# CARBON TRADING

K.S. KAVI KUMAR

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# Carbon Trading

## 1.0 Introduction

The available evidence suggests that in the absence of policy interventions the global climate change could pose serious challenges to human life. At the outset it would useful to take stock of the magnitude of the climate change problem. It is widely believed that stabilization of atmospheric concentrations of greenhouse gases GTC) at around 450 parts per million by volume (ppmv) would lead to about $2^{o}$C warming – which is considered as relatively less 'dangerous'. For such stabilization the cumulative greenhouse gas emissions since industrial revolution should be about 670 gigatonne of carbon (GtC). Since the cumulative emissions so far are close to 300 GtC, the 450 ppmv stabilization target would leave the world with an atmospheric carbon space of about 370 GtC. This would mean that the global emissions in 2050 should be reduced by 60 to 80 percent compared to the 1990 levels. Thus, responding to climate change problem would involve significantly large reductions in global emissions of greenhouse gases, plus learning to deal with committed change in climate through appropriate adaptations.

Policy responses to address climate change problem are broadly discussed under two heads: mitigation of greenhouse gas emissions and adapting to the climate change induced impacts. With the focus of the global negotiations squarely on the mitigation aspects, the emphasis has so far been on: (a) assessing the extent of mitigation of GHG emissions world over that could avoid 'dangerous' climate change (such as the one outlined above); (b) distribution of mitigation burden across the world nations that fulfills 'common but differentiated' principle of the Earth Summit in 1992; and (c) identifying cost-effective route for meeting mitigation targets and developing mechanisms and institutions that enable cost-effective mitigation. The mitigation response outlined in the Kyoto Protocol and the other subsequent agreements has focused so far on the last two aspects. It must be noted, however, that the emission reduction targets envisaged are rather arbitrary with the emphasis squarely on putting in place the appropriate mechanisms for achieving cost-effective mitigation.

Minimizing the cost of abatement of a given amount of GHG emissions requires ***all*** sources to reduce emissions such that their marginal costs of abatement are equal. Standard economic policy prescription would be a market based instrument – such as a tax on emissions or tradable permit system for emission rights (interchangeably referred in this paper as 'carbon trading'). In the absence of uncertainty, both these instruments provide similar solutions – although the distributional effects of the two policy instruments would be very different. Environmental economics literature showed that under uncertainty emission permits are better than taxes when the marginal benefit schedules are steeper than the marginal cost curves. In the climate change context, available evidence suggests that the marginal cost curve for reducing GHG emissions is very steep and the marginal benefit curve is relatively flat. Thus, following Weitzman's theory, it could be inferred that tax policy is likely to be more efficient than a permit system for addressing the climate change problem. However, if one considers the climate 'surprises' then the marginal benefit curve could be steeper than marginal cost curve and in such scenario a permit system may turn out to be more efficient than tax policy[1]. Hepburn (2007) provides additional reasons for the observed dominance of carbon trading, which include: (a) unlike trading, taxes do not automatically support international wealth transfers that are needed for de-carbonizing the developing country economies; (b) trading may increase firm's attention on carbon owing to the profit opportunities, whereas taxes would be seen as leading to additional costs to the firms. Further, given the success of some of the ongoing trading schemes (e.g., EU-ETS, described later) it is quite likely that carbon trading will continue to play an important role in GHG mitigation strategies. This note attempts to summarize the main features of the carbon trading scheme and discuss the features of some of the trading schemes in practice, besides giving an overview of the current status of the global carbon market.

**Box 1: Carbon Taxes and Carbon Trading**

While both carbon taxes and permit trading are market based instruments, they can be distinguished based on the following criteria:

[1] Box 1 compares the carbon taxes and permit trading based on several criteria.

