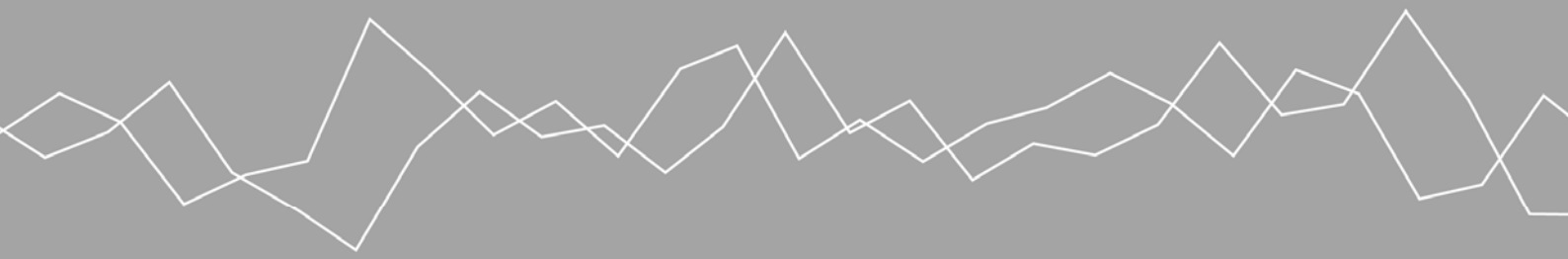
Carbon Trading



seo economisch onderzoek

Amsterdam, 31 August 2010
Commissioned by Duisenberg School of Finance and Holland Financial Centre

Carbon Trading

Literature Overview

Marco Kerste
Jarst Weda
Nicole Rosenboom

seo economisch onderzoek

Roetersstraat 29 - 1018 WB Amsterdam - T (+31) 20 525 1630 - F (+31) 020 525 1686 - www.seo.nl - secretariaat@seo.nl
ABN-AMRO 41.17.44.356 - Postbank 4641100 . KvK Amsterdam 41197444 - BTW 800943223 B01

SEO Economic Research carries out independent applied economic research on behalf of the government and the private sector. The research of SEO contributes importantly to the decision-making processes of its clients. SEO Economic Research is connected with the Universiteit van Amsterdam, which provides the organization with invaluable insight into the newest scientific methods. Operating on a not-for-profit basis, SEO continually invests in the intellectual capital of its staff by encouraging active career planning, publication of scientific work, and participation in scientific networks and in international conferences.

SEO-report nr. 2010-65

ISBN 978-90-6733-586-7

Preface

At Duisenberg school of finance, we are committed to providing excellent financial education in order to create the next generation of responsible financial leaders. To achieve this, leading industry practitioners and world-class academics have joined to develop a set of forward-looking financial programmes. These programmes integrate theory and practice, and encourage critical thinking and continuous reflection on the dynamic financial landscape.

The existing set of programmes at Duisenberg school of finance will soon be expanded. With the support of Holland Financial Centre, specifically the Centre for Climate & Sustainability, Duisenberg School is currently developing a Programme on Finance & Sustainability. As part of the Programme, Duisenberg School and Holland Financial Centre intend to offer top-notch education and conduct cutting edge research in the area of finance & sustainability.

While industry practitioners and policymakers around the world are facing the topic of finance & sustainability on a daily basis, academic interest in the topic is relatively recent. In designing a curriculum and a research agenda, therefore, we feel it is important to take into account not only the insights yielded by academic research but also by industry practitioners and policymakers. Accordingly, as a preliminary step, we have asked SEO Economic Research to conduct a broad, high-level literature overview on finance & sustainability.

The survey has resulted in four reports, each providing a literature overview on one aspect of finance & sustainability: (i) financing the transition to sustainable energy; (ii) carbon trading; (iii) innovations in financing environmental and social sustainability; and (iv) sustainable investment. The report you have before you describes the review on 'carbon trading'.

The survey has been conducted by SEO Economic Research; Duisenberg School has offered suggestions throughout the process. The result should be of use not only to Duisenberg in designing its curriculum and research agenda, but also, we hope, to anyone interested in the increasingly relevant subject of finance & sustainability.

Amsterdam, August 19, 2010

Prof. Noreena Hertz
Chair of Globalisation, Sustainability and Finance

Prof. Dirk Schoenmaker
Dean, Duisenberg school of finance

Sjoerd van Keulen
Chairman Holland Financial Centre

Table of Contents

Executive Summary and Further Research

From Pigou and the Kyoto Protocol…

The conceptual underpinnings for carbon trading began with Pigou (1920), who pointed to the benefits of taxing companies for the negative externality emanating from pollution. Forty years later, Coase (1960) noted the reciprocal nature of harmful effects and referred to trade as an efficient, effective market-based mechanism to regulate these effects. Other economists later applied his insights specifically to environmental problems.

Notwithstanding some earlier activities, it was only with the Kyoto Protocol, signed in 1997 by 37 industrialized countries and the European Community, carbon trading really became an economic force to take into account. Carbon trading occurs on compliance markets and voluntary markets.

…to carbon trading on voluntary markets

Academic literature points at two reasons why economic agents are active on voluntary carbon markets. The first are public relations and ethical motives. Offsetting emissions by buying credits that represent emission reduction elsewhere, might signal a sustainable image (relevant mainly for companies) or might simply 'feel good'. Pre-compliance is the second motive for voluntary trade, and refers to trade pending future regulation – e.g. because it is expected that certain voluntary rights might eventually become part of a compliance market. Contrary to compliance markets, voluntary trade is generally not based on legal obligations to reduce emissions. Trade volumes on voluntary markets are much more modest than trade volumes on compliance markets. Still, these markets have shown fierce growth in recent years.

…and on compliance markets

Compliance markets are based on regulation and mostly refer to cap-and-trade schemes. In a cap-and-trade scheme governments set a limit (or *cap*) on the permitted level of greenhouse gas emissions, and allocate emission allowances in accordance with this cap. By granting an (increasingly) insufficient amount of emission allowances, these permits have a (growing) value and, vice versa, emissions entail (growing) private costs. In this way negative externalities are priced.

The Kyoto Protocol is the backbone of most compliance markets. The Protocol provides in three trade mechanisms. Participants can:

- trade in Assigned Amount Units (AAUs);
- earn credits by investing in emission reduction projects in other member countries (the Joint Implementation mechanism, or JI), and/or
- earn credits by investing in emission reduction projects in developing countries (the Clean Development Mechanism, or CDM).

After ratifying the Kyoto Protocol, the EU implemented the EU Emission Trading Scheme (EU ETS), which has become the largest carbon trading market in the world. Essentially, it is based on the same mechanisms as Kyoto, with trade in European Union Allowances (EUAs) and a link

with JI and CDM. An important difference is that each country explicitly assigns its allocated allowances to sector and company level, based on National Allocation Plans (NAPs). There are other compliance markets – e.g., the Regional Greenhouse Gas Initiative in North America and the Greenhouse Gas Abatement Scheme in Australia – but the real waiting is on a US Federal cap-and-trade scheme. After repeated delay, however, the plans for an energy bill including cap-and-trade were abandoned mid-2010.

Emission reduction targets in the Kyoto Protocol only cover the period 2008-2012 (the first trading period). The Copenhagen Conference in December 2009 did not bring new targets, so negotiations continue. An impending lack of reduction targets implies a lack of caps, and thus puts carbon trading under the Protocol at risk. After the first (pilot) trading period 2005-2007 (Phase I), the second trading period in the EU ETS (2008-2012, Phase II) is also coming to an end. The EU, however, did decide on reduction targets for the post-2012 period (2013-2020, Phase III). This implies continuity for EU ETS trade, even in absence of new (legally binding) international post-Kyoto emission reduction targets. However, this precise relationship between a new global agreement on emission reduction and the future of EU ETS (Phase III) is under exposed in the current debate.

…resulting in pricing of carbon emission

A single global price for carbon is not (yet) in sight, because there is no global carbon market and thus no political consensus and supporting infrastructure. Still, market-linking through project-based and other mechanisms encourage arbitrage, and this should reveal a global carbon price range. The primary drivers of carbon prices are – at least in the long term – the number of credits created, the expected demand from industry, and the ease of closing any shortfall between supply and demand, using technology and investments available during the relevant commitment period.

Financial data show that carbon prices are highly volatile. The traded commodity is artificially 'created' and based on numerous methods to decrease emissions – from energy efficiency to renewable energy sources – implying that price determination is highly arbitrary.

…and new financial markets

Based on the foundation of trading in emission reduction rights – in AAUs, EUAs, CERs, ERUs and RMUs – new financial markets have emerged. Contractual and financial instruments are being developed to allow trading and to manage risks. Markets in spot, future and option contracts are increasingly maturing. The usual agents – brokers, traders, banks and the like – are providing intermediation services, and the financial sector at large is looking to seize the opportunities provided by carbon trading, resulting in new insurance products, derivatives and loan schemes. The development of financial markets has been an important element in funding emission reduction projects and activities. Generally referred to as 'Carbon Finance', trade in emission reduction rights awarded to projects provides revenue streams and leverage for other sources of finance.

Assessing the success of Carbon Trading

One of the main objectives of Carbon Trading is to reduce GHG emissions. Its success, and more specifically the success of its underlying mechanisms, is therefore most often measured in terms of resulting emission reduction or – as a proxy for this – the volume of emission rights traded. Assessing effectiveness is, however, highly complicated because the impact of carbon

trading has to be isolated from other policy measures, economic developments and potential over-allocation, the latter providing opportunities to comply with obligations without having to reduce emissions.

…directly based on effectiveness of the Kyoto mechanisms

Looking at Kyoto's AAUs, the low level of trade in allowances points to a lack of success. The main reason for this is the failure to impose actual emission constraints on (mainly) former Soviet Union and east European countries. Baseline emission projections did not foresee the recession following the collapse of the Soviet Union and thereby overestimated emissions. These countries could therefore remain well below emission targets, without having to invest in emission reduction projects. This has caused concerns on the environmental legitimacy of trading in AAUs. The excess credits of these countries are generally referred to as 'hot air' and several countries have declared not to buy these rights.

Of the project-based Kyoto mechanisms, CDM has been deemed a success while JI has had start-up problems and as a result JI trading activity is expected to be low until 2012. Notwithstanding its success, CDM has also been subject to criticism. The concept of 'additionality' – the question whether the reduction achieved by a project is additional to any that would occur without project activity – remains hotly debated, primarily due to its arbitrary nature. A second point of critique is the restricted scope of CDM. Success has focused on specific countries – most importantly neglecting the least developed countries – specific sectors and specific project types. In order to exploit the full abatement potential, barriers to enlarge its scope need to be addressed by public and private funding solutions. Finally, transaction costs of CDM are considered to be high. Although this has improved with simplified rules, concerns remain.

…and of the EU ETS

Many view Phase I of the EU ETS as a success, having laid the groundwork for the biggest emission trading scheme in the world. However, effectiveness in terms of reducing emissions has so far been limited. Cap levels during the first trading period were set too high, failing to impose real restrictions, and emissions actually increased. Phase II is again expected to show over-allocation. This is mainly caused by the recession, which resulted in a decrease of emissions without underlying investments in (structural) emission reduction, and in increasing New Entrants Reserves – in which unused allocations from installations that are closed down are added – hanging over the market as a potential allowance surplus. In view of inefficiencies so far, the new ETS Directive for Phase III imposes a stricter cap, progressively decreasing during the trading period. Some researchers indeed estimate a 'short' position during Phase III.

In addition to the over-allocation of emission rights, the *manner* in which rights are allocated to specific sectors and companies has been criticized as well. Emission rights in Phase I and II have mostly been awarded for free. This so-called 'grandfathering' of emission rights has led to windfall profits for energy companies, passing through permit prices to consumers – permits that were given to them for free in the first place. Moreover, allocation was based on historic emissions resulting in adverse incentives to emit more now in order to obtain large(r) free allocation in the future. Many therefore advocate auctioning allowances instead of grandfathering, in order to solve distribution issues and to have the private sector signal real expected abatement costs by means of bid-prices.

In view of this criticism, the EC considered to switch from grandfathering to auctioning. The directly affected companies were, however, strongly opposed to this. They feared substantial asymmetric costs on European companies (compared to non-European companies) forcing them to either shut down plants or move production to non-EU countries, which would result in emission reduction in Europe but an increase elsewhere (so-called 'carbon leakage'). In the end, the EC agreed on a hybrid system in which energy intensive sectors at risk to carbon leakage would obtain free allowances, while other energy intensive sectors would grow towards full auctioning in 2027. The energy sector would start with full auctioning in 2013. However, the criteria to define which sectors are at risk to carbon leakage are subject to debate. Some argue that the criteria are arbitrary and inefficient.

…or indirectly based on the impact on investments in emission reduction

Effectiveness of carbon trading (mechanisms) can also be assessed in a more indirect way. The question is then whether it indeed provides incentives to invest in emission reduction projects (or assets). Carbon trading influences the business case for investments by its impact on cash flows and risk.

Allowance prices impact the value of surrendered allowances, the sales revenue of free allowances, and the cost of other energy sources. Thereby they impact cash flows. Moreover, price volatility and uncertainty on carbon trading regulation impact risk. Effectiveness of both channels can be increased by improving carbon trading regulation. A lack of permit scarcity results in low prices, and thus in insufficient incentives via the *cash flow* channel. This is addressed in the new EC directive, but the challenges to determine effective fixed cap levels – amidst of economic and political dynamics – remain. A lack of long term policy certainty – or of trust in keeping policy promises – increases the cost of capital and diminishes investment incentives via the *risk* channel. More research is required to fully understand the impact on the investment business case via these two channels in order to fine-tune the regulatory framework. Studies on project selection - i.e., choosing between whether to invest in emission reduction assets or not - and determination of threshold prices for when these investments becomes financially attractive, could provide a good starting point.

Room for further research

This report will be used by Duisenberg School of Finance which is currently designing a research agenda for its Programme on Finance & Sustainability. Box 1 hopes to contribute to DSF's efforts in this area, by summarizing blind spots in the research areas encountered during the course of writing this report.

Box 1 Subjects for future research

Included in this box are areas for further research that were encountered when composing this literature overview. Within each area potential research questions have been defined. The list of research areas and questions is by no means comprehensive, but should offer an interesting starting point to define further research.

- Assess success (of Kyoto and EU ETS) trading mechanisms
  - How to improve ways to assess success and define success factors, which is conditional for adjustments and further improvements? For instance:
    - How to measure actual financial flows towards emission reducing investments resulting from the mechanisms, both directly as in terms of leveraging additional private capital?
    - How to separate the influence of trading mechanisms from the impact of economic factors, policy instruments, and (potential) over-allocation?
    - How to measure additionality of Green Investment Schemes under the JI mechanism? What can be learned from standards already used in assessing additionality of CDM?
- Improve success (of Kyoto and EU ETS) trading mechanisms
  - How to improve determination of cap levels in order to guarantee permit scarcity in a changing economic and political environment?
  - If auctions are used to allocate permits, can the use of reserve prices (i.e., minimum auction prices) increase effectiveness?
  - How to determine which sectors under the EU ETS are at risk to 'carbon leakage' based on economic criteria and how to take this analysis into account in the (hybrid) allocation methodology announced by the EC?
- Global versus local regulation
  - How do international and local agreements interact?
  - Can the importance of international/global reduction targets be quantified?
  - Can the importance of global versus local markets be quantified?
  - What are the costs and other consequences of failures to signal clear international reduction targets (e.g., Copenhagen)? E.g., what is the precise relationship between (legally binding) international agreements and the continuity of local elaborations such as EU ETS?
  - Can instruments be designed to prevent these costs?
- Voluntary markets
  - What is the effect of the rapid increase of standards on voluntary trade volume and prices?

Source: SEO Economic Research

1 Introduction

As recognized today by leading CEOs and leading thinkers, 'sustainability' is a key issue for business leaders to understand and manage. Whilst the term 'sustainability' is being used to mean different things by different parties, this paper will follow the extended WCED definition of sustainability incorporating both environmental and human rights objectives, based on the Three-Dimension Concept of the 'Declaration of Rio on Environment and Development'. The World Commission on Environment and Development (1987) defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The 'Declaration of Rio on Environment and Development' recognized that sustainable development is a balance of three dimensions: environmental protection, economic growth and social development (United Nations Conference on Environment and Development, 1992).[1] Research on finance & sustainability is still very much an emergent field. At the request of Duisenberg school of finance, SEO Economic Research has surveyed the literature on finance & sustainability. This has resulted in four reports, each providing a literature overview of one aspect of finance & sustainability:

- Financing the transition to sustainable energy;
- Carbon trading;
- Innovations in financing environmental and social sustainability; and
- Sustainable investment and reporting.

Each report provides comprehensive insights on a major topic within the field of finance & sustainability. Based on our findings from (academic) literature and relevant policy discussions, key topics per subject are identified and discussed. Moreover, areas where it is felt that the literature is underdeveloped have been identified in order to contribute to Duisenberg school of finance's overall thinking about research objectives for its Programme on Finance & Sustainability. The topics as well as the broader scope and focus points of each topic, have been defined in close cooperation with Duisenberg school of finance.

This report highlights leading literature and empirical research on 'Carbon Trading'. Given the extensive body of literature in the field it is not meant to be all-encompassing, but is meant to provide the reader with a strong base from which to carry out further research and investigation. Chapter 2 to chapter 4 provide an elaborate overview of the principles underlying carbon trading, from theoretical underpinnings (chapter 2) to markets and regulatory environment (chapter 3) and market functioning (chapter 4). In chapter 5 the more descriptive first part of the report is taken as a starting point to assess the success of carbon trade. Success is determined in terms of effectiveness in reducing carbon emissions. Issues and improvements are discussed where effectiveness has not lived up to expectations.

[1] In practical terms, the UN Global Compact – a framework for the development, implementation, and disclosure of sustainability policies and practices – has translated this into ten principles in the areas of human rights, labour, the environment and anti-corruption. These principles enjoy universal consensus (www.unglobalcompact.org).

2 Carbon Trading

2.1 Theoretical Background

The build-up of atmospheric greenhouse gases (GHGs) is expected to cause significant climate changes in the coming decades and beyond, such as an increasing global surface temperature, increasing precipitation and evaporation, and rising sea levels. Preventing climate change can be regarded as a *global public good*. Its impact is indivisible and influences are felt around the world rather than affecting one nation, town, or family. Global public goods are different from other economic activities, in the sense that there exist only weak economic and political mechanisms for solving these issues efficiently and effectively. It is difficult to determine and reach agreement on efficient policies, because public goods involve estimating and balancing costs and benefits, neither of which is easy to measure and both involve major distributional concerns (Kaul, Grunberg, & Stern, 1999; Nordhaus, 1999, 2006b, 2007).

Traditional fossil-fuel energy is relatively abundant and inexpensive. But while private costs of fossil fuels (i.e., the costs to companies or individuals) are mostly relatively low, total costs to society are not. The difference between private and societal costs is called an external cost, or *externality*. External costs are directly related to producing or delivering a good or service, but are not borne by its originator. GHG emissions are a schoolbook example of externalities. There is a link between public goods and externalities. Some authors claim that public goods (notably those that have benefits that are non-rivalrous in consumption and are non-excludable, so-called *pure public goods*) can be thought of as special cases of externalities. In essence, both are different ways of talking about goods with non-private aspects (Cornes & Sandler, 1996; Miller, 2006).[2]

There are two principal market-based instruments to address climate mitigation and the underlying issue of externalities: carbon taxes and carbon emissions trading, the latter also referred to as cap-and-trade or allowance trading. A *carbon tax* is a price instrument and is typically levied on the carbon content of fuel inputs, creating an incentive to either switch to lower-carbon inputs or to use inputs more efficiently.[3] Since governments have imperfect information about costs of fuel switching and energy efficiency improvement (i.e., mitigation costs), there is uncertainty how much abatement will occur for a given tax level. It is nearly impossible for governments to deduce a tax level that results in the mitigation efforts as intended by policy makers.[4] Nevertheless, carbon taxes continue to have a strong (theoretical) appeal on economists worldwide, inter alia because of the potentially much greater price stability that this brings relative to an emissions trading system, its revenue-raising capabilities and simplicity, and its low administration and compliance costs (PwC, 2009). Drawbacks include the difficult political environment for (international) taxation of emissions and the fact that impact on emission reduction targets is only indirect. Since this literature overview concerns carbon trading,

2 In addition to externalities, subsidization also results in relatively low price for conventional fuels. See Kerste & Weda (2010). For more information on fossil-fuel subsidies, see Victor (2009).

3 Other price-based approaches include fees and subsidies.

4 If there were an emission cap under global agreement, governments could simply adjust tax rates iteratively to keep emissions within the cap.

carbon taxes are not discussed further. This does however not imply any (theoretical) inferiority compared to carbon trading.[5]

Emissions Trading (ET) is based on quantitative limits rather than being price-based It regulates corporate environmental impact by putting a quantity cap on emission output. Combined with the possibility to trade in the capped emission outputs, which become scarce due to the cap, this results in a price on units of emission and thus in pricing the negative externality. ET does not prescribe by what means firms should comply to the quantity cap. As a result, emissions trading gives firms flexibility and the possibility to fit carbon management activities into the overall strategy. Carbon taxes and cap-and-trade schemes can and are used conjointly. The European Union opted for a trading scheme to address emissions from large sources (utilities, heat production, large energy-intensive industrial facilities), while several European countries introduced carbon taxes to target emissions from other sectors, notably residential and services, transport, waste management, and agriculture (Kolk & Pinkse, 2005; Nordhaus, 2007; Pinkse, 2007; The World Bank, 2010). These 'hybrid' systems provide evidence for benefits of a combination of taxes and trading..

2.2 Cap-and-Trade

In a cap-and-trade scheme governments issue emission permits representing a legal right to emit pollutants, which are freely tradable between trading scheme participants. More specifically, a central authority sets a limit (or cap) on the permitted level of greenhouse gas emissions and allocates permits/allowances that bestow the right to emit greenhouse gases below the current or expected level of emissions. Allowances are either given for free to emitters or are auctioned to them – the latter creates a source of fiscal revenue. The capped level is aimed at creating an overall shortage of allowances. By granting an (increasingly) insufficient amount of emission allowances, emission rights have a (growing) value and, vice versa, emissions entail (growing) private costs. A price is put on external costs, thereby 'internalizing' the negative externality (Coase, 1960; Convery, 2009; Ellerman, 2005; Lai, 2008).[6]

An emitter, faced with a shortage of allowances, can chose between 3 options: cut its emissions (e.g., by lowering its production), invest in cleaner technology to reduce emissions per unit of output, or buy sufficient allowances to compensate its shortfall compared with its actual emissions level (City of London, The London Accord, & CEAG Ltd, 2009, p. 10). Firms and sectors will have different marginal compliance costs (i.e., the marginal costs of fuel switching or increasing energy efficiency) so there is potential for gains from trading permits. If a firm has high marginal costs of mitigation while another has a much lower costs, the firm with the lower costs can sell a permit at a price above its marginal costs of mitigation, reduce its emissions accordingly, and make a profit. If the permit price is below the marginal mitigation costs of the buyer, the trade is profitable for both parties. In theory, carbon trading leads to cost-effective reduction of emissions, as abatement will occur where marginal costs of mitigation are lowest (Böhringer & Rosendahl, 2009; Burniaux, Château, Dellink, Duval, & Jamet, 2009; Carbon Trust & Climate Strategies, 2009; Egenhofer, 2007; Flachsland, Marschinski, & Edenhofer, 2009; Heal,

5 For more information on carbon taxes, see for instance Nordhaus (2007).

6 Evidently, achieving this depends on whether caps result in (sufficient) scarcity. This is further discussed in chapter 5.

