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The EU Emissions Trading System

Results and Lessons Learned

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Cover photo: A new Chemrec processing unit for creating biofuels from the byproducts of pulp and paper mills, Pitea, Sweden, May 2010. Source: chemrec.se/Chemrec-pictures.aspx.

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The complete report is available online at edf.org/euets.

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Executive summary

The European Union Emissions Trading System (EU ETS), the world's first and largest multinational cap-and-trade program to limit global warming pollution, has driven significant reductions in greenhouse gas emissions since the program's inception in 2005,[1] sparked innovation in low-carbon processes,[2] and achieved results at an estimated cost of just 0.01% of gross domestic product—a fraction of predicted costs.[3] The EU ETS has been established and extended over three successive phases: Phase I (2005–2007, often called the "pilot phase"); Phase II (2008–2012); and Phase III (2013–2020). The EU appears to be on target and in fact ahead of schedule for achieving the ambitious emission reduction target set for the years 2008–2012, in large measure because of the success of the EU ETS. As with any innovative policy measure, the EU ETS has stumbled in places, and policymakers should understand the lessons learned from its faults and subsequent reforms. For instance, because EU governments based the system's initial caps and emissions allowance allocation on *estimates* of regulated entities' emissions rather than on *actual historical emissions data*, governments issued too many emissions allowances ("over-allocation").[4] Now, however, caps are established on the basis of measured and verified past emissions and best-practices benchmarks, so over-allocation is less of a problem.

Unless otherwise indicated, this report uses the terms "EU ETS" and "ETS" to refer to the European Union Emissions Trading System.

One central finding from seven years of experience with the EU ETS has emerged: Despite initial dire warnings[5] that the ETS would impede economic growth by dramatically increasing costs to consumers and industry, the evidence shows that the ETS has played a significant

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The EU Emissions Trading System has played a significant and successful role in reducing Europe's global warming pollution at lower-than-expected cost, and is proving to be a practical, efficient way to spur innovation in a low-carbon economy.

and successful role in reducing the EU's global warming pollution at costs a fraction of those predicted.

The EU ETS is working. Most importantly, it is working *now*—on the ground and in the atmosphere. It is proving itself a practical, efficient way to spur innovation and reduce greenhouse gas emissions. In addition to driving emission reductions, the EU ETS can be seen as an economic development tool—together with other complementary policies, it has stimulated innovation in the emerging European low-carbon economy, as case studies provided in Appendix A to this report illustrate. Recent debates about the fluctuating price of emissions allowances should not obscure these environmental and economic successes. As even one commentator critical of some aspects of the EU ETS has noted, "if you are looking for a serious achievable policy, this is the best one we've got."[6]

Taking stock of the EU ETS as it prepares to enter its third phase, this report identifies six key results of the EU ETS, highlights the lessons learned from these outcomes, and provides recommendations for jurisdictions developing their own climate policies. Other regions, states, and local jurisdictions looking to decouple greenhouse gas emissions from economic growth using cap-and-trade systems should consider the refinements implemented over the course of the EU ETS's development.

Results, lessons learned, and recommendations

1. The EU ETS has achieved immediate and significant emission reductions at minimal cost.

Independent studies at the regional, national, and firm levels have confirmed that the EU ETS has been a significant contributor to the reduction in European emissions, independent of the effects of the 2009 recession.[7] Despite the modest ambitions of the EU ETS Phase I (2005–2007), the data suggest that from 2005 through 2007, the ETS reduced carbon emissions by 120 million to 300 million metric tons, or roughly 2–5% below the "business-as-usual" scenario.[8] Phase II coincided with the global economic recession but introduced tighter emissions targets and achieved additional reductions of approximately 340 million metric tons in its first two years (2008–2009), or roughly 8% below projected business-as-usual emissions.[9]

Overall, from 2005 to 2009, these estimates indicate that the ETS was responsible for reductions of more than 480 million tons of carbon dioxide (CO_2), which is greater than the entire 2009 CO_2 emissions of Mexico or Australia.[10] And while the economic recession has hit some European member states particularly hard, the ETS has succeeded in helping to decouple emissions growth from economic growth even in those European countries where growth has continued.[11]

These emission reductions have come at relatively low cost.[12] No negative effects on the overall economy are evident, and even the effects on energy-intensive sectors such as power, steel, and pulp-and-paper have been minimal.[13] By design, cap-and-trade programs like the EU ETS ensure that emission reduction objectives will be met at the lowest cost.

RECOMMENDATION Jurisdictions that wish to decouple emissions growth from economic development should emulate the successful design of and improvements to the EU ETS, which achieved significant reductions in emissions at low cost, even in its trial phase.

RECOMMENDATION Cap-and-trade critiques based on projected negative macroeconomic effects must be closely scrutinized in light of real-world evidence to the contrary. In designing cap-and-trade programs, policymakers can stimulate long-term emission reduction investments by maintaining a predictably declining, enforceable, science-based cap on carbon, even when a recession leads to increased allowance supply or a growth spurt leads to increased allowance demand. The science of verified emissions, not the price of allowances, should drive the decision on the allowable amount of emissions, and thus the size of the cap.

RECOMMENDATION Economic policymakers who wish to capitalize on the growing low-carbon sector should focus on the environmental integrity and enforceability of the emissions cap, which in turn will unleash the proven effectiveness of cap-and-trade in stimulating the deployment of low-carbon innovation.

2. Over-allocation of allowances occurred during the ETS Phase I, and allowance prices consequently dropped sharply, but the policy stability provided by enactment of Phase II targets led firms to make durable investments in reducing emissions and deploying low-carbon strategies.

When developing the pilot phase of the ETS, which ran from 2005 to 2007, the EU lacked reliable data on industry-wide and company-specific emissions for prior years. So it allowed its member states to allocate allowances to entities based on the entities' own estimates of their emissions, rather than on verified data of actual historical emissions. Each member state applied different rules for national allowance allocations, and some issued allowances based on the entities' own optimistic growth forecasts.[14] Entities were required to provide detailed data on actual emissions only during the pilot phase, not before. In April 2006, midway through the second year of the pilot phase, when the prior year's reports on actual emissions were published, it became obvious that member states had allocated too many allowances—almost 4% too many, by some estimates.[15] Allowance prices correspondingly dropped dramatically, as demand and perceived supply rebalanced themselves.

Later in the pilot phase, allowance prices actually dropped to zero. Why? Phase I was a trial period, but in theory, the EU could have designed its system so that surplus pilot phase allowances could be banked or saved for use in the next phase, from 2008 to 2012. The EU chose not to do so, however, because it had separately undertaken an international treaty obligation to limit EU-wide emissions to 8% below 1990 levels for 2008-2012; the ETS was one of the main policy tools that the EU sought to use to meet that obligation. Authorizing ETS pilot phase allowances to be banked for use in offsetting emissions increases during Phase II would have made it more difficult for the EU to comply with its international obligation, which pertained only to the 2008-2012 period and did not recognize reductions earned before 2008. When entities found that they could comply fully with the pilot phase obligations without using all their (over-allocated) pilot phase allowances, the price of the remaining allowances, which could not be used in the next phase, predictably fell to zero as the end of the trial period approached.

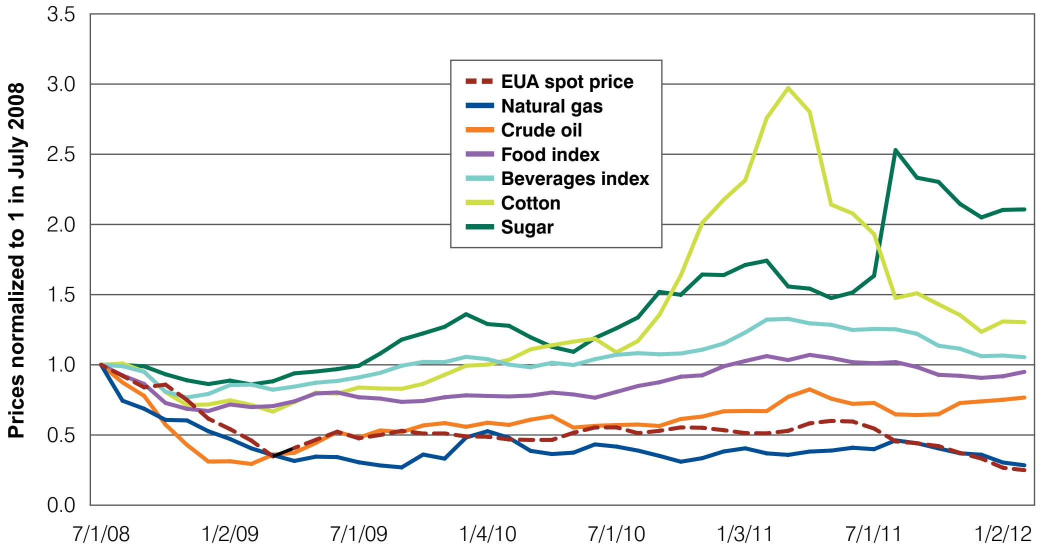
Nonetheless, since the inception of the program, EU allowance (EUA) prices have been less volatile than many other traded commodities (see Figure ES.1, next page). Even during Phase I, futures contracts for bankable permits that could be used in Phase II and III maintained relatively stable prices.

This market certainty fostered the investment and economic development that are the central long-term benefits of cap-and-trade programs; despite initial over-allocation and sometimes dramatic allowance price decline, the cap on carbon drove and is continuing to drive investments and innovation in carbon abatement, as indicated by the decline in overall emissions above and beyond those attributable to the recession, and by process and technological changes in the power sector.[16]

RECOMMENDATION Emissions caps and resulting allowance allocations should be based on measured and verified historical emissions, rather than on estimated or projected emissions.

FIGURE ES.1

Comparing the price volatility of European Union Allowances (EUAs) with various commodities, 2008–2012



Source: All commodities indexed relative to their value in July 2008. Source: EAU spot price data from Point Carbon. Other commodity data accessed from IMF Commodity Price Index, available at www.imf.org/external/np/res/commod/index.aspx.

Collecting reliable and accurate pre- and post-program data on emissions and economic activity as part of any emissions trading system is important not only to create incentives to reduce emissions, but also to establish a sound basis to construct business-as-usual scenarios needed to evaluate and verify a program's success.

RECOMMENDATION To smooth price volatility and to encourage durable, early investment in reducing global warming pollution, carbon market regulators should provide a predictable long-term policy environment that allows banking of allowances between trading periods. As long as an ambitious emissions cap is in place and reductions are being achieved, reductions achieved at low market prices for emissions allowances should not be regarded as a market "failure"; rather, low market prices for emissions allowances may indicate that firms are achieving emission reductions at lower costs than predicted. Efficient reductions allow society to achieve more ambitious targets at lower cost, freeing up capital resources for other useful purposes.

3. Windfall profits occurred in some member states but can be avoided using a variety of policy tools.

Some European companies earned windfall profits by passing through to consumers the price of allowances that they received for free. The problem, however, was largely concentrated in a few countries and occurred primarily in the electricity sector. The countries most affected were those with high-carbon sources of peak electricity and weak regulation of electricity prices, so that utilities were allowed to bill their customers for the "opportunity costs" of not selling emissions allowances that the utilities had in fact received for free.

RECOMMENDATION The most effective means of reducing or eliminating windfall profits are the auctioning of allowances and regulatory oversight of public utilities.

4. Reforms have improved elements of the EU ETS that allow emitters to tender credits earned from projects that reduce emissions in developing countries ("offsets"), but further reforms would be useful.

When the EU first developed the ETS, it decided to give regulated entities the flexibility to use not only emissions allowance trading to meet their emissions limits, but also, within certain quantitative limits, credits earned by projects that reduce emissions in developing countries. These credits could be tendered to offset emissions above a company's limits as long as the emission reductions achieved were certified through the Kyoto Protocol's Clean Development Mechanism (CDM) to be below what would have otherwise occurred. Certified Emission Reduction units (CERs), have been controversial because some have questionable "additionality," meaning it is difficult to prove that the emission reductions would not have occurred without the project. Further, by awarding emissions offsets for project-based reductions from business-as-usual emissions in industrializing nations without emissions caps, such as China and India, the CDM implicitly rewards developing countries for staying out of a global emissions cap-and-trade system.[17]

RECOMMENDATION Offset programs should have rigorous monitoring and accounting methodologies that clarify whether emission reductions are "additional" (i.e., below a credible baseline). Further, cap-and-trade programs should adopt reforms that allow offset credits only from jurisdictions that have capped some portion of their emissions, or—as the EU will begin requiring in 2013 for new projects—only from least-developed countries. To the extent that cap-and-trade programs wish to link their emissions trading programs to other nations' programs, they should do so preferentially with nations that adopt caps or limits on major emitting sectors, which may include limits aimed at reducing emissions from deforestation and forest degradation.

5. The ETS has made significant progress in preventing tax fraud and theft of allowances.

In January 2011, thieves stole approximately $67 million (€50 million) of EU allowances from some member states' carbon registries. While the sums stolen were not trivial, their scale in light of the annual value of the EU emissions allowance system was small—approximately 0.06%. For comparison, annual credit card fraud in the United States is 50% higher as a fraction of total value, estimated at roughly 0.09% of annual transaction value.[18] EU governments lost much greater revenues from large-scale fraudulent value-added tax transactions on sales of emissions allowances, but these resulted from a lack of harmonized EU tax structure, not from the design of the ETS itself.[19]

Fraud is not limited to the EU ETS. It occurs in many different markets. Markets for products that can be quickly traded internationally in transactions that are subject to national value-added tax (VAT) systems seem to be particularly vulnerable.[20] These fraud events have, however, highlighted a specific problem for the EU ETS: the lack of oversight of market participants.

