have been actually demonstrated, by reviewing implementation and outcomes of cap-and-trade emission trading schemes, where a "cap" is established to limit the total emission and emissions allowed under that cap may be traded in the market. A cap-and-trade system represents emissions trading schemes, being applied for several air pollutants in the U.S. and Europe. In what follows, three ETS implementation experiences are to be examined, the U.S. Acid Rain Program, the NO_x Budget Program, and the EU emissions trading scheme.

2. Theoretical advantages of emission trading schemes

Frequently advocated theoretical advantages of emission trading schemes are summarized below (Fig. 2).

A. Effective in emission reduction
B. Emissions can be reduced at lower cost.
C. Upgrading to lower-emission facilities is accelerated.
D. Administrative cost can be saved.
E. Applicable to broader industries and company scales
F. Technological innovation is accelerated.

Fig. 2 Theoretical advantages of emission trading schemes

A. Emission reduction effect

Emission allowances are traded in the market as assets with economic values, and this will cause companies to make efforts to reduce their own emissions. The higher the prices of emission allowances become, the larger the effect to accelerate emission reduction will be.

B. Lower reduction cost

If two companies are to pay different costs for emission reduction, an emission trading scheme will bring gains to both companies, because the company of lower cost will make efforts for larger reduction of emission, and will sell the excess amount of reduction to the company of higher cost as an emission allowance.

In this case, the total cost paid by the two companies is lower as compared with the case that the emission reduction target is equally shared by them. Thus, under an emission trading scheme, trading will cause reduction measures to be taken in the cost-ascending sequence so that emission will be able to be reduced at a lower cost.

C. Acceleration of upgrading to lower-emission facilities

If economic value of emission allowances is established in the market, it will have effects to stimulate companies to select lower-emission fuel when renewing their facilities, or to accelerate upgrading to higher-energy-efficiency facilities.

D. Administrative cost saving

The government only needs to determine a proper target for total emission, but need not have technical information necessary to achieve that target. This will save administrative cost as compared with regulations such as energy efficiency standards.

E. Broader applicability

One of the difficulties of the global warming issue, as is called a life-related environmental issue, is that CO_2 is emitted from every aspect of economic activities.

There is an assertion that emission trading schemes can be applied to every emission source, not only to large-scale sources such as power plants and steel mills but also to small-scale sources, which are difficult to cover with direct regulation, such as small factories and office buildings.

F. Acceleration of technological innovation

If an emission trading scheme is established as a non-temporary scheme, emission allowances will be recognized as assets having long-lasting economic values, accelerating companies' research and development of relevant technologies.

These are advantages of emission tracing schemes that are "expected" by theory. While there are theoretical counterarguments, we leave such theoretical stories, and are going to show some examples of trading schemes, and check if these theoretical advantages were actually demonstrated in those cases.

3. Examples of existing schemes

As examples to be analyzed, let us see U.S. SO_2 and NO_x emission trading schemes and EU's CO_2 emission trading scheme (Fig. 3).

Country,name (substance)	Introduced in	Main features
U.S. Acid Rain Program (SO_2)	1995	Phase I (1995 to 1999) for 100 MW or larger coal-fired power plants east of the Mississippi; Phase II (2000 to 2009) for 25 MW or larger power plants in whole U.S. Special provisions such as "bonus" allowance to the plants in Midwest states and extension allowance set aside for scrubbers.
U.S. NO_x Budget Program (NO_x)	1999	Regional program for controlling emission from large boilers and turbines of thermal power plants and factories in the period from May to September. Participants were Washington DC and its surrounding 11 states in 1999 to 2002, and increased to 21 states from 2003.
EU ETS (CO_2)	2005	Trading scheme for energy sector and energy-intensive industries. At present 25 EU countries are participating, and Bulgaria and Rumania will participate in2008. Emission allowances are allocated in accordance with each country's own rule (NAP). Kyoto mechanism (JI/CDM) can be used under certain conditions.

Fig. 3 Main features of emission trading schemes to be analyzed

In the context of climate change mitigation, discussion of emission trading schemes started with Kyoto Protocol. In the United States, however, emission trading had been implemented for emission control of various substances since before Kyoto Protocol. Especially in the 1990s, SO_2 and NO_x emission trading schemes were introduced as anti-air pollution measures, which are said to have brought about very good results. Now let us see outline of these schemes.

U.S. SO_2 emission trading scheme (ARP: Acid Rain Program)

ARP introduced in 1995 as an SO_2 emission trading scheme covers power plants in the whole United States (Fig. 4).

Period	Phase I (1995 to 1999)	Phase II (2000 to 2009)
Covered facilities	Compulsory participation: 263 coal-fired power plants with 100 MW or more capacity and with 2.5 lb/mmBtu or more emission rate in 1985. All of these plants are located in the East and Midwest. Voluntary participation: 182	Compulsory participation: all power plants with 25 MW or more capacity, more than 2000 plants in whole U.S. Voluntary participation: about 1500. A total of 3456 companies are participating in 2005.
Market scale (Total emission allowance)	8.7 Mt-SO_2 (1995)—7.0 Mt-SO2 (1999)	9.5 Mt-SO_2 (2005)
Emission allowance	2.5 lb/mmBtu x reference thermal input * Reference thermal input is an average over 1985 to 1987 period.	1.21 lb/mmBtu or actual emission rate in 1985
Allocation method	2.8% of total allowance is auctioned while most of the emission allowances are allocated free of charge based on grandfathering[1).	
Penalty for excess emission	$2000/t-$SO_2$ (Real value. Nominal value is adjusted by inflation rate.) Amount equal to excess emission is subtracted from allowance allocated for next year.	
Banking	Allowed without limit.	
Exceptions	Bonus allowances to Midwest states of Illinois, Indiana, and Ohio[2)], extension provisions for plants that installed scrubbers[3)], etc.	More than 30 special provisions, for individual circumstances of almost every state