- Environmental effectiveness – Unlike permit trading, carbon taxes do not guarantee achievement of emission target. Political economy forces point to less severe emission targets if carbon taxes are used. Carbon taxes on the other hand provide grater certainty about costs of achieving a target.
- Simplicity – Carbon taxes are considered simpler to implement than permit trading as the firms and government need not keep track of allowance transactions. The supporters of permit trading point at the same time that there is no clear evidence of high costs associated with trading institutions.
- Political acceptability – While it is often argued that allowance allocation involves considerable political pressures, one can not undermine the difficulties associated with political pressures for tax exemptions.
- Fiscal revenue – The revenue generated through carbon tax can be used for lowering distortionary taxes elsewhere in the economy, financing climate friendly technologies, funding development programs, and providing assistance to affected sectors. However, most of these could also be true with revenue generated through auction mechanism under permit trading.
- Volatility – Use of carbon tax avoids potential price volatility associated with permit trading system. Several economists including Nordhaus have warned that extreme price volatility in carbon trading may make it unpopular. However, it must be noted that price volatility can often be associated with flawed design. For instance, the recent price crash in EU ETS market is attributable to over allocation of permits.

## 2.0 Conceptual Basis for Trading

To understand the logic behind carbon trading it is useful to first describe the notion of marginal abatement cost (MAC). The marginal abatement cost (MAC) is the cost of reducing pollution (say, carbon emissions) by an

additional unit. It is generally assumed that the MAC increases as abatement increases. In other words, the more one abates pollution, the more costly it becomes to reduce pollution by an additional unit. The area under the MAC curve under any two abatement levels shows the corresponding cost of abatement.

Under the permit trading approach of environmental management, the regulator first determines a desired level of environmental quality and translates that into total number of allowable emission units. The allowable emission units are then distributed across polluters in the form of permits. The polluters are allowed to exchange these permits. A polluter will carry out the abatement as long as the cost of abatement is lower than the cost of purchasing a permit. Hence, given a similar aggregate emissions target, the level of (uniform) pollution charge necessary to achieve the target would be the same as the equilibrium price of a permit, assuming that the market for permits is perfectly competitive. The basis for permit trading arises because the MACs generally differ across firms and regions. In case of GHGs, the cost of abatement of emissions is relatively lower in developing countries compared to the developed countries. Hence, if several regions together have to achieve emission reduction targets, then the aggregate cost of meeting the target will be less if a region with higher marginal abatement costs can induce a region with lower marginal abatement costs to abate on its behalf. Since the GHGs like carbon dioxide ($CO_2$) are uniformly mixed pollutants, the location of the emission reduction does not have influence on the overall target of stabilizing the atmospheric concentrations of GHGs. By abating more, the lower cost region creates 'rights to emit,' or emission permits, which it can sell to the higher cost region. The difference in the marginal abatement costs associated with each region's commitment in the absence of trade creates a potential gain to be shared in some manner between the two regions. The aggregate emission reduction will be achieved at least cost when the regions trade until their marginal abatement costs are equal at what will then be the market clearing price for the 'right to emit' carbon. Figure 1 shows the conceptual basis for carbon trading.