The European Commission has tackled the challenge of oversight with recent registry reforms. Together with active steps by member states to address VAT fraud, the Commission's reforms have put in place the security necessary for the long-term integrity of the EU ETS, making significant future losses unlikely.

RECOMMENDATION Cap-and-trade regulators and market participants must establish effective governance and regulatory bodies, as well as preventive electronic security systems, that can adapt to evolving cyber attacks and other market security threats.

6. Companies and entrepreneurs have responded to the ETS and its complementary policies with a diverse range of profitable investments in low-carbon solutions.

Case studies, some of which are highlighted in Appendix A, demonstrate the innovative, entrepreneurial responses of firms and individuals to the EU ETS and its complementary energy and environmental policies in Europe.[21] For instance, an analysis by the German government indicates that renewable energy in Germany employs more than 367,000 people, providing 70,000 to 90,000 more jobs than a scenario in which fossil fuels provide the same growth in energy use.[22]

The EU's emissions trading infrastructure has evolved along with the ETS. In the EU there is now a diverse set of institutions and individuals with the knowledge and experience needed to accurately count and report emissions and invest in emission reductions. The ETS is persuading market actors to include the value of emission reductions in their operational decision-making and long-term investment planning.

RECOMMENDATION Countries, states, and other jurisdictions that wish to stimulate low-carbon innovation and encourage business to think creatively about reducing greenhouse gas emissions should institute an ambitious cap-and-trade system.

Going forward

Evolving and improving over time, the EU ETS is already working to reduce emissions and decarbonize the EU economy. Perhaps the most important lesson of the EU ETS is the benefit of starting cap-and-trade programs early, even if the initial design is not ideal. The design flaws and weaknesses of various policy tools are often difficult to anticipate, making practical experience a much-needed litmus test. What is important is evaluating results, making needed changes, and increasing policy ambition over time.

After a three-year trial period and almost five years of full operation, the EU ETS provides an example of an increasingly sophisticated and successful multinational emission reduction system. As the world's first large-scale CO_2 cap-and-trade system, the ETS offers a unique opportunity for other regions, nations, states, and even local jurisdictions that are considering carbon-trading systems to learn from its experience and continue to build on its success.

CHAPTER 1

Objectives and scope: the EU ETS in context

The year 2010 was the hottest on record,[23] with global greenhouse gas emission levels continuing to rise steadily.[24] With international climate treaty negotiations so far unable to deliver the emissions cuts needed to avert what scientists predict will be dangerous climate change, successful national and regional initiatives to reduce global warming pollution are ever more critical. National, regional, and sub-national approaches offer opportunities to overcome the political and regulatory uncertainty at the international level and send a clear signal that, one way or another, solutions to the climate challenge will emerge.

One of the boldest examples of a regional approach is the European Union's Emissions Trading System (EU ETS), the flagship of the EU's efforts to limit its greenhouse gas emissions to 8% below 1990 levels for the years 2008 through 2012 and drive its emissions down to 20% below 1990 levels by 2020.[25] Launched in 2005, the EU ETS is the world's largest and most ambitious legally binding cap-and-trade program to tackle global climate change.[26]

The EU ETS places a set of durable, successively tighter, legally binding caps on the carbon dioxide (CO_2) emissions of each entity covered by the system. It requires each emitter to report its actual emissions annually, and it allocates to energy-intensive companies a quota of carbon allowances, each representing a ton of CO_2. All allowances are identified by a standardized system of serialization and all transactions are recorded transparently in registries. A few

Photos.com/Christian Lagereek

The ETS caps carbon dioxide emissions from more than 11,000 power stations and industrial plants in 30 countries, and applies to approximately 40% of the EU's total greenhouse gas emissions.

months after the end of each year, each covered entity must surrender sufficient allowances to cover its entire emissions for the previous year, or face stiff penalties. Cleaner companies that reduce their emissions below their quotas can save their spare allowances for use in future years, or sell the allowances to companies that can use them to cover their emissions. This flexibility helps to ensure that emissions are cut in those areas and at those installations where it costs the least, resulting in cost-efficient emission reductions. The number of allowances is reduced over time, so the cap—and thus total emissions—decreases.[27]

The ETS currently caps carbon dioxide emissions from more than 11,000 power stations and industrial plants in 30 countries, and it applies to approximately 40% of the EU's total greenhouse gas emissions, rising to 43% in 2013 as the ETS expands its coverage.[28] The ETS aims to lower the total carbon emissions of covered sectors to 21% below the sectors' 2005 emissions by 2020.[29] The 30 countries participating in the EU ETS account for 20% of global gross domestic product (GDP) and 17% of world energy-related CO_2 emissions.[30]

The EU has updated the design of the ETS over three successive phases. Phase I, often called the pilot phase, was implemented from 2005 through 2007; Phase II is currently in effect, from 2008 through 2012; and Phase III will run from 2013 through 2020. In Phase I, the ETS set a cap of 2,181 million tons of carbon per year. In Phase II, the cap was set at 2,083 million tons of carbon per year. Phase II, however, added two countries and many installations not covered by Phase I. Without these additions, its comparable ETS-wide cap would be 1,909 million tons per year, a reduction of approximately 12% from Phase I.[31] In Phase III, the scope of the ETS will be extended to include additional sectors and greenhouse gases, but the cap for 2013 will be approximately 2,004 million tons. This represents a reduction of 11.3% below the Phase II cap, and 16.5% below 2005 verified emissions, without considering increases in the system's scope.The Phase III cap will continue to decline every year by 1.74% from the average of total Phase II allowances, resulting in a further reduction of more than 37 million tons per year.[32] Overall, the number of emission allowances will be 21% below the 2005 level by 2020, achieving the EU ETS 2020 emission reduction target.

Continuing to improve the EU ETS involves both critiquing its mistakes and identifying how to replicate its successes.

As the ETS prepares to enter Phase III in 2013, the EU and its member states continue to learn from experience and improve the ETS's design and performance. In preparation for Phase III, the EU adopted a Directive (2009/29/EC) to further improve the operation of the EU ETS. The law introduced several important changes to the system, including:

1. The scope of the EU ETS will be extended to include new sectors and new gases.

2. An EU-wide cap replaces the previous method of setting individual caps for member states based upon each state's National Allocation Plan.

3. EU allowances will be progressively auctioned, rather than distributed for free. Full auctioning, with limited exceptions, will be the rule for the power generation sector, while in most other ETS sectors free allocation will be phased out progressively starting in 2013. For those sectors at risk of significant carbon leakage, free allocation will continue.[33] The European Commission expects that at least 50% of all allowances will be auctioned in 2013, with this proportion rising each year.[34]

Continuing to improve the EU ETS involves both critiquing its mistakes and identifying how to replicate its successes. Despite some inevitable and expected growing pains, the ETS has already delivered real greenhouse gas emission reductions at lower cost than other policy instruments in the world's climate toolbox.[35]

Since criticism may be seen as more newsworthy, however, media reports on the performance of the EU ETS have concentrated their analyses on the EU ETS's self-acknowledged trial and error process while downplaying or ignoring its real successes.[36] In particular, the EU economic crisis and the drop in demand for—and price of—emissions allowances have dominated recent discussions about the ETS. The perceived lack of a long-term, stable price signal and the unexpectedly low price of allowances have led to heated debates in the EU and elsewhere about the ability of these new markets to stimulate both innovation and emission reductions.

Given the massive size of the European market, the first-of-its-kind innovation of the EU ETS, and the disparate actors involved, it is no surprise that there are lessons to be learned from the missteps of the EU ETS experience. However, most reports about the EU ETS have failed to put their critiques in the proper historical and institutional context, which is essential to understanding the evolution and efficacy of the ETS in reducing emissions at low cost, while promoting low-carbon economic growth. This report specifically attempts to provide that context by exploring both the flaws and successes of the ETS throughout its development.

The EU ETS is fulfilling its promise to cost-effectively reduce carbon emissions while stimulating low-carbon investment.

Although this report assesses the EU ETS and its components, it is not intended to provide a comprehensive analysis of the key design and policy features of the system. That is a topic that has been ably studied in other publications.[37] Instead, this report attempts to gather and address in a holistic and analytical fashion some of the recent, persistent, and sometimes contradictory critiques of the EU ETS, in order to offer an informed path to a low-carbon economy. Ultimately, this report attempts to assess whether the EU ETS has lived up to its promise to "promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner."[38]

In particular, this report will examine the lessons of the ETS via three questions that have provided the context for much of the public debate about the EU ETS:

1. Is the ETS reducing greenhouse gas emissions in Europe?

2. Is the ETS efficiently meeting its goals, given media attention to over-allocation of allowances, price volatility, windfall profits, and the integrity of international carbon offsets?

3. Has the ETS addressed its security vulnerabilities, and did these vulnerabilities affect the system's emission reductions?

Each of these questions deserves further exploration, since the answers may well determine not only the future of the ETS, but also whether and how other nations, states, and local jurisdictions follow the ETS example. Jurisdictions as diverse as California, China, the Republic of Korea, and Australia are implementing or are in the process of adopting cap-and-trade policies to reduce greenhouse gas emissions.[39] Regardless of the individual lessons of the flagship EU ETS experience, the larger verdict is in: The EU ETS is fulfilling its promise to cost-effectively reduce carbon emissions while stimulating low-carbon investment.

CHAPTER 2

Results

The EU ETS achieved immediate and significant emission reductions at low cost

On the first question—whether the ETS is contributing to the reduction in Europe-wide greenhouse gas emissions—the answer is yes; independent analyses have concluded that Phases I and II of the EU ETS have reduced Europe's carbon emissions, even as gross domestic product (GDP) has grown. While it is often difficult to attribute specific amounts of emission reductions to any particular policy or event, multiple studies examining the question at the EU-wide, national, sectoral, and individual firm levels agree that the EU ETS is responsible for emission reductions independent of complementary policies and the economic recession. This chapter will look at evidence from modeling studies and retrospective analyses that examine the effects of the ETS on CO_2 emissions in the EU as a whole, as well as studies using data available at the national, sectoral, and individual firm levels.

EU emissions have fallen while gross domestic product has grown

In ratifying the Kyoto Protocol, the 15 pre-2004 member states of the EU (EU-15) made a commitment to the international community to limit their cumulative greenhouse gas

Courtesy German Wind Energy Association/© BWE / Thorsten Paulsen

The EU ETS and corresponding investment in renewable energy have helped reduce Europe's carbon emissions, even as its economy has grown.

emissions to 8% below their 1990 levels for the years 2008-2012.[40] The ETS is a central element of the EU's international climate change strategy and was designed in significant part to help the EU-15 achieve its Kyoto target.[41] The EU appears set to achieve (and improve upon) its collective Kyoto goal partly because of the effectiveness of the ETS.[42] Already in 2011, the greenhouse gas emissions of the EU-15 were estimated to be 14.1% lower than in 1990.[43]

The ETS is also playing an important role in keeping the EU on track to meet its additional target of reducing greenhouse gas emissions to 20% below 1990 levels by 2020. From the start of the ETS in 2005 to the end of 2010, emissions in the sectors covered by the ETS have declined more than 13%, while GDP has increased.[44] Overall, in the EU's 27 member states (EU-27), greenhouse gas emissions in 2009 were 17% lower than emissions in 1990, while GDP grew by more than 40% and manufacturing by more than 12% in the same period.[45] In fact, the EU's success thus far in laying the foundation for its 20% target by 2020 has prompted persistent calls among stakeholders in Europe to tighten the EU's target even further: to 30% below 1990 levels by 2020.[46]

The EU ETS has achieved emission reductions at low cost

Ex post studies on the cost of the EU ETS continue to emerge, but what is clear from reports is that while the ETS has contributed to significant reductions in European emissions, the cost has been low—by some estimates, just 0.01% of the European Union's GDP.[47]

A 2006 McKinsey report estimated minimal costs from the EU ETS in the power, steel, and pulp-and-paper sectors. For only a small segment of pulp-and-paper plants, net costs were estimated to increase more than 2% as a result of the EU ETS, and then only by 3-6%.[48] Since then, studies conducted at the macroeconomic, sectoral, and individual firm levels have confirmed the minimal cost of the EU ETS for regulated entities.[49]

For a complete discussion of the U.S. SO_2 emissions trading program, see Appendix B, page 36. For a complete discussion of the U.S. Regional Greenhouse Gas Initiative (RGGI), see Appendix C, page 38.

For example, a 2008 analysis of the ETS's effect on production and profitability for the iron and steel sector in Phase I concluded that competitiveness losses in these sectors were small. These findings led the study's authors to conclude that "arguments against tightening the environmental stringency of the EU ETS in Phase II are not justified on grounds of competitiveness loss."[50]

A 2011 study that reviewed published literature on the costs and competitiveness effects of the EU ETS summed up the consensus that "being subject to the EU ETS did not significantly affect profits, employment or added value during the first phase and the beginning of the second phase."[51] The same study confirmed those results in a comprehensive analysis of the performance of more than 2,000 European firms covered by the EU ETS.[52]

While these studies focus on the economic costs of the ETS, they do not attempt to quantify the observed or expected improvements in public health or savings that accompany emission reductions. A recent report by the European Commission, for example, estimates that the health benefits of improved air quality if the EU ETS tightened its 2020 cap would be equivalent to \$4.3 billion (€3.3 billion) to \$10.4 billion (€7.9 billion). The EU would also save an average of \$26 billion (€20 billion) in fuel costs each year from 2016 to 2020.[53]

Based on available evidence from Phase I and the start of Phase II, claims that the ETS would harm Europe's economy[54] now appear grossly exaggerated. Historically, this is unsurprising—the ETS was modeled on the U.S. sulfur dioxide (SO_2) emissions trading program, which achieved similar successes at lower-than-expected costs (see Appendix B).[55] Cap-and-trade policies have consistently achieved results faster and cheaper than anticipated, as shown by the experience of the U.S. SO_2 emissions trading program, the U.S. Regional Greenhouse Gas Initiative (see Appendix C), and now the EU ETS.