1) A method to determine the emission allowance to be allocated in accordance with the average thermal input in the past (1985 to 1987). This is called “grandfathering,” because allocation depends on the past power generation result.
2) Chiefly for a political reason, an emission allowance “bonus” was given to those Midwest states that highly depend on high-sulfur coal.
3) A rule to allow plants that installed flue gas desulfurization systems to postpone the emission reduction time limit, and to allocate them additional emission allowances for that period.
Source: Edited from U.S. EPA, “Acid Rain Program: Overview” (http://www.epa.gov/airmarkets/arp/overview.html)

Fig. 4 Outline of U.S. SO_2 emission trading scheme

Before 1995, new or largely improved plants had to comply with an emission standard more stringent than that for existing plants. Then the standards were unified so that the same stringent standard as that for new plants were applied also to existing plants, and at the same time the emission tracing scheme was introduced.

At that time, several exceptions were allowed considering the cost burden of Midwestern and Eastern power producers, many of whose plants were old-fashioned coal-fired ones. The exceptions included giving additional emission allowances to power plants in Midwest states; and allowing plants that installed flue gas desulfurization systems to postpone the emission reduction time limit and allocating them additional emission allowances for that period.

Such exceptions, however, caused power producers' advantages to differ between states. For this reason, in Phase II from 2000 when power producers in the whole United States were covered by the scheme, Western states to which no exception was applied loudly insisted that they should have exceptions according to circumstances of the respective states. As a result, the scheme could no longer keep its ideal simple form, but came to have complicated emission allowance allocation rules including many exceptions.

U.S. NO_x emission trading scheme (NBP: NO_x Budget Program)

NBP introduced as an NO_x emission trading scheme covers stationary emission sources, including large boilers and turbines not only of power plants but also of factories.

While ARP is a federal program, NBP is a regional program of Eastern and neighboring states. For this reason, rules for emission allowance allocation to covered facilities were established by laws of the respective states.

EU CO_2 emission trading scheme (EU ETS)

It was European countries that first introduced emission trading schemes as climate mitigation measures. As this century began, Denmark and the U.K. introduced their respective domestic emission trading systems. Then, in 2002, EU adopted a Directive to introduce a pan-EU emission trading scheme, which was implemented in 2005 (Fig.5).

	Phase I (2005 to 2007)	Phase II (2008 to 2012)
Covered gas	CO_2	
Covered sectors	Energy, steel, ceramics, quarrying, paper and pulp	
Emission allowance allocation	Each country drafts a national allocation plan (NAP) for each Phase, and European Commission approves it.	
Auction	Up to 5% of allowances are auctioned, and remaining allowances are allocated for free. → Most of the emission allowances are allocated for free by grandfathering[1]. Auction is used by four countries for 0.13% of total allowances.	Up to 10% of allowances are auctioned, and remaining allowances are allocated for free. → Use of auction and benchmarking[2] will increase. (In most cases, however, a benchmark will be set for each technology type and each fuel type.)
Opt-out	U.K., Netherlands, Belgium, Poland, Czech	--
Opt-in	Austria, Sweden, Slovenia, Finland, Latvia, Lithuania	Each member country can freely apply the scheme to other sectors or gases. (Some countries, including the Netherlands, decided to expand the scheme to include N_2O.)
Banking	Each member country can freely allow banking to Phase II. (Actually most countries decided not to allow banking.)	Allowed.

Use of Kyoto Mechanisms	Use of JI is allowed from 2008, and use of CDM from 2005. Exchange rate is one to one. Detailed rules are given by JI/CDM Linking Directive (2004/101/EC).	
Penalty for noncompliance	40 Euro/ton-CO_2	100 Euro/ton-CO_2

1) A method to allocate emission allowance in accordance with the past emission result.
2) A method to allocate emission allowance by setting a benchmark for output or energy input.
Source: http://ec.europa.eu/environment/climat/emission.htm, accessed on January 25, 2007.