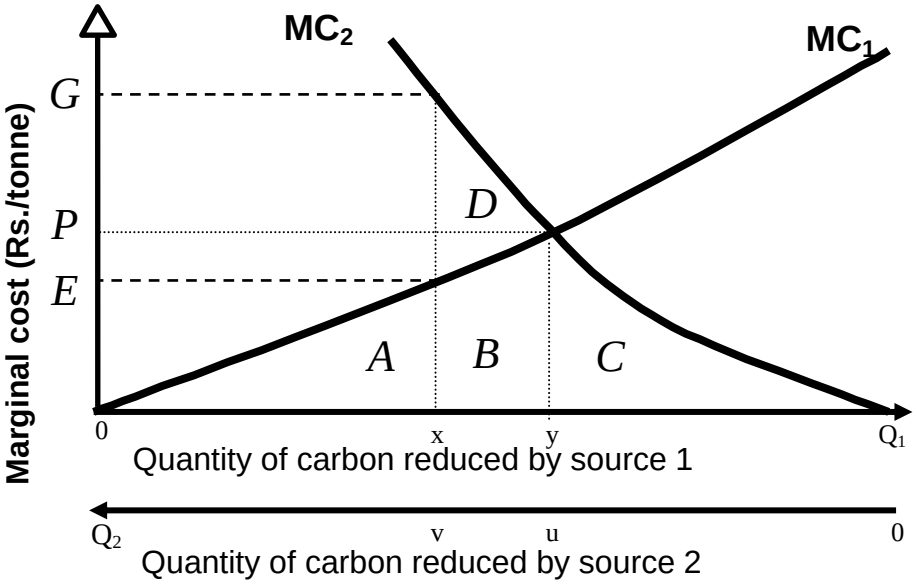



**Figure 1. Carbon Trading – Concept**

Consider two sources with marginal abatement costs, $MC_1$ and $MC_2$. The figure shows the quantity of carbon reduction for source 1 measured from left to right, and that of source 2 measured from right to left. Consider that the quantity of carbon reduction from *x* to *y* by source 1 is equal to the quantity of carbon reduction from *u* to *v* by source 2, and let this quantity of carbon reduction be 2 tons. As shown in figure, source 1 can reduce 2 tons of carbon at an extra cost of Area B. For source 2, the cost of abating the same amount of carbon (i.e., from level *u* to *v*) will be equal to area (B+D). Hence, source 1 will be better off by selling the additional 2 tons of carbon it had reduced at revenue greater than area B, and source 2 will be better off by purchasing the additional 2 tons from source 1 as long as the total cost is lower than the area (B+D). Thus, both the regions will gain from trade. Box 2 provides an example to illustrate the cost-effective nature of carbon trading.

As discussed in detail below the European Union Emissions Trading System (EU-ETS) has been one of the most active cap-and-trade markets for carbon.

The emissions trading in $CO_2$ under the EU-ETS has followed the practices pioneered by the United States Acid Rain Program, where a cap-and-trade system in emissions of sulphur dioxide and nitrogen oxides was developed following the passage of the 1990 U.S. Clean Air Act. The U.S. and European experiences suggest five steps in the creation of a cap-and-trade scheme. These steps are described below in the context of carbon trading.

a. Setting a Clear Goal – Capping Emissions

The first step is to pass regulation that sets mandatory limits (or caps) on $CO_2$ emissions over a specific time period. The national cap determines the supply of allowances over a given period, which will affect the price signal. The cap is set to achieve a reduction in emissions to a desired level over the target horizon. Typically, this cap is broken down into targets for different subperiods, providing interim goals for emission reductions along a path towards the long-term target.

b. Assigning Responsibility – Allocating Allowances

National regulations specify which individual firms are covered by the cap – whether private companies, public sector installations, or both. Each firm is given its own cap consistent with an aggregate reduction in $CO_2$ emissions. The firms are then allocated the appropriate number of carbon allowances. At the end of the period covered by the regulations, each firm must either reduce its $CO_2$ emissions to a level at or below its individual cap, or deliver allowances equal to the excess amount of emission. Firms that fail to meet their targets are fined.

c. Facilitating Cost-Effective Emission Reductions – Trading

Once allowances are allocated, the stage is set for trading to begin. Each firm must determine the most cost-effective means to reduce (or abate) its carbon emissions. The firm may invest in improving its production processes. Or it may judge that it is cheaper to buy allowances in the carbon market sufficient to cover its excess emissions. As explained above with the help of figure 1, suppose that Enterprise A has a level of $CO_2$ emissions that is above its regulated cap, and has limited or uneconomic abatement opportunities. Let

Enterprise B has a low-cost opportunity to reduce $CO_2$ emissions and can therefore sell its excess allowances to Enterprise A. At the end of this transaction, both parties are within their caps. Physical trading in carbon instruments takes place either on an organized exchange or over the counter, similar to other commodities. A number of carbon exchanges have emerged that trade spot, forward, and option contracts in carbon.