Despite the significant CO_2 emission reductions observed in the EU, however, some commentators have claimed that EU emission reductions have been caused by the recent economic recession and other factors—reductions that would have happened even without the ETS.[56] Is the real source of emission reductions in the EU indeed not the ETS, but other policies and the economic recession?

The EU ETS is responsible for a significant share of emission reductions independent of complementary policies and the economic recession

Because CO_2 emissions track power production and economic activity, a possible answer to the question of the role of the ETS in observed emission reductions comes from *ex post* analyses of the EU's emissions in proportion to economic growth (or contraction). These studies are based on an observed emissions intensity improvement (CO_2 per unit of economic activity) above historical trends. In other words, they estimate what emissions *would have been* in the absence of the EU ETS based on the relatively constant rate of change pre-EU ETS in the emissions intensity of sectors covered under the system. In the years before the EU ETS, these sectors demonstrated a stable improvement in emissions intensity (about 1% per year) due to efficiency gains. Assuming a continued trend of 1% in the absence of the EU ETS—a "business-as-usual" (BAU) scenario—allows a comparison with observed emissions, with any deviations due to new developments (e.g., the EU ETS).

BAU calculations for EU emissions also include adjustments for weather, fuel prices (i.e., the difference between coal and natural gas prices), GDP growth (or contraction), and other factors that influence CO_2 emissions levels. It is impossible to prove the accuracy of these estimates since the BAU projection is not observed in real time and never will be. However, a number of modeling uncertainties can be reduced or eliminated, particularly since the BAU evaluation is done *ex post*, when data on these other factors that affect emissions (e.g., recessionary effects) are known.

The majority of studies confirm that the ETS has significantly reduced European emissions above and beyond the contractive effects of the recession or other possible factors.

The EU ETS was responsible for emission reductions of 2–5% below business-as-usual in Phase I

So what do these models show in the case of the EU ETS? The majority of studies, using a variety of methodologies, confirm that the ETS has significantly reduced European emissions above and beyond the contractive effects of the recession or other possible factors.[57]

The best-known and most authoritative study confirming these findings comprises detailed analysis of the Phase I emissions of the industry and energy sectors covered by the EU ETS.[58] Phase I ended before the recession and offers an opportunity to examine emission reductions during a period of economic growth in Europe. EU GDP increased by at least 2% per year in Phase I.[59] Yet despite economic growth and an over-allocation of allowances in Phase I, the study concluded that the EU ETS independently prompted companies to invest in energy efficiency and emission reductions, especially in the energy sector, as firms responded to the law by converting to gas-fired power stations in place of dirtier coal or oil plants.[60]

Several other studies have confirmed Ellerman's findings that the ETS reduced emissions in both the energy and industrial sectors in Phase I.[61] For instance, a 2010 study comparing data on historical industrial emissions with allowance allocation in each EU member state found that Phase I of the ETS was responsible for significant emission reductions throughout the EU. Moreover, these ETS-induced reductions would have been even more pronounced if investors had more certainty about long-term caps and future EU ETS policy design features.[62]

The question then becomes *how much* did the ETS achieve in Phase I? Despite modest ambitions and a rushed implementation schedule, Phase I is estimated to have reduced carbon emissions to approximately 2–5% below what emissions would have been in the absence of the program,[63] or by 120 million to 300 million tons—about the size of the total CO_2 emissions of the Netherlands in 2009.[64] A 2008 analysis of emission reductions in the EU power sector—the largest sector in the EU ETS by share of emissions—concluded that in just the first two years of Phase I, the ETS was responsible for between 53 million and 98 million tons of emission reductions from fuel switching in the power sector.[65] The study used a complex model of energy use and price interactions between fuels to rule out the effect of prices on the observed change in fuel usage.[66]

Other studies have analyzed the effects of the ETS at national levels and found similar results. Germany is the largest economy in the EU, and it can be seen as a microcosm of the eastward expansion of the European Union since it includes the former East Germany. Germany is also one of the few EU member states to have verified and published pre-2005 emissions data from ETS installations, allowing the creation of more accurate business-as-usual emissions scenarios.[67]

Using a variety of economy-wide and ETS sector-specific scenarios, a 2008 study found that the EU ETS reduced emissions in Germany. Estimates ranged from 45 million to 120 million tons in Phase I, with significant reductions accomplished in both the power and industrial sectors.[68] Later estimates narrowed the range to 71 million to 86 million tons, equivalent to a 6% reduction in German emissions compared with what emissions otherwise would have been.[69]

Prior to the introduction of the EU ETS in 2005, German emissions were growing. After the introduction of the ETS, German emissions declined, despite economic growth throughout Phase I. As the authors of the 2008 study noted, "this change of trend in the absolute level of emissions is remarkable given the marked acceleration of economic activity in Germany during [Phase I], in contrast to the pre-policy period."[70]

The pilot phase successfully reduced emissions and met its key carbon-trading infrastructure goals: to establish a price for carbon, begin trading in emissions allowances across the EU, and create the institutions necessary for monitoring, reporting, and verifying emissions.

Phase I was designed as a pilot phase[71] to encourage learning-by-doing and the development of a proper trading infrastructure, including emissions data and registries. Little information was available regarding actual industry and company emissions prior to the beginning of the program, and the Phase I implementation schedule was rushed. For instance, when Phase I began in January 2005, only one national allowance registry in the EU was operational. It took another year and a half until all registries were operational.[72] In effect, this kept Phase I emissions targets modest, yet the evidence shows that Phase I still had an independent effect on reducing carbon emissions in the EU.

In addition to reducing emissions, the pilot phase successfully met its key carbon-trading infrastructure goals: to establish a price for carbon, begin trading in emissions allowances across the EU, and create the institutions necessary for monitoring, reporting, and verifying emissions. For instance, the ETS has made carbon management systems a priority for companies across the EU.[73] In addition to providing investors with the information they need to know about performance, liability, and risks, the carbon management stimulated by the ETS has allowed companies to discover unnoticed emission reduction opportunities.[74]

The EU ETS continued to reduce emissions in Phase II, independent of the global economic recession

Building on the success and experience of Phase I, Phase II introduced more ambitious emissions targets and ensured that allocations of allowances were based on verified emissions data recorded during Phase I, with the European Commission imposing a formula to assess the stringency of member states' Phase II national allocation plans. On average, the commission review cut 10.4% from member states' initial national allocations for Phase II.[75]

Total emissions in the sectors covered by the ETS declined by 4% from 2008 (the beginning of Phase II) to 2010.[76] Recent data from the European Environment Agency show that reductions in the ETS sectors continued in 2011, down 1.8% from 2010 levels, while EU GDP increased by approximately 1.4%.[77]

A recent study by the Centre for European Policy Studies (CEPS), an independent policy research institute based in Brussels, appears to confirm that the ETS continued to drive down EU emissions in Phase II, independent of the global economic recession that struck Europe in earnest in 2009.[78] CEPS used EU-wide and ETS sectoral-level emissions and economic data to extend observed emission intensity trends to the initial years of Phase II (2008 and 2009).

Their results show even greater reductions in total emissions and improvements in emissions intensities during Phase II than those achieved in the trial period. "Period 2 emissions were even lower than the mere continuation of the trend" from Phase I.[79] The authors call for more detailed analysis at the production level to confirm their results, but they conclude that the ETS stimulated emission reductions in the ETS sectors both in Phase I and II.

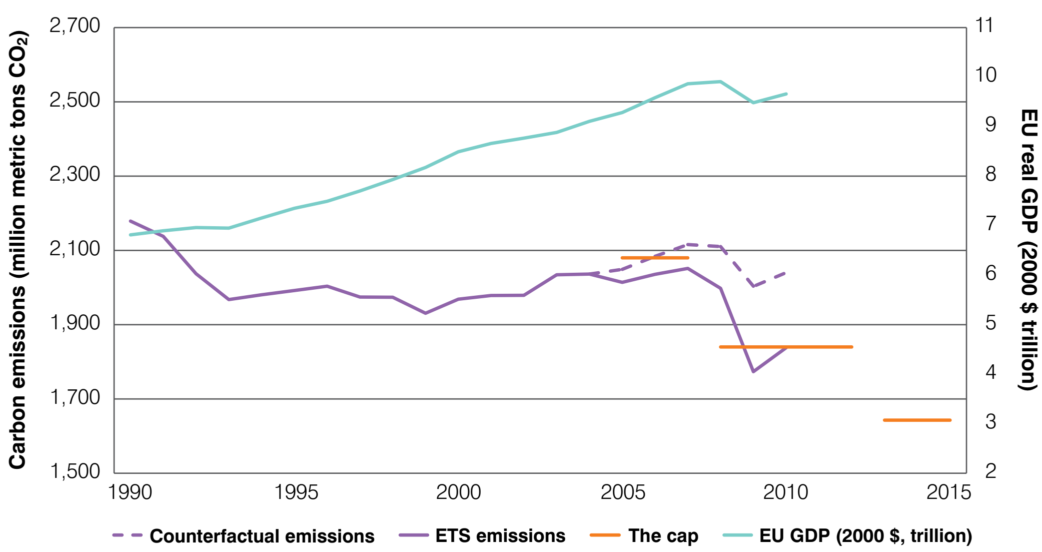
Further evidence for the effectiveness of the reforms to the ETS in Phase II comes from studies of the emissions and economic performance of individual companies across the EU. For example, in order to understand the effects of the ETS at firm level, researchers studied a wide range of more than 2,000 firms across ETS-covered sectors and countries, representing more than 3,600 installations and 59% of total ETS-verified emissions. The study found that the tightening of the ETS cap and the more stringent allocations to industry installations that marked the beginning of Phase II led to significant emission reductions at firms in 2008, even controlling for production changes and reduced economic activity due to the global financial crisis in late 2008.[80]

Estimates of the amount of emissions reduced by the ETS, as opposed to other factors, are beginning to emerge. For example, analysis from New Energy Finance indicates that the ETS was responsible for 40% of the 3% reduction in emissions in the EU in 2008, the first year of the ETS's post-pilot Phase II, with the recession accounting for only about 30% of the observed reductions.[81] More recent research indicates that these trends continued beyond 2008. In 2009 alone, for example, the ETS was likely responsible for more than 230 million tons of CO_2 reductions, more than Egypt's total emissions in that year.[82]

Figure 1 shows the trend in emissions covered by the ETS since 1990 along with EU GDP growth.[83] The dotted business-as-usual line starting in 2004 represents an emissions growth

FIGURE 1

EU ETS sector emissions (million metric tons CO_2), emissions caps, and EU GDP, 1990–2015



Note: Even assuming an emissions growth rate 1% less than the growth in GDP (represented by the dotted business-as-usual line), the data suggest that the ETS has succeeded in reducing emissions beyond what would be expected from the recession alone. ETS sector emissions declined a further 1.8% in 2011, according to recent estimates, while GDP increased approximately 1.4%. However, verified 2011 emissions data will not be available until mid-2013, and thus the graph does not depict the likely drop in 2011 emissions.

Source: GDP data: World Bank. EU emissions: A. Denny Ellerman, "The EU ETS: Path to the Future or Dead-end?" presentation, Sept. 5, 2011, available at www.dors.dk/graphics/Synkron-library/Konference%202011/Abstracts/Ellerman.pdf. European Environment Agency, "European Union's total greenhouse emissions down 2.5% in 2011," September 7, 2012, available at eea.europa.eu/highlights/european-union2019s-total-greenhouse-emissions.

rate without the EU ETS. To account for the increased efficiency typically associated with GDP growth, the "BAU" dotted line assumes that emissions would have grown at a rate 1% less than the growth in GDP. Overall, from 2005 to 2009, these estimates indicate that the ETS was responsible for reductions of more than 480 million tons of CO_2,[84] which is more than the entire 2009 CO_2 emissions of Mexico or Australia.[85]

Emissions data released by the European Commission show that even though CO_2 emissions regulated by the EU ETS increased 3% from 2009 to 2010,[86] the increase in emissions was less than either the overall increase in industrial output (7.4% year-on-year) or the increase in power demand. As one carbon analyst noted, "electricity production in 2010 rose by 4% whereas emissions only rose by 1.8% compared to 2009 levels. It is evident that this sector must have implemented energy efficiency measures."[87] When seen against increases in power demand and industrial output, the emissions figures suggest that the ETS is achieving its purpose: to gradually decouple carbon pollution from economic development.[88]

Additional evidence for ETS-induced reductions comes from case studies and interviews, but these methods do not allow for quantification of emissions reductions. According to these studies, the ETS has spurred investment in energy efficiency and reductions in large-scale coal power emissions. Surveys also show that the EU ETS affects the behavior of firm managers and encourages investments in energy efficiency, although the effect varies among different industries and may be more pronounced for large investments than for small ones.[89]

The ETS has spurred investment in energy efficiency and reductions in large-scale coal power emissions.