Fig. 5 Outline of EU CO_2 emission trading scheme

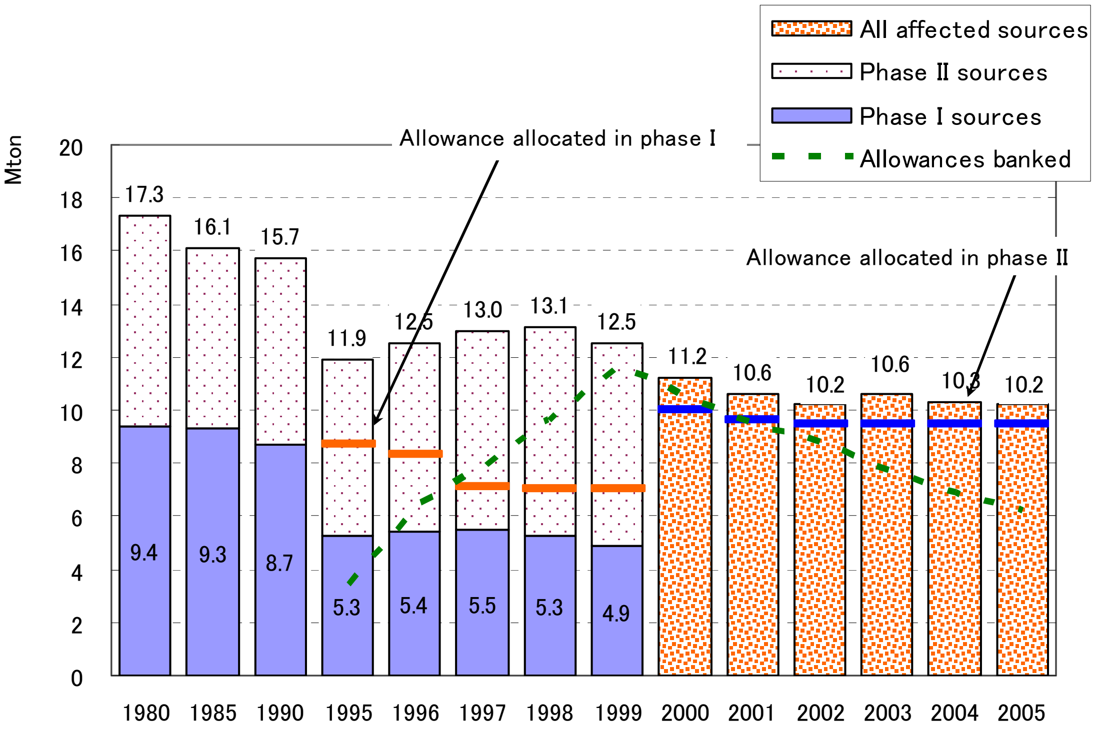
Allocation of emission allowances to covered facilities is done by each country independently. The emission cap of a whole country depends on the extent to which the Kyoto Protocol target of that country has been attained. The more difficult a country's attainment of target is, the stricter the emission allowance for companies in that company becomes. For this reason, similar facilities in different countries are not necessarily allocated the same number of emission allowances. In the EU ETS, efforts are made, through European Commission's guidance and approval processes, to minimize difference between countries. However, not only industrial structure and energy composition but also the Kyoto Protocol target differs between countries so that it would be difficult to harmonize completely emission allowance allocation rules of respective countries.

4. Evaluation of emission trading schemes' effectiveness

In what follows, let us check, one by one, whether the "theoretical advantages" shown in Fig. 2 were actually demonstrated in the U.S. and EU examples.

A. Were emissions reduced?

First, let us see the U.S. SO_2 emission trading scheme (ARP: Acid Rain Program) in detail.



Source: Reference [9]

Fig. 6 Effects on Emissions Reductions: SO_2 emission from covered facilities of the U.S. Acid Rain Program

Fig. 6 shows annual SO_2 emissions from the covered facilities. In Phase I (1995 to 1999), the program covered more than 260 old coal-fired power plants located chiefly in the East. On the other hand, in Phase II (2000 to 2009), the program was expanded to over 2000 power plants in the whole United States.

Emission allowances were determined based on the average fuel consumption over the 1985 to 1987 period, and the Phase II allocation was so strict that the emission per fuel consumption should be a half or less as compared with Phase I. Power producers covered by Phase I, knowing that future emission allowances would be much stricter, reduced their emissions early, and carried forward surplus allowances. This is called “banking” of emission allowances.

Thus, many companies, using the banking provision, provided against stricter emission allowance allocation of Phase II by reducing their emissions in the early stage. This prevented considerable reduction in total emission in spite of stricter allowances in Phase II.

As shown in Fig. 6, in 2000, the accumulated amount of surplus emission allowance carried over from Phase I was almost as much as the total allowance for a year. As a result, in Phase II, actual emissions could exceed allocated allowances, and this made additional activities for emission reduction unnecessary.

In 1995, when the emission trading scheme was introduced, the total emission from the covered plants was reduced by 25% as compared with 1990. Then the emission remained almost unchanged, not assuming a continuously reducing trend. Similarly even after Phase II started, the emission has been almost at a constant level.

Emission trading scheme, not the only factor of reduction

Methods to reduce SO_2 emissions from power plants can be roughly divided into two options. One is change of fuel to that of less sulfur content, and the other is installation of flue gas desulfurization systems. It is known that plants' selections largely differed depending on the state. Roughly speaking, Midwest power plants chiefly selected an option to change fuel to that of less sulfur content, and Eastern plants chiefly selected an option to install flue gas desulfurization systems.

Introduction of the emission trading scheme increased the demand for Western high-quality coal with less sulfur content. The largest factor that made possible fuel shift of Midwest plants is said to have been progress of rail transportation, which considerably reduced transportation cost, making it possible for Midwest power plants to use Western coal.

In the East where there are many old power plants, installation of flue gas desulfurization systems was virtually subsidized by allocation of additional emission allowances, which accelerated installation of such systems in the Eastern states.