d. Ensuring Accountability – Monitoring and Reporting

As with any market, a cap-and-trade market may not develop efficiently without the necessary infrastructure. Experience suggests that a successful cap-and-trade system relies on the following elements:

- registration of the ultimate owner of allowances or credits
- independent monitoring of emissions from a facility
- reporting of emissions to a central authority over a given period
- verification of the level of emissions and confirmation of reductions

These components are critical for promoting both public and business confidence in the system, allowing the market to function properly, and minimizing uncertainty. While some of these functions may be provided by financial intermediaries, a central authority may have responsibility for some or all of the functions.

e. Ensuring Compliance – Reconciliation

At the end of the period covered by the scheme, regulators must reconcile a firm's emissions against its holdings of allowances to ensure compliance. The firm must either deliver the equivalent number of allowances for its excess emissions, or pay some predetermined fine if they are short. This fine effectively sets an upper limit on prices for emissions. Without effective compliance and enforcement, the incentives will not be in place to ensure an aggregate reduction in emissions. In the case of the U.S. Acid Rain Program, compliance has been very high, with over 99 per cent of firms meeting their targets, thanks to rigorous monitoring, reporting requirements, and stringent penalties. By 2007, the Environmental Protection Agency reported that sulphur

dioxide emissions were 41 per cent below their 1980 levels, while emissions of nitrogen oxides were 57 per cent below their 2000 levels.

Box 2 Provides an example that shows how trading of permits leads to cost – effective emission reductions.

**Box 2: Cost Effectiveness of Carbon Trading**

Suppose there are three firms characterized by the following MACs. From the table it can be seen that it costs Rs. 15 for firm 1 to reduce its emission from 6 units to 5 units, whereas for a similar reduction firms 2 and 3 would incur Rs. 40 and Rs. 20, respectively. Without regulation each firm would have to emit six units of emissions each and there would be 18 units of emissions in total. Suppose the objective is to reduce aggregate emissions to 9 units. Let there be two options for achieving this objective: (a) to stipulate that each firm has to reduce its emissions to three units; and, (b) the firms can trade emission permits among themselves while ensuring that the aggregate emission are 9 units.

| **Units of Emissions** | **Marginal Abatement Cost in Firm 1 ($MAC_1$)** | **Marginal Abatement Cost in Firm 2 ($MAC_2$)** | **Marginal Abatement Cost in Firm 3 ($MAC_3$)** |
|---|---|---|---|
| **6** | 0 | 0 | 0 |
| **5** | 15 | 40 | 20 |
| **4** | 30 | 75 | 40 |
| **3** | 50 | 110 | 75 |
| **2** | 75 | 150 | 120 |
| **1** | 100 | 200 | 170 |
| **0** | 150 | 260 | 230 |

Under option 1, the total abatement cost for the three firms would be, $TAC_1$ = Rs. 95, $TAC_2$ = Rs. 225, and $TAC_3$ = Rs. 135. The overall abatement cost

would be TAC = Rs. 455.

Under option 2, the three firms would trade till their marginal abatement costs are equal. Thus, firm 1 will reduce four units of its emissions, firm 2 will reduce two units of its emissions, and firm 3 will reduce three units of emissions. In other words, firm 1 will sell one unit of emission permit it has generated through excess abatement to firm 2, while firm 3 will not participate in the trading. The total abatement costs for the three firms would then be, $TAC_1$ = Rs. 170, $TAC_2$ = Rs. 115, and $TAC_3$ = Rs. 135. The overall abatement cost would be TAC = Rs. 420.

Since the overall abatement costs are lower under option 2, it can be inferred that trading has enabled the three firms to meet the emission reduction target in a cost effective manner.