2007; Leung, Yung, Ng, Leung, & Chan, 2009). Moreover, since cap-and-trade is based on quantitative limits, there is high certainty that a country will stay within its cap, provided that enforcement is effective. It fixes the volume of emissions and then lets the market find the appropriate price level (The World Bank, 2010; WEF, 2009). This is not to say that emissions trading is not subject to theoretical criticism as well, including for instance the question whether an efficient outcome is necessarily fair, equitable, or desirable (Hepburn, 2007; Woerdman, 2001).

2.3 Emergence of Carbon Trading

The conceptual underpinnings for carbon trading began with Pigou (1920) pointing out the social benefits of forcing companies to pay for the costs of their pollution by setting taxation equal to the value of the negative externality emanating from the pollution (Grubb, Laing, Counsell, & Willan, 2010).[7] Forty years later, Coase (1960) stated the basic idea underlying tradable permits, by noting the reciprocal nature of harmful effects and suggesting that property rights and allowing trade (i.e., market-based solutions) could regulate these harmful effects effectively and efficiently (Ellerman, 2005; Hepburn, 2007). Other economists later applied his insight specifically to environmental problems (Crocker, 1968; Dales, 1968; Montgomery, 1972). Despite some early activities, tradable permits have only been implemented on a larger scale and deemed a real success since the mid 90s, when a global agreement on carbon reduction targets was in the making (Ellerman, 2005)\

The influence of regulation on carbon markets and carbon trading is substantial. The World Bank (Capoor & Ambrosi, 2008) concludes "[t]he carbon market has so far been essentially a compliance-driven market, where buyers largely engage in carbon transactions because of carbon constraints (current or anticipated) at international, national or sub-national levels". In 1997, the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) provided for carbon trading through three "flexible mechanisms". The Kyoto Protocol made no provision for how emissions allowances should trade or what form its market should take. Instead, the private sector was challenged to devise its own market solutions for emissions trading, from which a transparent carbon price would emerge to inform investment decisions. The first Kyoto commitment period runs from January 2008 to December 2012 and it has prompted the emergence of major international markets in carbon. The largest carbon trading market by far is the European Union Emissions Trading Scheme (EU ETS).[8]

7 See Nordhaus (2006a; 2007) and Pezzey (2003) for further discussion on the concept of Pigovian Taxes.

8 The first forward carbon trades, however, occurred many years earlier, long before the Protocol came into force. For instance, in the 1970s the Environmental Protection Agency (EPA) in the US offered states the option to employ variants of tradable permits for the control of localized air pollutants. The first voluntary trades, by parties not subject to regulatory requirements, occurred in the late 1980s. Still, trading on a large scale only became reality due to the Kyoto Protocol.Nowadays, voluntary carbon trade is driven by two factors: corporate social responsibility (CSR) and the anticipation of legislation.

3 Carbon Markets and Regulatory Environment

3.1 Compliance Markets

3.1.1 Global Regulatory Background: Kyoto Protocol

At the heart of the regulation governing and impacting carbon emission trading is the Kyoto Protocol. Amongst many other sources, information on background and regulatory content of the Protocol can be found in Part I of Carbon Trust (2009) and on the website of the UNFCCC.[9]

The Kyoto Protocol is complementary to the United Nations Framework Convention on Climate Change (UNFCCC), which entered into force in 1994 and enjoys near universal membership. The UNFCCC is aimed at tackling the challenge posed by climate change. Whereas the UNFCCC *encourages* stabilization of Green House Gas (GHG) emission, the targets in the Kyoto Protocol are *binding*. More specifically, by signing the Kyoto Protocol in 1997, 37 industrialized countries and the European Community (the so-called *Annex B parties*) have committed to reducing their emissions[10] by an average of 5 percent against 1990 levels over the five-year period 2008-2012.[11]

Although focus is on domestic action against climate change, the Kyoto Protocol also introduces three market-based mechanisms thereby creating a 'carbon market' (UNCCF, 2010):

- Emissions Trading (ET);
- The Clean Development Mechanism (CDM);
- Joint Implementation (JI).[12]

The targets for the Annex B parties are expressed in allowed emissions under the Protocol and result in 'assigned amount units' (AAUs), thereby creating the necessary scarcity to enable carbon trading. Article 17 of the Protocol covers Emission Trading, allowing countries to sell excess emission units to countries that are over their targets.[13] Kyoto is thus a 'cap-and-trade system' that imposes national caps (limits) on the emissions of Annex B countries. The cap level, which indicates how many emissions the respective country can produce, is strongly related to the effectiveness of carbon trading, which is discussed in detail in chapter 5.

Under the Clean Development Mechanism (CDM), defined in Article 12, Annex B Parties can earn credits by implementing emission-reduction projects in developing countries. These credits

9 UNFCCC website: http://unfccc.int/2860.php (accessed on June 24, 2010).

10 'Emissions' refer to six greenhouse gases: CO2 (which is the most important GHG), methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.

11 The Kyoto Protocol entered into force on 16 February 2005. The detailed rules for the implementation of the Protocol were adopted at COP 7 in Marrakesh in 2001, and are called the "Marrakesh Accords." The 38th country, USA, has not ratified the Kyoto Protocol (UNCCF, 2010).

12 Furthermore, credits can be earned for Land Use, Land-Use Change and Forestry (LULUCF) projects. These credits can be traded only at country level. LULUCF is discussed in paragraph 4.1.2.

13 Further defined in 'Modalities, rules and guidelines for emissions trading under Article 17 of the Kyoto Protocol', decision 11/CMP.1.

can be counted towards meeting Kyoto targets. The Joint Implementation (JI) mechanism, defined in Article 6, is comparable to CDM but arranges the earning of emission units by one Annex B Party with projects in one of the other Annex B Parties. In Kyoto terminology: with CDM parties can earn certified emission reduction (CER), with JI parties can earn emission reduction units (ERU). The trading mechanisms under the Kyoto Protocol are further discussed in chapter 4.

3.1.2 European Union Emissions Trading Scheme

EU Regulation

In 2002, the EU and all its Member States ratified the Kyoto Protocol, thereby committing themselves to reduce GHG emissions by 8 % in the period from 2008 to 2012. Based on a legally binding burden-sharing agreement (BSA), the 8 %-target is shared between the Member States. The BSA sets individual emissions targets for each Member State.[14]

An important instrument in achieving the EU-emission reduction targets is the implementation of the EU Emissions Trading Scheme (EU ETS). Amongst many other sources, elaborate information on background, development towards and content of legislation underlying the EU ETS can be found in Convery & Redmond (2007), Egenhofer (2007), Ellerman & Buchner (2007) and EC.[15]

The legal foundation for the EU ETS is the Emissions Trading Directive, enacted in 2003, followed by the 'Linking Directive' which links Joint Implementation (JI) and Clean Development Mechanism (CDM) credits to the EU ETS.[16] The EU ETS was launched in 2005, covering a three-year trial trading period (2005–2007). This is not part of any obligation under the Kyoto Protocol, but was designed to familiarize European firms with emissions trading. The second trading period covers the period 2008-2012, coinciding with the first commitment period under the Kyoto Protocol. From then on, consecutive five-year periods (starting from the 2013-2017 trading period) are intended the span the post-Kyoto commitment periods.

Both the Kyoto Protocol and the BSA allocate emission rights to nations, not to individual legal entities. Different from the Kyoto Protocol, under EU regulation each EU member state developed its own National Allocation Plan (NAP). The NAP allocates the country's total BSA target between the trading sectors (those that initially participate in the ETS) and the non-trading sectors. Moreover, it specifies how the permits, called European Union Allowances (EUAs), in the trading sector are distributed among the individual sources, thereby creating the potential supply and demand for allowances in the market. The NAPs are determined by discussion and negotiation between member states and the participating firms, and the NAPs are then submitted to the European Commission for approval.

During the first and second trading periods of the EU ETS, respectively 95 % and 90 % of permits have been assigned to companies based upon historical emissions and free of charge

14 Council Decision 2002/358/EC of 25 April 2002. The Linking Directive makes emission credits from CDM and JI projects (CERs and ERUs, respectively) fungible with EUAs.

15 EU website: http://ec.europa.eu/environment/climat/emission/implementation_en.htm (accessed on June 24, 2010).

16 Directive 2003/87/EC of October 13, 2003, respectively Directive 2004/101/EC of November 13, 2004.

according to Article 10 of the Directive. This so-called *grandfathering* of emission rights has been subject of criticism. Permit prices are passed through to consumers – permits that were given away for free in the first place – resulting in (adverse) distribution effects (Woerdman, Arcuri, & Cló, 2008). For instance, electricity generators could earn windfall profits this way, by passing the market value of the allowances through to the final price. Moreover, allocation based upon historical emissions leads to perverse dynamic effects, where firms have an incentive to emit more now in order to receive a larger free allocation in the future. Grandfathering may also result in rent-seeking behavior by companies as they spend valuable resources in lobbying to obtain a higher allocation (Clò, 2010; Hepburn, 2007; Woerdman et al., 2008).

Critics therefore advocate auctioning permits instead of grandfathering, in order to solve the redistributive concerns. Indeed, auctioning of emission permits provide benefits over simply assigning them for free. First of all, auctions prompt the private sector to reveal their expected abatement costs, thereby dissolving information asymmetry between companies and governments. Secondly, auctioning promotes greater managerial focus on ET, and thus on companies' abatement efforts. Finally, free allocation can be regarded as a regressive transfer of wealth from (relatively poor) citizens to (relatively wealthy) shareholders (Hepburn, 2007).[17] The new ETS Directive addresses the criticism on grandfathering by a bigger role for auctioning in Phase III (see paragraph 3.1.5).

EU ETS

The European Union Emissions Trading Scheme covers over 11,000 installations, including combustion plants, oil refineries, coke ovens, iron and steel plants, and factories making cement, glass, lime, brick, ceramics, pulp, and paper. Land and air transport are not included (see Box 2) and EU ETS only covers the most important greenhouse gas, CO_2. Former European trading schemes – the UK Emissions Trading Scheme (UK ETS), and schemes in Norway and Denmark – have all been subsumed within the EU Emissions Trading Scheme (Betsill & Hoffmann, 2009; City of London et al., 2009; Hepburn, 2007).

[17] This does not mean grandfathering is less efficient then auctioning. For a discussion on the efficiency of both systems, see Woerdman et al. (2008). He concludes that the final verdict depends on the definition of efficiency – only if equality is taken into account auctioning is more efficient than grandfathering.

Box 2 Aviation and EU ETS[18]

In 2008, the Council of the EU and the European Parliament agreed the basis on which international aviation will be brought into EU ETS from 2012 (Phase 3).[19] This means airlines of all nationalities will need allowances to cover the emissions from their flights to, from or within the EU. The outcome, however, was contentious in light of rising oil prices and strong opposition at the International Civil Aviation Organization (ICAO), and led to strong rebukes from airlines and threats of legal action by some states (Rock, Baines, & LeBoeuf, 2008).[20]

After 2 'pre-trading' years in 2010 and 2011, trading will be possible in 2012 (first trading phase) and thereafter (second trading phase). The cap levels will be based on average 2004-2006 emission levels: in 2012, 97% of average 2004-2006 emission levels is allowed, from 2013 on the cap will be 95% of average 2004-2006 emission levels. 15% of allowances will be allocated via auction, 3% is special reserve for new entrants and fast growers, the remainder are free allowances (Verschueren, 2009).

Transport (including international aviation) accounts for approximately 24% of total EU-27 GHG emissions (European Environment Agency, 2009), of which 3% stems from aviation (Anger, 2009). This percentage is expected to increase, due to rapid expansion and estimated future growth caused by globalization, economic growth, liberalization and business model innovation.

The first impact estimations show that the financial burden on the aviation industry will be rather modest in the first years after the introduction of the trading scheme, and therefore will induce only low competition distortions, and that emission reductions within air transportation will be comparably low unless the system design becomes more restrictive (Vespermann & Wald, 2010).

EU firms within the scope of the EU ETS now face a carbon-constrained reality in form of legally binding emission targets.[21] It is regarded the most important European climate policy instrument, since it covers almost half of the total European CO_2 emissions. As was mentioned in chapter 2, it is the largest carbon market in the world by a substantial margin, both by value and by volume with annual trading quadrupling from US$ 24 billion in 2006 to US$ 101 billion in 2008, and still growing in 2009 (Table 4). Combined with Clean Development Mechanisms, it comprises over 90 % of the world's carbon markets. Through the implementation of the "Linking Directive" it has become the hub of the global carbon markets. (Abadie & Chamorro, 2008; Ellerman, 2005; Hepburn, 2007).

3.1.3 Other Operational Compliance Markets[22]

New Zealand

On November 25 2009, New Zealand's ETS has expanded from forestry to become the first mandatory, economy-wide scheme outside Europe. This was decided by passing the Climate Change Response (Moderated Emissions Trading) Amendment of 2009 through Parliament. New Zealand tries to align itself with Australia's proposed Australian Pollution Reduction Scheme (see below) in the hope of future linkage between the two markets.

18 For more information on implications of EU ETS for airlines, see: CE Delft (2007a; 2007b) and CE Delft & MVA (2007).
19 Directive 2008/101/EC (13 January 2009) and Directive 2003/87/EC (consolidated version).
20 See also http://ec.europa.eu/environment/climat/aviation/index_en.htm.
21 Firms whose emissions exceed the allowances they hold at the end of the accounting period must pay a fine (€40 for each extra metric ton of CO2 emitted during the pilot period, and €100 during the commitment period). Those fined must also make up the deficit by buying the relevant volume of allowances (Convery and Redmond, 2007).
22 The overviews in paragraph 3.1.3 and 3.1.4 are based on Kossoy & Ambrosi (2010) and WEF (2010).

New Zealand chose to implement this economy-wide scheme step by step, starting with a transition period of 2010-12. In the first period, there is a fixed price of government-issued NZ ETS allowances (called New Zealand Units, or NZUs) used for compliance purposes of NZ$ 25 (US$ 18 or € 13). Importantly, however, during the transition period there is an unlimited supply of allowances, hence, there will be no cap on emissions.[23] This might pose a challenge in terms of commitment to its international emission reduction target. From the start, the scheme will regulate stationary energy, industrial process and liquid fossil fuels for transport. Thereafter sectors will be added in 2013 and 2015.

New South Wales Greenhouse Gas Abatement Scheme (NSW GGAS)

Until 2009, the Greenhouse Gas Abatement Scheme (NSW GGAS) in New South Wales, Australia, was the largest non-Kyoto trading scheme in terms of physical volume and financial value (Hepburn, 2007).[24] The scheme, which launched in 2003, is aimed at reducing GHG emissions associated with the production and use of electricity. In 2006, the NSW government decided to extend the GGAS to 2021 or until the establishment of a national ETS. The delay of the proposed Carbon Pollution Reduction Scheme (CPRS), potentially Australia's central instrument to manage GHG emissions, has created uncertainty about the scheme's future (certificates under the NSW GGAS would not be eligible under a federal scheme), and the number of new GGAS accreditations tapered off in 2009 as a result of the Australian senate's continued rejection of CPRS legislation (Hamilton, Sjardin, Peters-Stanley, & Marcello, 2010; Kossoy & Ambrosi, 2010). In 2008 there were still 18 million NSW greenhouse gas abatement credits (NGACs) transacted, representing € 77 million in value (Tvinnereim, 2008).

Japan

Although there is not yet an active government-based ETS in Japan (proposed legislation is discussed below), there is a mandatory cap-and-trade scheme in the Tokyo metropolitan, which targets 1,400 office and commercial buildings (including universities) and factories. The scheme covers 1% of Japans emissions but it regulates the energy use of services instead of the CO_2 emissions for industries.

North America

The most notable recent development in emissions trading in the US has been the Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade scheme covering ten Northeast and Mid-Atlantic states, which began its first three-year compliance period at the start of 2009. The initiative caps emissions from the power sector. Emission rights are auctioned and can thereafter be traded between electric power generators. This scheme is significant for the fact that it was established in a country that has not yet signed up to any international emission reduction targets, and for generating proceeds of over US$ 430 million in its quarterly emission auctions. These proceeds have been distributed back to the states to invest in energy efficiency and renewable energy (WEF, 2010).

Alberta (Canada) has initiated a compliance market in 2007. The Climate Change Emissions Management Act was amended to require companies with an emission intensity of more than 100kt CO_2e per year to reduce their emissions by 12% from their baseline (an average of 2003-

23 No cap has yet been announced for 2013 and thereafter.
24 Since 2009, the RGGI is the largest non-Kyoto market (Table 4).

2005 emissions). Reduction deficits can be met through trade, payments into the Climate Change and Emissions Management Fund at a set price or by buying Emission offsets (Goddart, Haugen-Kozyra, & Ridge, 2008).

3.1.4 Announced Compliance Markets

Table 7 gives an overview of cap-and-trade schemes that were, as of April 2009, in its deliberation or design phase and that will be, once operational, mandatory.

Table 1 Future cap-and-trade policies that are (partly) mandatory (as of April 2009)

Deliberation Phase	Design Phase
Canada	Australia
Florida	California
Japan	Korea*
NAFTA-CEC*	Copenhagen Accord
PEMEX*	Western Climate Initiative
US Congress	

Source: SEO Economic Research, adapted from (Betsill & Hoffmann, 2009); * = Mandatory or voluntary status still unsure

US: Waxman-Markey and Kerry-Boxer

In 2009, progress seemed to be made towards the long awaited US Federal cap-and-trade scheme as the *Waxman-Markey American Clean Energy and Security Act* passed the House of Representatives. This act pledges to cut US emissions by 17% by 2020 and 83% by 2050 (compared to 2005 levels), and includes a cap-and-trade provision. According to this act, the majority of the cap-and-trade permits (85%) will be given away for free to the most heavily-emitting industries, grandfathering their emission rights. As of now it is uncertain whether the act in its current form will pass the US Senate.[25]

Meanwhile, the *Kerry-Boxer Climate Bill* has been working its way through committee stages. It is similar to the Waxman-Markey Act in many ways, but would set a slightly more stringent target (a 20% reduction from 2005 levels by 2020), places greater emphasis on the use of domestic rather than international offsets, and gives the US President more control over what types of offsets would be eligible under the scheme (WEF, 2010). Mid-2010, after months of heavy debate between Democrats and Republicans, the plans for an energy bill including cap-and-trade were abandoned as the leader of the senate majority presented a narrower energy bill.[26]

At state-level, California is set to introduce a cap-and-trade scheme in 2012 as a way of meeting the requirements for emissions reductions under its global warming legislation, AB32.[27]

[25] See also http://thinkcarbon.wordpress.com/2009/07/11/comparison-of-waxman-markey-eu-ets-and-cprs-emissions-trading-schemes/ for a snapshot comparison of the proposed Waxman-Markey Cap-and-Trade Scheme, the EU Emissions Trading Scheme and the Carbon Pollution Reduction Scheme in Australia (website accessed on July 9, 2010).

[26] See http://www.csmonitor.com/USA/Politics/2010/0727/Stripped-down-energy-bill-leaves-out-cap-and-trade.

[27] AB 32 is the California Global Warming Solutions Act of 2006. It requires that California's state-wide greenhouse gas emissions be reduced to the 1990 level by 2020. Based on the current understanding, this is a reduction of about 25 %.

Japan

On March 12, 2010, the government of Japan proposed the *Basic Act on Global Warming Countermeasures*. Thus far, the climate policy of Japan has excluded market-based approaches and price instruments. With the 'Basic Act' a mandatory ETS is established, a carbon tax is implemented, and a feed-in tariff for all renewable energy sources is included. Furthermore, the Act aims to achieve a 10% share of total primary energy supply from renewable sources by 2020, and is in line with Japans mid-term and long-term GHG emissions reduction goals. There is growing opposition to the proposed bill from leading business organizations that have concerns about the costs to the economy. The ETS will be active in one year but observers believe that, due to the opposition, this will take longer. This is not the case for the carbon tax and feed-in tariff.

Australia

Unlike in New Zealand, the Australian economy-wide trading scheme, the Australian Pollution Reduction Scheme (CPRS) did not make it through the Senate (twice). Therefore, the Prime Minister announced that further plans on this subject are postponed and re-examined by the end of 2012. The CPRS would have covered approximately 75 % of Australia's emissions. This would be in line with its mid-term commitment of reducing GHG emissions by at least 5 % below 2000 levels by 2020.

3.1.5 Future Developments

UNFCCC: Beyond Kyoto

Emission reduction targets in the Kyoto Protocol, at the heart of catalyzing carbon trading, go only as far as 2012. Hopes and belief were that the 15th Conference of the Parties to the UNFCCC in Copenhagen in December 2009 would address this issue. Copenhagen, however, did not deliver in this regard: no agreement was reached on post-2012 emission reduction targets, nor on a new deadline for a post 2012 agreement. Negotiations are deferred to the next Conference (COP 16 in Mexico), "with significant issues between the major players still to be resolved" (WEF, 2010).

This does not mean nothing good came out of Copenhagen. According to the World Bank, "probably the most significant aspect of the Accord is that it enshrines the continuation of the Kyoto Protocol" (WEF, 2010). Table 2 summarizes the main results of the conference.[28]

[28] For further information on the outcome of the Conference, see UNFCCC (2010).

Table 2 Main elements of Copenhagen Accord

Item	Content
Shared vision	Recognize need to keep rise in global temperatures to less than 2°C based on scientific evidence
Mitigation	Developed nations to set national emissions cut targets for 2020 by end-Jan 2010 Signatories to Kyoto Protocol to cut emissions further Developing nations to submit emissions mitigation plans by end-Jan 2010
Technology	Technology mechanisms for technology development and transfer to be established
Funding	Copenhagen Green Climate Fund (CGCF) to be set up Majority of funding for adaptation measures, deforestation relief, clean-tech development to be channelled through CGCF Developed nations to provide $30 bn. in additional funding in 2010-12 $100 bn. in annual funding to be mobilized by 2020 predicated on implementation and transparency of mitigation actions by developing nations
Verification	Assessment of progress in implementing accord to be completed by 2015. Strengthening of long-term targets to be considered.

Source: (Mizuguchi, 2010)

Box 3 Bali/COP13: Bali Action Plan

'Copenhagen' was preceded by the Bali conference in December 2007. It consisted of 2 ad hoc working groups: one on Long-term Cooperative Action under the Convention (AWG LCA), and the other on further commitments for Annex I Parties under the Kyoto Protocol (AWG KP). The conference resulted in a definition of the negotiation process for post-2012 commitments, the Bali Action Plan (part of the Bali Road Map), which should have been completed in Copenhagen in 2009. The main subjects of negotiation were technology transfer, the fight against deforestation, market mechanisms, and the scope and content of Article 9 of the Kyoto Protocol, which stipulates the first review of the Protocol.[29] Also the Adaption Fund was launched, which is geared towards innovative financing leverages. This funding mechanism has its own independent source of finance. Its main income source is the 2 % levy on Clean Development Mechanisms (discussed in detail in paragraph 4.1.2) that could raise between $300 million and $600 million over the medium term, depending on the carbon price (The World Bank, 2010).

To differentiate between developing and developed countries, the Conference stated different targets for each. Developing countries did not receive quantified emission targets but should take mitigation actions that are "measurable and reportable". Developed countries committed to the Kyoto Protocol were to agree on new quantified emission limitation and reduction commitment (Pew Center on Global Climate Change, 2007)..