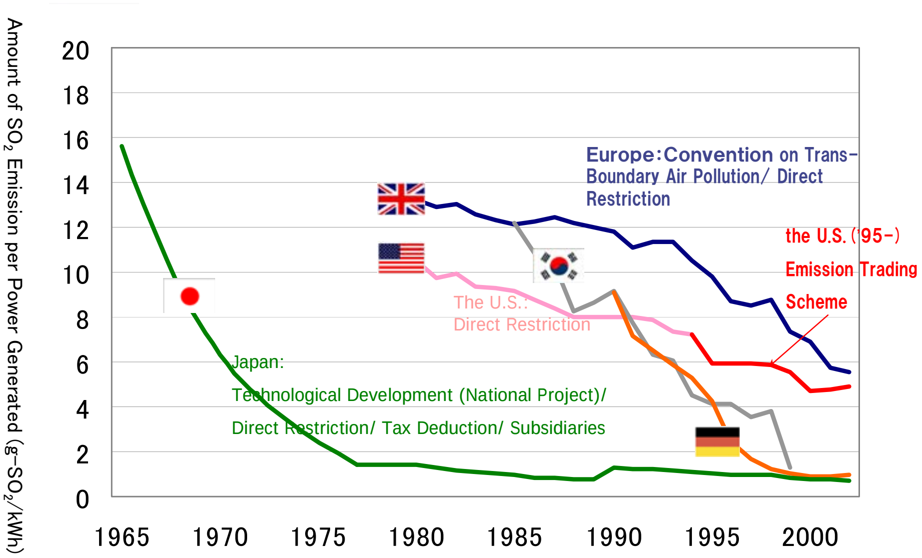
Almost all of the actual emission reduction occurred only in particular states where these promising options could be adopted. Power producers select an option by considering various factors. SO_2 emission reduction in the United States of the 1980s and later was realized as a result of varieties of external factors and policy factors, and from those factors you cannot extract only introduction of the emission trading scheme and evaluate its effect (Fig. 7).

-- Fuel shift: contribution of external factors, including elongation of coal transportation distance and cost reduction owing to liberalization of rail transportation
-- Flue gas desulfurization: policy to promote installation of flue gas desulfurization systems, from the viewpoint of protecting the Midwestern coal industry
→ The emission trading scheme was not the only factor to reduce emissions.

Fig. 7 Factors that accelerated SO_2 emission reduction

Emission trading scheme, not a factor of considerable reduction

To cope with air pollution by SO_2, which has been a common issue of developed countries, the United States introduced an emission trading scheme, but other countries tried to control emissions by such policies as direct regulation of emissions from factories. In the United States, the total emission from power plants was reduced to a certain extent after the trading scheme was introduced. Was this, however, a better result as compared with other countries with different policies?



Source: Reference [6].

Fig. 8 International Comparison on SO_2 Emission Amount per Power Generation:

SO_2 Emission from Coal & Oil Thermal Power Plants (Amount of SO_2 Emission per Power Generation of 1kWh)

Fig. 8 shows changes in SO_2 emission factors (SO_2 emissions per power generated) of thermal power plants in several countries. As shown in the figure, the U.S. emission was temporarily reduced in 1995 when the emission trading scheme was introduced. The long-term trend, however, has remained almost unchanged since before introduction of the emission trading scheme, and it cannot be said that introduction of the trading scheme largely accelerated emission reduction.

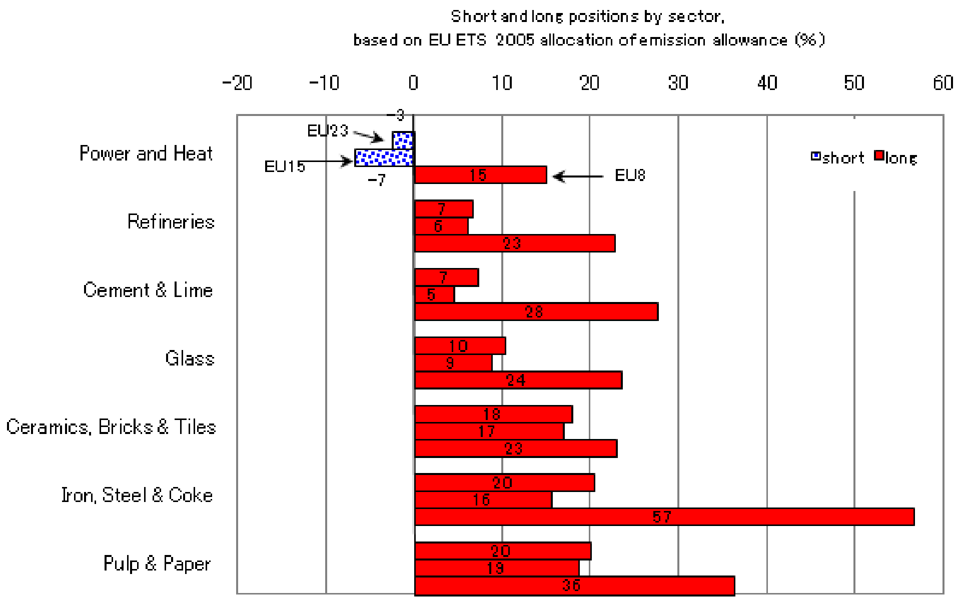
On the other hand, Japan rapidly improved the emission factor in the 1960s by a combination of various policies such as technology development, direct regulation, and financial support, and attained the world's lowest level in the 1970s. Germany and Korea also tightened regulations from mid-1980s, and considerably improved their emission factors in the 1990s.

Thus, it can be said that the emission trading scheme had a certain reduction effect, but more effect was obtained also by other policy measures.

There are often such arguments that highlight only emission reduction in and after 1995, and insist that the trading scheme had a large effect, but such arguments turn out to be wrong if we make comparison of emission changes in several countries for a long term.

Strict allowance allocation, politically difficult

The emission reduction effect of the emission trading scheme depends on strictness of total emission allowance setting. Stricter allocation, however, would lead to a jump in the emission allowance price, hampering competitiveness of domestic industries. For this reason, a high emission allowance price cannot be maintained from the viewpoint of policy, and measures including loosening of emission target itself or additional supply of emission allowances by the government are apt to be taken until the price drops into a range allowable by companies.



Source: *Reference [3]*

Fig. 9 Generous Allowance Allocations under the EU ETS

Let us confirm this in the emission allowance setting of the EU ETS's Phase I. Fig. 9 shows the relation between the initial allocations of EU allowances (EUAs) and the CO_2 emissions from the covered facilities in 2005.