## 3.0 Overview of Carbon Market

Carbon trading refers to a wide range of trading possibilities. In the classic scenario it refers to a cap-and-trade system wherein a cap is specified to an entity and if it abates lower than the cap it becomes a net seller, and if its emissions exceed the cap then it becomes a net buyer. Under the Kyoto Protocol the Annex-I countries can participate in such emissions trading during the Kyoto commitment period. Besides this, there are other forms of carbon trading with the carbon permits originating from project based emission mitigation activities such as clean development mechanism (CDM). Similarly, carbon permits are also traded among entities based on voluntary commitments.

The Kyoto Protocol (in its Article 17) allows Annex-I countries to participate in emissions trading for the purpose of fulfilling their commitments, provided trading is supplemental to domestic action. Thus, the Annex-I countries that are unable to meet their Kyoto targets can purchase carbon credits from other countries in the form of: (a) assigned amount units, (b) certified emissions credits, (c) emission reduction units, and (d) removal units on the basis of land use, land-use change and forestry activities.

Broadly carbon market can be divided into regulated and voluntary markets. These two markets can be viewed in two different ways:

Demand side: When viewed from the demand side of carbon permits, 'regulated' market refers to countries and companies that have a mandatory cap on the amount of $CO_2$ they can produce. 'Voluntary' market on the other hand refers to entities taking action to meet other goals (such as corporate social responsibility, brand building, product differentiation, and even moral obligations).

Supply side: When viewed from the supply side of carbon permits, 'regulated' market refers to carbon instruments that have been certified as compliant with a mandatory system (e.g., CDM), whereas, 'voluntary' market refers to carbon instruments that have been developed outside any mandatory system (e.g., voluntary carbon standard).

Figure 2 provides an overview of the carbon market looking from the supply side.

AAUs – Assigned Amount Units, are issued to countries with emission cap under Kyoto Protocol (i.e., Annex-I countries); EUAs – European Union Allowances, the allowances in use under EU-ETS. Both AAUs and EUAs represent one metric ton of carbon dioxide equivalent.

CERs – Certified Emission Reductions, a unit of GHG emission reductions issued pursuant to the Clean Development Mechanism of the Kyoto Protocol; ERUs – Emission Reduction Units, a unit of GHG emission reductions issued pursuant to Joint Implementation of the Kyoto Protocol. Both CERs and ERUs represent one metric ton of carbon dioxide equivalent.

CFIs – Carbon Finance Instruments are instruments used for compliance with the Chicago Climate Exchange commitments.

CCBA – Climate, Community and Biodiversity Alliance; VCS – Voluntary Carbon Standard; VER – Verified Emission Reductions; CN Protocol – Carbon Neutral Protocol.