The EU ETS has been in effect only since 2005, and further research is needed to confirm and elaborate on its effects. Studies linking the ETS to emission reductions have been criticized on the grounds that changes in emissions are difficult to attribute to the ETS. Indeed, it is challenging to disentangle factors other than the ETS that have influenced CO_2 reductions.[90] Some portion of the EU's observed emission reductions are attributable to the global financial crisis and the economic recession that followed. Individual member states and the EU as a whole have also adopted emission reduction policies complementary to the EU ETS, including renewable portfolio standards, feed-in tariffs for renewable energy, and carbon taxes. However, even EU ETS countries without complementary national programs have experienced significant reductions, indicating a likely role for the EU ETS.[91]

Determining the exact proportion of emission reductions attributable to the EU ETS versus other factors is difficult because business-as-usual scenarios can never be observed, but uncertainties can be minimized using robust models based on accurate data. These observations highlight the importance of collecting reliable and accurate pre- and post-program data on emissions and economic activity as part of any emissions trading system, not only to create incentives to reduce emissions, but also to establish a sound basis to construct the scenarios needed to evaluate and verify a program's success.

While the amount of reductions attributable to the ETS is difficult to pinpoint, "the exact number or percentage is not as important as the evidence that there was some effect" from the EU ETS.[92] Ultimately, the case for emission reductions from the EU ETS rests upon the fact that observed emissions show a perceptible flattening after the introduction of the EU ETS despite robust economic growth and other factors that typically drive emissions. There could be other factors that caused the observed change in emissions, but the EU ETS is the most obvious explanation.

The EU ETS provides the flexibility needed to identify and deliver cost-effective emission reductions

Efforts to untangle the emission reductions attributable to factors other than the EU ETS must be placed in the larger context of the benefits of a cap-and-trade system for pollution reduction: A cap-and-trade system allows regulated entities the flexibility to find the lowest-cost solution to achieve the environmental goal mandated by the cap. This provides a distinct advantage over less flexible command-and-control policies, as it harnesses dynamic market changes and innovation in order to deliver pollution reduction results.

In this way, a flexible trading system such as the EU ETS allows society to capture the environmental benefits of efficiencies and cost reductions in seemingly unrelated sectors of the economy. An instructive example comes from the U.S. experience with the sulfur dioxide emissions trading program mandated by the 1990 amendments to the Clean Air Act. The law was intended to cut nationwide emissions of sulfur dioxide to 50 percent below 1980 levels by the year 2000, but it did not mandate that polluting factories install any particular pollution reduction technologies (such as "scrubbers").

Instead, the program was designed to allow for a broad set of compliance alternatives, in terms of both timing and technological options. As a 1998 analysis of lessons learned from the system points out, "this allowed mid-western utilities to take advantage of lower rail rates (brought about by railroad deregulation) to reduce their SO_2 emissions by increasing their use of low-sulfur coal from Wyoming and Montana, an approach that would not have been possible if scrubber requirements had been in place. Also, a less flexible system would not have led to the technological change that may have been induced in scrubber performance and rail transport."[93]

The flexibility of the SO_2 trading program allowed it to convert efficiencies occurring in an unrelated sector of the economy (railroads) into low-cost pollution reduction tools. Cap-and-trade programs harness process and organizational innovations in industry for environmental purposes, driving private profit motives to deliver public benefits. Although quantifying these benefits can sometimes be difficult, this uncertainty does not obscure the important advantage of flexible market-based solutions like the EU ETS in stimulating proven low-cost emission reductions.

CHAPTER 3

Learning-by-doing: reforms in response to the EU ETS's early challenges

The ETS has proved effective in contributing to the EU's emission reductions goals. Yet critics have argued that a series of separate problems such as over-allocation, price volatility, windfall profits, unreliable offsets, and fraud have eroded the system's ability to achieve emission reductions fairly and efficiently.

The discussion below focuses on these five problems of the early ETS and subsequent reforms to address them.

Over-allocation of allowances occurred during Phase I, but firms still invested in emission reductions

A number of critics have accurately pointed out that during the pilot phase, EU ETS allowances were over-allocated—that is, the EU issued more carbon emissions allowances than companies actually needed. This avoidable design flaw has negative ramifications;

Five early problems and reforms of the EU Emissions Trading System

1. During Phase I, the EU over-allocated emissions allowances. The EU has addressed this problem by basing new allocations on verified emissions levels and by tightening the emissions cap. As explained more fully below, over-allocation did not prevent emission reductions or investments in production efficiency. Going forward, over-allocation can be avoided by further tightening the cap and/ or extending the cap into the future.
2. During Phase I, the ETS experienced significant price volatility. The EU has reduced volatility considerably by allowing banking between commitment periods. Notwithstanding, ETS allowance price volatility has been less than the price volatility of other commodities over the same period.
3. Windfall profits were real but were also isolated and predictable. The auctioning mechanism now in place will largely eliminate the risk of future windfalls.
4. Offsets from projects in developing nations were occasionally unreliable. The offset system has been reformed and restricted, but further reforms could be useful.
5. Fraud and theft of allowances occasionally occurred during the program's early stages, but the scale was small in comparison to the overall program. Security and value-added tax (VAT) reforms have significantly reduced the risk of further breaches.

providing too many allowances has the effect of setting the total emissions cap too high to induce desired emission reductions.

As noted earlier, an important cause of this over-allocation was that when EU authorities set out to establish the pilot phase, they lacked reliable data on companies' actual historical emissions. To set the cap and make the companies' trial experience with emissions trading a comfortable one, EU member states simply issued companies as many allowances as the companies thought they would need during the three years of the pilot phase. Unsurprisingly, companies over-estimated their anticipated emissions in order to avoid actual reductions, and more allowances were issued than the companies actually needed.[94] Over-allocation appears to have been concentrated in a few countries, particularly in Eastern Europe, and from the non-power sectors.[95] A 2011 report estimated that for the pilot phase, the market had approximately 2.5% more allowances than emissions. However, this includes the effect of European companies actively reducing their emissions after the ETS was in place,[96] because the companies expected the pilot phase would be followed by a phase with tighter caps.

The ETS, then, was a victim of its own success at spurring emission reductions, as those reductions further increased the excess of allowances. Had pilot phase allowances instead been "bankable"—savable, and thus applicable later in Phase II, when more valuable to industry—it is likely that even more emission reductions would have occurred.

This over-allocation of allowances in Phase I of the EU ETS, combined with a lack of experience and capacity in emissions trading by market participants, resulted in the volatility of the European Union Allowance (EUA) price in the trial period. Allowance prices have also fluctuated in Phase II, although not as much as in Phase I. The current relatively low price is likely due in part to the success of the program in inducing actual emission reductions (allowance trades will naturally decline if regulated entities succeed in meeting their reduction targets); in part to the success of parallel policies for reducing emissions; and in part to the economic downturn.[97]

Important accounting and allocation reforms for Phases II and III of the trading system have reduced the potential for over-allocation.

Emissions caps and resulting allowance allocations are now based on measured and verified historical emissions, rather than on estimated or projected emissions

The over-allocation of emissions allowances in Phase I provides a crucial lesson from the learning process of the trial period.

Phase I was primarily designed to provide learning-by-doing, rather than to stimulate significant emission reductions. As a result, allowances were allocated generously. EU regulators patterned their new system on the successful U.S. sulfur dioxide (SO_2) emissions cap-and-trade system, described in Appendix B, which has successfully cut U.S. acid rain pollution since 1995 at a small fraction of the anticipated cost.[98]

However, there is an important difference between the U.S. Acid Rain Program and the EU ETS. Because the EU lacked reliable data on historical emissions, it initially allowed each of its member states to allocate CO_2 allowances based on facilities' estimated future emissions and on optimistic growth scenarios.[99] In contrast, the U.S. allocated SO_2 allowances to facilities based on actual historical emissions or fuel use.

Estimating emissions and forecasting emissions growth is an inherently imprecise practice. If emissions increase more slowly than forecasted, there will be excess allowances in the system. EU allowance prices unsurprisingly fell when annual emissions reports for 2005, independently verified and filed in 2006, showed that companies' actual emissions were less than forecasted.[100] This behavior is consistent with a well-functioning market adjusting to new economic information.

Important accounting and allocation reforms for Phases II and III of the trading system have reduced the potential for over-allocation. Specifically, in Phases II and III, the EU has moved to a more centralized cap and allocation process based on actual historical emissions data, which it began collecting in Phase I.[101] Similarly, jurisdictions considering cap-and-trade programs should gather actual emissions data prior to establishing caps and allocating allowances, and that is precisely what jurisdictions from California to the Republic of Korea have begun to do. The more centralized nature of this EU-wide cap will also prevent member states from inflating their own caps, as occurred in Phase I.

In Phase III, the EU will allocate allowances for the industrial and heating sectors based on rigorous best-practices benchmarks, which reflect the average greenhouse gas performance of the best-performing 10% of installations in the EU that produce the same product.[102] Successful implementation of these standards will further reduce the risk of over-allocation.

In addition, the EU now authorizes banking or saving of allowances for use in future phases, which reduces the risk of over-allocation. Emitters facing the prospect of tighter emissions caps in future phases will save any unneeded allowances for use or sale in the future, when demand for scarcer allowances is stronger and prices will likely be higher, instead of dumping the allowances in the marketplace during the current phase and driving allowance prices down.

The EU is tightening emissions caps over time, reducing the availability of allowances and increasing the economic rewards of low-carbon investment

The EU has tightened the ETS emissions caps since Phase I, reducing the number of allowances in the system and increasing the economic rewards of low-carbon innovation. For example, when the pilot period ended and Phase II began in 2008, verified emissions exceeded the free allowance allocation by nearly 200 million tons, or 10%, resulting in a significant shortage of allowances and prices of $29.75 (€20) to $44.60 (€30) per ton in the first half of 2008.[103] Phase III's caps are tighter, starting in 2013 with a cap 16.5% below verified 2005 emissions. The Phase III cap will continue to decline annually by a linear factor of 1.74% from the average of total Phase II allowances.[104] This will achieve a reduction of approximately 37 million tons every year.[105] This annual reduction in the EU cap is scheduled to continue indefinitely after 2020, although legislative changes are needed to tighten the cap further in order to achieve the EU's more ambitious 2050 carbon reduction targets.

Jurisdictions considering cap-and-trade programs should gather actual emissions data prior to establishing caps and allocating allowances.

Current discussions in Europe include proposals to tighten the EU ETS cap further, e.g., to 30% below 1990 levels by 2020,[106] not only to strengthen emission reductions, but *also to stimulate economic growth*. At least one study suggests that doing so could create millions of jobs and bolster investment and GDP growth.[107]

A cautionary note: Current proposals to remove allowances from the ETS must be carefully evaluated

While the ETS Directives have already tightened the EU's emissions caps in Phases II and III, prices in the allowance market are nonetheless currently well below analysts' predictions. Ironically, the EU ETS's role in reducing emissions earlier and at lower cost than many of its initial critics predicted is now contributing to the opposite critique. Initial warnings that "the ETS will cost too much" have been replaced by "it doesn't cost enough." Now, critics argue that the price of emissions allowances is too low to stimulate needed incentives for investment in longer-term emission reductions.

Thus, there are "Goldilocks" proposals for regulatory intervention to guide prices to a "just right" level. Proposals include cancelling a large number of emissions allowances in order to reduce their supply and boost their price; withholding allowances from upcoming auctions; and tightening the EU ETS emission reduction target for 2020, among others.[108]

The economic recession did reduce emissions in the EU and, therefore, the need for allowances, particularly within the industrial sectors covered by the ETS. For example, the European steel production sector experienced a surge of available allowances because of the recession (as well as the initial over-allocation).

Yet attempts to eliminate "extra" allowances that firms accumulate when they suffer an economic downturn pose two significant risks that must be carefully evaluated.

First, changing the rules in the middle of the game erodes the regulatory certainty that market participants need if they are to plan the significant investments required for low-carbon development. The U.S. SO_2 program has clearly shown that regulatory uncertainty is the most significant contributor to price volatility and destabilization in cap-and-trade markets. As Figure B2 in Appendix B illustrates, the price of SO_2 allowances dramatically increased in 2006 in response to uncertainty about proposed new regulations.[109] Then, after a court decision in 2008 invalidated the proposed regulations, the price of allowances crashed to nearly zero.

Second, forcing firms to give up allowances in hard economic times makes it difficult to resist the call to award additional allowances in the more frequent times of growth, thus defeating the purpose of removing the "surplus" allowances in the first place. The size of the cap should be determined by the science of verified emissions, not by the price of allowances.

Consequently, it is helpful to have a science-based policy that consistently achieves emission reductions but has less impact on the economy during occasional economic downturns. A predictable cap guided by the evidence of climate science provides a flexible, automatic stabilizer that helps to smooth unexpected downturns in the macroeconomy by reducing the costs of emission reductions.[110]

A binding cap on emissions that declines based on predictable rules sends a durable market signal that stimulates investment in emission reductions during times of recession as well as growth. It is the cap, not the prospect of a high allowance price, that spurs action to cut emissions.[111] One of the key advantages of a cap-and-trade system is that it stimulates the lowest-cost carbon emission reductions. Clearly, reductions under the EU ETS are being achieved in a cost-effective manner under the current cap, or there would be greater demand for purchasing additional allowances at higher prices. Thus, the current low allowance prices should be recognized not as a failure of the system, but as another indication that emission reductions are typically much cheaper than pundits predict.

The size of the cap should be determined by the science of verified emissions, not by the price of allowances.

In fact, allowance price volatility is likely to induce economic actors to take early actions—i.e., to reduce emissions early—specifically to gird against carbon risks.[112] Nonetheless if a jurisdiction wishes to try to modulate allowance price volatility, it should consider cap-and-trade design tools built on predictable, known-in-advance rules that minimize the need for arbitrary government intervention.[113] California's price reserve mechanism, as discussed further below under "banking" provisions, provides one example.