In the figure, a negative value means lack of EUA caused by the emission exceeding the allocated EUA, and a positive value means excess of EUA caused by the allocated EUA exceeding the emission. It can be seen from the figure that excessive EUAs were allocated to sectors except the energy sector. This is because in general looser EUA setting was made to trade-related industries taking into consideration their international competitiveness, and stricter EUA allocation was made only to the energy sector (electric power companies) that are less exposed to international competition.

As a result, in the EU emission trading market, electric power companies have become chief buyers of EUAs, and other industrial sectors have become chief sellers of EUAs.

In the market as a whole, EUAs are showing a tendency to be excessive, lowering their prices. This causes attainment of reduction targets by purchasing EUAs in the market to be in sight even for electric power companies that are lacking EUAs, thus eliminating necessity of additional measures such as facility renewal.

The case of EU ETS implies that in an actual emission trading scheme it is difficult to set strict emission allowances, and especially to trade-related industries tolerant allowances are apt to be allocated taking international competitiveness into consideration (Fig. 10).

U.S. SO_2 emission trading program (ARP)
-- Had a certain emission reduction effect.
But…
-- There is no evidence that the ARP is more effective than other policy measures. Japan, not having implemented an emission trading scheme, succeeded in a considerable emission reduction much earlier than the United States.
EU ETS
-- Phase I has not have a significant reduction effect because of non-strict setting of reduction targets.

Fig. 10 Emission reduction effects of emission trading schemes

B. Split results of cost evaluation

Then let us see cost saving effects.

The emission trading scheme theory says that trading in the market causes emission reduction measures to be implemented in the cost effectiveness descending order so that the total emission reduction cost can be saved. In economics, this effect is represented by the difference between the emission reduction cost under the trading scheme (A) and that in the case where the same amount of emission reduction as that by the trading scheme was attained by regulations (B). “The case where the same amount of emission reduction as that by the trading scheme was attained by regulations,” however, does not actually occur. Therefore you cannot but use a value estimated on various assumptions as cost B.

1 Mil.US $ Price as of 1995

	A. With trade	B. Without trade	C. Cost Reduction	D. Reduction Effect C/B
Ellerman et al. (2000) a)	735 167	1361 525	626 358	46% 68%
Carlson et al. (2000) b)	871 561*	790	-81 228*	-10 29 *
Keohane (2006) c)	c-1) 747 c-2) 747 c-3) 779 c-4) 747 c-5) 747	546 900 941 930 2,555	-201 153 162 183 1,808	-37% 17% 17% 20% 71%

a) Placing marginal cost at 350$/ton, the upper line represents the reduction costs based on the actual amount of emission in Phase 1. The cost reduction effect is the sum of emission trading within the Phase and emission trade banking overlapping the Phases. The lower line represents the reduction costs for emission reduction 2 Mil. Ton per year needed to comply with the Phase 1 target. Refer to Ellerman et al. (2000), p.281.

b) Average cost value of 1995 and 1996 in Carlson et al. (2000) table 3. The upper line figures were the actual costs seen under the trading program, whereas the bottom line figures in brakets represent the theoretical values when assuming efficient trading was performed.

c) Keohane (2006) table 6-9, counterfactural cases are; under that of c-1) rational regulation, c-2) uniform emission rate standards, c-3) uniform emission rate standards including reduction amount due to voluntary participation , c-4) emission standards according to type of power plant, c-5) standard exhaust gas desulfurization unit

Fig. 11 Example of Estimated Cost Savings under the ETS

Results of estimating the cost saving effect of the US SO_2 emission trading scheme by the above method are shown in Fig. 11. As is seen from the table, evaluation results largely differ depending on analysis.

Why do the results assume such large differences? The cause is chiefly differences in the evaluation method. For instance, analysis a) in Fig. 11 compares the theoretical cost calculated on the assumption that trades in the market are perfectly transparent and every trade is efficient (A) with the cost in the case where a uniform emission standard is applied to every covered facility in order to attain the same amount of reduction as that by the trading scheme (B). This means that analysis a) is estimating a “potential amount” of cost saving that can be theoretically expected to be attained by emission trading.

Such an evaluation has two problems. One is an assumption of “perfectly efficient” trades in the market. That is, analysis a) is estimating, on the assumptions of complete information and companies’ rational actions, the ideal minimum cost that is reached when the total emission reduction attained by measures implemented in the cost ascending sequence becomes equal to the total emission allowance.

In actual cases, however, not all trades are done efficiently. Irrational trades may be concluded due to such factors as unreliable information, various costs for trading, and companies’ decision making errors. For this reason, the actual cost becomes higher than the theoretical value.

The other problem is that in estimation of cost B the assumption of inflexible regulation applying a uniform emission standard is not properly reflecting the reality. In actual regulations, such measures as allowing excess emissions from individual facilities as far as the cap of the total emission from all facilities is not exceeded or allowing operation of less-efficient old facilities in exchange for introduction of high-efficient new facilities are taken. Evaluations ignoring such flexibility that actual regulations have will overestimate the cost of regulatory measures.

Thus in the comparison of the emission reduction cost under an emission trading scheme (A) and that in the case where the same amount of emission reduction is attained by regulations (B), cost estimation itself is very difficult, and evaluation differs between evaluators depending on their assumptions.