EU ETS Phase 3

The strong link between Kyoto and EU ETS could cast identical uncertainty on the post-2012 period for the EU carbon market. Recent EU policy indicates otherwise. In April 2009, the Council of the European Union adopted a climate-energy legislative package.[30] The main goal of this act is to achieve a one-fifth part of energy from renewable sources in the final consumption of energy and a 10% share of energy from renewable sources in each member state's transport energy consumption by 2020. Each member states gets a mandatory national target for this commitment in order to provide certainty for investors and to give an incentive for technological development in the renewable energy sector.

[29] UNFCCC website: http://unfccc.int/meetings/cop_13/items/4049.php and http://unfcccbali.org/unfccc/ (accessed on July 7, 2010).

[30] European Commission, *Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading system of the Community* (Brussels, April 23, 2009). This Directive was amended and adopted by the European Parliament (EP) and of the Council of the European Union in April 2009 (Parker, 2010).

To achieve this main goal, the EU designed several new rules for a better implementation. In summary:

- The EU decided that heavy industry will contribute more to the overall target of GHG emission reduction;
- GHG emission permits will increasingly be auctioned instead of given for free (see below);
- Up to 300 million emission allowances are set aside to finance clean technologies;
- There are new rules for cleaner cars, new quality standards for fuel and biofuels and a carbon capture framework.[31]

The shift from giving away allowances for free – grandfathering – to auctioning follows from criticism on grandfathering, as explained in paragraph 3.1.2. Auctioning, however, entails higher private costs for the regulated sectors. This generally causes companies (or sectors) to resist the auctioning of permits and lobby for allocation of free permits. In Europe industrial lobbies pointed to risk of 'carbon leakage' by claiming that the unilateral and stricter European climate policy imposes higher costs on European companies, worsening their market position against international competitors and forcing them to either shut down plants or move their production activity to non-EU countries. Substantial asymmetric costs on the European economic agents could be detrimental for both the European economic growth and ineffective for the environment. Emissions would decrease in Europe, but proportionally increase in the rest of the world (Clò, 2010; The World Bank, 2010). To limit the risk of carbon leakage the new ETS Directive differentiates between energy sectors (full auctioning from 2013 onwards), energy intensive sectors not exposed to carbon leakage (80% grandfathering in 2013, gradually declining to 30% in 2020 and full auctioning in 2027) and energy intensive sectors exposed to carbon leakage (pure grandfathering).[32] Grandfathering in Phase III will, however, not be based on historic emissions, as in Phase I and Phase II, but on a performance benchmark. This implies than only the most efficient plants will really receive permits for free (Clò, 2010).
Furthermore, the European Union has formally, but conditionally, increased its emission target for 2020. For the period beyond 2012, the EU will commit to reach a 30%, instead of 20%, reduction by 2020 compared to 1990 levels, if a "satisfactory international agreement" is reached, i.e., if other developed countries make comparable commitments for emission reduction, and if developing countries make their contribution "dependent on their responsibilities and respective capabilities".[33] This decision was made at the end of January 2010, after the Copenhagen meeting.

The World Economic Forum (2009, p. 37) claims that, regardless whether a new international agreement on emission reduction is reached (i.e., a post-Kyoto treaty), "the future of the EU ETS is secure [since the] EU has shown a strong commitment to climate goals in general (…) and to the EU ETS in particular". This suggests that EU ETS will persevere, even in absence of a new legally binding international agreement. Only a more stringent European emission reduction target is dependent on a new international agreement.[34] The latest development, the adoption of

31 *Council adopts climate-energy legislative package*, Council of the European Union, Brussels, 6 April 2009.
32 This solution is not without its flaws, see chapter 5.4.2.
33 http://unfccc.int/files/meetings/application/pdf/europeanunioncphaccord_app1.pdf (accessed on July 17, 2010) and *Questions and Answers on the Commission's proposal to revise the EU Emissions Trading System* (EU MEMO/08/35).
34 See the answer to question 6 in *Questions and Answers on the Decision on effort sharing* (EU MEMO/08/797).

a cap for 2013 on July 9 2010, confirms EU ETS's fortitude.[35] However, (detailed) deliberation on the relationship between legally binding international agreement and the future of the EU's emission reduction efforts is virtually non-existent in current debate. This could provide room for further research.

3.2 Voluntary Markets

3.2.1 Background

The voluntary market represents purchases of carbon credits by organizations or individuals who are not legally obliged to make any emissions reductions, or who wish to make emissions reductions claims over and above that legally required, and therefore are under no legal constraints governing the kind of emission offsets that they purchase. Although the concept of voluntary offsets predates regulation-based ET, it was stimulated as the Kyoto mechanisms came into force in 2005 and the concept of carbon trading became more of a reality.

Hamilton et al. (2009) divide voluntary markets in the legally binding Chicago Climate Exchange (CCX) and the broader, non-binding Over-The-Counter (OTC) offset markets. The CCX is a cap-and-trade system, further detailed below, while OTC offset markets are not.[36] Most credits purchased in the OTC market originate from emission reduction projects and are thus offsets. Credits are called Verified (or Voluntary) Emission Reductions (VERs). OTC trading can also refer to voluntarily buying credits from compliance markets, such as CDMs.[37]

On the supply side, voluntary markets reach projects and locations outside the scope of the regulated market mechanisms, as well as projects with high transaction costs or other barriers (e.g., land-use). Hence, voluntary markets increase project supply and project diversity.

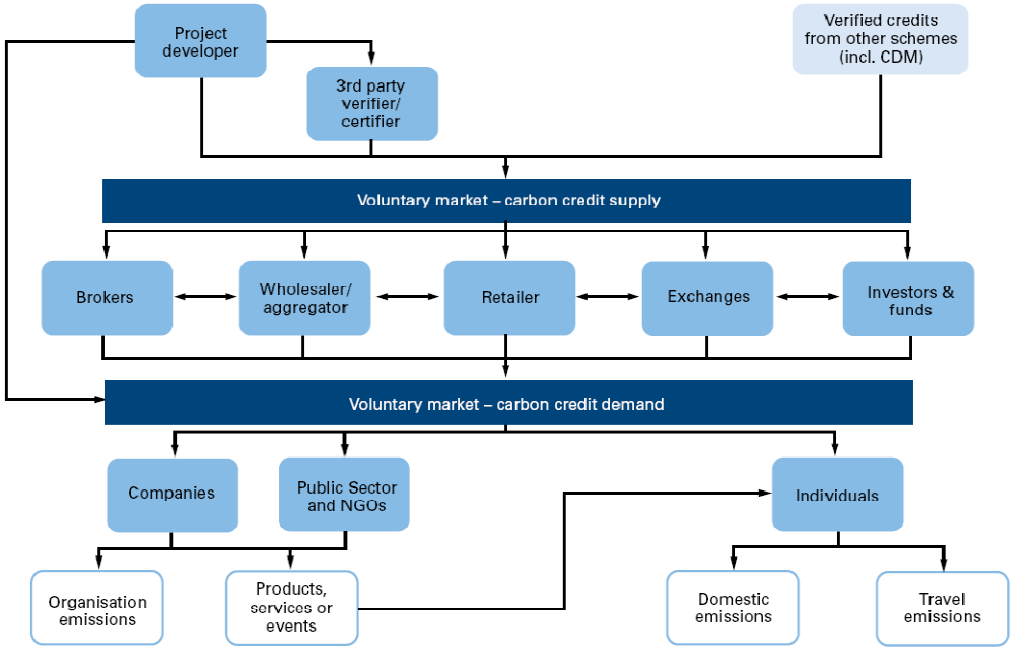
Buyers in voluntary markets are generally driven by 'pure voluntary' or 'pre-compliance' motives. The former is focused on offsetting own emissions and strongly relates to "public relations and ethics" (Hamilton et al., 2009). This market is developing as consumers come to understand climate change and want to take personal action. Projects typically demonstrate community benefits or strong sustainability components. A large number of these projects are within close range of the trading place, which makes it easier for traders to identify to the source of their credits – e.g., a lot of credits traded on the CCX in Chicago concern North American projects. Well-known examples include projects to offset emissions from air travel, and carbon labeling of consumer products. The latter, pre-compliance, refers to the purchase of rights that are expected to become part of future regulatory systems. Companies that expect to face a shortage of rights in the future hope to buy emission rights at a low price now, while other companies hope to sell the purchased rights at a higher price in the future. Pre-compliance driven trade is particularly dominant in countries where legislation is imminent, such as the US and Australia (countries in a so-called *regulatory vacuum*), and buyers are seeking pre-compliance and early action offsets (Capoor & Ambrosi, 2008; Hepburn, 2007).

35 *Commission decision of 9 July 2010 on the Community-wide quantity of allowances to be issued under the EU Emission Trading Scheme for 2013*, C(2010) 4658 final, European Commission, Brussels. Aviation is not included in this decision. The cap to be allocated to aircraft operators will be determined by a separate decision of the Commission.

36 OTC markets include several Government Voluntary Offset Programs, which are discussed below.

37 For all clarity: a part of voluntary markets are OTC markets, but not all OTC markets are voluntary markets.

Figure 1 Voluntary Market Supply Chain



Source: (Carbon Trust & Climate Strategies, 2009, p. 66)

The volume and value of credits traded on voluntary markets is much smaller than the compliance markets of the Kyoto Protocol (Table 4 at the end of this chapter) and credit price is much lower. Since there is no regulatory framework, voluntary markets grow organically. They are still regarded as in their early days of evolution, as was underlined by rapid growth in 2006, 2007 and 2008. In 2009, however, the voluntary carbon market saw a sharp decline in trading volume (see 2009 data in Table 4) as companies and individuals cut back on discretionary spending in view of the financial crisis. In the second half of 2009 the market did recover slightly, thanks to the *American Clean Energy and Security Act* passing the House of Representatives in the US (as discussed above), though by far not enough to balance the discretionary cut-backs. It has led companies to start securing credits in the voluntary market which they eventually hope to use to meet their compliance needs (Carbon Trust & Climate Strategies, 2009; WEF, 2010).

.

Quality of offset credits have been an important concern hampering the development of voluntary OTC markets. Signalling market maturation, recent years have seen the emergence of third party verification and voluntary standards. This has improved quality assurance. Most popular standards in the voluntary OTC market were Voluntary Carbon Standards (48% of VERs in 2008), Gold Standard (12%), Climate Action Reserve (10%) and American Carbon Registry (9%).[38] Third party verification generally follows the development of standards.

3.2.2 Operational Voluntary Markets

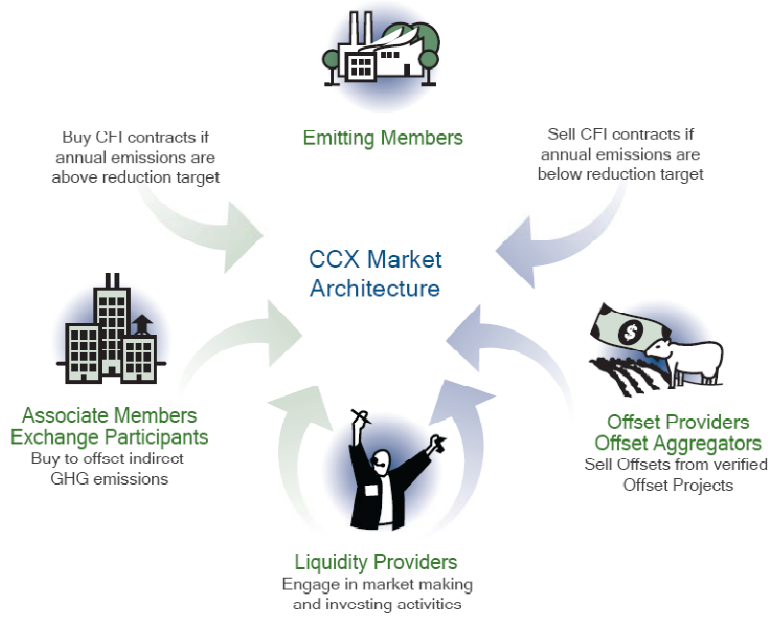
North America: Chicago Climate Exchange (CCX) and Climate Action Reserve

The Chicago Climate Exchange (CCX), a voluntary scheme launched in 2003, is currently North America's only cap-and-trade system for all six greenhouse gases with projects and global

[38] For a full overview and description of standards, see (Hamilton et al., 2009).

affiliates worldwide. CCX Members allegedly represent 17 % of the Dow Industrials, 22 % of the largest coal burning electric utilities and 11 % of the Fortune 100. Two US states (Illinois and New Mexico) and several cities and counties are also active on the CCX. The CCX is the only voluntary but legally binding cap-and-trade system. That is, although a voluntary scheme, companies that decide to participate (members) make a legally binding commitment to reduce GHG emissions. Trade is between the members.

Figure 2 CCX Market Architecture



Source: (Chicago Climate Exchange Inc., 2009)

An example of a voluntary OTC scheme in North America is the Climate Action Reserve. This is an offsets program which establishes regulatory-quality standards for the development, quantification and verification of greenhouse gas (GHG) emissions reduction projects and issues carbon offset credits known as Climate Reserve Tonnes (CRT) generated from these projects. Account holders can trade CRTs but it also possible for individuals or organizations to offset their emissions for activities like travel and business operations by purchasing small quantities of CRTs. In 2009, trade in CRTs almost tripled in value because it was considered likely these rights would become eligible under a federal (compliance) scheme.[39]

Japan

Japan has a voluntary Experimental Integrated ETS (as from October 2008), which includes several existing initiatives such as the Keidanren Voluntary Action Plan, for a domestic offsets scheme, and the Japan-Voluntary Emissions Trading Scheme (J-VETS), which targets smaller emitters. It covers about 70 % of CO_2 emissions from industrial sectors. Transaction activity is reported to be extremely limited so far (Kossoy & Ambrosi, 2010).

[39] This scheme is just one example. As explained above, more standards and 3rd party registrations exist.

Upcoming Markets[40]

China has three voluntary environmental exchanges that do not involve the central government:

- The China Beijing Environmental Exchange (CBEEX) provides a market platform, amongst others for trading emission rights from CO_2, and facilitates CDM transactions;
- The Tianjin Climate Exchange (TCX) is an integrated exchange for the trading of environmental financial instruments;
- The Shanghai Environment Energy Exchange (SEEE) provides a platform for trading all kind or rights focusing on environment and energy. It is exploring a new market mechanism aligned with the requirements of the CDM. The aim of the exchange is to reduce transaction costs and bring more transparency to CER pricing.

In **Mexico**, 21 % of national emissions is currently covered by the voluntarily program for greenhouse gas accounting and reporting. The aim is to expand this to 80 %. The program establishes baselines, develops standards and the expectation is that sectoral crediting complements CDM as the source of carbon market finance for Mexico.

The **Republic of Korea** has the Korean Certified Emission Reduction (KCER) Program, a government-operated GHG reduction program. The KCERs are issued by the government for five-year crediting periods and benchmarked using CDM, ISO standards and IPCC guidelines. The KCERs are either purchased by the government, sold into the voluntary market or banked in preparation for emissions trading. A trading scheme is under development through the Basic Act for Low Carbon Green Growth and will be finished by the fall of 2010.

3.2.3 Future Developments

Announced Voluntary Markets

Brazil is exploring the possibilities of introducing a domestic cap-and-trade scheme, primarily covering the energy, transport, industrial and agribusiness sectors. This country has a voluntary target of emission reduction (38.9 % by 2020) and the scheme would help realize this target (Kossoy & Ambrosi, 2010).

In **India** there are two schemes active under the National Action Plan on Climate Change. With the use of market-based instruments the aim is to increase energy efficiency and the use of renewable energy. The first scheme is the Perform Achieve and Trade (PAT) mechanism for trading energy efficiency certificates which is expected to become operational in 2011, with an initial commitment period of three years. The second scheme, the Renewable Energy Certificate (REC) mechanism is intended to support an increase in installed renewable capacity from 15-65 GW in five years and is expected to become operational in 2011. RECs will only be issued to renewable energy generators, but will be freely tradable. RECs will be traded through regulator approved power exchanges, within a price band (Kossoy & Ambrosi, 2010).

Market Development

Especially the emergence of commonly accepted standards points to maturation of voluntary carbon markets. This feeds purchasers' trust in transactions and should increase their popularity. The current number of standards however, totalling 17 in 2009, is seen as rather high and some

40 The overview in this paragraph is based on Kossoy & Ambrosi (2010).

consolidation is expected. Pre-compliance motives are expected to become more important the more it becomes clear which offset credits will qualify for future compliance markets, like was seen with CRTs in the US. At the same time, uncertainty of future legislation as well as on length and impact of the economic downturn could hinder voluntary market growth. , These uncertainties make it hard to predict future voluntary market growth, but estimates have projected annual volumes of between 200 and 550 $MtCO_2e$ by 2012 (Carbon Trust & Climate Strategies, 2009).

There is an overlap between voluntary and compliance markets, as companies and individuals outside the regulatory regime partly fulfil their need for credits from the compliance markets (CERs), or credits from CDM projects in the process of validation or registration. Some analysts predict that CERs could grow to form half of all voluntary trades (Carbon Trust & Climate Strategies, 2009).

3.3 Summary

An overview of operational cap-and-trade policies around the globe is presented in Table 3 (a snapshot dating from April 2009).

Table 3 Operational cap-and-trade policies as of April 2009 (excluding inactive policies)

Operational Phase	Initiated	Regulatory Status	Allocation*	Compliance
Chicago Climate Exchange (US)	2000	Voluntary (not binding)	Free	Purchase of CFIs[41]
EU Emissions Trading Scheme	1999	Mandatory	Free	Penalty
Japan (Experimental Integrated ETS)	2002	Voluntary	Free	Return government subsidy
New Zealand	2007	Mandatory	Free	Penalty
New South Wales GGAS	1998	Mandatory	Free?	Penalty (A$ 12/excess ton)
Regional Greenhouse Gas Initiative (US)	2003	Mandatory	Auctioning	N/A
Switzerland	2000	Voluntary (but binding)	Free	Carbon tax

Source: SEO Economic Research, adapted from (Betsill & Hoffmann, 2009); * = Allocation during current compliance period

Currently the most liquid emissions trading markets are EU-ETS, global Kyoto compliance markets and US's Regional Greenhouse Gas Initiative (Table 4). Voluntary markets are significantly smaller than regulated markets, in terms of traded volume and value, but are growing rapidly. In addition, several voluntary markets were announced in developing countries.

[41] The tradable instrument on CCX is called the Carbon Financial Instrument (CFI) contract, which represents 100 metric tons of Exchange Allowances or Exchange Offsets.

Table 4 Carbon market at a glance, volumes and values[42]

	Volume (mtCO2e)				Value (MUS$)			
	2006	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
Allowances Markets								
EU ETS	1.104	2.060	3.093	6.326	24.436	49.065	100.526	118.474
New South Wales	20	25	31	34	225	224	183	117
Chicago Climate Exchange	10	23	69	41	38	72	309	50
RGGI	na	na	62	805	na	na	198	2.179
AAUs	na	na	23	155	na	na	276	2.003
Subtotal	**1.134**	**2.108**	**3.278**	**7.362**	**24.699**	**49.361**	**101.492**	**122.822**
Spot & Secondary Kyoto offsets								
Subtotal	25	240	1.072	1.055	445	5.451	26.277	17.543
Project-based Transactions								
Primary CDM	537	552	404	211	5.804	7.433	6.511	2.678
JI	16	41	25	26	141	499	367	354
Voluntary market	33	43	57	46	146	263	419	338
Subtotal	**586**	**636**	**486**	**283**	**6.091**	**8.195**	**7.297**	**3.370**
Total	**1.745**	**2.984**	**4.836**	**8.700**	**31.235**	**63.007**	**135.066**	**143.735**

Source: The World Bank (Capoor & Ambrosi, 2008, 2009; Kossoy & Ambrosi, 2010)

[42] See Hamilton, Sjardin, Peters-Stanley, & Marcello (2010) for a comparable overview.

4 Market Functioning

4.1 Market Characteristics

4.1.1 Introduction

What changes hands in Emissions Trading (ET) is the right to emit a certain volume of CO_2 (or an equivalent amount of another greenhouse gas). The intention is to put a price on emissions that have until now been cost-free, and to allow trade in permits, so that those who can most easily reduce emissions have the greatest incentive to do so. Cap-and-trade fixes the volume of emissions and then lets the market find the appropriate price level.[43]

4.1.2 Mechanisms[44]

The Kyoto Protocol makes provision for four instruments that provide flexibility to its signatories in implementing their reduction goals: Emissions Trading (ET), Joint Implementation (JI), Clean Development Mechanism (CDM) and Land Use, Land-Use Change and Forestry (LULUCF). The underlying philosophy of flexible mechanisms is that the Annex B countries can make some of the reductions to which they have committed themselves, outside of their own country (Abadie & Chamorro, 2008).[45] Within the EU ETS, mechanisms are either resembling or linked to the Kyoto mechanism.

Emissions Trading

Emission reduction targets for Annex B Parties are expressed as levels of allowed emissions, or Assigned Amount Units (AAUs) for the 2008-2012 commitment period. Emissions Trading (ET), set out in Article 17 of the Kyoto Protocol, allows countries that have AAUs to spare – i.e., emissions permitted but not used – to trade their excess capacity with countries that are over their targets (UNFCCC, 2010). Within EU ETS, trading is arranged rather the same way with emission rights called European Union Allowances (EUAs).

Related to Kyoto's AAU trade are Green Investment Schemes (GIS). In these schemes, the seller agrees with the buyer to use the proceeds of the sale of AAUs for climate change mitigation programmes.[46]

Clean Development Mechanisms

Clean Development Mechanism (CDMs) are projects that reduce emissions in developing and newly industrializing countries (Article 12 of the Kyoto Protocol). By investing in these projects, countries or companies acquire Certified Emission Reductions (CERs), which can be used to

43 The difference between carbon markets and markets for standard commodities (like oils, coals and gas) is that the former is structurally less liquid and deep than the oil market (Reinaud, 2007). Temporary mismatches between supply and demand therefore give rise to wide fluctuations in price. This is one of the reasons why price volatility in carbon markets may well be above standard levels in financial markets (Abadie & Chamorro, 2008). Carbon prices and price volatility are further discussed in chapter 4.2.

44 For an elaborate discussion of the Kyoto mechanisms, see for instance Carbon Trust et al. (2009).

45 For more information on flexible mechanisms: Carbon Trust & Climate Strategies (2009) provide an excellent and elaborate introduction to and assessment of all three Kyoto mechanisms, updated in an overview article by one of the authors of the report (Grubb et al., 2010).

46 Green Investment Schemes have developed due to the virtually non-existent trade of AAUs between countries because of current excess supply. This is further discussed in chapter 5.2.

meet their own commitments without having to reduce emissions themselves. Over 200 types of CDM projects are eligible under the Kyoto Protocol, including renewable energy, energy efficiency, forestry, and industrial gas capture.