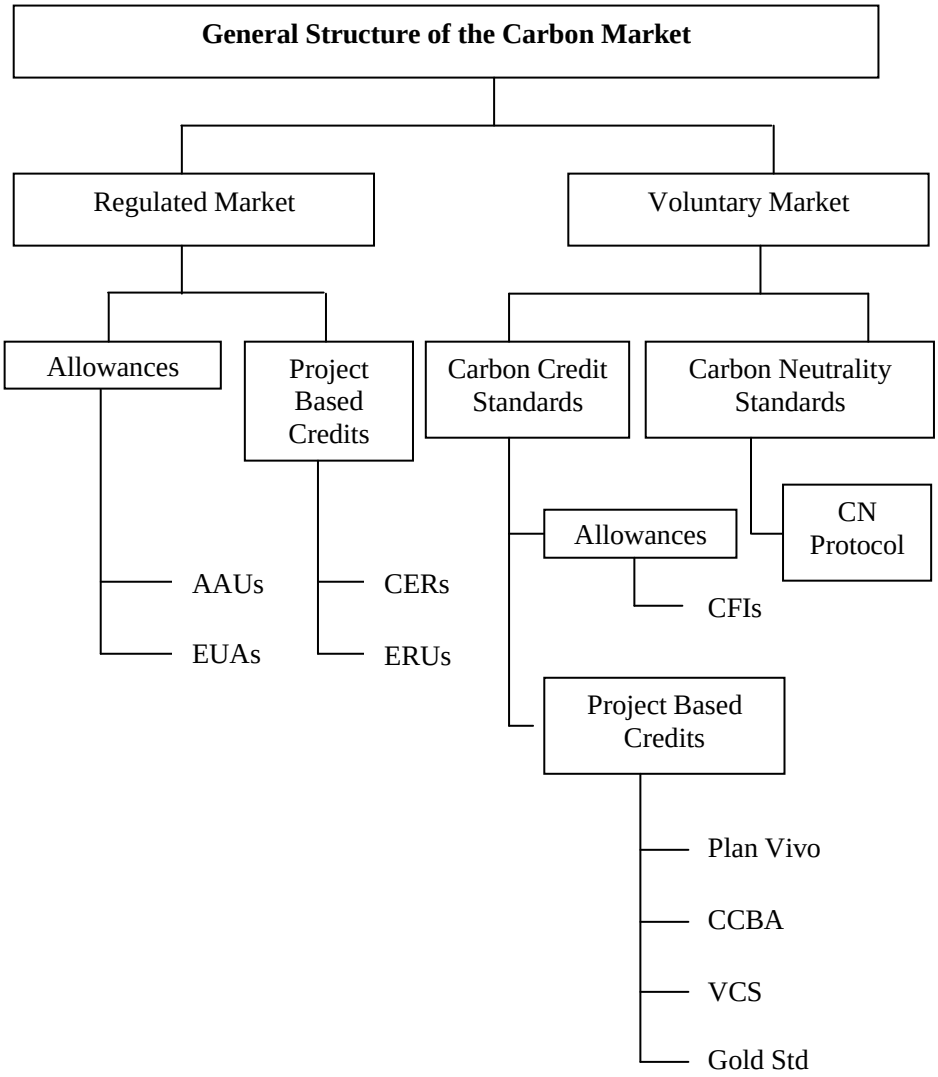



**Figure 2. Carbon Market – Overview**

### 4.0 Carbon Trading Systems – Some Examples

Though the trading in terms of AAUs is one of the Kyoto flexibility mechanisms, its merit and likelihood is debatable. The Eastern European countries are likely to be net sellers of AAUs because their manufacturing

activities (and hence emissions) have contracted sharply after the collapse of communist rule. The Eastern European excess AAUs are referred to as 'hot air' – as they do not result from efficiency improvements, but from contraction of the industrial sectors. Most countries that are likely to be short of AAUs during the first commitment period of the Kyoto Protocol (2008-2012) have said that they do not intend to buy the 'hot air' unless the Eastern European countries guarantee that the money from the sale of AAUs will be earmarked for programs that will reduce carbon emissions – referred to as 'Green Investment Schemes'.

Unlike the AAU trades, trading through the major subsidiary scheme of the Kyoto Protocol, the EU-ETS, is vigorous. Similarly, the Certified Emission Reductions generated through the CDM represent a major trading instrument. In addition, the voluntary market, especially the transactions in Carbon Finance Instruments, also represents major trading activity. These trading systems are discussed briefly here[2].

**European Union – Emissions Trading System (EU-ETS)**

The European Union Emissions Trading Scheme (EU-ETS), launched in 2005, sets mandatory caps on $CO_2$ emissions for the 27 member countries of the European Union. The EU-ETS is by far the largest source of carbon allowances (referred to as European Union Allowances, EUAs). The EU-ETS has consecutive trading phases, with the first phase running from 2005 to 2007 and a second phase from 2008 to 2012. A review of the third trading phase of the ETS starting in 2013 is in preparation. In Phase I, the scheme is mandatory for 11,500 energy-intensive installations (covering energy production, ferrous metals production, cement manufacture, ceramic and brick manufacture, glass production and pulp & paper production) across the EU that account for almost half of Europe's $CO_2$ emissions. The number of allowances given to installations covered by the scheme is based on national emissions caps set by EU member states in their National Allocation Plans (NAPs). While the NAPs are calculated by national governments, these national plans must be approved