Many factors led to cost saving

The market price of emission allowance is almost half the emission reduction cost supposed around 1990 when introduction of the trading scheme was considered. Not a few people say that this is a cost saving effect of the trading scheme, but such an argument is not correct.

	year	Total cost 1 Bil. US $ per year	Marginal cost US$ per ton)	Average cost US$ per ton)
Carson at el.	2000	1.1	291	174
Ellerman et al.	2000	1.4	350	137
Burtraw et al.	1998	0.9		239
White (EPRI)	1997		436	
ICF (EPA)	1995	2.3	532	252
White et al (EPRI)	1995	1.4-2.9	543	286-334
GAO	1994	2.2-2.3		230-374
Van Horn Consulting (EPRI)	1993	2.4-3.3	520	314-405
IFC (EPA)	1990	2.3-5.9	579-760	248-499

Source: Burtraw and Palmer, "SO2 Cap-and-Trade Program in the United States: A "Living Legend" of Market Effectiveness" in Reference [5] Chapter 2 (pp.41-66)

Fig. 12　Example of Estimated SO_2 Emission Reduction Cost

Fig. 12 shows change in evaluated costs with time. Interestingly, the later the study is, the smaller the estimated value becomes. This is because the estimated emission reduction cost of year 2000 was subjected to a large downward adjustment because of improvement of external conditions, including the progress of fuel transportation, which could not be supposed in the first half of the 1990s to happen.

-- Inflexible regulatory measures are assumed for comparison basis.

-- Perfect functioning of the emission allowance market is assumed.

-- Factors having no direct relation with the emission trading scheme, such as fuel cost lowering and progress of technology, are not separated.

Fig. 13　Reasons for overestimation of emission reduction cost saving effect of U.S. SO_2 emission allowance market

Thus evaluation of the cost saving effect in itself is difficult and apt to lead overestimation (Fig. 13). Though it is true that the emission reduction cost has lowered, the cost lowering is a result of improved "external conditions," and it would be oversimplification to say the cost has been saved by introduction of the trading scheme.

C. Emission trading scheme, not accelerating facility renewal

Both EU ETS and U.S. SO_2 emission trading scheme ARP are said to have failed to induce as much facility renewal as expected (Fig. 14). The reasons of failure, however, were quite different, almost opposite to each other, between the two schemes.

-- EU ETS: Target setting period is short, and the prospects for the future are opaque. This has caused companies to postpone investments, hardly leading to facility renewal that is desirable in the long run.

-- U.S. SO_2 emission trading scheme ARP: Target setting period is long, but the target itself was so easy as to cause lowering of the emission allowance price. As a result, capital investment at the same level as that of other countries, such as investment for installation of flue gas desulfurization systems, was not implemented.

Fig. 14 Emission trading schemes did not accelerate facility renewal

In the EU ETS, the emission allowance allocation rule covers only a short period of five years. For this reason, it is said that the prospects for the future allocation are opaque, and the scheme hardly leads to large-scale emission reduction activities accompanying facility changes.

On the other hand, the United States established a long-term rule to allocate emission allowances more than ten years from the time of introduction of the scheme, but unforeseeable changes in external conditions occurred, and a certain extent of emission reduction was realized at a low cost. As a result, easy attainment of the targets led to lowering of the emission allowance price, and opportunity for further reduction, which would have to be realized by facility renewal, was lost.

From these cases, it can be seen that neither short-term target setting as seen in the EU case nor long-term target setting as seen in the U.S. case led to considerable emission reduction accompanying facility renewal for their respective reasons.

Emission allowance price riding a roller coaster due to institutional factors

An emission trading scheme is a system to lead companies indirectly by a price signal. In order to stimulate companies to make changes and renewals toward facilities more effective in emission reduction, it will be desirable that the market price of emission allowance is kept at a reasonable level.

Source: Reference [9], Point Carbon (http://www.pointcarbon.com)

Fig. 15 Emission Allowance Market Price has emerged to fluctuate rapidly

As shown in Fig. 15, however, the market price, which must be functioning as a price signal, goes largely up and down in a short period. For instance, in the case of EU ETS, the market price slumped when the emission data of year 2005 was finalized, making it clear to the market participants that a large amount of emission allowance was remaining.

Today enterprise risk management has advanced, and companies can keep up with changes in the market price within their expectation. In the emission allowance market, however, institutional factors such as information about political move concerning future allocation of emission allowances disturb the market more largely than the fundamentals including environmental impacts, changes in fuel prices, weather, and economic conditions. A price change due to institutional factors is difficult to predict, and once it occurs, it will largely shift the price level, which will not return to the original level.

For this reason, significant uncertainty due to institutional factors will make companies hesitate in decision making about investment, and as a result the market price signal does not lead to facility renewal, which must be the most essential objective of the scheme.

On the other hand, policies taken by the Japanese government, including regulations, agreements, and national technology development programs, has a more direct and sure impact on companies' activities. Such policies consistently influence companies' activities, and can surely stimulate a certain extent of facility renewal.

D. Administrative cost, not small

It is said that under an emission trading scheme, the government only needs to determine an appropriate emission level, and does not need to have technical knowledge about practical measures.

In actual cases, however, allocation of emission allowances is a significant controversial issue in institutional design, because it determines the covered companies' cost burden. This makes it inevitable to coordinate stakeholder's interests, and the cost for such coordination is not negligible as a part of the administrative cost.

In the EU ETS, by rule, 90% or more emission allowances are allocated to covered companies for free. Though in general different countries use different emission allowance allocation methods, many countries use a method called grandfathering, which is a method to determine allocations based on the emission results in a reference year.

In actual fact, however, establishing such a rule does not at all assure smooth proceeding thereafter.