According to the Kyoto Protocol, developing countries have no quantified emission targets for the first Kyoto period (2008-2012) – see Box 4 for an elaboration on the pros and cons of emissions trading in developing countries. Instead, the CDMs of the Kyoto Protocol are intended to induce technological change in developing countries. The purpose is twofold: it is a means of reducing compliance costs for industrialized countries, and it is a means of assisting developing countries in achieving sustainable development. In developing countries a lot of additional investment is needed to "green" the annual investment in power sectors, in order to keep up with economic and population growth.[47] Unless investments are specifically directed towards low-carbon technology (at a larger scale than is currently being achieved), they will go towards a carbon-intensive development path. Carbon finance mechanisms such as CDM potentially play an important role in redirecting these investments (Hagem, 2009; J. I. Lewis, 2010).[48]

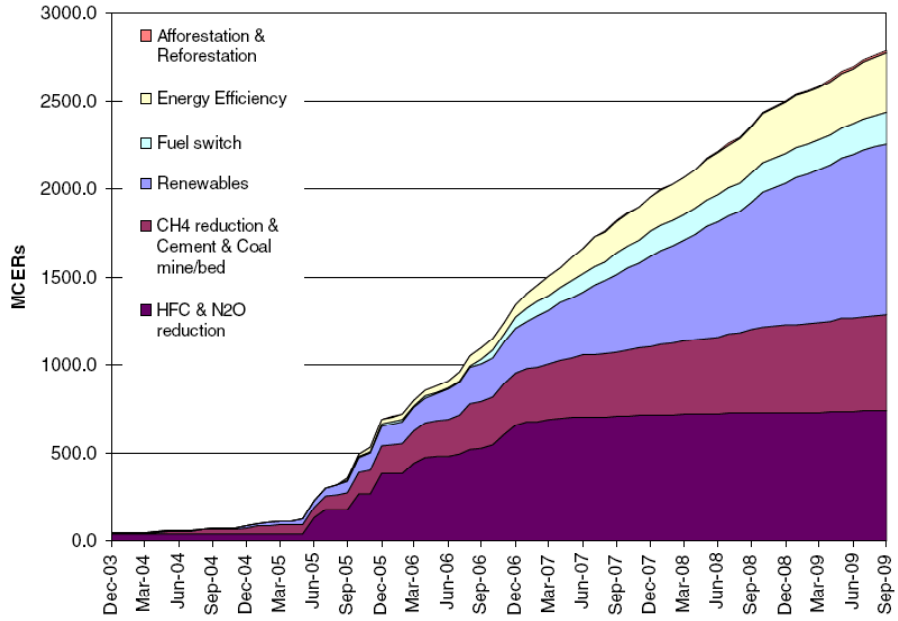
Box 4 Developing countries: CDM or Emissions Trading?

Submitting developing countries to cap-and-trade schemes could eliminate level-playing field concerns. EU countries, for example, are only willing to accept a higher reduction target (30 % instead of 20 % compared to 1990 levels) if developing countries "contribute adequately according to their responsibilities and respective capabilities".[49] Also, it could prevent detrimental re-location of production sites. Regulatory inequalities regarding GHG emissions can cause companies to move their production sites to countries where environmental requirements are the least strict. The *Pollution Haven Hypothesis* (PHH) predicts that poor countries with lax environmental regulations can become pollution havens as polluting industries migrate to these countries from rich countries with stringent pollution standards (Cave & Blomquist, 2008; Silva & Zhu, 2009).

There are, however, important downsides to submitting developing countries to emissions trading. The World Bank (2010) points out that the cost of administering climate policy and the institutional and human capital required are substantial. Setting up a market for auctioning and trading permits can be highly complex. A regulator is required to monitor the exercise of market power by participants and to monitor and enforce at the level of individual emitters.

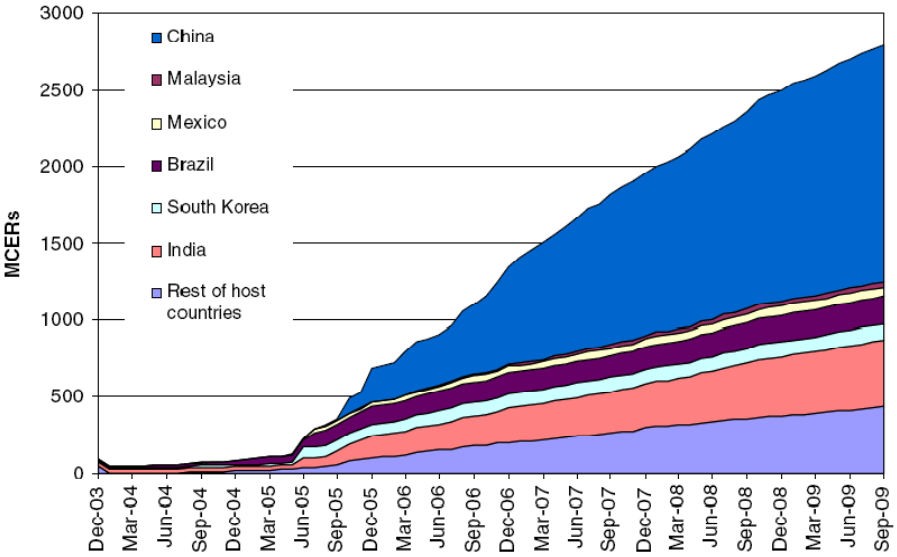
47 Much of this investment will need to take place in China.
48 In recent years there has been criticism on CDMs, which is further discussed in chapter 5.3.
49 UNFCCC website: http://unfccc.int/home/items/5264.php (accessed on July 6, 2010).

Figure 3 Accumulation of CERs by project type



Source: (Grubb et al., 2010, p. 4)

Figure 4 Accumulation of CERs by host country



Source: (Grubb et al., 2010, p. 6)

In 2008 and 2009 37 % of CERs, were based on renewable energy or energy efficiency. This proportion is expected to grow to nearly 60 % by 2012, as the potential for industrial gas projects has largely been exhausted.[50] By the end of 2012, New Energy Finance estimates that the CDM will have caused around US$ 15 billion to flow from developed to developing countries for investment in low-carbon projects (WEF, 2010).

[50] This point is also made by Grubb et al. (2010). For a more detailed analysis, see Michaelowa et al. (2008).

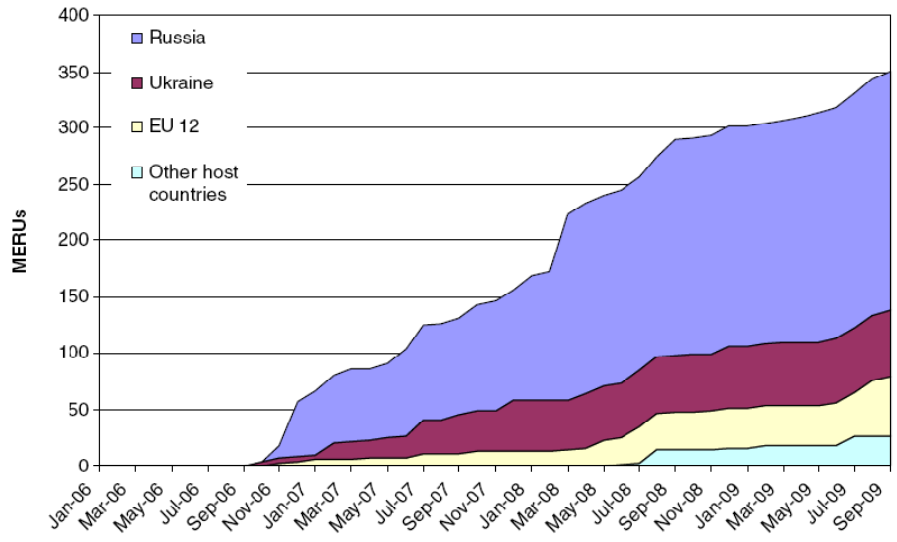
Rights under the CDM are also eligible within the EU ETS. CERs accounted for 17 % by value of carbon trading under the EU-ETS in 2009 (WEF, 2010).

Joint Implementation

Joint Implementation (JI) are projects carried out jointly by industrial countries. It refers to the opportunity for countries or companies to implement climate protection projects in other countries that have signed the Kyoto Protocol. After successful completion of a JI, a country or company is awarded Emission Reduction Units (ERUs), that can be offset against their initial commitments (Article 6.1 of the Kyoto Protocol). While Clean Development Mechanisms are targeted at developing countries, JI mechanisms are targeted at industrial countries. In practice, these are mostly "economies in transition" – i.e., former Soviet Bloc countries. As is the case with awarding credits for CDM projects, ERUs are only awarded if a JI project is considered supplemental (as opposed to substitutive) to domestic actions (Hepburn, 2007; WEF, 2010). In Europe, potential overlap between savings from JI projects and EU ETS is tackled by 'double counting' rules: ERUs from projects at facilities under the EU ETS scope are prohibited, and emissions savings from power stations under EU ETS as a result of JI energy efficiency projects are discounted before awarding ERUs (Grubb et al., 2010).

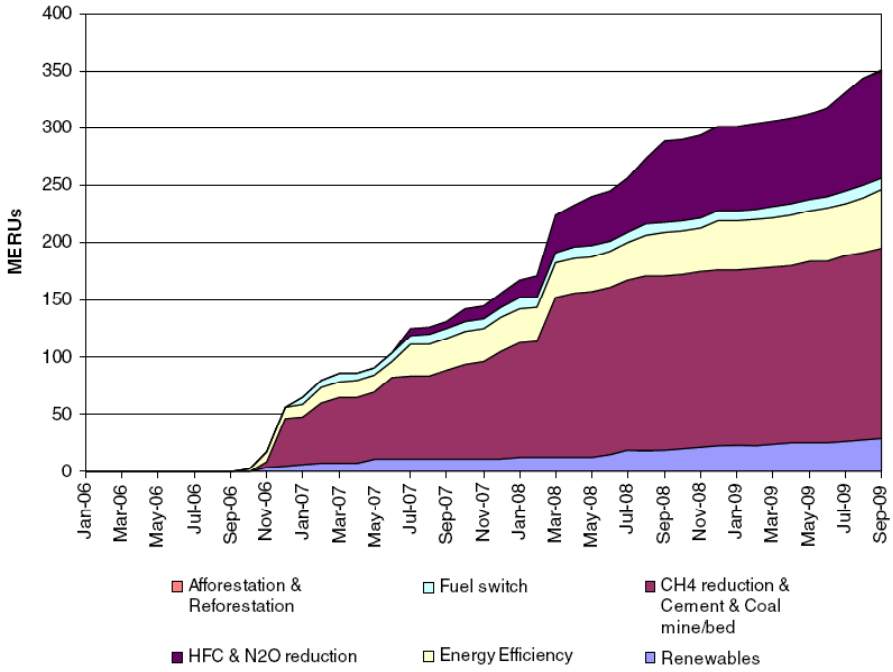
Russia accounts for almost two thirds of the projected savings to 2012 from JI projects, the remainder is divided roughly equally between Ukraine and the EU's new member states (Figure 5). Since Russian projects are dominated by coal mine methane projects and N2O reductions, so are the total expected ERUs by 2012 – i.e., ERUs that could be generated by the end of 2012 from all of the projects currently in the JI pipeline, across all stages from beginning of public comments to those already registered (Figure 6).

Figure 5 Accumulation of ERUs by host country



Source: (Grubb et al., 2010, p. 8)

Figure 6 Accumulation of ERUs by project type



Source: (Grubb et al., 2010, p. 7)

Initially, JI projects were intended to involve minimal international oversight, as projects would originate in countries that had complied with the complete array of Kyoto Protocol provisions for annual reporting and review of national emission inventories. As transition economies were worried that they could not meet these requirements, a second 'track' of JI was established through the Marrakech Accords, which resembles CDM procedures (Table 5), with projects being directly endorsed through a multilateral Joint Implementation Supervisory Committee (JISC), supported by the UNFCCC. Under *Track 1* procedures, which parties can use if they meet all eligibility conditions, ERUs can be issued upon its own verification of emission reductions; *Track 2* projects require determination acceptance by the JISC before the host party can issue and transfer ERUs (Grubb et al., 2010; Korppoo & Gassan-zade, 2008).

Table 5 Joint Implementation: Track 1 versus Track 2 requirements by stages

Type of Eligibility	Key Requirements (Eligibility for previous levels is required at each level)	Stage at which eligibility is checked	When eligibility is established
Kyoto eligibility	Party to Kyoto Protocol, target under Annex B	Publication of the Project Design Document (PDD)	Submission of the PDD to the UNFCCC Secretariat
Eligibility to participate in the mechanisms	Designated Focal Point and JI procedures	Final determination by the JISC	Project's submission to the JISC
Eligibility for Track 2	Assigned Amount, registry	ERUs transfer out of the national registry	Every year starting 2008
Eligibility for Track 1	Inventory system, annual inventories, incl. most recent	ERUs transfer out of or to (procurement) the national registry	Every year starting 2008

Source: (Korppoo & Gassan-zade, 2008, p. 6)

Land Use, Land-Use Change and Forestry

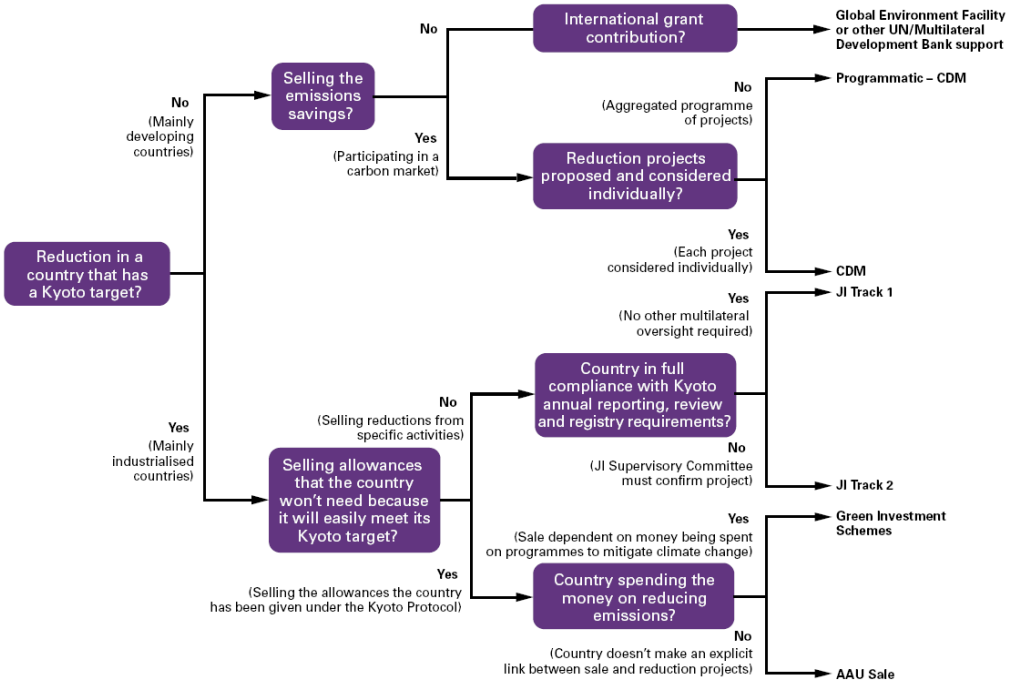
Land use, land-use change and forestry (LULUCF) activities are set out in Article 3 of the Kyoto Protocol. It allows Annex B parties to take into account GHG emissions associated with afforestation, reforestation and deforestation since 1990 in assessing compliance with their Kyoto targets. Additional allowances (called Removal Units, RMUs) can be issued for each tonne of CO_2 sequestered by LULUCF. RMUs have limitations because they cannot be banked for use to offset emissions after 2012, and because EU ETS does not allow sequestration as an eligible activity nor does it allow the use of RMUs for compliance with its scheme (City of London et al., 2009).

LULUCF project activities that are not eligible under CDM, except afforestation and reforestation, are also permitted under the Joint Implementation mechanism. JI allows any other LULUCF projects, such as promoting improved forest management, increased fire and pest controls and preservation of old growth forests. There are however some institutional problems with crediting LULUCF projects under JI. Only RMUs (not AAUs) can be converted into ERUs for Joint Implementation, therefore if a country has not met its Kyoto reporting obligations or if its accounting does not generate RMUs, the country cannot host JI LULUCF projects (Korppoo & Gassan-zade, 2008).

Summary

Figure 7 and Table 6 provide an overview of Kyoto mechanisms:

Figure 7 Characteristics of the Global Carbon Mechanisms



Source: (Carbon Trust & Climate Strategies, 2009)

Table 6 Summary of mechanisms for Annex I countries under the Kyoto Protocol

	Joint Implementation (JI) 'Track 2'	JI 'Track 1'	Green Investment Schemes (GIS)	Industry-level cap-and-trade (EU ETS)
Supervision of transactions	Multilateral supervision	Bilateral supervision subject to national compliance with full-scope Kyoto Protocol MRV procedures		
Reduction unit	Emission Reduction Unit (ERU)	ERU	Assigned Amount Unit (AAU)	EUA backed by AAU
Governing body and procedure	JI Supervisory Committee, 'final determination'	Host country	Host country	EU
Units issued by Crediting period	Host country Kyoto first period: from 1st Jan 2008, currently to end 2012.	Host country As JI track 2	Kyoto Protocol Variable	EU Kyoto Protocol first period with banking forward allowed
Eligibility of land-related activities	Afforestation and reforestation plus other uses as selected under KP Article 3,4	Afforestation and reforestation plus other uses as selected under KP Article 3.4		CO2 only from qualifying sources which excludes for example land use
Third party verification	'Determination' of Project Design Document by 'Accredited Independent Entity'	Kyoto Protocol provisions for national emissions, bilateral agreement for projects plus ITL procedures		KP + EU + ITL procedures
Methodologies	Projects can use: – Approved CDM methodologies – Elements of CDM methodologies – New methodologies	Bilateral	Bilateral	n/a
Additionality	Projects can use: – additionality tool from CDM; – other scenario or comparability approaches	Host country determination	Not explicitly required	Not explicitly required

Source: (Grubb et al., 2010); Adapted by SEO Economic Research

4.2 Carbon Price

Carbon prices are determined in a system of interlinked policy-led financial markets, similar to currency markets. A single global price for carbon[51] is not (yet) in sight, because there is no global carbon market and thus no political consensus and supporting infrastructure. Still, market-linking through project-based and other mechanisms encourages arbitrage and this should reveal a global carbon price range, one that could drive significant behavioral change (Houser, 2009; WEF, 2009).[52]

The primary drivers of prices are – at least in the long term – the number of credits created, the expected demand from industry, and the ease of closing any shortfall between supply and demand, using technology and investments available during the relevant commitment period (WEF, 2009).

51 As is advocated by Stern (2006, p. 468).

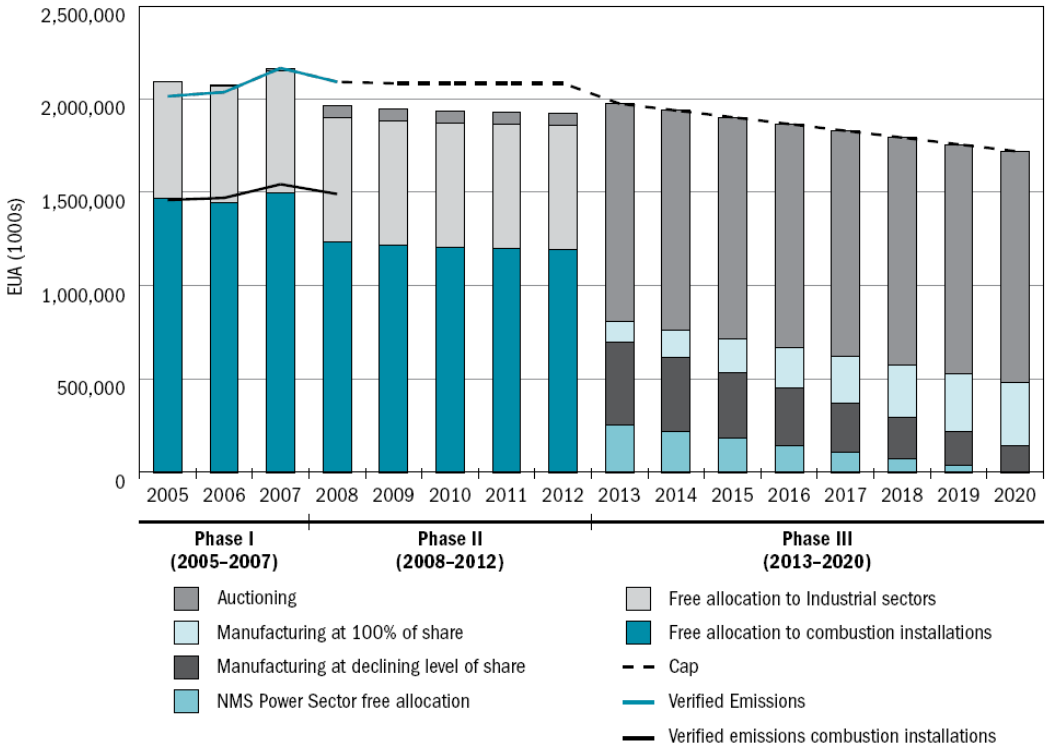
52 For instance, European companies obtaining emission rights via the Clean Development Mechanism (CDMs), which is part of the Kyoto mechanisms, can also use these rights to fulfil their obligations under the EU ETS. In this way, Kyoto and EU ETS are linked.

4.2.1 Determination of Prices

Emission Caps and Allowance Allocation

Policy drivers, such as cap levels and the availability of offsets, are essential in the supply of and demand for allowances and therefore have major consequences for allowance prices. In January 2008, the EC proposed putting 1974 million tons of EUAs in the market in 2013, and reducing this to 1720 million EUAs in 2020 (Figure 8). Emissions by participants of the ETS are thereby expected to be reduced by 21 %, compared to the 2005 allowance level. Increasing scarcity of EUAs should increase allowance prices accordingly (Abadie & Chamorro, 2008; Edwards, 2009).

Figure 8 Allocation and emission in the EU ETS



Source: (Grubb, Brewer, Sato, Helmayr, & Fazekas, 2009, p. 25)

Economic and Production Growth

Economic prosperity and levels of industrial production, notably in countries that participate in an emissions trading scheme, have a major impact on demand and supply of emission allowances (Alberola, Chevallier, & Chèze, 2009; Edwards, 2009; The World Bank, 2010). That is, companies in (industrial) sectors in which production grows faster (slower) than anticipated in their baseline projections – projections on which caps are based and on which the companies consequently base their allocation needs and permit stock – exhibit a 'short' ('long') compliance position. They have less (more) allowances than verified emissions and thus become allowance buyers (sellers) or, provided that there is allowance surplus elsewhere within the company, pool their company allowances. These companies have a positive (negative) impact on allowance prices.

Prices of Energy Commodities

In some industries, particularly power generation, the price of natural gas relative to the price of coal affects operating choices and therefore the demand for emission allowances. For example, a high gas price vis-à-vis coal prices, stimulates the use of coal which, with coal emitting twice the CO_2 content of natural gas, leads to more demand for emission allowances (Edwards, 2009; Reinaud, 2007). The other way around, emissions trading also has an effect on energy prices. For instance, if utilities pass through (some of the) compliance costs related to emissions trading. This has led to windfall profits, which are discussed in chapter 5.

Policy Uncertainty

While climate change is inherently a long-term, uncertainty-ridden challenge, political systems are skewed towards addressing more immediate concerns and are therefore ill-prepared to consider and adopt long-term action against long-term risks (Blyth & Yang, 2006).[53] This is most importantly reflected in the short commitment periods, in both Kyoto and EU ETS. Because allocations and targets can change in future commitment periods investors will only have short foresights into the trading scheme while, on the other hand, committing themselves to investments that span 20 to 30 years (Reinaud, 2007). Irreversible investment decisions will be based on pre-implementation expectations of climate change policy, so investors bear the risk that the actual marginal cost of abatement may differ from those expectations. As a result, policy uncertainty may lead to a delay in investment, thereby impacting the prices of CO_2 allowances. A delay of 'green investments' would result in lower supply of emission rights, a delay of 'dirty investments' would result in lower demand of emission rights. Measuring the exact impact is challenging. IEA (2007) have attempted to model policy risk as element of price uncertainty. They have used one-off price jumps as a proxy for the influence of policy change on prices and find this is a dominant factor in price uncertainty.