EU emissions allowance prices have been moderately volatile, but volatility has not impaired the EU ETS's effectiveness in reducing emissions

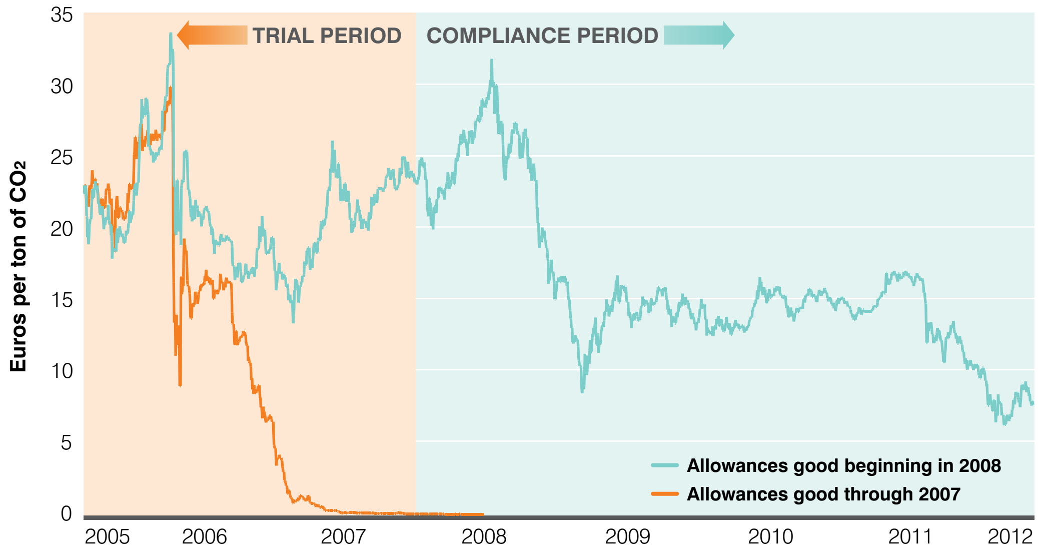
A separate criticism of the EU ETS is that allowance price volatility has damaged the system's ability to drive needed investments in emission reductions; commentators point to sudden downswings in the price of EU allowances as an indication of the system's flaws.[114] Over a two-week period in April-May 2006, during Phase I of the ETS, the price of allowances dropped by 50% in less than a week, before recovering moderately. One day in April 2012, the price of allowances dropped by approximately 11% in response to news that emissions in the EU were lower than expected.[115] Figure 2 shows the price history of EUAs from 2006 to 2012.

One valid concern with price volatility is that steep and lasting declines in allowance prices could discourage low-cost abatement efforts and investment in new technologies, ultimately increasing the cost of future reduction efforts needed to meet the emissions cap.[116] Is price volatility a problem for the efficacy of the EU ETS? For three reasons, the answer is no.

First, as explained below, long-term EUA prices are stable, and long-term prices are more important than short-term prices in determining firms' investments in emission reductions.

FIGURE 2

European Union Allowance (EUA) prices for both trial period allowances and Phase II allowances, 2005-2012



Source: Point Carbon, database of spot and future prices for EUAs, available at pointcarbon.com/news/marketdata/euets/forward/eua/.

Second, short-term price volatility of EUAs has not been unusual compared with other commodities. Third, much of the reported volatility was due to the fact that excess allowances from Phase I could not be banked or saved for use in subsequent phases. Each of these reasons is explained more fully below.

Expectations of future emissions caps are the most important driver of low-carbon innovation

While recent EUA price drops can appear severe, concerns about the negative effects of short-term price volatility are not grounded in substantial empirical data. Price volatility is not a sign of market failure. There is little evidence to suggest, for example, that short-term price swings in EU allowances are hindering innovation. The expectation of a carbon price five, ten and twenty years from now is far more important in influencing the long-term investment that is essential for low-carbon development.[117]

So how do EUA prices look a few years down the road? The market appears confident in the stability of EUAs over the longer term. Current prices for EUA futures increase further in the future—and discounting these futures to the present results in a stable price.[118] Data also suggest that the ETS has indeed had a tangible effect in spurring low-carbon innovation in Europe.[119] Thus, evidence of low prices in the near term does not indicate that the ETS is failing to spur investment in—and deployment of—innovative technologies. To the contrary, the ETS and complementary energy and environmental policies have helped give the EU "the global lead in green technology deployment."[120]

Furthermore, as the U.S. SO_2 market demonstrates, the success of a cap-and-trade program in spurring faster-than-expected deployment of clean technologies and strategies and in reducing emissions does not depend solely on a high or constant price for its allowances. In fact, lower allowance prices can be a sign of an ETS's success: Unexpected innovations often lower allowance prices as emission reductions are achieved at a lower cost, and fewer allowances are needed.[121] As Figure B2 of Appendix B shows, the price of SO_2 allowances changed dramatically during the program's first 10 years but still spurred significant investments in

SO_2 reductions. While the expectation of high carbon prices can encourage technological innovation, the U.S. SO_2 program demonstrates that low carbon prices do not impede emission reductions.

Indeed, by keeping costs low, a cap-and-trade program makes more ambitious emission reductions affordable. For example, a recent UK study found that, under the right conditions, global carbon trading could reduce greenhouse gas emission reduction costs by up to 70% compared with other policy options. These efficiencies could potentially allow the world to reduce global emissions by an additional 40-50% at the same macroeconomic cost while providing substantial financial flows to the developing world to support the move to a low-carbon economy with sustainable growth.[122]

ETS price volatility has been no greater than the volatility that is part of the normal functioning of a complex market.

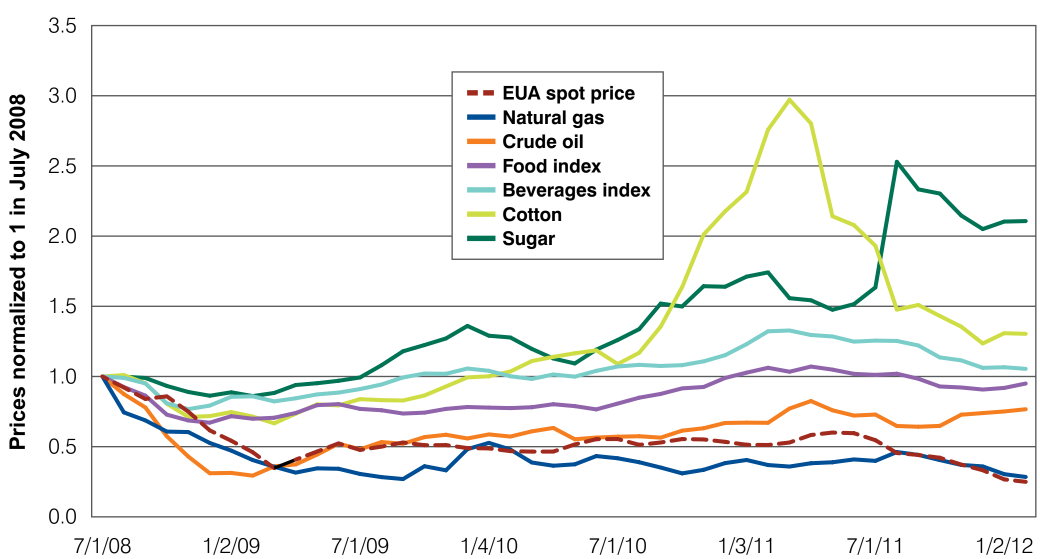
Price volatility in allowances can occur for a number of reasons, including "changes in economic activity, weather events, fuel prices, and technology development."[123] Some price volatility is part of the regular functioning of a market. So how has the price of allowances fluctuated compared with similar commodities? EUA price volatility has been typical, and in fact has even been less severe than other commodities, as shown in Figure 3.[124]

For example, the price of an ETS allowance has displayed less volatility than coffee, cocoa, oranges, rice, and many other commodities.[125] From July 2008 until March 2012, EUA prices were also less volatile than fossil fuel prices. Coal prices have fluctuated 3% more than the price of EUAs, West Texas oil prices 11% more, and natural gas prices have been 24% more volatile.[126]

While the price of EUAs has indeed fallen recently, in large part this is due to renewed fears of a widening economic crisis in the EU.[127] An economic crisis would nearly always lead emissions—and thus demand for allowances—to drop along with the price. Future price swings are anticipated while a variety of economic and political factors play out in the European market, from the Greek crisis to the phase-out of nuclear power in some member states such

FIGURE 3

Comparing the price volatility of European Union Allowances (EUAs) with various commodities, 2008–2012



Source: All commodities indexed relative to their value in July 2008. Source: EAU spot price data from Point Carbon. Other commodity data accessed from IMF Commodity Price Index, available at www.imf.org/external/np/res/commod/index.aspx.

as Germany. Some participants in the carbon market use stop orders—market orders that automatically sell allowances when EUA prices hit a certain low level. As with all commodities, these stop orders create a self-reinforcing sell-off that contributes to some of the swings in the price of EUAs.[128]

Some degree of price fluctuation is a normal aspect of complex markets, including the ETS allowance market. For example, firms are constantly exposed to fossil fuel price volatility when making investments and other business decisions, and this, in part, translates into allowance price volatility. Firms hedge against these risks by purchasing futures for commonly needed commodities. Similarly, 90% of carbon allowance trading occurs in futures markets, which reduces price uncertainty for market participants.[129] Clearly, while carbon allowances may be a new commodity, the dynamism of the larger market is constant, and allowances have proved to be no more susceptible to those forces than any other traded commodity.

Regulatory changes can also play a significant role in price volatility. In June 2011, for example, the price of EU allowances dropped 22% as investors worried that new energy efficiency legislation (and worsening European economic conditions) could reduce emissions—and thus demand for EUAs.[130] But unlike price changes that are part of the normal functioning of the market, durable price changes in response to regulatory uncertainty can be reduced, particularly if an ETS sets long-term carbon reduction targets. By sending an unwavering market signal, formalizing the long-term reductions reduces price volatility over time.

While recent EUA price drops have been significant, the effectiveness of any cap-and-trade program should be judged more on its ability to meet (and surpass) increasingly ambitious caps on emissions at low cost. Price drops are the normal and expected function of any commodity that responds to a number of external forces in the market. Because the EU ETS has performed its function of reducing emissions and stimulating low-carbon investment, criticism of low allowance prices is misplaced.

Banking or saving of surplus allowances helps to smooth volatility in carbon markets.

Banking of allowances is now permitted and is reducing price volatility

Banking or saving of surplus allowances (and the closely related concept of "borrowing" from future allocations[131]) helps to smooth volatility in carbon markets by enabling companies to choose whether to sell surplus allowances or save them for future use, when emissions caps tighten. The objective is to encourage early investments in emission reductions in-house by offering facilities the flexibility to reduce their emissions now and hold allowances for later use.[132] While there is a possibility of emissions in later years exceeding the cap for that period because of banked allowances, the availability of banking promotes early action to reduce emissions, and a strong cap ensures that overall emissions do not exceed the cap.[133] Moreover, experience indicates that emitters tend not to draw all the allowances out of their savings accounts; accordingly, banking helps achieve not only early reductions, but reductions beyond what caps require. The textbook example is the U.S. sulfur dioxide emissions trading program, where strong over-compliance during the early years resulted in a "bank" of emissions allowances that were drawn upon in later years and significantly dampened price volatility.[134] The banking of unneeded allowances acts as a powerful tool for encouraging emitters to make early reductions and to manage capital stock turnover in a way that favors reduced emissions.

For example, an electric power generation company managing several large boilers might consider replacing or upgrading a boiler ahead of schedule in order to over-comply and bank the resulting surplus allowances for the future, when caps tighten and emission reductions are likely to be more expensive or when there is an uptick in economic growth. Allowance banking thus can spur early reduction and reduce the cost of compliance. Experience with the U.S. sulfur dioxide program demonstrates precisely that behavior.[135]

During Phase I of the EU ETS, installations that reduced emissions below allowable levels or otherwise had more allowances than they needed were not authorized to carry saved allowances forward for use during Phase II. As previously stated, Phase I was a learning-by-doing period, which allowed time for actual emissions data to be generated. Without such verified emissions data, allowing excess Phase I permits to be banked and used in Phase II could have led to a permanent over-allocation of allowances. Further, Phase II's purpose was compliance with the Kyoto Protocol from 2008 to 2012, and emission reductions achieved prior to 2008 were not eligible for Kyoto compliance.

The absence of banking meant that the trial period would almost certainly end in either a deficit or surplus of EUAs.[136] When emissions were projected to be high—thus anticipating a deficit at the end of Phase I—Phase I permit prices were high.[137] When a surplus was anticipated, the value of the permits fell. Since the permits would not have any value after 2007, their price went to zero as the end of 2007 approached, as predicted (see Figure 2). Throughout the corresponding time period in Phase II, however, allowances maintained their value, largely because of the future value created by bankable credits.

Banking of Phase II allowances for use in Phase III has reduced the problem of over-allocation and price fluctuation. Even with the reduced demand due to the recession, Phase II allowance prices have never dropped to the lows of Phase I because they can be carried forward. In Phase III, allowable emissions will be reduced from year to year (unlike in Phase II), and an increasing share of permits will be auctioned, rather than allocated for free. Thus, despite the reduced demand caused by the deep recession, Phase II permits have future value and, as a result, present value.

This long-term price durability provides an important market signal in encouraging low-carbon investments. If investors predict that their Phase II bankable allowances will increase in value, they will invest in carbon reductions earlier and save their valuable allowances for future use or sale.