In grandfathering, selection of the reference year affects the amounts of allowances to be allocated to companies. If a year when production output considerably increased or decreased due to special procurement or slump is selected as a reference year, too large or too small allowances will be allocated to companies. If the reference year is shifted as occasion demands, influence of a particular past year will cease at the time of shift, but on the other hand such shift has another demerit, because emission reduction will lead to decrease in the allowance to be allocated in the future, which will dampen companies' efforts toward emission reduction.

But these are not only problems of grandfathering: you must consider how to allocate emission allowances to new facilities that have no emission results in the past, and how to deal with allowances having been allocated to facilities that ceased operation halfway.

Though various rules are being discussed in order to accelerate selection of and renewal to more efficient and less CO_2 emission facilities, allocation rules considering circumstances of particular companies will be disadvantageous to companies of different circumstances, causing a conflict of interests.

Thus, arguments continue endlessly, but after all, in emission allowance allocation in an actual scheme, the more seriously you try, the more detailed and concrete circumstances you must review, and as a result the initial optimistic expectation that the emission trading scheme will only require a small amount of administrative cost will be betrayed (Fig. 16).

-- Since allocation of emission allowances determines the covered companies' cost burden, political coordination is inevitable.
→ In the United States, there is a regional difference in SO_2 emission from power plants—more emission in the East and Midwest, and less emission in the West. Allocation of emission allowances became a significant controversial issue linked also with regional interests.
→ In the EU ETS, it took a longer time than expected for each country to draft an emission allowance allocation plan. After all, it was more than a half year after the scheme had started that the European Commission completed approval of all 25 countries' allocation plans.

Source: Quoted from Reference [2].

Fig. 16 Administration cost larger than initial expectation

E. Only applicable to large-scale facilities

It is said to be one of the theoretical advantages of emission trading schemes that such schemes can cover a wide range of economic entities.

Actually, however, coverage of the U.S. NO_x and SO_2 emission trading schemes as well as that of the EU ETS is limited to large-scale facilities (Fig. 17).

-- In the U.S SO_2 emission trading scheme (ARP), mandatory monitoring and reporting of emission limited voluntary participation of facilities.
→ Only power plants for which monitoring and reporting had been mandatory since before the scheme participated voluntarily.
-- The Dutch government excluded small-scale companies with 25,000 ton or less annual emission from EU ETS.
→ When taking into account the costs for trading, the advantage of including small-scale companies in trading is small.

Source: Quoted from Reference [2].

Fig. 17 Limited coverage of emission trading schemes

This is because when taking into account the costs for participation, including those for measurement and reporting of emissions, the advantage of including small-scale companies in the scheme turns out to be small.

In Japan, a total of about 10,000 type 1 and 2 designated energy management factories are reporting their emissions under the Law Concerning the Rational Use of Energy (Energy Conservation Law). Even this mandatory reporting is a burden to small-scale factories, some of which fail to report.

Introduction of an emission trading scheme would require not only even higher accuracy of emission calculation but also certification by an external organization, which would much increase the burden.

If we want to be realistic, we must estimate the number of factories to be covered by the emission trading scheme to be much less than the number of factories being regulated by the Energy Conservation Law. It is not correct to say that an emission trading scheme can cover wider range of economic entities than regulations.

Relating to this, some people propose shifting the regulation coverage to upstream fuel suppliers. Then, they say, the number of covered companies will be limited, and exclusion of small-scale companies will not occur. In this context an emission trading scheme covering the upstream sector is being considered.

So far, however, there has been no example of introducing an emission trading scheme covering the upstream sector.

In general, under an emission trading scheme, covered companies must pay the cost to purchase emission allowances. In order to lighten companies' cost burden, the government sometimes takes such compensative measures as allocating emission allowances for free or granting a subsidy for the purchase cost. This is because if the energy price rises without such compensative measures, a phenomenon just like oil shock might occur depending on the situation, largely shaking the economic activities.

In case the scheme is designed to cover the upstream sector, however, it is difficult to understand how various price shifts occur, who finally pay the cost, and as a result how consumers and companies are influenced. This prevents the government from taking appropriate compensative measures in this case.

For this reason, it will be politically difficult for the government to decide to introduce such a trading scheme. Even if such a scheme is introduced, various restrictive regulations on trading are inevitable in order to avoid political and economic confusions, and this will almost cancel the scheme's "theoretical advantages."

F. Technological innovation is not accelerated

Reports from case studies of the U.S. NO_x and SO_2 emission trading schemes say that those trading schemes had effects to stimulate gradual changes including spread, cost reduction, and efficiency improvement of existing technologies.

However, there has been no example in which an emission trading scheme produced new technology that had not existed before, or realized introduction of technology whose commercialization had been considered to be difficult.

As for SO_2, major desulfurization technologies had been developed in Japan and other countries and widely spread before introduction of the emission trading scheme.

It is reported that introduction of the emission trading scheme in the United States had an effect to accelerate spread of established technologies, but after then, research and development focused on small improvements of technologies whose commercialization was in sight, thus damping enthusiasm to develop alternative technologies (Fig. 18).

-- Major desulfurizaiton technologies had been established by the 1980s. Introduction of the emission trading scheme urged companies to employ only commercialized low-cost technologies such as wet flue gas desulfulization and shift to low-sulfur fuel, and development of alternative technologies such as dry flue gas desulfulization was put off.
-- After introduction of the trading scheme, research activities concerning desulfurizaiton stagnated. The trading scheme did not have an effect to stimulate research and development of new technology, but was only effective in small improvements of existing technologies, such as cost reduction and efficiency improvement.

Source: Quoted from References [7] and [8].

Fig. 18 Innovative technology development, not accelerated

Trade-off between covered range and carbon price

So far, emission allowance prices could not be held high in emission trading markets. Why? The reason can be found in political difficulty in allocating strict emission allowances as we have seen before.