Macroeconomic Risk Factors

Carbon allowances form a specific market among energy commodities. Carbon futures – which are traded since 2005 on EU ETS – are only remotely connected to macroeconomic risk factors. As was mentioned above, prices on the carbon market are essentially a function of allowance supply (fixed by a regulator), and power demand arising from electric operators. The transmission of macroeconomic shocks to the carbon market through volatility spillovers between energy markets appears a promising area for future research (Chevallier, 2009). The impact of the recent financial crisis could be an interesting starting point. In this regard, Chevallier states "The sensitivity of carbon futures to macroeconomic influences is carefully identified following a sub-sample decomposition before and after August 2007, which attempts to take into account the potential impact of the "credit crunch" crisis. Collectively, these results challenge the market observers' viewpoint that carbon futures prices are immediately correlated with changes in the macroeconomic environment".

[53] More generally, being regulation-based the development of carbon trading cannot be seen separate from the political arena. In other words, development may be influenced by elements influencing public policy in general, like the short term political agenda and the lobby-industry. An example of the former is the vast amount of 'green deals' promised by many governments during the financial crisis. Examples of the latter include the aviation industry trying to keep it from being subject to an emission cap and energy related industries trying to prevent emission rights from being auctioned instead of grandfathered.

Other Factors

Other CO_2 price drivers include other (non-Carbon Trading) policies aimed at climate change (e.g., support for renewable electricity production), the external supply of project-based mechanisms (e.g., an abundance of CERs and ERUs dampens CO_2 prices), weather (e.g., a dry year in countries producing hydro power, such as Norway and Sweden, leads to more demand for fossil fuels in those countries and the countries that import hydro power from them), and hedging strategies of power producers engaged in forward transactions (Edwards, 2009; Reinaud, 2007).

4.2.2 Price Uncertainty and Volatility

For carbon trading to affect long-term infrastructure investment decisions, a stable price signal is essential. Carbon prices, however, are inherently volatile since the traded commodity is artificially 'created' from a whole set of dissimilar practices, practices ranging from energy efficiency improvements in industrial processes, to capturing coalmine methane and generating hydro-electric power. Putting a price on carbon therefore is highly arbitrary. Some strategies currently practiced to track or estimate future carbon prices are looking at energy prices (i.e., the difference between coal and gas prices) or speculating about future political decisions (Gilbertson & Reyes, 2009).

Since the supply of allowances is fixed, cap-and-trade makes the market intrinsically more volatile and may lead to uncertainty about price shifts in the business cycle or in the relative prices of low-carbon and high-carbon (fossil) fuels directly affecting permit prices. For instance, costs for new low-carbon technologies may decrease through economies of scale as they achieve greater market penetration, but then again they may rise if greater penetration leads to greater scarcity in the underlying resource, or if supply chain constraints are hit. These factors feed through to uncertainty in carbon prices and the resulting price volatility makes it difficult to plan abatement strategies and reduces the incentive to spend R&D on new abatement technologies. Two ways to reduce price volatility are the provision to take (abundant) emission rights from one compliance period to the next (banking or carry-over) – which is allowed in EU ETS (Betsill & Hoffmann, 2009) – and by allowing borrowing (Blyth, 2010; Edwards, 2009; The World Bank, 2010).

4.3 A New Financial Market

4.3.1 Starting Point: Trading Emission Units

Four types of emission units can be traded and sold under the Kyoto Protocol's emissions trading schemes.[54] They each are equal to one tonne of CO_2 and correspond with previously discussed flexible mechanism (UNFCCC; Allianz Glossary of Emissions Trading; Hepburn, 2007):

- Assigned Amount Units (AAUs): emission units that represent the targets accepted by Annex B countries (countries with commitments under the Kyoto Protocol) for limiting or reducing GHG emissions. Article 17 of the Protocol allows countries to sell their spare emission units;

[54] As explained, EU ETS provides for trading in EUAs in a similar manner as well as for a link with Kyoto mechanisms CDM and JI.

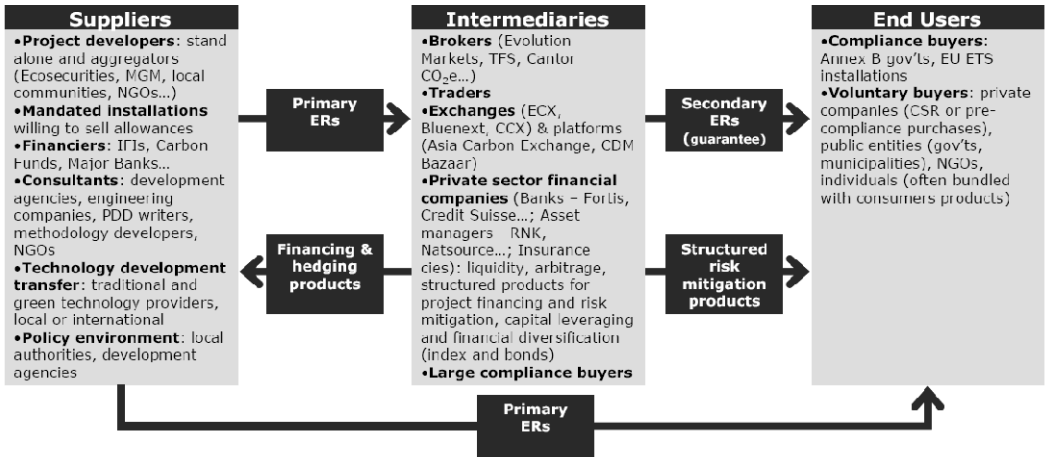
- Certified Emission Reductions (CERs): certificates issued by bodies of the UNFCCC for successful completion of Clean Development Mechanism (CDM) projects (project-based exchanges between industrialized countries and developing countries);
- Emission Reduction Units (ERUs): emission certificates issued for the successful completion of Joint Implementation (JI) projects (project-based exchanges between industrialized countries). Emission credits are accompanied by a corresponding transfer of emission caps;[55]
- Removal Units (RMUs): credits arising from emissions reductions created by countries by means of projects that reduce emissions, on the basis of land use, land-use change and forestry (LULUCF) activities. These project-based emission credits are only traded at country level, and can be used towards fulfilling national obligations as of 2008.

4.3.2 Financial Products and Intermediation

The Kyoto Protocol challenged the private sector to devise its own market solutions for trading emissions allowances, which should ultimately lead to a transparent carbon price that is intended to inform (energy) investment decisions. The financial services industry subsequently developed a range of contractual and financial instruments that allow companies to buy and sell allowances (to comply with legislation), to manage their emissions price risk, and to underwrite the economics of carbon-reducing investments (City of London et al., 2009).

By putting a price on carbon, emissions trading creates a whole new financial market, a market strongly linked to other commodity markets such as oil, coal and gas. As a result, managing climate change has also become the domain of managers with expertise in financial and commodity markets (Pinkse, 2007). These financial intermediaries include brokers, traders, exchanges and platforms, the private sector financial companies (e.g., banks, asset managers, insurance companies) and large compliance buyers (see Figure 9).

Figure 9 Players and Institutions in the Carbon Market



Source: (Capoor & Ambrosi, 2008)

[55] The formal crediting period for JI is aligned with the first commitment period of the Kyoto Protocol (Grubb et al., 2010).

Over the past years, the financial industry has created several financial products related to carbon trading, such as (Capoor & Ambrosi, 2008; City of London et al., 2009):

- Monetization of future carbon receivables: loans provided by financial institutions against future carbon credit proceeds in forward purchase contracts;
- Carbon delivery guarantees: credit enhancement and guarantees for the delivery obligation of primary market projects to secondary market buyers;
- Derivatives: e.g., swaps between CERs and EUAs and between CERs and ERUs, carbon spread options based on the differential price between CERs and EUAs, call options on future carbon credits[56];
- Insurance/guarantees: e.g., protection from pricing fluctuation, delivery risks and projects or credits eligibility under the regulatory schemes;
- Miscellaneous: e.g., green credit cards, carbon neutral products.[57]

In Europe, the imminence of EU ETS spurred the opening of a futures market in allowances in 2004. When EU ETS commenced in 2005, 7 brokers were operating in the market. In 2006 they had been joined by 5 exchanges. The European Climate Exchange (ECX), which manages the European Climate Exchange Financial Instruments (ECX CFI), is the largest futures market in terms of volume of operations and liquidity. Others include Nord Pool, Bluenext and the European Energy Exchange (EEX) share the remainder of the market (Abadie & Chamorro, 2008; Capoor & Ambrosi, 2008; Daskalakis, Psychoyios, & Markellos, 2009).[58]

In the years following 2004, futures have been dominant in EUA transactions (see Figure 10). In 2009, spot contracts became more substantial amounting to more than 22% of EUA transactions (Kossoy & Ambrosi, 2010).[59] The reason for this was that companies were cashing in on allowances in view of the tight credit environment and – with a slowly recovering economy – spot volumes have stabilized in 2010 accounting to 10-15% of EUA volume.[60]

56 Derivatives are traded either between two or more parties in over-the-counter markets (where trading is non-public and largely outside government regulation) or on exchanges (where trading is public, multilateral and closely regulated by governments and the exchanges themselves).

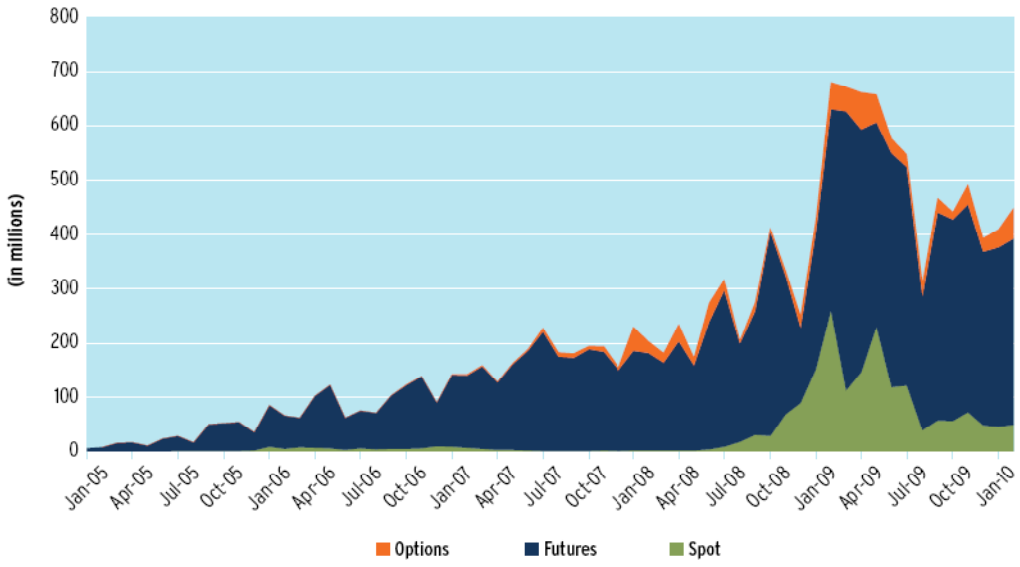
57 The financial sector is also constantly working on financial innovations in the field of carbon trading. For example, City of Londen et al. (2009) have proposed the issuance of carbon-linked bonds. These are government issued bonds where the base interest rate is fixed, but actual interest payments vary depending on whether or not the issuer keeps an environmental promise.

58 For up-to-date figures, see for instance www.ecx.eu.

59 In terms of volume (billions tCO_2e). EUA transactions totaled US$118,5billion in 2009.

60 For an elaborate overview of EU ETS spot, futures and option carbon markets and more information on the effect of the economic downturn on the European emission market, see Kossoy et al. (2010).

Figure 10 Monthly EUA trading



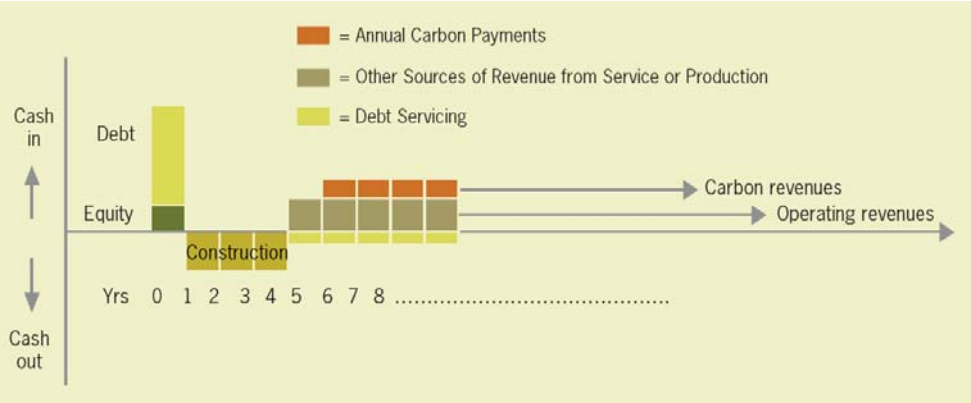
Source: (Kossoy & Ambrosi, 2010, p. 8)

Kossoy et al (2010) estimate the value of the EU ETS option market at US$10.6 billion in 2009. EUAs accounted for the major part of this – 83% compared to 17% in CERs. The carbon options market has matured and is behaving more and more like other option markets, with financial and technical trades outweighing asset-backed trades (i.e. trades for compliance purposes).

4.3.3 Carbon Finance

Carbon Finance (CF) refers to resources provided to activities generating (or expected to generate) GHG emission reductions through the transaction of the related emission reduction rights. It is the generic name for the revenue streams generated by projects from the sale of their GHG emission reductions, or from trading in carbon permits (Bosi, Cantor, & Spors, 2010; Kossoy & Ambrosi, 2010, p. 71). The orange blocks in Figure 11 exemplify the additional revenues from CF, which enhance the overall viability of low-carbon projects. CF plays a catalytic role in leveraging other sources of finance in support of low-carbon investments (debt and equity).

Figure 11 Additional project revenue streams provided by carbon finance

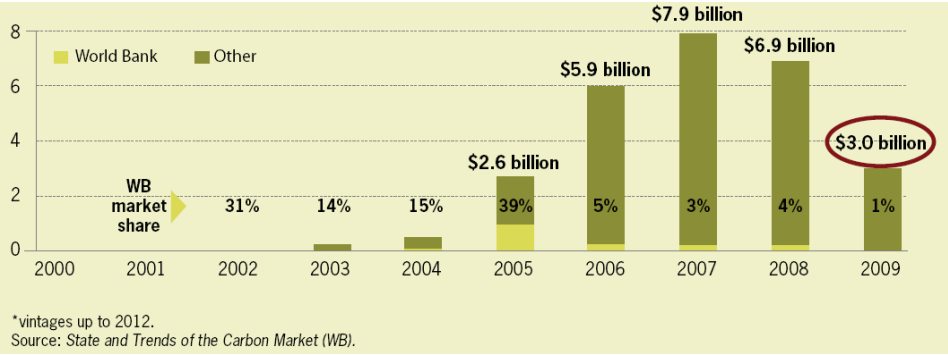


Source: (Bosi et al., 2010, p. 11)

Carbon finance is accessible through regulated mechanisms – project-based compliance markets such as CDMs and JI under the Kyoto Protocol – and through voluntary markets. Carbon finance, particularly under CDM, enables projects in developing countries to access additional sources of financing, provided they can demonstrate that the project is generating additional emission reductions – i.e., additional to those in the baseline or 'business-as-usual' (BAU) scenario (Ranade & Bhada, 2010).[61] The difference in (marginal) abatement costs between OECD and developing counties (short-run marginal abatement costs per ton CO_2 are at least 5 times lower in developing countries) implies international trade in emissions reduction credits is mutually beneficial (The World Bank, 2006).

The global market for GHG reductions through project-based transactions has doubled in value between 2006 and 2007, reaching US$ 13.6 billion in 2007, of which US$ 5.5 billion traded on the secondary CDM market (Girishankar, 2009). Figure 12 underlines the growing value of CDM and JI transactions until 2007, after which the market declined significantly in 2009, largely due to global economic downturn, the emergence of competing carbon assets (AAUs) and the approaching end of the first Kyoto Protocol commitment period in 2012, which closes the window for new projects that otherwise would have entered the CDM/JI pipeline (Bosi et al., 2010).

Figure 12 Value of CDM & JI transactions (per year)*



Source: (Bosi et al., 2010, p. 13)

[61] The challenge of additionality is further discussed in chapter 5.3.2..

The World Bank, in conjunction with public and private sector partners in the Prototype Carbon Fund (PCF), established the first global carbon fund in 2000. This is a compliance fund: the return for fund participants is their pro rata share of emission reductions generated by the fund portfolio and is thus not a financial return. Currently, there are 11 World Bank funds and facilities, including the administration of country carbon funds for Italy (ICF), Denmark (CCF), Spain (SCF) and the Netherlands (NCDMF and NECF). In terms of number of projects, the WB has one of the largest portfolios, with at present 211 active projects worldwide (Bosi et al., 2010). The World Bank Carbon Finance Unit (CFU) does not lend or grant resources to projects, but rather contracts to purchase project-based emission reductions in developing countries (CERs) and economies in transition (ERUs), paying for emission reductions annually or periodically once they have been verified by a third party auditor, using resources provided by governments and private participants in industrialized countries (Girishankar, 2009).

Investments in sustainable energy in developing countries are skewed towards the wealthiest nations within developing regions[62] which mirrors the presence of significant investment barriers in the poorest countries in these regions, e.g., lack of sources for funding (Girishankar, 2009; Kossoy & Ambrosi, 2010).

The World Bank identifies 5 actions that can make Carbon Finance fit better into public and private sector investment decision-making (Kossoy & Ambrosi, 2010):

- Scale up: expand demand-side of market (implementing more stringent emission reduction targets) and build a credible supply at scale;
- Long-term predictability (lengthier contracts and long-term pricing signals);
- Comprehensive insurance/guarantee products (e.g., underwrite political risks and contract-frustration risk at country and sector levels);
- Frontload future demand (e.g., the issuance of bonds and monetization of future receivables);[63]
- Combine (blend) limited financial resources.

[62] E.g., in 2008 88 % of investment in South America went to Brazil, while China and India jointly accounted for 80 % of investment in Asia/Oceania (Kossoy & Ambrosi, 2010, p. 42). Only 2 % of current and proximal global CDM/JI projects are located in Africa (Bosi et al., 2010).

[63] Payment for carbon credits generally occurs on delivery (i.e., once the project is operational, "pay-upon-performance"), as opposed to frontloading (advance payments). Monetization of Emission Reduction Purchase Agreements (ERPAs) is rare due to high inherent project risk, CF regulatory risk and market uncertainties (Kossoy & Ambrosi, 2010).

5 Assessing Carbon Trading

5.1 Introduction

It seems logical, 13 years after establishing the Kyoto Protocol and 5 years after the start of EU ETS, to evaluate carbon trade. Has it so far lived up to the high hopes and optimism surrounding its international implementation with Kyoto and – if not – how can it be improved? The latter has been touched upon by many authors, discussing a multitude of options which could contribute to a better functioning of specific carbon markets or carbon trading in general. More often than not however, the question *how* to assess functioning of trading and markets is not addressed.

There are exceptions. For instance, Hepburn (2007, p. 383) clearly defines the assessment process stating "[a]ssessment of the performance of current carbon trading arrangements requires two preliminary stages, namely the specification of a plausible counterfactual and the specification of criteria of assessment". Counterfactuals can range from 'no current nor future action' to 'full implementation of carbon reduction policies' implying a world of differences in the outcome of assessments. As assessment criteria Hepburn (2007) mentions "effectiveness (in delivering emission reductions), efficiency (at least cost) and equity (with acceptable distributional consequences)".

Although not always explicit, in most cases analysis seems focused on effectiveness, which requires a definition of the underlying goal(s). Examples include:

- Hepburn (2007) sees emission reductions as primary task of carbon trading arrangements, which should be achieved efficiently and respecting distributional consequences.
- Focusing on EU ETS regulation, Deutsche Bank (M. C. Lewis & Curien, 2009, p. 16) also sees this as one of the aims but adds "incentivizing CCS technology for power generation such that it becomes commercially viable by 2020, and providing proof that a market can achieve this in a cost-efficient, transparent and predictable manner".
- According to Environmental Audit Committee (2010, p. 9) the EU ETs has twin objectives, namely "limiting emissions and encouraging investment in low-carbon technology".
- The World Economic Forum (WEF, 2009, p. 35) sees as the intention of carbon markets to "put a price on emissions that have until now been cost-free, and second to allow trade in permits, so that those who can most easily reduce emissions have the greatest incentives to do so". In its 2010 Green Investing report the pricing goal is further detailed as providing "a price signal which shifts investment decisions towards low-carbon technologies" (WEF, 2010, p. 47).

Keeping in mind that most authors (more or less explicitly) see reducing carbon emissions as the primary goal, this chapter first provides an overview of literature on accomplishments of Kyoto and EU ETS in terms of emission reduction. It subsequently investigates relating issues and

potential improvements to these systems.[64] Thereafter the more indirect channel towards emission reduction is discussed: how do carbon markets/prices influence decisions on emission reduction investments?

5.2 Kyoto Mechanisms: Emissions Trading

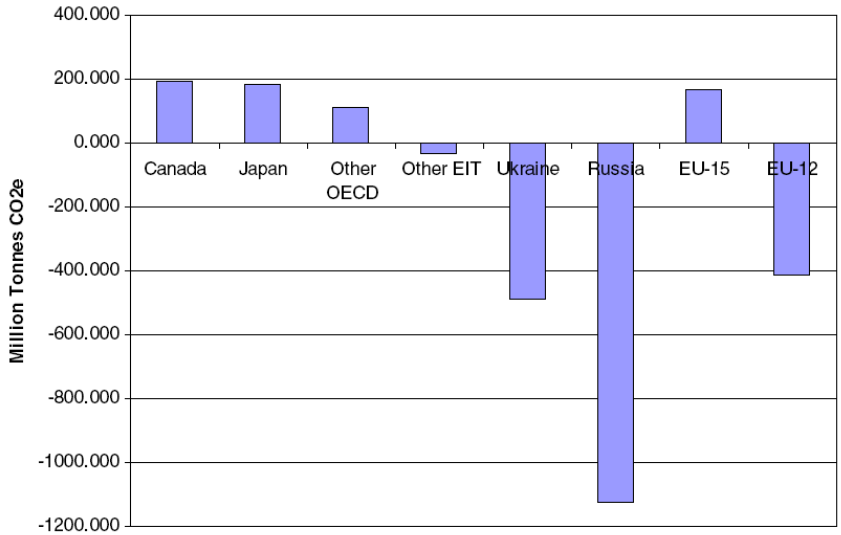
5.2.1 Accomplishments

Under the Kyoto Protocol governments can trade emission rights (AAUs, see chapter 4). Trade in AAUs however has been minimal, accounting for less than 1 % of total $MtCO_2e$ volume traded on allowance markets in 2009 (Kossoy & Ambrosi, 2010). This mechanism has obviously failed to contribute to climate change in its original design.

5.2.2 Issues and Potential Improvements

The primary reason for the low level of trade is the high targets set under Kyoto, causing concerns on the environmental legitimacy of trading in AAUs. Although not intended to be lax, especially targets for former Soviet Union and east European countries failed to impose real constraints because baseline projections overestimated economic developments in the 90s.[65] Emissions of these countries remained well below Kyoto targets, "for reasons that have little to do with their climate change policies" (Grubb et al., 2010), as is illustrated in Figure 13. Because this surplus has not resulted from efforts to transition to a low-carbon economy, it is widely referred to as *hot air*.