As early as 2009, an analysis by New Carbon Finance confirmed that the Phase II changes were having their intended effect: "banking of allowances is taking place and the design of the system is working as originally intended by the European Union."[138] Reports indicate that power companies, which account for a majority of ETS emissions, are hedging their CO_2 emissions costs by banking allowances up to three years in advance.[139] This means that emission reductions are taking place now, and allowances earned are being saved in anticipation of tighter caps later on.[140] Additional Phase III reforms, including the extension of the trading period from five to eight years and the provision of a steady linear emission reduction

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Long-term price durability, such as that provided by the EU ETS, provides an important market signal in encouraging a range of low-carbon investments, including those in solar panel technology.

schedule, are intended to ensure even greater price stability and further reduce the volatility experienced in the transition from Phase I to Phase II.[141]

Prior to the adoption of the EU ETS, some commentators recommended that the EU firmly set price ceilings to reduce market instability. The EU wisely resisted such restrictions, since price ceilings effectively "bust the cap" by allowing an unrestricted number of allowances to be issued when a certain price is reached.[142] Basing the bankability of allowances on verified emissions reduced allowance volatility without resorting to price controls.

The EU also avoided price floors in the market. Politically, adopting price floors makes it hard to resist adopting price ceilings as well. Furthermore, floors may raise the costs of achieving emission reductions without improving total carbon abatement—if firms must pay a minimum price above the actual cost of achieving emission reductions, the price of meeting the cap is artificially high. Increasing the cost of carbon reduction in this manner is contrary to the proper function of cap-and-trade programs, which allow the market to ferret out the cheapest means of meeting a carbon cap.

California's proposed carbon trading system highlights an innovative alternative mechanism for reducing price volatility. California will automatically place 1% of its allowances into a price containment reserve (this percentage grows to 7% by 2018).[143] Allowances in this set-aside are given a fixed annual price that escalates predictably. The availability of the set-aside as a source of fixed-price permits achieves the same stabilizing effect as a price ceiling, but it doesn't bust the cap by allowing unlimited allowances at that price.

Banking and associated concepts such as allowance price reserves create incentives for firms to invest in emission reductions early and efficiently while also reducing price volatility.

Further, California sets a minimum price for auctioning its allowances (starting at $10 per ton), with any unsold allowances offered for sale at a later auction.[144] However, over-the-counter trades between allowance holders are permitted at any price. This contrasts with a strict price floor for over-the-counter trades, which would increase the risk of traders holding illiquid allowances that a price floor prevents them from trading. The fear of being unable to trade the allowances would decrease their value further, increase the risk of holding allowances, and discourage participation in the market. California's alternative design avoids the risks of a strict price floor on trades.

Along with other cap-and-trade design elements such as the EU's allocation of allowances for longer trading periods and a declining cap, banking and associated concepts such as allowance price reserves create incentives for firms to invest in emission reductions early and efficiently while also reducing price volatility.[145]

EU ETS windfall profits occurred primarily in the electricity sector and can be avoided using a variety of policy tools

Although price volatility attracted some notice from critics, media criticism in the EU ETS's early years was primarily focused on the issue of windfall profits. One comprehensive analysis estimated that windfall profits for the coal, gas, and oil power sectors in Europe totaled $16.6 billion (€11.4 billion) for Phase I.[146] By comparison, the European utilities market as a whole is worth approximately $1.0 trillion (€730 billion).[147] This section outlines three causes of windfall profits in an emissions trading system, explains how to avoid them, and explains why reforms to the ETS have mostly eliminated the risk of future windfall profits.

Where and why did windfall profits occur, and how did they affect the integrity of the ETS? Windfall profits occur when a firm reaps a profit from an event it did not control or from revenue it did not earn. In the ETS, some power utilities earned windfall profits from the allowances they were given for free. If an electricity producer makes power at a cost of $50 per megawatt hour by emitting one ton of CO_2, it will be required to surrender one EUA; the company received the EUA for free, but if the EUA trades for $15, the utility could have sold it on the market for $15 without generating any electricity. Thus, the opportunity cost of producing the megawatt hour of power is not $50 but $65, and the utility will price its electricity accordingly. In a deregulated market where the utility can successfully pass this price increase through to its customers, the utility will increase its revenue without increased costs. This is in fact what occurred: some companies, principally in the electricity sector, reaped windfall profits in the early days of the EU ETS when they charged customers for the market price of allowances they held even though they received the allowances for free. These profits were widely criticized.

Despite the wide attention they received, windfall profits were not an EU-wide issue, as they varied from country to country. The EU is a complex multinational entity, composed of countries with diverse regulatory and energy infrastructures. Windfall profits were concentrated in a few countries,[148] especially those with deregulated electricity markets and high-carbon sources of peak electricity supply. The size of windfall profits also differed between power companies; a 2009 study for the European Commission estimated that companies passed through 38% to 83% of the opportunity costs of the free allowances they received.[149]

Because of the design compromises necessary to secure reenactments of the EU ETS, windfall profits were a foreseeable outcome, with results more or less consistent with *ex ante* studies that assessed the potential windfall profits for ETS sectors.[150] This predictability also means that windfall profits are largely avoidable with basic design safeguards.

Auctioning allowances provides one mechanism to eliminate windfall profits

The simplest way to eliminate windfall profits is to auction the initial allocation of permits. When a company pays for an EUA at auction, the company's profits do not increase when the cost of the EUA is incorporated into the price at which it sells its products. Windfall profits are simply not possible with the full auctioning of permits.

The simplest way to eliminate windfall profits is to auction the initial allocation of permits.

It may not be possible, however, to obtain a social or political consensus for full auction at the beginning of a new cap-and-trade program. At the same time, windfall profits—real or perceived—can undermine public support for such programs. Consequently, alternative means of reducing or eliminating windfall profits are useful to consider. Some jurisdictions have proposed another equivalent mechanism for eliminating windfall profits, in which administrators freely allocate the allowances, either to electricity distributors or other entities, while mandating that the value of the allowances be used to lower the rates of some or all customers.[151] This policy eliminates utilities' windfall profits by returning the value of allowances to customers.

The EU ETS has already adjusted its design to drastically reduce any additional windfall profits in the future. In the preliminary stages of the EU ETS, emitters successfully persuaded policymakers to give them allowances for free.[152] These kinds of political compromises are not unique to the EU ETS and often are essential in securing passage of controversial but important social and economic policies that can then be improved over time. In the third phase of the ETS (scheduled for 2013-2020), the EU will move toward full-scale auctioning of allowances.[153] At least 50% of allowances will be auctioned from the start of Phase III in 2013, compared with around 3% in Phase II. Notably, most EU states will auction 100% of the allowances in their power sectors. Industrial sectors that pose less risk of windfall profits will receive free allowances based on a CO_2 efficiency benchmark. The benchmarks will be set on the basis of the average of the top 10% most greenhouse-gas-efficient installations in the EU, creating an incentive for industrial companies to reduce emissions per unit of economic input. The ETS will increase the percentage of auctioned allowances for the industrial sector over time.[154]

While some may say full auctioning is essential to the credibility and success of the ETS, the U.S. SO_2 trading program provides a clear example of an emissions trading program that was successful without full auctioning (see Appendix B). How did the SO_2 program avoid windfall profits even though most allowances were freely allocated?

Windfall profits in the utility sector can be managed with regulated electricity prices, capital gains taxes, and other regulatory tools

At the time the United States enacted the sulfur dioxide program, most large electricity companies were regulated by public utility commissions, and those commissions did not allow the utilities to raise rates for allowances they had received for free. In Europe, the price of electricity is largely determined by a deregulated electricity market, which allows utilities to raise electricity rates and reap windfall profits. However, not all EU countries have fully deregulated markets. For instance, Italy's electricity market in Phases I and II was considerably more regulated than Germany's and, partly because of this, projected windfall profits for Italian utilities were a quarter of those for German utilities.[155]

In other EU countries, electricity prices are often set by regulatory agencies. Similarly, the California Public Utilities Commission (CPUC) approves electricity prices at levels that will compensate utilities for their operating costs, infrastructure investments, and a reasonable rate of return, but no more.[156] In a California cap-and-trade system with free allowances, the CPUC could simply not allow regulated utilities to pass along to their customers the hypothetical "foregone opportunity costs." Alternatively, the CPUC could adjust other parts of its regulatory program to balance the windfall from any free allowance allocation with a decrease in other compensation mechanisms. Moreover, in the United States, if a person receives something of value as a gift and then sells that gift for a high price to another person, the seller must pay capital gains tax on the difference between the sale price and the seller's "cost basis"—which was zero. In countries with similar capital gains taxes, governments can tax windfall profits that might accrue from passing on to customers the "costs" attributed to free allowances. In sum, regulated electricity markets allow for more control over prices and prevention of potential windfall profits.[157]

Regulated electricity markets allow for more control over prices and prevention of potential windfall profits.

The carbon intensity of peak demand electricity sources determines the level of windfall profits

Even when comparing deregulated markets in the EU, the price and carbon intensity of electricity can vary dramatically, with corresponding impacts on the level of windfall profits observed. The price of electricity is determined by the "marginal cost plant."[158] Base-load electricity—i.e., generating stations that operate more or less continuously to provide power, such as nuclear, coal, and large-scale hydroelectric—have large upfront costs to build the plant and low operating costs. Peak demand sources of electricity, on the other hand—such as natural gas or oil plants that operate only intermittently—are cheap to build but generally expensive to operate because of high fuel costs. These expensive generating stations are often turned on only to meet spikes in electricity demand. Since these stations may not be profitable at a low price per kilowatt hour, the grid operator often must raise prices to entice the peak demand source to produce electricity.

In a deregulated market, the prevailing price of electricity is determined by these peak demand generating stations. Therefore, if the peak demand station requires $0.15 per kilowatt hour to cover its costs, all plants producing at that time can charge at least $0.15 per kilowatt hour.

The carbon trading system directly affects the operating price of the marginal cost plant, which will have the greatest impact on the price of electricity. In some countries, peak demand is sometimes met by low-carbon energy sources, such as hydroelectric in Spain or nuclear in France.[159] The ETS does not affect the cost to produce hydroelectricity in Spain, and therefore the prevailing price would remain at $0.15 per kilowatt hour. Other facilities such as coal or gas plants that also receive this prevailing price will not see an increase in profits.

In contrast, countries such as Germany meet peak demand by using high-carbon sources. As Table 1 illustrates, coal plants set Germany's electricity price approximately 75% of the time.[160] Assuming that the cost of EUAs increases the cost of coal-powered electricity from $0.15 to $0.17 per kilowatt hour, for example, this price increase would apply to all other power producers. This is the most likely explanation for high windfall profits in Germany. Point Carbon projected German utilities to have windfall profits per kilowatt hour four times larger than Spanish utilities.[161] Similarly, as shown in Table 2, German utilities have ETS-induced price increases from two and a half to 19 times larger than French utilities.[162]

TABLE 1

Estimated proportion of time that coal and gas plants set the prevailing price of electricity, by country

Country	% of time price-setting plant is coal	% of time price-setting plant is gas
UK	35%	65%
Germany	75%	25%
Spain	25%	40%
Italy	20%	70%
Poland	95%	5%

Source: Point Carbon Advisory Services: "EU ETS Phase II—The potential and scale of windfall profits in the power sector" March 2008.

TABLE 2

Projected price changes due to the EU ETS in four countries, using a price of $25.23 (€20) per EUA

Country	Projected price increases due to ETS	
	$/kWh	€/kWh
Belgium	.0025–.0176	.002–.014
France	.0012–.0063	.001–.005
Germany	.0163–.0239	.013–.019
Netherlands	.0113–.0138	.009–.011

Source: Jos Sjim, Karsten Neuhoff and Yihsu Chen: "CO_2 cost pass-through and windfall profits in the power sector." *Climate Policy*, 2006, at 60, available at faculty.ucmerced.edu/ychen/climate_policy_2006.pdf.

Regions considering a cap-and-trade system for the power sector can therefore understand potential windfalls by knowing their mix of peak demand plants. California, for instance, generates 42% of its annual electricity supply from natural gas, which has half the carbon emissions of coal, and another 38% from low-carbon energy sources such as nuclear, renewables, and hydroelectric. Only 7.7% of its power comes from coal.[163] Even if California does not auction its carbon allowances or regulate its utility market, the state's high proportion of low-carbon, marginal-cost plants decreases the expected level of windfall profits.

Windfall profits are being eliminated and did not impair the ETS's environmental performance

Even with some countries' high-carbon utilities receiving windfall profits in the EU ETS, incentives are still strong for emission reductions. Recall the example of Germany, which meets its peak demand primarily through coal power plants. Assuming again that the cost of EUAs increases the cost of coal-powered electricity from, for example, $0.15 to $0.17 per kilowatt hour, low-carbon sources such as wind and hydroelectric will receive this price increase as well, with no additional increase in costs. This increases the profitability of low-carbon sources and incentivizes their growth relative to dirty sources, an important and encouraging trend. According to a leading authority on the performance of the ETS, the system increased the profits of geothermal, hydro, nuclear, wind, biomass, and solar energy production by $11.5 billion (€7.9 billion) in Phase I.[164]

It is important to note that while windfall profits are an important political and distributional issue, they do not impair the emission reduction performance of the program. Because allowances in the ETS are allocated based on historical emissions, utilities cannot gain additional profit by increasing current emissions. This is a fundamental difference between cap-and-trade allowance-based systems and "offset" credit programs. As further described below, offset programs award credits based on reductions from a projected business-as-usual scenario, thereby creating perverse incentives to exaggerate pre-project emissions in order to "earn" additional credits, even while absolute emissions increase.[165] Cap-and-trade programs that distribute allowances based on verified historical emissions avoid this problem; a fixed cap reduces emissions, regardless of the profits of the market participants.