[2] Please refer Hood (2010) for a detailed review of existing and proposed emissions trading systems.

by the European Commission. Banking of allowances across the first two phases covered by the plan is left to the discretion of individual member states, but because of the large oversupply in the first period, member states have refrained from allowing their installations to bank these emissions. Banking is mandatory from the second phase onwards. The 'linking directive' allows installations to meet part of their cap through project-based credits (such as CERs and ERUs). This link between EU-ETS and the project based flexibility mechanisms of the Kyoto Protocol (namely, CDM and JI) has led to a close link between the price of EUAs in the second phase and CERs/ERUs in the secondary market. The European climate policy for the post-2012 era contains the three '3x20' climate targets for 2020 – namely, increase in the proportion of renewable energy in the overall energy to 20 percent; increase energy efficiency by 20 percent ; and reduce GHG emissions by 20 percent from their 1990 levels. The chances for reaching these stringent targets depend to a great extent on EU-ETS.

The EUA prices have been very volatile, with the price in the first phase showing more volatility than in the second phase. Figure 3 shows the average EUA price. After the high of mid-2008, the prices have remained more or less stable around $ 17-18 per ton of $CO_2$. The indecisiveness of the climate negotiations at the Copenhagen summit has not done much to the confidence of the EU-ETS market.

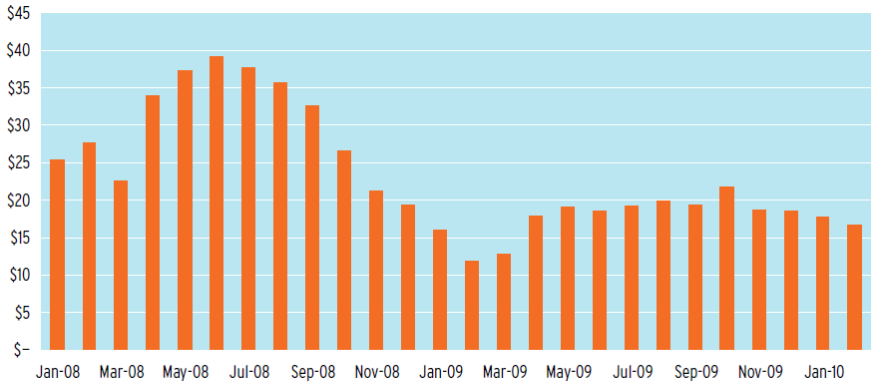



**Figure 3. The Average Price of EUA**

(Source: World Bank, 2010)

Hepburn (2007) argues that the single most achievement of EU-ETS is its ability to bring the pan-European Union attention to the pressing nature of climate change problem. There is also some evidence to suggest that the EU-ETS has prompted several European firms to undertake abatement activities. The EU-ETS has also highlighted several problems associated with carbon trading. It is well documented that the single most design error of the EU-ETS was its free distribution of allowances in the first place (with the past emissions serving as an indicator of allowance quota). Such procedure could in principle lead to rent-seeking behavior by the firms and the best way to avoid these problems is to auction the allowances. The prospects for allowance auction appear bright in the EU-ETS. Starting in 2013, the bulk of allowance allocation will no longer be free. The proportion of allowances to be auctioned will rise from 0.13 percent in the first phase and 3.6 percent in the second phase to at least 50 percent by 2013, and could reach as high as 75 percent by 2027. No free allocations will be made with respect to the electricity production sector. The revenues from auctioning are expected to total at least 15 to 20 billion euros per year starting from 2013.