Figure 13 Kyoto targets set too high



Source: (Grubb et al., 2010); 2007 emissions relative to Kyoto targets; based on UNFCCC data as at 10-2009

64 For sake of reference: an idea of the magnitude of the environmental challenge can be derived from the IEA World Energy Outlook scenario's (IEA, 2008). Starting from a baseline in 2005 of 27,000 mega tonnes (Mt) of CO_2 emissions, its Reference scenario (i.e. status quo) results in emissions of 40,000 Mt in 2030. The 450ppm (i.e. the required CO_2 concentration level) results in emissions of 25,700 Mt in 2030.

65 These countries faced a recession following the collapse of the Soviet Union.

Trading in AAUs would therefore in many cases give countries with a shortage of emission rights the opportunity to fulfill their targets by buying AAUs without requiring additional emission reduction effort by the country selling the rights. Some countries, including Austria, Germany, and The Netherlands, have stated that they will not buy hot air unless payments are "greened" by being directed to producing other environmental benefits (Hepburn, 2007).[66]

By linking the proceeds of selling (hot air) AAUs to projects that would reduce emissions – so-called Green Investment Schemes (GIS) – transition countries have found a way to monetize their excess AAUs favoring emission reduction.[67] Although challenges remain, mainly in credibly linking proceeds to sound emission reduction, this is a promising development. The first trade of allowances to fund GIS has only materialized in 2008 due to required legislation, making it is too early to evaluate experience (Carbon Trust & Climate Strategies, 2009).

5.3 Kyoto Mechanisms: CDM and JI

5.3.1 Accomplishments

Clean Development Mechanism (CDM) and Joint Implementation (JI) are project-based mechanisms under the Kyoto Protocol. Whereas CDM has been a greater success in terms of emission savings than expected (Grubb et al., 2010), JI saw a slow start with projected emission savings in 2012 only amounting to 10% that of CDM (based on projects submitted per 9-2008 (Carbon Trust & Climate Strategies, 2009)). The first reason for this is that the formal crediting period of JI was aligned with the first commitment period of Kyoto, which started later than expected - in 2008.[68] In anticipation of this, the first JI projects were initiated late 2006. Administrative processes were an issue as well. Track 2 JI projects (see chapter 3) must pass a verification procedure. Independent Entities (IEs), responsible for verifying projects, could not cope with the large demand for project determination. In addition, Central European countries entering the EU joined the EU ETS in which they could trade emission reductions more effectively and obtain higher prices than under JI (Korppoo & Gassan-zade, 2008). According to New Energy Finance the trade volume of JI will remain low until 2012 (NEF, 2009).

As said, CDM has proven to be a success. It is the dominant mechanism within Kyoto. One of CDM's main objectives is to involve developing countries in climate change, being essential for total emission reductions.[69] The mechanism has lived up to this primary task, having played "an important role in driving private-sector interest in projects to reduce emissions [in developing countries]" (Hepburn, 2007, p. 385). In terms of financial flows, UNFCCC estimates the value of CDM credits amounting to US$ 4.5-8.5 billion per year, with an expected private capital leverage multiple of ten (UNFCCC, 2008).[70] More conservatively, WEF (2010) states that CDM will have stimulated roughly US$15bn low carbon investment flows from developed to developing

66 That trading has been low can be seen as a failure of system-design but on the other hand also as a success in culture shift: market parties have not (fully) exploited hot air potential at the cost of climate change.
67 GIS is distinctively different from CDM and JI, since the former involves up-front finance (as opposed to finance against future emission credits of CDM and JI projects) and it is led by governments as part of national strategies complying with Kyoto obligations (Grubb et al., 2010; Hepburn, 2007).
68 Compared to CDM starting in 2000.
69 See for instance IEA (2007) and Wagner et al. (2009).
70 JI credits are included in this figure.

countries by the end of 2012.[71] Underlining measurement difficulties, Grubb et al. (2010) conclude "the Mechanisms clearly represent a substantial share – perhaps a quarter to a half – of the total mitigation technology investment in developing countries".

The starting period of the mechanism saw focus of investments in hydrofluorocarbons (HFC-23, industrial gases used in refrigerators). These gases have high (adverse) climate change potential compared to CO_2 but require only modest investments (Pinkse, 2007; WEF, 2009). Although attracting criticism (see below), this is also used to indicate the efficiency of CDM – stimulating emission reductions at low cost (Hepburn, 2007).

Carbon Trust & Climate Strategies (2009) assess the performance of CDM projects in terms of actual versus expected CERs produced and find that 'project type' is the dominant driver in determining whether projects live up to expectations.[72] Other factors include project size (smaller projects have higher yield) and host country (in terms of e.g., investment stability).[73]

5.3.2 Issues and Potential Improvements

Required Funding

It is important to see the above accomplishments, positive as they are, in perspective. According to McKinsey, total mitigation funding needs by developing countries amount to US$ 300 billion (in 2005$) per year (McKinsey&Company, 2009). Evidently, there is still a long way to go and carbon trading cannot be expected to fulfill total investment needs – it should go hand-in-hand with other public and private funding solutions. Lewis (2010) concludes that "the scale of CDM mitigation currently occurring in developing countries is insufficient", partly based on previous findings by (Hultman, 2009; Schneider, 2007; Teng, Chen, & He, 2008; Wara, 2009). However, both from a political point of view as well as from an effectiveness standpoint, it seems impossible to expect that developed countries will buy the CERs representing the total required investments in the developing countries. This was underlined after the G8 in 2008, where it was stated that all of the major economies, including China, should take additional action to reduce emissions (G8, 2008).[74]

Additionality

One of the most hotly debated issues of the CDM mechanism from the start, is project additionality (Grubb et al., 2010; J. I. Lewis, 2010; NEF, 2009).[75] Because host countries of CDM projects are not restricted by emission caps, the CDM mechanism effectively creates new emission credits. In other words, "[i]f carbon finance is being used to promote renewable energy projects that are not necessarily replacing fossil fuel energy projects, then they may not be contributing to a deviation from business as usual greenhouse gas emission, and may in fact be

71 This immediately points to the measurement challenge. Background of the difference between the two estimates are not clear.

72 E.g., in terms of technology used, N_2O projects have the highest yield.

73 For a more detailed analysis of CDM project performance, see for instance New Carbon Finance (2008), 'False expectation: why CDM projects underperform'.

74 One of the options to address this problem is introducing an emission cap on (some) developing countries. For an analysis of the difference in impact on incentives to invest between the two mechanisms – CDM versus a cap for developing countries – see for instance Hagem (2009).

75 A condition for the approval of a CDM project is that the reduction achieved by the project shall be additional to any that would occur without project activity (UNFCCC, 1998, article 12). The problem with this criterion is that it must be based on a counterfactual baseline for emissions (Hagem, 2009).

contributing to global emissions by allowing developed countries to emit more as they offset their reduction targets with these projects" (J. I. Lewis, 2010, p. 8).

It is therefore essential that reductions are explicitly assessed as 'additional' to those that would occur without the project. The CDM Executive Board governs assessment of additionality. This has proven to be a challenging task, prone to a lack of certainty due to its subjective nature and focus on judgment.[76]

A major concern regards the incentives for sellers and buyers alike to inflate baseline emissions to maximize emission reduction of the CDM. To this end, 'bad policies' – policies driving up baseline emissions – that are implemented after adoption of the Kyoto Protocol are not taken into account when assessing additionality (the 'E+' rule). On the other hand, policies directed at low-carbon technologies are also not taken into account so as not to diminish incentives to implement 'good policies' (the 'E-' rule). Performance of additionality assessment shows mixed results and is expected to become more challenging as time goes by (Grubb et al., 2010).[77] In terms of future development or improvement, the authors conclude "[a]n honest political debate is required based on recognition that project-by-project additionality is an imperfect art with an unavoidable trade-off between administrative costs and the level of assurance".[78]

Although different in nature, JI faces similar challenges. Especially in terms of the relatively young GIS practice, more attention is required to establish norms of good conduct – like the E+ and E- rules for CMD – including international oversight.

Coverage

The majority of supply of CDM credits is concentrated in relatively few countries (China has a share of 59% (WEF, 2010)). Especially the small role of African countries and the least developed countries has attracted criticism. In this regard, the mechanism does not address emission reduction in the poorest countries. In addition, focus has been on only a few sectors (energy supply, industry and waste), while other sectors like energy efficiency in building or forestry have been largely left untouched. This limits the mechanism to exploit its full potential – covering only some 50% of total mitigation potential (Grubb et al., 2010). The background for this can differ per type of project. For instance, McKinsey's abatement cost curve shows that most energy efficiency project have *negative net cost*, implying they should be financially attractive.[79] Apparently, other barriers prevent these projects from being funded and thus the CDM mechanism from being effective.[80] These barriers should be addressed before the abatement potential will be exploited. On the other hand, the abatement cost curve also shows projects with *positive net cost*, implying a requirement for additional policy support for them to become financially interesting.

---

76 Notwithstanding the design of various methodologies to assess additionality.

77 The main reason for this is that the number of projects initiated before start of CDM is decreasing. For more information on assessment of CDM additionality, see for instance: Michaelowa et al (2008).

78 According to (Bosi et al., 2010) the problem could be mitigated by exogenous criteria, standards and benchmarks.

79 McKinsey (2009) defines a global abatement cost curve, categorizing abatement opportunities in terms of costs and abatement potential. Costs are taken net of potential energy savings and are referred to as 'net costs'.

80 For more information on barriers to SE investments, see the separate report on *Financing the transition to sustainable energy* (Kerste & Weda, 2010).

As stated above, initial focus was on non-CO_2 gases. This meant that investments were flowing to a small part of industry sectors, not addressing the lock-in risk of investments in high-carbon assets by the energy sector. As such, the design of the mechanism does not provide clear signals regarding the key technologies of central importance (Hepburn, 2007). Notwithstanding this, the share of credits referring to renewable energy (RE) and energy efficiency (EE) projects has been increasing. With the potential for industrial gas projects getting exhausted, RE and EE are expected to amount to 60% by 2012 (WEF, 2010). This focus on high-yielding projects has spurred criticism on the excessive profits made in the system. It is, however, not surprising that a new market provides excessive opportunities at start (inframarginal rents) which is not 'wrong' in terms of market economics principles (Grubb et al., 2010).

Economic Efficiency

Transaction costs of CDMs are high. For a large part this is caused by the necessity to prove additionality on a project-by-project basis – maybe a logical requirement but certainly not an easy one to live up to. Bureaucracy is extensive (Lewis, 2010), while the approval process is long and laborious (Grubb et al., 2010). Early experience showed transaction costs amounting to several hundred thousands Euros per project (Fichtner, Graehl, & Rentz, 2003; Michaelowa, Stronzik, Eckermann, & Hunt, 2003). Simplified rules for smaller projects – by now presenting almost half of the projects – have decreased costs.[81]

Concerns continue with regards to timely verification and validation of projects in the system, as well as the issuance of credits with increasing number of projects. Both indicate the need for additional capacity in the Executive Board.

5.4 EU ETS

5.4.1 Accomplishments

The Environmental Audit Committee indicates "[t]he effectiveness of the EU ETS will be determined primarily by its success in reducing emissions" (Environmental Audit Committee, 2010, p. 9).[82] Although Phase I (2005-2007) showed an increase in emissions, caused by overallocation of permits, it is generally not seen as a failure but as a success – mainly in terms of the implementation of the system as such (Environmental Audit Committee, 2010; Hepburn, 2007). The EU ETS Phase I laid the groundwork, correctly measuring and recording emissions (NEF, 2009).

But maybe the main achievement of the system has been that it resulted in an explicit carbon price (Hepburn, 2007). The question whether this has prompted abatement efforts is more difficult to answer.[83] In general, EAC (2010) points to the difficulties to assess effectiveness of the EU ETS. Reasons include that it is "impossible" to separate effects from the impact of

81 For a more detailed review of how to streamline the CDM processes, see for instance Purdy (2009).

82 At the same time, the EAC points to the difficulties to assess effectiveness of the EU ETS. Reasons include that it is "impossible" to separate effects from the impact of economic factors and policy instruments and that emissions at or below the cap do not necessarily imply success because of potential over-allocation of emnission rights.

83 Hepburn (2007) provides some evidence to support a positive answer, based on surveys and other "tentative" results.

economic factors and policy instruments, and that emissions at or below the cap do not necessarily imply success because of potential over-allocation of emission rights.

5.4.2 Issues and Potential Improvements

Cap Level

Cap levels during the ETS pilot trading period (2005-2007) were too high (Clò, 2009; Environmental Audit Committee, 2010; M. C. Lewis & Curien, 2009; Pearson & Worthington, 2009). This results in an abundance of allowances (or a lack of permits scarcity) and therefore a falling CO_2 price and insignificant incentives to reduce emissions. During the pilot phase of the EU ETS the emission reduction burden imposed on *ETS sectors* was thus too weak. Indirectly, the amount of emissions the *non-trading sectors* should have abated to grant compliance with the Kyoto target was excessive when compared to their abatement potential and marginal abatement costs (Clò, 2009, 2010; Kettner, Koeppl, Schleicher, & Thenius, 2007; Neuhoff, Keats, & Sato, 2006).[84]

Phase II again is expected to show over-allocation (Carbon Trust & Climate Strategies, 2009; Environmental Audit Committee, 2010; M. C. Lewis & Curien, 2010; Pearson & Worthington, 2009). The recession is an important reason for this, lowering emissions without underlying efforts towards a low-carbon economy. In addition, though reduced compared to Phase I, caps were unevenly distributed, posing stringent caps on the power sector while providing the industrial sector allowances based on business-as-usual projections.[85] Shortfall in the power sector can therefore be purchased from the industrial sector without much additional reduction effort. Finally, the New Entrants Reserve (NER)[86] is gaining permits due to the recession instead of disbursing them to new entrants. These permits are expected to be given away by most countries, effectively weakening the emission caps because no emission reduction are attached to these permits (Pearson & Worthington, 2009). In its update on emission shortfall/surplus of January 2010, Deutsche Bank shows that it is whether or not NERs are released during Phase II will determine the difference between a surplus or (a small) short position. In order to address the surplus in Phase II, a.o. Sandbag (Pearson & Worthington, 2009) advices to cancel excess NERs – as already committed to by France and Ireland – and to provide incentives to companies to cancel permits 'voluntary' (e.g., by means of tax measures). Others advocate tightening post-2020 caps, which are not set in stone yet, providing signals to affect the current price level (for instance Tilford (2009)).[87]

Given these former inefficiencies and in the light of the European unilateral commitment to a stricter emission reduction target, the new ETS Directive 2009/29/EC imposes for the third post-Kyoto trading period (2013-2020) a progressively stricter cap, making the ETS regulation each year costlier (Clò, 2010). Deutsche Bank (M. C. Lewis & Curien, 2010) indeed estimates a short position during Phase III.

---

84 Emission reductions in line with commitments under the Kyoto Protocol are divided over sectors which are part of EU ETS (the trading sectors) and those that are not. The latter category should be stimulated to reduce emission in other ways, e.g., public policy instruments.

85 Industry was thus provided with 'hot air' emission permits.

86 The EU ETS allows member states to set aside a national pool of spare allowances for new or expanding industrial installations. Unused allocations from installations that are closed down are also added to this pool of allowances.

87 This only works if the market is efficient and reacts now to future (expected) developments, which is subject to discussion. See below under 'Price signals'.

Options to further support more efficient cap levels include buying emission units for retirement by leading industrialized countries (although politically difficult in this time of recession in view of the costs involved), early commitment to increase post-2012 emission cutbacks in advance of global agreement, and protection against import from e.g., CERs although this would isolate Europe from global mechanisms and distort international price (Carbon Trust & Climate Strategies, 2009).

Allocation of Permits

Determination of National Allocation Plans (NAPs) is not without its pitfalls, as it involves asymmetric information and lobbying. Governments are relying on companies to reveal their abatement cost curve in order to determine an appropriate NAP. Companies however have an incentive to exaggerate their cost estimates in order to obtain a more generous allowance and a looser emission cap (Abadie & Chamorro, 2008; Hepburn, 2007).

In Phase I and Phase II, emission rights have largely been given away for free.[88] This so-called grandfathering of emission rights has been subject of criticism In the new ETS Directive this has been addressed by a bigger role for auctioning. To avoid 'carbon leakage' – substantial asymmetric costs on the European companies forcing them to either shut down plants or move their production activity to non-EU countries – the directive defines a hybrid system of grandfathering and auctioning:

- energy sectors: full auctioning from 2013 onwards;
- energy intensive sectors not exposed to carbon leakage: 80% grandfathering in 2013, gradually declining to 30% in 2020 and full auctioning in 2027;
- energy intensive sectors exposed to carbon leakage: pure grandfathering (see also chapter 3.1.2).

Clò (2010) analyses this aspect of the new directive and concludes that (i) grandfathering does not necessarily reduce the risk of carbon leakage because Phase III includes – unilaterally – a more stringent cap on European industry; (ii) the criteria to determine whether sectors are exposed to leakage risk are highly arbitrary and inefficient; and (iii) despite its declared intentions grandfathering remains dominant under the new directive for the ETS manufacturing sectors. The first conclusion should be seen in light of general pros and cons of grandfathering versus auctioning, as discussed in chapter 3. The second conclusion implies room for further research on the determination of carbon leakage risk per sector based on sound economic principles. As to the third conclusion, with auctioning as default for the energy sector which covers 65% of emissions within ETS, auctioning will still become the dominant overall mechanism in assigning EUAs in Phase III (Kossoy & Ambrosi, 2010). The importance of this point also depends on further work in terms of the second conclusion: the high percentage grandfathering in the manufacturing industries is the result of an arbitrary method; if sound economic reasoning would result in an equally high share of manufacturing industry being exposed to carbon leakage, grandfathering as a dominating mechanism might be justifiable for these sectors.

[88] Under the ETS, utilities have received at least 95 % of the allocated permits for 2005-2007 free of charge. For 2008-2012, this percentage drops to 90 %.

Price Signals

Coming to an explicit carbon price has been an essential part of EU ETS – pricing carbon emissions means pricing externalities and providing incentives for low-carbon investments. Emission prices (and revenues from potential emission sales) are included in investment decisions. Evidently, incentives diminish with a decreasing price-level as well as with volatility of prices, making it more difficult to predict future price levels. Figure 14 shows the development of carbon price within the EU ETS.

Figure 14 EU ETS emissions allowance prices: April 2005 – December 2009

Source: (Environmental Audit Committee, 2010, p. 21)

The figure shows how the carbon price has developed towards zero during Phase I due to caps being too low. A good start in Phase II was again followed by a sharp decline in price level during the second half of 2008 and 2009. This does not necessarily mean the market is not functioning well. On the contrary, a declining price due to the recession is a sign of natural adaption to changed circumstances and thus showing market flexibility. This is however not the whole story. Because of full bankability of Phase II allowances in Phase III, in an efficient market compliance parties with short positions (over the entire period of Phase II and III) would buy now in view of the low prices.[89] In other words, in a rational market, "the mechanism mandating the bankability of EUAs should ensure that today's price trades at the level required to clear the market in Phase 3 adjusted for the time value of money" (M. C. Lewis & Curien, 2009, p. 27).[90] According to the authors, there are two reasons why this is not happening:

1. *Supply of EUAs is fixed to 2020*
   Uncertain demand – how prolonged will the recession be? – leads to volatile demand. In efficient markets supply would adapt to changing demand. This is not possible in the EU ETS, preventing the market to be cleared. Deutsche Bank (M. C. Lewis & Curien,

[89] Important in this regard is that 2008-2020 is expected to show a net short position on average, even after correcting for the use of CERs and ERUs and the net demand of the aviation sector (M. C. Lewis & Curien, 2010).

[90] For further theoretical background on this, see the Deutsche Bank reports 'Banking on Higher Prices' and 'It takes CO2 to Contango'.

2009) proposes to introduce targets subject to periodic review or even introduce some sort of central bank for allowances.[91] Although this seems to add to market uncertainty, Deutsche Bank advocates that it forces market participants to take into account what authorities want to achieve on the long term. Further research on this option seems appropriate.

2. *Free allocation of allowances*
   Because all installations start off with a long position, they behave differently then when they had to buy permits as they go. Grandfathering thus leads to market distortions, reducing market efficiency. For instance, because many installations have been given more allowances than needed they have an incentive to sell permits in times of need for cash while facing a reluctant credit environment – even if they might need these permits in the future.

The low carbon price has led many to advocate – in addition to lower caps – implementing reserve price auctions, or at least further investigate this option (Carbon Trust & Climate Strategies, 2009; Environmental Audit Committee, 2010; Grubb et al., 2009; M. C. Lewis & Curien, 2009; Pearson & Worthington, 2009; Tilford, 2009).[92] The general idea is to set a minimum price level for the EAUs to be auctioned in Phase III. If the price falls below this level, permits are not sold, effectively resulting in withdrawal of permits from the market.[93] Deutsche Bank (M. C. Lewis & Curien, 2009) concludes that the Directive does not prohibit setting reserve prices, although a final conclusion taking the "spirit of the text" into consideration is open to debate.[94]

Long-term Incentives

The Phases within EU ETS design, as is the case in Kyoto, are relatively short. Investments in energy generating assets, however, are based on expectation over decades. Regulation uncertainty on future Phases can result in suboptimal investment decisions (Hepburn, 2007).[95] By lengthening the trading allowance periods, more certainty would be created for companies involved. In addition, there is less chance of betting on Emission Trading failure – e.g., by building fossil-fueled power plants – and less opportunity for companies to influence policy design by lobbying for a generous allocation (Pinkse, 2007).

Policy Overcrowding

Policy measures to decrease CO_2 emission aimed at the sectors under the EU ETS, reduce effectiveness of emission trading . Generally, emission reduction projections in view of setting emission caps do not take emission reduction policies into account (Carbon Trust & Climate

91 This requires a change of the Directive.

92 Interestingly, in reaction to recent solutions proposed in this direction in the UK, (anonymous) employees of the European Commission stated that intervention is not expected. Reasons lie in EC policy not to react to short term developments as investments are based on long term expectations. In short, prices should reflect (long term) supply and demand (press release, http://www.businessweek.com/news/2010-02-08/u-k-lawmakers-call-for-stricter-co2-caps-market-intervention.html). Evidently, this opposes the analysis by Deutsche Bank - discussed above - on market inefficiencies.

93 Exact design varies between authors. For additional background information, see for instance: Hepburn et al. (2006) and Grubb et al. (2006).

94 More practical, a problem might arise due to allowances not going to the market preventing full bankability.

95 Future policy decisions will impact price of allowances and thus business cases surrounding energy investments. Regulatory risk will be included in business case metrics, which is economically logical from the perspective of the investor but might lead to sub optimality in terms of climate change. The longer policy is 'fixed', the lower the regulatory risk.

Strategies, 2009). That means that when emissions are reduced due to policy measures, it will be easier for companies to fulfil their emission obligations without having to buy rights or invest in emission reduction. For instance, subsidizing a certain renewable energy technology is intended to decrease emissions in that sector. If the emission cap is not reduced, meeting obligations is (partly) funded by society and companies do not face incentives to (further) decrease emissions. New climate policies within the boundary of the cap-and-trade scheme aiming to reduce emissions should therefore be combined with an equal reduction in emission caps to ensure the emission reduction actually takes place (Blyth, 2010).[96]

5.5 Impact on Emission Reduction Investment Decisions

5.5.1 Impact on Cash Flows and Risk

Emissions trading impacts cash flows in a given period through four mechanisms (Abadie & Chamorro, 2008; Laurikka & Koljonen, 2006):

1. existing cost categories: fuel costs;
2. new costs: the value of surrendered allowances;
3. energy outputs: the price of power and heat; and
4. additional revenues: free allowances.