The three causes of windfall profits listed above offer three clear mechanisms for avoiding them. Auctioning allowances—or an alternative equivalent like that instituted by California—can single-handedly eliminate the risk of windfall profits in the EU ETS; indeed, the EU has increased the share of allowances that will be auctioned. Other useful tools in the toolkit include regulatory instruments and a mix of auction and free allocation designed with existing and anticipated marginal electricity production in mind.

The scope and utility of the CDM have changed over time, and the rules under which it operates must also evolve to keep it relevant.

Reforms have improved elements of the EU ETS that allow emitters to tender credits earned from projects that reduce emissions in developing countries ("offsets"), but further reforms would be useful

The Clean Development Mechanism (CDM) is an international carbon market mechanism created by the 1997 Kyoto Protocol. The CDM awards tradable carbon credits to projects in developing countries that either remove greenhouse gases from the atmosphere ("sinks" projects) or reduce emissions that otherwise would have occurred. CDM projects generate Certified Emissions Reductions (CERs), that can be used by developed countries to comply with a portion of their emission reduction obligations under the Kyoto Protocol. The EU decided that firms under the ETS can also use CERs to meet a portion of their domestic carbon reduction requirements.[166] Other nations (e.g., Australia) may soon allow CERs to be surrendered for compliance under their own programs.

The CDM was a useful first step; it involved developing nations in mitigation activities, encouraged billions of dollars of investments in sustainable development in developing countries[167] that would otherwise not have occurred, and it helped investors gain global experience in tracking emissions and trading carbon credits.[168] At the time it was created, the CDM fulfilled a specific purpose. The scope and utility of the CDM have changed over time, and the rules under which it operates must also evolve to keep it relevant. While a CDM policy dialogue incorporating stakeholder feedback on the past performance and future direction of the CDM is taking place at the international level and further improvements to the system are expected,[169] the Conference of the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC) recognizes the inherent limitations in the CDM. At the Durban climate talks in December 2011, the COP emphasized that "various approaches, including opportunities for using markets, to enhance the cost-effectiveness of, and to promote, mitigation actions, bearing in mind different circumstances of developed and developing countries, must meet standards that deliver real, permanent, additional and verified mitigation outcomes, avoid double counting of effort, and achieve a net decrease and/or avoidance of greenhouse gas emissions."[170]

New market-based mechanisms to stimulate low-carbon investments in developing countries are being considered for adoption at the 2012 UN climate negotiations in Qatar and at subsequent meetings. The institutional knowledge gained from the CDM experience can and should inform the improved development of these new mechanisms, particularly as some advanced industrializing nations begin the transition to true cap-and-trade systems applicable to some or all sectors of their economies.

This section examines how many CERs were used in the ETS, whether they represented verifiable emission reductions, and how reforms to the CDM and the ETS will address some key problems with the CDM. In addition to the reasons for CDM reform that directly relate to the ETS and are discussed in this report, there are other significant and compelling reasons for the international community to reform the CDM itself to improve its contributions to combating climate change and promoting sustainable development.[171]

The use of offsets in the EU ETS has stimulated needed investment in emission reductions in developing countries despite structural challenges with the CDM

Transactions in EUAs comprise approximately 84%, and the CDM comprises less than 13%, of the global carbon market. By far the biggest demand for CERs is in Europe.[172] In Phase I of the ETS, EU member states were not given explicit limits on the amount of CERs that they could use to meet their emissions targets under the cap, although the European Union's position was that no more than half of a country's reductions from business-as-usual could come from CERs or other external credits.[173] Few CERs were expected to be issued before 2008, however, and none was used for compliance in Phase I.[174] In Phase II, the use of emissions credits was explicitly limited—across the ETS, only 13.4% of emissions allowances per year could come from the CDM or from similar "Joint Implementation" projects (although JI projects differ from the CDM in important ways).[175] If all countries used the maximum allowable amount of CERs, this would total 279 million tons of carbon credits per year,[176] although actual use of the credits has been less than the maximum allowed and is forecast to decrease further in Phase III as a result of EU ETS reforms.[177]

New market-based mechanisms to stimulate low-carbon investments in developing countries are being considered for adoption at the 2012 UN climate negotiations in Qatar and at subsequent meetings.

Thus, even though the EU ETS accounts for the vast majority of the global CER market, CERs represent only a small portion of units surrendered for compliance in the EU ETS. It is also important to note that emission reductions achieved in developing countries through CDM projects are above and beyond those described for the EU in Chapter 2, which analyzes only domestic EU ETS emission reductions.

Many of the developing country projects funded by the CDM involve energy efficiency and renewable energy production. In 2009, 23% of CDM projects involved fuel switching and energy efficiency, 20% involved hydroelectric power, and 16% involved wind power.[178]

One of the challenges with CDM projects in general—and not just those generating credits sold into the EU ETS—has been ensuring the additionality of emission reductions.[179] For a project to qualify for CDM credits, it must prove that the emission reductions it creates would not have occurred without the credits. It is difficult to be certain whether some emission reductions are truly additional. Special care must be taken when developing baselines for such projects, particularly regarding conflicts of interest, since buyers, sellers, project developers, and verifiers all have an incentive to inflate the measure of "what would have otherwise occurred" in order to ensure that the project generates more credits.[180]

In that respect, the CDM incorporated precisely the problem that the EU faced when it asked emitters prospectively how many allowances they would need for the pilot phase of the ETS. The EU rectified that problem by ensuring that Phase II was based on verified historical emissions data, with binding caps. It remains to be seen to what extent new market-based mechanisms in the UNFCCC context will take similar steps to rectify this aspect of the CDM's problems.

One of the few empirical studies of additionality in CDM projects found that 20% of CERs from 2005 until 2007 came from projects that had "unlikely or questionable" additionality.

Nonetheless, the report also found that this proportion was decreasing as the CDM Executive Board strengthened its verification process.[181] As part of its efforts to strengthen the environmental performance of the CDM, the Executive Board adopted standardized baselines and monitoring methodologies for issuing its CERs.[182]

The CDM, however, faces a larger, structural challenge: It fails to give major emitting developing countries incentives to cap either sectoral or national emissions, since developing countries are not required to have emissions caps to participate in the program. In fact, by awarding offsets for reductions from business-as-usual emissions in industrializing nations that do not have sectoral or economy-wide emissions caps, such as China and India, the CDM has implicitly rewarded developing countries for staying out of a much-needed global cap-and-trade system.[183] Even though studies have confirmed the additionality of emission reductions in most CDM projects, the use of CERs from uncapped, industrializing nations may create a system-wide incentive for those countries to avoid limits on their own emissions.

Reforms have set stricter standards for the environmental and development benefits of eligible offsets

Even though studies have confirmed the additionality of emission reductions in most CDM projects, the use of CERs from uncapped, industrializing nations may create a system-wide incentive for those countries to avoid limits on their own emissions.

About 18% of CERs in 2012 are expected to be generated from a controversial type of emission reduction: the destruction of HFC-23, a potent greenhouse gas emitted as a by-product during the production of refrigerants. [184] The destruction of HFC-23 costs $0.25–0.63 (€0.20–0.50) per ton of CO_2 equivalent, which makes the profit from destroying the gas by-product more valuable than the production of the refrigerant itself. This difference could incentivize the operation of refrigerant factories simply for the value of destroying the by-product.[185]

In response to concerns about the environmental integrity of HFC-23 projects, the CDM Executive Board quickly moved to authorize CERs only from factories that had been operating since 2001, and it based the level of crediting on output levels in 2001-2004 so that an increase in current HFC-23 output would not increase any factory's profits.[186]

CDM reforms occur through both action of the international CDM Executive Board and EU ETS reforms. However, the CDM Executive Board's failure to act on controversial CDM emissions has the potential to undermine the credibility of the CDM generally, and therefore other emissions trading systems that allow use of CERs, including the EU ETS.

As a result, the EU ETS has adopted additional CDM reforms that go beyond those instituted by the CDM Executive Board, including reforms related to industrial gas projects and eligible nations. For example, in January 2011, EU member states went one step further than the CDM Executive Board and confirmed that the EU ETS would no longer accept CERs from HFC-23 and nitrous oxide projects as of May 2013.[187]

Another EU reform intends to bring the CDM closer to its original goal of encouraging investments in low-income countries. Starting in 2013, the ETS will accept CERs from new CDM projects only if the projects are located in nations defined as "least-developed countries" (LDCs). This represents a dramatic transformation (and restriction) of the CDM market—LDCs have issued only 0.003% of the CERs in the global market thus far.[188]

An alternative approach to international offsets was proposed in U.S. federal legislation that passed the House of Representatives but stalled in the Senate.[189] The Waxman-Markey bill created incentives for the "graduation" of uncapped developing countries to larger-scale emission reduction approaches. In particular, the bill envisioned phasing out project-scale offset approaches and transitioning to crediting at sectoral and larger geographic scales (states/provinces and nations) based on criteria such as a country's level of economic development and share of global emissions. Starting in 2013, California's ETS picks up on this innovative approach, keeping open the prospect of linkages with other capped emissions trading systems but limiting international offsets to those coming from sectoral programs.

Qualitative restrictions such as these create incentives for major emitting nations to move beyond project-based offsets to systems that credit reductions only below a baseline measured at an aggregate scale. Scaled-up crediting systems offer the potential to simplify administration, generate other economic efficiencies, and help address environmental concerns. Specifically, higher-scale systems account for leakage within the sector/jurisdiction and reduce concerns over additionality and permanence of emission reductions. These concerns may be acute for individual activities, but confidence over additionality and permanence will tend to be greater for a whole region or sector reducing below a baseline of historical emissions.[190]

With a 2015 deadline looming for international negotiations to approve a new global climate framework that includes all nations, the CDM can serve as a useful transition tool that focuses offset investments in poorer developing nations while informing the transition to a true cap-and-trade system in more-advanced developing countries[191] Cap-and-trade programs considering a link to another national or sub-national emissions trading system should preferentially consider systems that adopt caps or limits on major emitting sectors, which may include limits aimed at reducing emissions from deforestation and degradation.

Adopting targeted reforms such as those implemented by the EU ETS or advanced under California's program, the CDM can continue to help drive more ambitious—and affordable—reduction targets in the EU and other capped countries while delivering substantial funding to developing countries (approximately $1.2 billion, or €860 million, per year as of 2009).[192]

Cap-and-trade programs considering a link to another national or sub-national emissions trading system should preferentially consider systems that adopt caps or limits on major emitting sectors.

Strengthened oversight of the EU ETS significantly reduces the potential for tax fraud and allowance theft

The EU ETS was sharply criticized over tax fraud and thefts of allowances from national registries connected to the ETS electronic trading system. Reports indicate that the cyber-attacks were relatively isolated events that largely originated in countries where security protocols were inadequate.[193] Nonetheless, the confidence of market participants in the security of the system is critical to the effective functioning of the ETS, and the means of ensuring this security are now clear, based on the early experience of the EU ETS.

The ETS began with a separate allowance registry for each of its member states. ETS fraud, which falls into the two broad categories of tax fraud and theft of allowances, exploited a lack of consistent security and coordination between these registries.

The first type of fraud is a "Value-Added Tax (VAT) carousel." Criminals purchased allowances in countries that did not impose a value-added tax and sold them in other countries with the cost of the VAT included. But instead of delivering the VAT payments to authorities, the thieves disappeared with the proceeds.[194] VAT fraud was significant during the summer of 2009, until the fraud was uncovered and the EU reformed the application of the VAT with specific anti-fraud measures, including a domestic reverse charge or a VAT zero rate.[195]

Europol estimated that tax fraud led to roughly $7.1 billion (€5 billion) in uncollected tax revenue[196]—a statistic that has been widely repeated in the media— but the World Bank has disputed this estimate, based on the actual prices and volumes of carbon trades.[197]

While VAT fraud is serious, the threat is not confined to the carbon market; it has a long history in other EU commodity markets.[198] In 2006, VAT fraud in EU-wide commodities was estimated at $131 billion (€100 billion) per year.[199] In carbon markets that have harmonized tax regimes or do not trade between conflicting tax jurisdictions, this type of tax fraud is impossible.

The second type of fraud is theft. The storyline of the largest allowance theft reads like a Hollywood movie script: On the morning of January 19, 2011, attackers phoned a bomb threat into the building that houses the Czech Republic's carbon trading registry. As the registry's employees were evacuated for an hour, criminals entered the building, transferred nearly half a million allowances to a registry in another country, and pocketed the cash from the sale.[200] This theft was possible because the Czech registry did not impose a delay on transactions with non-trusted sources and did not require multiple parties to confirm the allowance transfers, both of which are basic, easily implemented security measures.

Flexible market-based solutions like the EU ETS—and the U.S. SO_2 emissions trading program on which it was modeled—deliver public benefits by driving low-cost pollutions reductions.

While the sums stolen in allowance thefts were not trivial (approximately $67.3 million, or €50 million),[201] their scale in light of the value of the allowances in the EU ETS (nearly $117 billion, or €87 billion)[202] is small (approximately 0.06%). For comparison, annual credit card fraud in the United States is 50% higher as a fraction of total value, estimated at roughly 0.09% of annual transaction value.[203] The small scale of allowance thefts counsels against overestimating their impact on the credibility and effectiveness of the ETS as a whole.