It can be said that the wider the covered range of a scheme is, the lower the socially acceptable carbon price is. For instance, in case of policy focused on development of particular field of technology such as solar energy or wind energy, a cost of even hundreds of dollars per ton of CO_2 is acceptable, because such energy occupies a very limited share in the whole energy supply. Actually, in subsidizing schemes and alternative energy introduction regulations, development and spread of technologies have been promoted by paying a cost equivalent to hundreds of dollars per ton of CO_2 (Fig. 19).

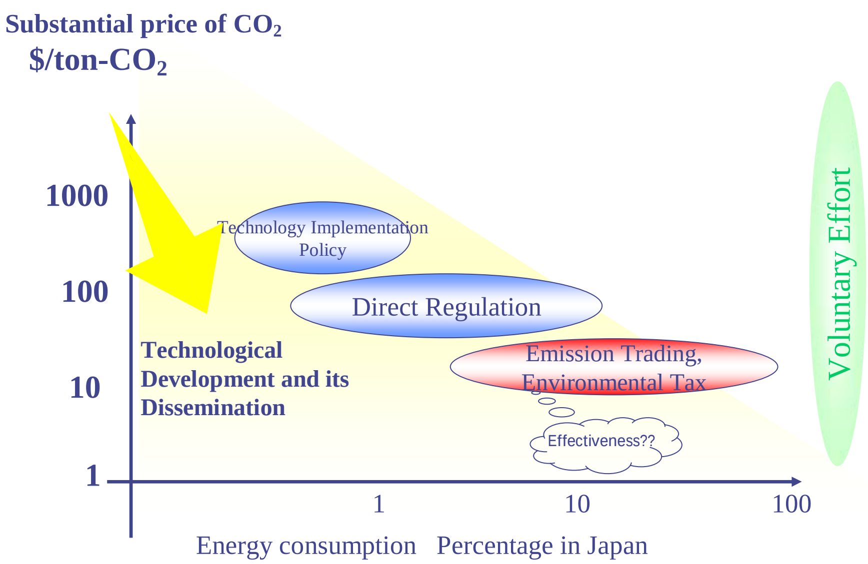


Fig. 19 Range Covered by the Scheme and Trade-off of Carbon Price

In the case of schemes covering fossil fuel in general, such as emission trading schemes, the socially acceptable cost level is much lower. Such a low price signal cannot stimulate companies' technology development activities.

5. Conclusions

As shown in the above consideration of ex-post evaluations of emission trading schemes in the United States and EU, it cannot be said that the "theoretical advantages" expected in ex-ante evaluations were fully realized by those schemes (Fig. 20).

Further ex-post verification is needed to evaluate effectiveness of cap-and-trade emission trading schemes.

Since advantages of such a scheme are not clear, careful consideration on possible harmful effects and comparison with other policy measures are needed when considering introduction of such a scheme into Japan.

	Theoretical advantage	Ex-post evaluation
A	Emission reduction effect	As for SO_2, Japan, Germany, and Korea, adopting direct regulations, realized much more emission reductions more rapidly. Strict emission allowance setting is unrealistic, and allowance allocation is apt to be loose.
B	Reduction cost saving effect	Evaluation results differ depending on analysis. Careful examination is required, because the effect is sometimes overestimated.
C	Effect to stimulate investment for emission reduction	Institutional uncertainty in the future and unstable market price are apt make companies hesitate about investment.
D	Administrative cost saving effect	Coordination cost for emission allowance allocation is not small.
E	Applicable to broader range of economic entities	Emission monitoring cost limits the coverage to large-scale emitters.
F	Technology development accelerating effect	The schemes had cost reducing and efficiency improving effects on existing technologies, but no move to technology development in long perspective occurred.

Fig. 20 Theoretical advantages of emission trading schemes, not realized

[References]

[1] Carlson, C. et al., Sulfur Dioxide Control by Electric Utilities: What are the Gains from Trade?, The Journal of Political Economy, vol. 108, no.6, pp.1292-1326, 2000.

[2] Ellerman et al., Market for Clean Air: The U.S. Acid Rain Program, Cambridge University Press, 2000.

[3] Ellerman, A. D. and Buchner, B., Over-allocation or Abatement? A Preliminary Analysis of the EU ETS Based on the 2005 Emission Data, FEEM Working Paper, Fondazione Eni Enrico Mattei (FEEM), 2006.

[4] Keohane, N. O., Cost Savings from Allowance Trading in the 1990 Clean Air Act: Estimate from a Choice-based Model, in Freeman, J. and Kolstad, C eds. Moving to Markets in Environmental Regulation: Lessons from 20 Years of Experience, Oxford University Press,

pp.194-229, 2006.

[5] Harrington, Morgenstern and Sterner eds., Choosing Environmental Policy: Comparing Instruments and Outcomes in the United States and Europe, RFF Press, 2004.

[6] Masayo Wakabayashi and Taishi Sugiyama, Case Study Review about Effectiveness of Emission Trading Schemes, Central Research Institute of Electric Power Industry Report Y06010, 2006 (in Japanese).

[7] Popp. David, Pollution Control Innovations and the Clean Air Act of 1990, NBER Working Paper 8593, national Bureau of Economic Research, 2001.

[8] Taylor, M. et al., Regulation as the Mother of Innovation: The Case of SO_2 Control, Law & Policy, vol. 27, no2, pp.348-378, 2005.

[9] U.S.EPA, Acid Rain Program 2005 Progress Report, EPA430-R-06-015, 2006.