The most direct channel is via allowance prices (for more information on determination of emission price and its volatility, see chapter 4).Because carbon prices influence cash flows the uncertainty surrounding these prices poses a risk to be taken into account in assessing the cost of capital[97] (Abadie & Chamorro, 2008). In addition to the direct effect of volatile emission prices on revenues of selling and costs of buying these rights, the way in which CO_2 and fuel price variations feed through to electricity price variations is an important determinant of the overall investment risk. In their thorough report on climate policy uncertainty and investment risk IEA (2007)[98] have modelled two elements of price uncertainty

- policy risk: reflected by a one-off price jump;
- (market) price volatility: reflected by an annual price fluctuation.

The authors have thus separated the total effect of changes in prices in a policy and a volatility effect. In general, they find that policy uncertainty is the dominant factor in the risk premium.

Policy Uncertainty

Public policy impacts pricing of carbon emissions. The international carbon cap-and-trade market is a direct consequence of regulation, reflected in international law (Kyoto Protocol) with part of practical requirements – like NAP-levels – determined at country level. At a supranational level

[96] In reality, policy measures as such do not decrease emissions. In many cases, governments provide financial incentives to decrease emission. This still requires companies to take action. The point here is that these policy initiatives should be aligned with cap-and-trade regulation so as not to undermine the incentives that are at the heart of carbon trading.

[97] Or: discount rate. Note that also in developing countries, which are not restricted by emission caps, projects will have to take these cash flow and risk impact into account.

[98] The report looks at how investments by the power sector in coal, gas, oil, nuclear and CCS technologies is affected by climate change policy uncertainty. Their conclusions are based on a quantitative analysis and provides a conceptual framework to assess the scale of effects of policy uncertainty.

governments have imposed emission caps, thereby determining total supply. In addition, market mechanisms have been created to facilitate a match of supply and demand. City of London et al. (2009, p. 5) conclude "[t]o ensure that scarce investment resources are deployed on the climate change mitigation effort, institutions and businesses need firm regulatory ground on which to base their investment decisions. However, recently businesses have been receiving mixed messages from politicians around the world". As an important recent example, outcome of Copenhagen have resulted in "a significant step backwards" for prospects of international carbon markets (Blyth, 2010). Also, the recent developments in the US imply serious uncertainty for the future of CO_2 pricing.

Climate policy risk will not impact all investment business cases in the same way. IEA (2007) indicates:

- policy risk will be greater for investment decisions made close to a potential policy change. This is relevant for the timing of policy setting: regulation should be announced well ahead of implementation. A practical example is the post-2012 regime which is drawing closer without clarity on its design;
- policy risk is more pronounced if climate policy is a dominant economic driver. For instance, Carbon Capture and Storage (CCS) exists because of climate policy and will thus be relatively sensitive to regulatory risk;
- price-regulated sectors will be dependent on the regulator for the degree to which price increases can be passed through to consumers, which could increase the impact of policy risk;
- risk premiums depend on the technology being considered, the market context and the exact climate change policy mechanism under consideration.

With specific regard to CDM projects, J.I. Lewis (2010) points to the uncertainty of project approval. The incoming cash flows by selling the emission rights are therefore an uncertain parameter. The author concludes that "while the CDM could certainly help tip a project that is on the borderline of being profitable towards profitability, this is unlikely to be a sufficient factor for determining whether to invest in the first place".

Low-carbon investment business cases require assessment of expectations over the long term (see previous paragraph). In terms of regulatory risk, this implies that public policy should provide clarity on future direction and design and the comfort this will be adhered to. Hepburn (2007) points to short commitment periods in both the Kyoto protocol and EU ETS, preventing investors to properly assess return on low-carbon assets. IEA (2007) indicate that the period of 5 to 15 years into the future is generally the most important period to recoup investments. Policy should therefore be fixed for a period of approximately 10 years ahead. Their results suggest that "climate policy risk may be brought down to modest levels compared to other risks if policy is set over a sufficiently long timescale into the future".[99] A second prerequisite is signaling creditability that 'fixed' really means fixed. In other words, promising that policy will not change is as valuable as the degree to which policy makers have not broken their promises in the past.

[99] Climate policy which is set over a sufficiently long time results in fuel price risk being the dominant variable, with policy risk only contributing relatively little.

In conclusion, companies will have to incorporate regulatory risk surrounding carbon markets in business cases for low-carbon investments. In practice, this is generally reflected in the cost of capital. Based on their findings IEA (2007) do not see policy risk as a serious threat to capacity levels in the long run but do indicate that it weakens investment incentives for low-carbon technologies.[100]

5.5.2 Long-Term Investment Decisions

Carbon pricing/emissions trading tends to under-deliver on investment in long-term solutions. There are three main reasons for this. First, markets may under-deliver on investment in R&D if companies are unable to retain the eventual commercial – emission reduction – benefits of such expenditure.[101] Second, there is a moral hazard problem in long-term investment incentives stemming from regulatory uncertainty: future governments may not feel bound by the commitments of their predecessors to provide continued levels of pay-off that are sufficiently high to recoup companies' initial investments. Third, emissions trading enables opportunistic behaviour of carbon traders. Emission credits that can be purchased on the market, sometimes represent reductions achieved through reductions from projects that merely utilize existing technologies or over-allocation of allowances, therefore not realizing one of the key arguments of an emissions trading scheme: to spur innovation and motivate firms to invest in more sustainable production technologies that lower GHG emissions (Pinkse, 2007). Finally, some authors argue that carbon market risks tend to accumulate in a non-linear way: the variance in possible prices increases at an accelerating rate over time. This means that the long-term risk profile (more than 25 years ahead) is disproportionately higher than the medium-term risk profile, and that companies tend to discount any price signals (e.g., policy announcements and targets) at a higher rate if they refer to longer timescales. This phenomenon is amplified by risk aversion on the part of companies. If companies apply a discount rate that increases over time, there is a growing divergence with the socially optimal discount rate for environment-related projects, which most economists argue should *decrease* over time (Blyth, 2010; Gagelmann & Frondel, 2005; Menanteau, Finon, & Lamy, 2003; Pinkse, 2007).

5.5.3 Project Selection and Threshold Prices

Companies under a cap-and-trade scheme have the choice between investing in emission reduction projects in order to stay within their emission cap or even obtain excess emission rights they can sell on the one hand and purchasing emission rights for emission above their cap level on the other.[102]

Generally, the carbon market price is assessed too low (for instance: WEF (2009); City of London et al. (2009)). With the recent developments in carbon prices there does not seem to be much debate about this conclusion. Various authors provide more perspective to this discussion by analyzing the threshold carbon price necessary to make investments in specific low-carbon technologies financially attractive – mostly with a focus on Carbon Capture Storage (see for

100 Finally, it is valid to question whether companies are able to cope with policy risks or whether governments should underwrite them. For additional information on policy instruments and regulatory risk, see the separate report on *Financing the transition to sustainable energy* (Kerste & Weda, 2010).

101 This type of market failure – positive externalities – creates a rationale for (additional) grants for the development of new technologies.

102 Choices can be made based on various selection methodologies, including Net Present Value, cost/benefit analysis (CBA) and real option theory. See for instance Copeland et al. (2000).

instance Abadie & Chamorro (2008) quoting results of (Blyth et al., 2007; Martinsen, Linssen, Markewitz, & Vögele, 2007; Newell, Jaffe, & Stavins, 2006; Sekar, Parsons, Herzog, & Jacoby, 2007)). The choice between investing in projects to reduce emissions or purchasing emission allowances (or a combination of these two) implies the need for project selection methodologies. Project selection will normally be based on standard finance theory (Net Present Value) or cost/benefit analysis. Risks will be reflected in the discount rate, with the choice for the cost of capital potentially having significant impact on the outcome of the business case. In case managers face options to change course during a project or are able to postpone investments[103], real option analysis might be used facilitating risk-neutral valuation based on the risk-free rate.[104] In determining threshold prices, many times 'trigger' prices are determined above which it is optimal to invest in emission reducing projects *immediately*, i.e., when the value of the option to invest is highest. Real option analysis can be used for this kind of exercise. This also has the benefit that the riskless rate of return can be used instead of having to value project risk, both on the revenue and on the expenditure side.

Evidently, calculation of threshold prices and the outcome of project selection depends on the choice between these methodologies – as well as the choice for a discount rate when discounting cash flows.[105] As yet, no clear consensus seems to appear, on methodology nor on final threshold prices.[106] More research is needed in this field.

103 Called 'managerial flexibility'.
104 For more information on real option analysis, see for instance Copeland & Keenan (1998).
105 In addition, the choice for the econometric calculation methods (models) applied are also of importance.
106 A quick check results in threshold prices calculated for CCS varying between 12 and 55 €/ton CO_2.

References

Abadie, L. M., & Chamorro, J. M. (2008). European CO2 prices and carbon capture investments. *Energy Economics, 30*(6), 2992-3015.

Alberola, E., Chevallier, J., & Chèze, B. (2009). Emissions compliances and carbon prices under the EU ETS: A country specific analysis of industrial sectors. *Journal of Policy Modeling, 31*(3), 446-462.

Anger, A. (2009). Including aviation in the European emissions trading scheme: Impacts on the industry, CO2 emissions and macroeconomic activity in the EU. *Journal of Air Transport Management, 16*, 100-105.

Betsill, M. M., & Hoffmann, M. J. (2009). *Constructing "Cap and Trade": The Evolution of Emissions Trading Systems for Greenhouse Gases.* Paper presented at the Open Meeting of the Human Dimensions of Global Environmental Change Research Community, Bonn, Germany.

Blyth, W. (2010). *Climate Policy after Copenhagen: Managing Carbon Price Risk in an Uncertain World.* London: Chatham House.

Blyth, W., Bradley, R., Bunn, D., Clarke, C., Wilson, T., & Yang, M. (2007). Investment risks under uncertain climate change policy. *Energy policy, 35*(11), 5766-5773.

Blyth, W., & Yang, M. (2006). *Impact of Climate Change Policy Uncertainty in Power Investment.* Paris: IEA/OECD.

Böhringer, C., & Rosendahl, K. E. (2009). Strategic partitioning of emission allowances under the EU Emission Trading Scheme. *Resource and Energy Economics, 31*(3), 182-197.

Bosi, M., Cantor, S., & Spors, F. (2010). *10 Years of Experience in Carbon Finance: Insights from working with Kyoto mechanisms.* Washington, DC: The World Bank.

Burniaux, J. M., Château, J., Dellink, R., Duval, R., & Jamet, S. (2009). *The economics of climate change mitigation: how to build the necessary global action in a cost-effective manner.*

Capoor, K., & Ambrosi, P. (2008). *State and trends of the carbon market 2008*. Washington, DC: The World Bank.

Capoor, K., & Ambrosi, P. (2009). *State and trends of the carbon market 2009*. Washington, DC: The World Bank.

Carbon Trust, & Climate Strategies. (2009). *Global Carbon Mechanisms: Emerging lessons and implications*. London: Carbon Trust.

Cave, L. A., & Blomquist, G. C. (2008). Environmental policy in the European Union: Fostering the development of pollution havens? *Ecological Economics, 65*(2), 253-261.

CE Delft. (2007a). *Allocation of allowances for aviation in the EU ETS: The impact on the profitability of the aviation sector under high levels of auctioning*. Delft: CE Delft.

CE Delft. (2007b). *Competitiveness issues for Dutch aviation from EU ETS*. Delft: CE Delft.

CE Delft, & MVA. (2007). *Implications of EU emission Trading Scheme for Competition Between EU and Non-EU Airlines*. Delft: CE Delft.

Chevallier, J. (2009). Carbon futures and macroeconomic risk factors: A view from the EU ETS. *Energy Economics, 31*(4), 614-625.

Chicago Climate Exchange Inc. (2009). Trading Carbon Financial Instrument Contracts on CCX and CCFE: Cash, Futures and Options.

City of London, The London Accord, & CEAG Ltd. (2009). *Delivering Copenhagen: The Role of the City's Financial Services Sector in Supporting Action on Climate Change*. London: CEAG Ltd.

Clò, S. (2009). The effectiveness of the EU Emissions Trading Scheme. *Climate Policy, 9*(3), 227-241.

Clò, S. (2010). Grandfathering, auctioning and Carbon Leakage: Assessing the inconsistencies of the new ETS Directive. *Energy Policy, 38*(5), 2420-2430.

Coase, R. H. (1960). The Problem of Social Cost. *Journal of Law and Economics, 3*, 1-44.

Convery, F. J. (2009). Origins and Development of the EU ETS. *Environmental and Resource Economics, 43*(3), 391-412.

Convery, F. J., & Redmond, L. (2007). Market and Price Developments in the European Union Emissions Trading Scheme. *Review of Environmental Economics and Policy, 1*(1), 88-111.

Copeland, T., Koller, T., Murrin, J., & McKinsey, I. (2000). *Valuation: measuring and managing the value of companies*. New York: John Wiley & Sons.

Copeland, T. E., & Keenan, P. T. (1998). How much is flexibility worth? *The McKinsey Quarterly*(2).

Cornes, R., & Sandler, T. (1996). *The theory of externalities, public goods, and club goods*: Cambridge Univ Pr.

Crocker, T. D. (1968). *The Structuring of Atmospheric Pollution Control Systems*. New York: Norton.

Dales, J. H. (1968). *Pollution, Property and prices*. Toronto: University Press.

Daskalakis, G., Psychoyios, D., & Markellos, R. N. (2009). Modeling CO2 emission allowance prices and derivatives: Evidence from the European trading scheme. *Journal of Banking & Finance, 33*(7), 1230-1241.

Edwards, R. (2009). *Carbon finance for developing country greenhouse gas emissions mitigation from 2010 – 2020 and the role of a Global Climate Change Fund*. London: Climate Change Capital.

Egenhofer, C. (2007). The Making of the EU Emissions Trading Scheme: Status, Prospects and Implications for Business. *European Management Journal, 25*(6), 453-463.

Ellerman, A. D. (2005). A note on tradeable permits. *Environmental and Resource Economics, 31*(2), 123-131.

Ellerman, A. D., & Buchner, B. K. (2007). The European union emissions trading scheme: Origins, allocation, and early results. *Review of Environmental Economics and Policy, 1*(1), 66.

Environmental Audit Committee. (2010). *The role of carbon markets in preventing dangerous climate change*. London: The Stationery Office Limited.

Fichtner, W., Graehl, S., & Rentz, O. (2003). The impact of private investors transaction costs on the cost effectiveness of project-based Kyoto mechanisms. *Climate Policy, 3*(3), 249-259.

Flachsland, C., Marschinski, R., & Edenhofer, O. (2009). Global trading versus linking: Architectures for international emissions trading. *Energy Policy, 37*(5), 1637-1647.

G8. (2008). *G8 Statement on Climate Change and Environment*.

Gagelmann, F., & Frondel, M. (2005). The impact of emission trading on innovation-science fiction or reality? *European Environment, 15*(4), 203-211.

Gilbertson, T., & Reyes, O. (2009). Carbon Trading: How it works and why it fails. *Dag Hammarskjöld Foundation Occasional Paper Series*(7).

Girishankar, N. (2009). *Innovating development finance-from financing sources to financial solutions*. Washington, DC: The World Bank.

Goddart, T., Haugen-Kozyra, K., & Ridge, A. (2008). *Alberta: North America's First Compliance Offset Carbon*. Edmonton: Alberta Agriculture and Rural Development.

Grubb, M., Brewer, L., Sato, M., Helmayr, R., & Fazekas, D. (2009). *Climate Policy and industrial competitiveness: Ten insights from Europe on the EU Emissions Trading System.*

Grubb, M., Laing, T., Counsell, T., & Willan, C. (2010). Global carbon mechanisms: lessons and implications. *Climatic Change*, 1-35.

Grubb, M., & Neuhoff, K. (2006). *Allocation and competitiveness in the EU emissions trading scheme: policy overview*. Cambridge, UK: Faculty of Economics, University of Cambridge, UK.

Hagem, C. (2009). The clean development mechanism versus international permit trading: the effect on technological change. *Resource and Energy Economics, 31*(1), 1-12.

Hamilton, K., Sjardin, M., Peters-Stanley, M., & Marcello, T. (2010). *Building Bridges: State of the Voluntary Carbon Markets 2010*. New York/Washington: Bloomberg New Energy Finance/Ecosystem Marketplace.

Hamilton, K., Sjardin, M., Shapiro, A., & Marcello, T. (2009). *Fortifying the Foundation: State of the Voluntary Carbon Markets 2009*. Washington, DC & New York, NY: Ecosystem Marketplace & New Carbon Finance.

Heal, G. (2007). A celebration of environmental and resource economics. *Environmental Economics and Policy, 1*(1), 7-25.

Hepburn, C. (2007). Carbon trading: a review of the Kyoto mechanisms. *Annual Review of Environment and Resources, 32*, 395-393.

Hepburn, C., Grubb, M., Neuhoff, K., Matthes, F., & Tse, M. (2006). Auctioning of EU ETS phase II allowances: how and why. *Climate Policy, 6*(1), 137-160.

Houser, T. (2009). Ensuring US Competitiveness and International Participation.

Hultman, N. E. (2009). How can the Clean Development Mechanism better contribute to sustainable development. *AMBIO: A Journal of the Human Environment, 38*(2), 120-122.

IEA. (2007). *World Energy Outlook 2007*: International Energy Agency.

IEA. (2008). *World Energy Outlook 2008*: International Energy Agency.

Kaul, I., Grunberg, I., & Stern, M. A. (1999). *Global public goods: International cooperation in the 21st century*. New York: United Nations Development Programme.

Kerste, M., & Weda, J. (2010). *Financing the Transition to Sustainable Energy*. Amsterdam: SEO Economic Research.

Kettner, C., Koeppl, A., Schleicher, S., & Thenius, G. (2007). Stringency and distribution in the EU Emissions Trading Scheme–the 2005 Evidence. *Nota di Lavora, 22*, 2007.

Kolk, A., & Pinkse, J. (2005). Business responses to climate change: identifying emergent strategies. *California Management Review, 47*(3), 6-20.

Korppoo, A., & Gassan-zade, O. (2008). *Joint Implementation: Looking Back and Forward*. Cambridge: Climate Strategies.

Kossoy, A., & Ambrosi, P. (2010). *State and trends of the carbon market 2010*. Washington, DC: The World Bank.

Lai, Y. B. (2008). Auctions or grandfathering: the political economy of tradable emission permits. *Public Choice, 136*(1), 181-200.

Laurikka, H., & Koljonen, T. (2006). Emissions trading and investment decisions in the power sector--a case study in Finland. *Energy Policy, 34*(9), 1063-1074.

Leung, D. Y. C., Yung, D., Ng, A., Leung, M. K. H., & Chan, A. (2009). An overview of emissions trading and its prospects in Hong Kong. *Environmental Science & Policy, 12*(1), 92-101.

Lewis, J. I. (2010). The evolving role of carbon finance in promoting renewable energy development in China. *Energy Policy, 38*(6), 2875-2886.

Lewis, M. C., & Curien, I. (2009). *The ETS Review: Unfinished Business*. London: Deutsche Bank AG.

Lewis, M. C., & Curien, I. (2010). *The Crying of Lot 2013: Phase-3 Auctions and the EUA Price Outlook*. London: Deutsche Bank AG.

Martinsen, D., Linssen, J., Markewitz, P., & Vögele, S. (2007). CCS: A future CO2mitigation option for Germany? A bottom-up approach. *Energy policy, 35*(4), 2110-2120.

McKinsey&Company. (2009). *Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve*.

Menanteau, P., Finon, D., & Lamy, M.-L. (2003). Prices versus quantities: choosing policies for promoting the development of renewable energy. *Energy Policy, 31*(8), 799-812.

Michaelowa, A., & Castro, P. (2008). *Empirical Analysis of Performance of CDM Projects*. London, UK: Climate Strategies.

Michaelowa, A., Stronzik, M., Eckermann, F., & Hunt, A. (2003). Transaction costs of the Kyoto Mechanisms. *Climate policy, 3*(3), 261-278.

Miller, N. H. (2006). *Notes on Microeconomic Theory*.

Mizuguchi, H. (2010). *Likely Green Investment Trends in 2010*. Tokyo: Daiwa Institute of Research Ltd.

Montgomery, W. D. (1972). Markets in licenses and efficient pollution control programs. *Journal of Economic Theory, 5*(3), 395-418.

NEF. (2009). *Global Carbon Quarterly Q3 2009*. London: Bloomberg New Energy Finance.

Neuhoff, K., Keats, K., & Sato, M. (2006). Allocation, incentives and distortions: the impact of EU ETS emissions allowance allocations to the electricity sector.

Newell, R. G., Jaffe, A. B., & Stavins, R. N. (2006). The effects of economic and policy incentives on carbon mitigation technologies. *Energy Economics, 28*(5-6), 563-578.

Nordhaus, W. D. (1999). *Global public goods and the problem of global warming*. Toulouse: The Institut d'Economie Industrielle (IDEI).

Nordhaus, W. D. (2006a). After Kyoto: Alternative mechanisms to control global warming. *The American Economic Review, 96*(2), 31-34.

Nordhaus, W. D. (2006b). *Paul Samuelson and global public goods: A commemorative essay for Paul Samuelson*.

Nordhaus, W. D. (2007). To tax or not to tax: Alternative approaches to slowing global warming. *Review of Environmental Economics and Policy, 1*(1), 26.

Parker, L. (2010). *Climate Change and the EU Emissions Trading Scheme (ETS): Looking to 2020*. Washington, DC: Congressional Research Service.

Pearson, A., & Worthington, B. (2009). *ETS S.O.S.: Why the flagship 'EU Emissions Trading Policy' needs rescuing*. London: Sandbag.

Pew Center on Global Climate Change. (2007). Thirteenth Session of the Conference of the Parties to the UN Framework Convention on Climate Change and Third Session of the Meeting of the Parties to the Kyoto Protocol.

Pezzey, J. C. V. (2003). Emission Taxes and Tradeable Permits A Comparison of Views on Long-Run Efficiency. *Environmental and Resource Economics, 26*(2), 329-342.

Pigou, A. C. (1920). *The economics of welfare*. London: Macmillan.

Pinkse, J. (2007). Carbon emissions trading: managing climate change through financial markets. *Aenorm, 56*, 17-20.

Purdy, R. (2009). Governance Reform of the Clean Development Mechanism after Poznan. *CCLR The Carbon & Climate Law Review, 3*(1), 5-15.

PwC. (2009). *Carbon Taxes vs Carbon Trading: Pros, cons and the case for a hybrid approach*. London: PricewaterhouseCoopers LLP.

Ranade, M., & Bhada, P. (2010). *A City-Wide Approach to Carbon Finance*. Washington, DC: The World Bank.

Reinaud, J. (2007). *CO2 allowance & electricity price interaction: Impact on industry's electricity purchasing strategies in Europe*: OECD/International Energy Agency.

Rock, N., Baines, T., & LeBoeuf, D. (2008). Aviation and the EU Emissions Trading Scheme: Turbulence Ahead? In K. Carnahan (Ed.), *Geenhouse Gas Market Report 2008: Piecing Together a Comprehensive International Agreement for a Truly Global Carbon Market*. Geneva: International Emissions Trading Association, IETA.