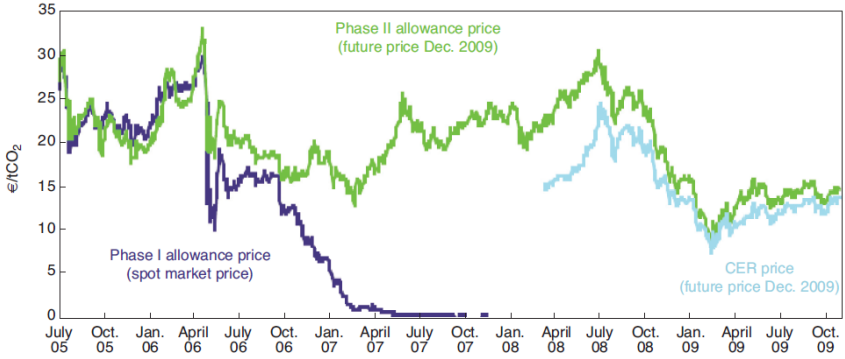
The emission reductions generated through the EU-ETS represent not more than 1 percent of global emissions. Hence, if the large emission reductions of 60 to 80 percent mentioned above are to be realized by 2050, the carbon markets have to expand very rapidly over the coming decades.

**Clean Development Mechanism**

The Kyoto Protocol outlined the Clean Development Mechanism in Article 12 with an aim to help non-Annex-I countries in achieving sustainable development goals and to provide Annex-I countries with an alternative mechanism for complying with their targets[3]. With substantial emission reductions from the developing countries, CDM has played an important role (along with EU-ETS) in driving private sector interest in projects to reduce carbon emissions. However, concerns are also raised with regard to excessive concentration of CDM projects in a select few countries including China and

[3] For further discussion on 'Clean Development Mechanism' refer dissemination paper number 13 (http://coe.mse.ac.in/disseminationpaper.asp)

India. In terms of the permit prices, the CER (future)[4] prices followed closely the allowance prices (second phase) of EU-ETS due to the 'linking directive' (see figure 4).




Note: Since the allowances could not be banked for use in the second phase, the first phase allowances fell.

**Figure 4. Price of Allowances and CERs**

(Source: ECX, www.ecx.eu)

The financial upheaval in 2009 has resulted in significant reduction of CDM market activity with the project-based transactions declining by 54 percent compared to the previous year. Despite the impressive strides made in the CDM market and entry of CERs into the secondary market for trading, similar to EU-ETS, the present scale of operations through CDM and the need of the hour (namely, de-carbonizing the global economies, especially the developing countries) are mismatched.

## Chicago Climate Exchange

Almost by definition allowances do not exist in the voluntary market because allowances are issued for compliance with mandatory emission caps. Chicago Climate Exchange (CCX) is in a slightly grey area because companies that

[4] The spot price refers to immediate delivery of assigned allowances or CERs, while the future price is the current price of allowances or CERs delivered at a subsequent date.

participate in the CCX are doing so voluntarily, but once they have committed to participate, the cap becomes binding. Primary participants in CCX committed to reducing GHG emissions by 1 percent per year for four years from 2003-06. The instruments used for compliance with CCX commitments are called carbon finance instruments (CFIs). The CFIs are widely used in the US market for other voluntary offset activity, and hence they serve as a price benchmark.

CCX had grown consistently from its start in 2004, but it suffered a 40 percent decline in trade volume during 2009. Prices dropped sharply, from US$4.8 per tCO2e to US$0.8 per tCO2e. The overall value also dropped significantly with the value in 2009 remaining at 16 percent of 2008 market value. The Waxman-Markey bill introduced in 2009 has created considerable momentum in the US offset market, but interest in the exchange seemed to decrease since the CCX credits were not explicitly mentioned for future eligibility in the federal compliance regime.

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The Ministry of Environment and Forests, Government of India has designated Madras School of Economics as a Centre of Excellence in the area of Environmental Economics for a period of ten years from April 1, 2002. The centre carries out research work on: Development of Economic Instruments, Trade and Environment, and Cost-Benefit Analysis. The Centre is primarily engaged in research projects, training programmes, and providing policy assistance to the Ministry on various topics. The Centre is also responsible for the development and maintenance of a website (http://coe.mse.ac.in), and for the dissemination of concept papers on Environmental Economics.

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