Schneider, L. (2007). *Is the CDM fulfilling its environmental and sustainable development objectives? An evaluation of the CDM and options for improvement.*: Report prepared for WWF by Öko-Institut EV Berlin.

Sekar, R. C., Parsons, J. E., Herzog, H. J., & Jacoby, H. D. (2007). Future carbon regulations and current investments in alternative coal-fired power plant technologies. *Energy Policy, 35*(2), 1064-1074.

Silva, E. C. D., & Zhu, X. (2009). Emissions trading of global and local pollutants, pollution havens and free riding. *Journal of Environmental Economics and Management, 58*(2), 169-182.

Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., et al. (2006). *Stern Review: The economics of climate change*.

Teng, F., Chen, W., & He, J. (2008). *Possible Development of a Technology Clean Development Mechanism in a Post-2012 Regime*: Harvard Project on International Climate Agreements
Belfer Center for Science and International Affairs
Harvard Kennedy School.

The World Bank. (2006). *The Role of the World Bank in Carbon Finance: An Approach for Further Engagement*. Washington, DC: The World Bank.

The World Bank. (2010). *World Development Report 2010: Development and Climate Change*. Washington, DC: The International Bank for Reconstruction and Development / The World Bank.

Tilford, S. (2009). Carbon price collapse threatens the EU's climate agenda [Electronic Version]. *CER Bulletin*. Retrieved July 2010 from http://www.cer.org.uk/articles/65_tilford.html.

Tvinnereim, E. (2008). The First Six Months of 2008. In K. Carnahan (Ed.), *Geenhouse Gas Market Report 2008: Piecing Together a Comprehensive International Agreement for a Truly Global Carbon Market*. Geneva: International Emissions Trading Association, IETA.

UNCCF. (2010). Retrieved June 24, 2010, from http://unfccc.int/2860.php

UNFCCC. (2008). *Identifying, analysing and assessing existing and potential new financing resources and relevant vehicles to support the development, deployment, diffusion and transfer of environmentally sound technologies*. Bonn.

UNFCCC. (2010). Retrieved June 24, 2010, from http://unfccc.int/2860.php

United Nations Conference on Environment and Development. (1992). *Rio Declaration on Environment and Development*. Paper presented at the United Nations Conference on Environment and Development.

Verschueren, K. (2009, November 12). *European Emission Trading system for Aviation*. Paper presented at the Airneth Seminar, The Hague.

Vespermann, J., & Wald, A. (2010). Much Ado about Nothing?-An analysis of economic impacts and ecologic effects of the EU-emission trading scheme in the aviation industry. *Transportation Research Part A: Policy and Practice*.

Victor, D. (2009). *The Politics of Fossil-Fuel Subsidies*. Winnipeg/Geneva: The Global Subsidies Initiative.

Wagner, G., Wang, J., Dudek, D., Haverkamp, J., Keohane, N., & Petsonk, A. (2009). *The CLEAR Path: Rewarding early actions by emerging economies to limit carbon*. Washington, DC: Environmental Defense Fund.

Wara, M. (2009). The Clean Development Mechanism's early performance. In S. Schneider, A. Rosencrantz & M. Manstrandrea (Eds.), *Climate Change Science and Policy*. Washington: Island Press.

WEF. (2009). *Green Investing: Towards a Clean Energy Infrastructure*. Cologny/Geneva: World Economic Forum.

WEF. (2010). *Green Investing 2010: Policy Mechanisms to Bridge the Financial Gap*. Cologny/Geneva: World Economic Forum.

Woerdman, E. (2001). Emissions trading and transaction costs: analyzing the flaws in the discussion. *Ecological Economics, 38*(2), 293-304.

Woerdman, E., Arcuri, A., & Cló, S. (2008). Emissions Trading and the Polluter-Pays Principle: Do Polluters Pay under Grandfathering? *Review of Law & Economics, 4*(2), 565-590.

World Commission on Environment and Development. (1987). *Our common future*.

Appendix A Glossary

Accredited Independent Entity (AIE): Accredited independent entities (AIEs) are independent auditors that assess whether a potential project meets all the eligibility requirements of the JI (determination) and whether the project has achieved greenhouse gas emission reductions (verification).

Additionality: A project activity is additional if anthropogenic GHG emissions are lower than those that would have occurred in the absence of the project activity.

Afforestation: The process of establishing and growing forests on bare or cultivated land, which has not been forested in recent history.

Annex I (Parties): Annex I Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

Annex B (Parties): The 39 industrialized countries (including the European Economic Community) listed in Annex B to the Kyoto Protocol have committed to country-specific targets that collectively reduce their GHG emissions by at least 5.2% below 1990 levels on average over 2008–12.

Assigned Amount Unit (AAU): Annex I Parties are issued AAUs up to the level of their assigned amount, corresponding to the quantity of greenhouse gases they can release in accordance with the Kyoto Protocol (Art. 3), during the first commitment period of that protocol (2008–12). One AAU represents the right to emit one metric ton of carbon dioxide equivalent.

Backwardation: A downward sloping forward curve (i.e., the price of the future is less than the spot price of underlying commodity). Antonym: contango.

Banking or carry over: Compliance units under the various schemes to manage GHG emissions in existence may or may not be carried over from one commitment period to the next. Banking may encourage early action by mandated entities depending on their current situation and their anticipations of future carbon constraints. In addition banking brings market continuity. Banking between Phase I and Phase II of the EU ETS is not allowed but is allowed between Phase II and further Phases. Some restrictions on the amount of units that can be carried over may apply: for instance, EUAs may be banked with no restriction while the amount of CERs that can be carried over by a Kyoto Party is limited to 2.5% of the assigned amount of each Party.

Baseline: The emission of greenhouse gases that would occur without the policy intervention or project activity under consideration.

Biomass Fuel: Combustible fuel composed of a biological material, for example, wood or wood by-products, rice husks, or cow dung.

California Global Warming Solution Act AB32 (AB32): The passage of Assembly Bill 32 (California Global Warming Solution Act AB32) in August 2006 sets economy-wide GHG emissions targets as follows: Bring down emissions to 1990 levels by 2020 (considered to be at least a 25% reduction below business-as-usual) and to 80% of 1990 levels by 2050. Covering about 85% of GHG emissions, a cap and trade scheme (still under design) would be a major instrument, along with renewable energy standards, energy efficiency standards for buildings and appliances as well as vehicle emissions standards.

Cap and trade: Cap and trade schemes set a desired maximum ceiling for emissions (or cap) and let the market determine the price for keeping emissions within that cap. To comply with their emission targets at least cost, regulated entities can either opt for internal abatement measures or acquire of allowances or emission reductions in the carbon market, depending on the relative costs of these options.

Carbon Asset: The potential of greenhouse gas emission reductions that a project is able to generate and sell.

Carbon Finance: Resources provided to activities generating (or expected to generate) greenhouse gas (or carbon) emission reductions through the transaction of such emission reductions.

Carbon Dioxide Equivalent (CO_2e): The universal unit of measurement used to indicate the global warming potential of each of the six greenhouse gases regulated under the Kyoto Protocol. Carbon dioxide—a naturally occurring gas that is a byproduct of burning fossil fuels and biomass, land-use changes, and other industrial processes—is the reference gas against which the other greenhouse gases are measured, using their global warming potential.

Certified Emission Reductions (CERs): A unit of greenhouse gas emission reductions issued pursuant to the Clean Development Mechanism of the Kyoto Protocol, and measured in metric tons of carbon dioxide equivalent. One CER represents a reduction in greenhouse gas emissions of one metric ton of carbon dioxide equivalent.

Chicago Climate Exchange (CCX): Members to the Chicago Climate Exchange make a voluntary but legally binding commitment to reduce GHG emissions. By the end of Phase I (December, 2006), all Members will have reduced direct emissions 4% below a baseline period of 1998–2001. Phase II, which extends the CCX reduction program through 2010, will require all Members to ultimately reduce GHG emissions 6% below baseline. Among the members are companies from North America as well as municipalities or U.S. States or Universities. As new regional initiatives began to take shape in the U.S., membership of the CCX grew from 127 members in January 2006 to 237 members by the end of the year while new participants expressed their interest in familiarizing themselves with emissions trading.

Clean Development Mechanism (CDM): The mechanism provided by Article 12 of the Kyoto Protocol, designed to assist developing countries in achieving sustainable development by allowing entities from Annex I Parties to participate in low-carbon projects and obtain CERs in return.

Climate Action Reserve (CAR): The Climate Action Reserve is a U.S.-based offsets program that establishes regulatory-quality standards for the development, quantification, and verification of greenhouse gas (GHG) emissions reduction projects in North America; issues carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracks the transaction of credits over time in a transparent, publicly-accessible system.

Community Independent Transaction Log (CITL): The Community Independent Transaction Log (CITL) conducts "supplementary checks" to those by the ITL for transactions involving registries of at least one EU Member State, such as the issuance, transfer, cancellation, retirement, and banking of EUAs.

Conference of Parties (COP): The supreme body of the Convention. It currently meets once a year to review the Convention's progress. The word "conference" is not used here in the sense of "meeting" but rather of "association," which explains the seemingly redundant expression "fourth session of the Conference of the Parties."

Conference of the Parties serving as the Meeting of the Parties (CMP): The Convention's supreme body is the COP, which serves as the meeting of the Parties to the Kyoto Protocol. The sessions of the COP and the CMP are held during the same period to reduce costs and improve coordination between the Convention and the Protocol.

Contango: A term used in the futures market to describe an upward sloping forward curve (i.e., futures prices are above spot prices). Antonym: backwardation.

Crediting period: The crediting period is the duration of time during which a registered, determined or approved project can generate emission reductions. For CDM projects, the crediting period can be of either seven years (renewable twice) or of ten years (non-renewable).

Designated Focal Point (DFP): Parties participating in the Joint Implementation (JI) mechanism are required to nominate a Designated Focal Point (DFP) for approving projects.

Designated National Authority (DNA): An office, ministry, or other official entity appointed by a Party to the Kyoto Protocol to review and give national approval to projects proposed under the Clean Development Mechanism.

Designated Operational Entities (DOEs): Designated operational entities are independent auditors that assess whether a potential project meets all the eligibility requirements of the CDM (validation) and whether the project has achieved greenhouse gas emission reductions (verification and certification). **Determination:** Determination is the process of evaluation by an independent entity accredited by the host country (JI Track 1) or by the Joint Implementation Supervisory Committee (JI Track 2) of whether a project and the ensuing reductions of anthropogenic emissions by sources or enhancements of anthropogenic removals by sinks meet all applicable requirements of Article 6 of the Kyoto Protocol and the JI guidelines.

Eligibility Requirements: There are six Eligibility Requirements for Participating in Emissions Trading (Art. 17) for Annex I Parties. Those are: (i) being a Party to the Kyoto Protocol, (ii) having calculated and recorded one's Assigned Amount, (iii) having in place a national system for inventory, (iv) having in place a national registry, (v) having submitted an annual inventory, and (vi) submit supplementary information on assigned amount. An Annex I party will automatically become eligible after 16 months have elapsed since the submission of its report on calculation of its assigned amount. Then, this Party and any entity having opened an account in the registry can participate in Emissions Trading. However, a Party could lose its eligibility if the Enforcement Branch of the Compliance Committee has determined the Party is non-compliant with the eligibility requirements.

Emission Reductions (ERs): The measurable reduction of release of greenhouse gases into the atmosphere from a specified activity, and a specified period of time.

Emission Reductions Purchase Agreement (ERPA): Agreement which governs the transaction of emission reductions.

Emission Reduction Units (ERUs): A unit of emission reductions issued pursuant to Joint Implementation. One EUA represents the right to emit one metric ton of carbon dioxide equivalent.

Emissions Trading Scheme (ETS): see cap and trade.

EU-10: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.

EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, United Kingdom.

European Union Allowances (EUAs): the allowances in use under the EU ETS. An EUA unit is equal to one metric ton of carbon dioxide equivalent.

European Union Emission Trading Scheme (EU ETS): The EU ETS was launched on January 1, 2005 as a cornerstone of EU climate policy towards its Kyoto commitment and beyond. Through the EU ETS, Member States allocate part of the efforts towards their Kyoto targets to private sector emission sources (mostly utilities). Over 2008–12, emissions from mandated installations (about 40% of EU emissions) are capped on average at 6% below 2005 levels. Participants can internally reduce emissions, purchase EUAs or acquire CERs and ERUs (within a 13.4% average limit of their allocation over 2008–12). The EU ETS will continue beyond 2012, with further cuts in emissions (by 21% below 2005 levels in 2020 or more, depending on progress in reaching an ambitious international agreement on climate change).

First Commitment Period: The five-year period, from 2008 to 2012, during which industrialized country have committed to collectively reduce their greenhouse gas (or "carbon") emissions by an average of 5.2% compared with 1990 emissions under the Kyoto Protocol.

Green Investment Scheme (GIS): A GIS is a voluntary mechanism through which proceeds from AAU transactions will contribute to contractually agreed environment- and climate-friendly projects and programs both by 2012 and beyond.

Greenhouse gases (GHGs): Both natural and anthropogenic, greenhouse gases trap heat in the Earth's atmosphere, causing the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases. The emission of greenhouse gases through human activities (such as fossil fuel combustion or deforestation) and their accumulation in the atmosphere is responsible for an additional forcing, contributing to climate change. The Kyoto Protocol regulates six GHGs: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_20), as well as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Global Warming Potential (GWP): An index representing the combined effect of the differing times greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation.

Internal rate of return: The annual return that would make the present value of future cash flows from an investment (including its residual market value) equal the current market price of the investment. In other words, the discount rate at which an investment has zero net present value.

International Transaction Log (ITL): the ITL links together the national registries and the CDM registry and is in charge of verifying the validity of transactions (issuance, transfer and acquisition between registries, cancellation, expiration and replacement, retirement, and carry-over). It is the central piece of the emissions trading under the Kyoto Protocol.

Japan-Voluntary Emissions Trading Scheme (JVETS): Under the J-VETS, companies receive subsidies to implement mitigation activities in line with voluntary commitments and can resort to emissions trading (incl. offsets) to meet their commitments with more flexibility. Though growing, impact remains limited: over the first three years of the scheme, participants (288 companies) have reduced their emissions by about one million tCO_2e. The J-VETS has contributed to the development of MRV system, third-party verification system, and the registry system. The J-VETS has been incorporated to the Experimental Integrated ETS as one of participating options.

Joint Implementation (JI): Mechanism provided by Article 6 of the Kyoto Protocol, whereby entities from Annex I Parties may participate in low-carbon projects in hosted in Annex I countries and obtain Emission Reduction Units in return.

Kyoto Mechanisms (KMs): the three flexibility mechanisms that may be used by Annex I Parties to the Kyoto Protocol to fulfill their commitments. Those are the Joint Implementation (JI, Art. 6), Clean Development Mechanism (CDM, Art. 12) and International Emissions Trading (Art. 17).

Kyoto Protocol: Adopted at the Third Conference of the Parties to the United Nations Convention on Climate Change held in Kyoto, Japan in December 1997, the Kyoto Protocol commits industrialized country signatories to collectively reduce their greenhouse gas emissions by at least 5.2% below 1990 levels on average over 2008–12 while developing countries can take no regret actions and participate voluntarily in emission reductions and removal activities through the CDM. The Kyoto Protocol entered into force in February 2005.

Monitoring Plan: A set of requirements for monitoring and verification of emission reductions achieved by a project.

National Allocation Plans (NAPs): The documents, established by each Member State and reviewed by the European Commission, that specify the list of installations under the EU ETS and their absolute emissions caps, the amount of CERs and ERUs that may be used by these installations as well as other features such as the size of the new entrants reserve and the treatment of exiting installations or the process of allocation (free allocation or auctioning).

New South Wales Greenhouse Gas Reduction Scheme (NSW GGAS): Operational since January 1, 2003 (to last at least until 2012), the NSW Greenhouse Gas Abatement Scheme aims at reducing GHG emissions from the power sector. NSW and ACT (since January 1, 2005) retailers and large electricity customers have thus to comply with mandatory (intensity) targets for reducing or offsetting the emissions of GHG arise from the production of electricity they supply or use. They can meet their targets meet their targets by purchasing certificates (NSW Greenhouse Abatement Certificates or NGACs) that are generated through project activities.

New Zealand Emissions Trading Scheme (NZ ETS): The NZ ETS will progressively regulate emissions of the six Kyoto gases in all sectors of the economy by 2015. Forestry is covered since 2008 and by July 1, 2010, stationary energy, industrial process, and liquid fossil fuel will be phased-in. The government recently announced, however, that full implementation could be delayed if adequate progress is not made in establishing similar regulations in other developed countries.

Offsets: Offsets designate the emission reductions from project-based activities that can be used to meet compliance—or corporate citizenship—objectives vis-à-vis greenhouse gas mitigation.

Primary transaction: A transaction between the original owner (or issuer) of the carbon asset and a buyer.

Project Design Document (PDD): A central document of project-based mechanisms, the PDD notably describes the project activity (including environmental impacts and stakeholders consultations), the baseline methodology and how the project is additional as well as the monitoring plan.

Project Idea Note (PIN): A note prepared by a project proponent presenting briefly the project activity (e.g., sector, location, financials, estimated amount of ERs etc.).

REDD plus: All activities that reduce emissions from deforestation and forest degradation, and contribute to conservation, sustainable management of forests, and enhancement of forest carbon stocks.

Regional Greenhouse Gas Initiative (RGGI): Under RGGI, 10 Northeast and Mid-Atlantic states aim to reduce power sector CO_2 emissions by 10% below 2009 levels in 2019. Within this 10-year phase, there are three shorter compliance periods. During the first and second compliance periods (2009–2011 and 2012–2014) the cap on about 225 installations is set at 171 $MtCO_2e$ (or 188 M short ton CO_2e). This is followed by a 2.5% per year decrease in cap during the third compliance period (2015–2018).

Reforestation: This process increases the capacity of the land to sequester carbon by replanting forest biomass in areas where forests have been previously harvested.

Registration: The formal acceptance by the CDM Executive Board of a validated project as a CDM project activity.

Removal unit (RMU): RMUs are issued by Parties to the Kyoto Protocol in respect of net removals by sinks from activities covered by Article 3(3) and Article 3(4) of the Kyoto Protocol**.**

Secondary transaction: A transaction where the seller is not the original owner (or issuer) of the carbon asset.

Supplementarity: Following the Marrakesh Accords, the use of the Kyoto mechanisms shall be supplemental to domestic action, which shall thus constitute a significant element of the effort made by each Party to meet its commitment under the Kyoto Protocol. However there is no quantitative limit to the utilization of such mechanisms. While assessing the NAPs, the European Commission considered that the use of CDM and JI credits could not exceeded 50% of the effort by each Member State to achieve its commitment. Supplementarity limits may thus affect demand for some categories of offsets.

United Nations Framework Convention on Climate Change (UNFCCC): The international legal framework adopted in June 1992 at the Rio Earth Summit to address climate change. It commits the Parties to the UNFCCC to stabilize human induced greenhouse gas emissions at levels that would prevent dangerous manmade interference with the climate system, following "common but differentiated responsibilities" based on "respective capabilities".

Validation: Validation is the process of independent evaluation of a project activity by a Designated Operational Entity (DOE) against the requirements of the CDM. The CDM requirements include the CDM modalities and procedures and subsequent decisions by the CMP and documents released by the CDM Executive Board.

Verified Emission Reductions (VERs): A unit of greenhouse gas emission reductions that has been verified by an independent auditor. Most often, this designates emission reductions units that are traded on the voluntary market.

Verification: Verification is the review and ex post determination by an independent third party of the monitored reductions in emissions generated by a registered CDM project, a determined JI project (or a project approved under another standard) during the verification period.

Voluntary market: The voluntary market caters for the needs of those entities that voluntarily decide to reduce their carbon footprint using offsets. The regulatory vacuum in some countries and the anticipation of imminent legislation on GHG emissions also motivates some pre-compliance activity.

Western Climate Initiative (WCI): The WCI covers a group of seven U.S. states (Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington) and four Canadian provinces (British Columbia, Manitoba, Ontario, and Quebec), with an aggregate emissions target of 15% below 2005 levels by 2020. Other U.S. and Mexican states and Canadian provinces have joined as observers.

Source: (Kossoy & Ambrosi, 2010, pp. 71-75)

Appendix B Cap-and-Trade Policies

Table 7 Policy Overview (April 2009)

Venue	Current Status	Year Initiated	Operational Ever?	Gasses	Sectors	Regulatory Status
Australia	Design	2007	No	All Kyoto	Stationary energy; transport; fugitive; industrial processes; waste and forestry	Mandatory for some
BP	Inactive	1997	Yes	CO2 and methane	Internal business units in four segments	Voluntary
California	Design	2005	No	All Kyoto	Electricity generation and large industrial facilities	Mandatory
Canada	Deliberation	1998	No	No Data	Industry	No Data
CCX	Operational	2000	Yes	All Kyoto	Multiple	Voluntary (but binding)
Denmark	Inactive	1999	Yes	CO2	Electric Generation	Mandatory
EU	Operational	1999	Yes	CO2	Various (excludes electricity generation)	Mandatory
Florida	Deliberation	2007	No	All Kyoto	Electrical and possibly industrial stationary sources	Mandatory (prop being discussed)
Illinois	Inactive	2006	No	CO2 and maybe others over time	Electric generation units with a capacity of 25MW or higher, or emit 25,000 metric tons of CO2 annually at the start of the program. Other, smaller sources and gases would be included over time	No Data
Japan	Operational	2002	Yes	CO2	Industrial (multiple sectors)	Voluntary
Korea	Design	2008	No	Discussions mostly on CO2	Industry?	Mandatory/voluntary Debate
Kyoto Protocol	Design	1997	No	CO2	Up to Parties	Voluntary
Massachusetts	Inactive	2001	No	No Data	No Data	No Data
NAFTA-CEC	Deliberation	2001	No	No Data	No Data	No Data
NEG/ECP	Inactive	2001	No	No Data	No Data	No Data
New Mexico	Inactive	2005	No	No Data	No Data	No Data
New Zealand	Operational	2007	Yes	All Kyoto	Forestry, transport, energy, industry, agriculture, wastes	Mandatory for some
New Jersey	Inactive	1998	No	All Kyoto	Stationary and non-stationary sources (not differentiated by sector)	Voluntary
Norway	Inactive	1998	Yes	CO2	Energy, mineral oil refining, iron/stell, cement, ceramic	Mandatory
NSW	Operational	1998	Yes	All Kyoto	Electricity retailers and large users	Mandatory
Oregon	Inactive	2004	No	No Data	No Data	No Data

Venue	Current Status	Year Initiated	Operational Ever?	Gasses	Sectors	Regulatory Status
PEMEX	Deliberation	2009	No	Unclear	PEMEX(oil), the Federal Electric Commission (power – in general) and cement makers, metals, chemicals and textiles are being considered as well	No Data
RGGI	Operational	2003	Yes	CO2	Power	Mandatory
Shell	Inactive	1998	Yes	CO2 and methane	Internal business units	Voluntary
Switzerland	Operational	2000	Yes	CO2	Varied--businesses that want out of carbon tax	Voluntary (but binding once in)
UK	Inactive	1998	Yes	CO2 or all Kyoto	various (excludes electricity generation)	Voluntary (but binding)
US Congress	Deliberation	2003	No	No Data	No Data	No Data
WCI	Design	2004	No	All Kyoto	Economy Wide	Mandatory

Source: (Betsill & Hoffmann, 2009)

seo economisch onderzoek

Roetersstraat 29 . 1018 WB Amsterdam . T (+31) 20 525 16 30 . F (+31) 20 525 16 86 . www.seo.nl