Further, fraud and thefts occurred in the spot market for carbon allowances, which accounts for only 10% of EU ETS carbon trading. The rest of trading occurs in futures markets, which have stayed open and maintained stable prices, even during the spot market closures of January 2011.[204]

So how did the EU respond? When the thefts were discovered, the EU quickly shut down the registries and conducted an investigation. The European Commission then implemented additional security measures to restore the integrity of the ETS market infrastructure. All member states met the new security standards implemented in January 2011, and the commission subsequently laid out several complementary short-, medium-, and long-term steps that all registries must pursue. Additional stakeholder consultations resulted in a new registry regulation that the European Commission put forward in May 2011 and adopted in November 2011.[205]

The new registry regulation implements a series of important reforms to improve regulatory oversight and market security, including mandatory two-person transaction confirmations; 26-hour delivery delay on non-trusted market transactions; new security checks in opening accounts; the creation of restricted, trusted account lists; limits on the number of transactions initiated; and common security procedures across all trading registries in Europe.[206] Europol is allowed to monitor accounts, and law enforcement authorities are permitted to immediately block access to specific allowances.[207] The regulation also consolidates all national registries into a single Union Registry supported on one software platform maintained by the European Commission.[208]

One notable achievement was the speed with which the agreement on enhanced security and new regulations was put together across 27 member states. The quick response shows that the ETS can respond rapidly to market security issues.

But will the reforms be enough to prevent security breaches in the future? The same question, of course, can be asked for any electronically networked system. The challenge of market

The ETS appears no more and no less vulnerable to fraud and cyber-attack than any other traded commodity market, and it is now subject to oversight similar to other financial markets.

oversight confronted by the EU ETS is not unique, since theft, fraud, and money laundering are serious concerns in all markets. The credit crunch, for example, exposed the elaborate $50 billion fraud of Bernie Madoff. Advancing technology creates its own challenges. In 2012, the Dow Jones Industrial Average temporarily lost $1 trillion in a "flash crash" that market regulators continue to study for clues to prevent similar problems.[209] Cyber-attacks happen at the national and international levels in a variety of sectors and to a wide range of institutions. The ETS appears no more and no less vulnerable to fraud and cyber-attack than any other traded commodity market, and it is now subject to oversight similar to other financial markets.[210]

Thefts and fraud may occur again, but that should not call into question the overall integrity of the system.[211] Regardless of the financial effects, neither VAT fraud nor allowance theft has caused adverse environmental or emissions effects, since no new allowances were created and emissions were still capped.

Governance and market oversight institutions for the ETS, as in other sectors, must evolve, because cyber-crime and other market security threats will continue to evolve. The new European Commission Registry, like any trading mechanism, will need to be vigilant to adapt to new threats. In addition, each company and market participant must continue to assess and address security risks. Indeed, the new European Commission regulation directs participants to report suspicious activity or concerns to law enforcement. The reforms it contains are expected to improve the integrity of the EU ETS market infrastructure significantly.[212]

CHAPTER 4

Going forward

The EU has acknowledged both the positive and the cautionary lessons of the initial years of the ETS, which provide important insight for those considering how best to institute their own cap-and-trade system. EU Commissioner for Climate Action Connie Hedegaard observed, "all the experience Europe has gained for good and for worse, what to do, but also what not to do … can be used so that others can move to the right solutions."[213]

Cap-and-trade systems like the EU ETS are based on a simple idea: The market can be a powerful tool in achieving environmental and economic progress. Legislators set the targets, and the market determines and rewards the lowest-cost solutions to meet them, rather than having the government try to pick winners. While the concept is relatively straightforward, implementation is not always easy.

In the ETS pilot phase, the EU created the world's first and most comprehensive greenhouse gas market, controlling emissions from 27 countries and a significant part of the EU's economic activity. The trial phase allowed regulators and market participants to experiment with policy options. Early teething problems with the EU ETS were partly the result of the rapid speed with which the ETS was adopted, motivated by the EU's desire to show a strong determination to tackle climate change. Additional design flaws were largely the result of two politically unavoidable choices: a high level of decentralization and free allocation of allowances.[214]

Lessons learned from Phases I and II have allowed the European Commission to propose and adopt changes considered by some as unthinkable before the ETS's adoption in 2003.[215] The EU has thus learned important lessons that have led to reforms and improvements in the ETS's ability to drive investment in low-carbon development and incentivize significant emission reductions.

In sum, the ETS has moved swiftly to address the challenges of the system's early years. The most important reforms to the ETS are:

1. emissions of covered facilities are now measured and verified;

2. full auctioning of allowances is being phased into the ETS;

3. the EU has tightened emissions caps over time;

4. banking or saving of surplus allowances is now authorized;

5. the integrity of CDM offsets has improved, and CDM offsets are now targeting low-carbon development in lower-income countries; and

6. significant reforms have improved the security of the ETS infrastructure.

In an indication of the carbon market's permanent place in the EU economy, owners of facilities covered by the ETS are now incorporating carbon prices into their day-to-day operational decisions and into long-term investment planning.[216] Carbon emissions are now a central consideration in the business planning of EU energy and industrial sector participants.

iStockphoto

Regions, nations, states and local jurisdictions that are considering capping carbon pollution can learn from the experience and build on the success of the EU ETS, the world's first large-scale CO_2 cap-and-trade system.

Although the EU ETS has evolved and improved over time, it is already working to reduce emissions and decarbonize the EU economy as a key element in the EU's package of climate and energy policies. A suitable set of complementary policies and measures is essential if the EU is to achieve its aspirational emission reduction target of 80% below 2005 levels by 2050. A more ambitious EU ETS target for 2020 or 2030 would help achieve that long-term goal.

Perhaps the most important lesson the EU ETS experience provides is the benefit of starting early, regardless of the initial level of ambition. The design flaws and weaknesses of various policy tools are often difficult to anticipate, but they can be removed over time as political support grows, the fear of competitive distortions is better managed, and the policy becomes an established instrument. Practical experience provides a much-needed litmus test. What is important is getting started, evaluating results, making needed changes, and increasing ambition over time.

After a three-year trial period and almost five years of full operation, the EU ETS provides an example of an increasingly sophisticated and successful multinational market that incentivizes effective emission reductions via durable emissions caps; a requirement that each emitter covered by the system tender one emission allowance for each ton of actual emissions; strong penalties for failure to report emissions and transactions and for failure to tender sufficient allowances; trading and banking of allowances using a standardized, serialized registry for transactions; and, consequently, allowance prices that respond in real time to a changing world. As the first large-scale CO_2 cap-and-trade system, the ETS offers a unique opportunity for other regions, nations, states, and even local jurisdictions considering carbon-trading systems to learn from its experience and continue to build on its success.

APPENDIX A

Making low-carbon solutions smart business

The EU ETS and complementary policies as a market driver in the emerging low-carbon economy

Case study #1: Siemens' Renewable Energy Engineering Centre

Siemens Transmission and Distribution is building an industrial facility in Manchester, England, that will directly employ hundreds of workers. This Renewable Energy Engineering Centre will design high-voltage transmission systems for the UK and northwest Europe "to meet the expanding needs of the renewables market," especially for offshore wind power.[217] Energy from offshore wind farms can be lost in transportation to shore. Since Siemens predicts a large expansion in European offshore wind farms, the company is investing in improving its expertise in transmission technology.

More than 340 jobs will be created in Manchester from the project.[218] It is the first engineering center of its kind outside Germany and represents a 2% growth in Siemens' workforce in the UK.[219] Manchester needs valuable jobs like these—the percentage of the city's population claiming unemployment benefits is 21% higher than the UK average.[220]

Siemens directly attributes its investment in the project to the United Kingdom's dedication to capping carbon pollution. According to Siemens, "Due to the Government's commitment to carbon reduction targets, and the consequential need to invest in offshore wind generation, there is a buoyant market for [high-voltage grid connection] systems to transport the power."[221]

In addition to participating in the EU ETS, Britain has also pledged to cut carbon emissions by 80% from 1990 levels by 2050. It is the first country in the world to set such a long-range and significant carbon reduction target into law.[222]

Because predictable long-term caps are the single greatest driver of investment, the response of the market to Britain's commitments has been extraordinary. Venture capital and private equity investment in low-carbon technologies in Britain is the highest in the world per capita; in absolute terms, it is more than twice that of any other European country.[223] More than 51,000 companies in Britain provide low-carbon and environmental goods and services,[224] and the British government projects that by 2020, more than 1.2 million people in the UK will be employed in green jobs.[225]

Case study #2: Job growth in the German economy

Germany is a world leader in renewable energy, representing 13% of global investments in the sector.[226] Because of indirect employment from supplying intermediate products and components to the renewable sector, all regions of Germany are set to benefit from renewable energy expansion.[227] By 2030, German renewable energy exports are expected to reach $47–69 billion (€33-48 billion in 2005 Euros).[228]

Courtesy German Wind Energy Association/© REpower Systems AG

Employment in Germany's renewable energy sector—including manufacturing, operating and maintaining renewable energy facilities like this wind turbine—more than doubled from 2004–2010.

In response to Germany's renewable energy sector growth strategy, the increase in clean energy jobs has been extraordinary. In 2004, 160,500 people in Germany were employed in manufacturing, operating and maintaining renewable energy facilities, and in the supply of biogenic fuels. By 2010, the sector's employment had more than doubled, to 367,000.[229]

The net employment gain from renewable energy in 2009 alone was between 70,000 and 90,000, compared with a scenario in which that same energy was provided by fossil fuels.[230] Extensive modeling suggests that in virtually all scenarios, this net gain in employment will grow even larger through at least 2030.[231] These net job gains are especially impressive since Germany has historically relied heavily on coal power, and German utilities have had some of the highest ETS-induced electricity price increases in Europe—from two and a half to 19 times larger than French utilities, for instance.[232]

While German clean energy job growth cannot be directly attributed to the EU ETS, the ETS has likely contributed to its success and will contribute even more in the future. Half of the revenues from EU ETS allowance auctions are intended to fund complementary measures related to climate change, both domestically and abroad.[233] In Phase II, 97% of allowances were freely distributed and 3% were auctioned.[234] Still, the sale of ETS allowances generated approximately $511 million (€400 million) per year in Phase II (2008-2012) to fund German domestic and international projects related to climate change, including renewable energy projects.[235]

Starting in 2013, EU allowances will be progressively auctioned, with at least 50% of all allowances auctioned in 2013, and the proportion rising each year.[236] It is reasonable to assume that EU ETS-revenue-driven funding will increase dramatically in the coming years and further galvanize deployment of renewable energy.

Apart from the EU ETS, other policies, including Germany's feed-in tariffs for renewable energy adopted in 2000 and its firm commitments to renewable energy goals, have contributed to strong market confidence and spurred renewable energy investment and development.[237]

Germany's experience provides a prime example of the economic benefits and competitiveness that countries can secure by taking climate action now, including by using revenues generated from cap-and-trade systems like the EU ETS to invest in low-carbon technologies. A cohesive, economy-wide effort, not isolated individual projects, is necessary to achieve the full potential of economic benefits from climate change mitigation. Germany has shown that when low-carbon investment is part of a broader effort, it reduces unemployment.

Case study #3: Turning pulp and paper mill byproducts into productive biofuels

Pulp and paper mills release significant greenhouse gas emissions and represent approximately 7% of the installations covered by the EU ETS.[238] In Sweden, pulp and paper production accounts for roughly half of the energy use in the industrial sector.[239]

The Värö pulp mill, operated by the Swedish paper company Södra Cell, has now eliminated all of its fossil fuel use,[240] simply by using its own industrial byproducts. "Black liquor" is the cooking fluid that results from digesting pulpwood into paper pulp, and a typical pulp mill produces nearly two tons of black liquor per ton of pulp.[24] Black liquor and excess bark, another byproduct of the pulping process, are both boiled to generate steam that powers the mill.[242] These biofuel sources now provide over 99% of the mill's power.[243]

The Värö pulp mill can export much of this excess power to the surrounding area. The mill provides 50% of the heating for the local town of Varberg and exports 65 gigawatt hours per year to the electric grid.[244] The mill employs 350 people.[245]

Studies suggest that the EU ETS was a key factor in reducing the Swedish pulp and paper industry's energy use—dramatic reductions in the industry's energy use have led to a surplus of allowances worth $11.5 – 35 million (€9-28 million) per year.[246] Industry insiders have said that the EU ETS and an additional Swedish carbon tax are "steering pulp and paper firms away from the use of fossil fuels."[247] Further, Sweden's Renewable Energy Certificates program generates revenue from the sale of power generated from biomass byproducts.

Chemrec is another innovative company in the Swedish pulp and paper industry that is boosting its bottom line in response to the EU ETS. Chemrec, which was named one of the world's top 100 private clean-tech companies out of nearly 5,000 nominations,[248] has introduced technology that produces large quantities of renewable motor fuels or electricity from black liquor. The ambitious company claims that given existing levels of black liquor byproducts, up to half of Sweden's heavy road transportation could be run on these biofuels.[249]

According to the company, Chemrec's fuel reduces net greenhouse gas emissions by 95% compared with petroleum-based diesel oil—the traditional fuel for heavy road transports.[250] Independent analysis by the European Commission confirms the very low carbon emissions of the fuel.[251] Although black liquor may otherwise be used for low-carbon energy generation on-site, as at the Värö pulp mill, its use as a biofuel could achieve even greater efficiency.

The equipment for gasifying black liquor into biofuel typically costs more than twice as much as a standard recovery boiler.[252] However, the EU ETS and Sweden's Renewable Energy Certificates program have provided a profitable market for the technology by incentivizing low-carbon biofuels. Investors predict even more profit from cost-effective carbon capture during the Chemrec gasification process.[253]

Case study #4: Atmospheric trash into flowers

At Europe's largest oil refinery, the Shell Pernis Refinery near Rotterdam, engineers have developed a remarkable system for using waste CO_2 as a productive agricultural fertilizer. The refinery's two tall stacks used to emit 6 million tons of CO_2 per year, roughly 3% of the total emissions of the Netherlands.[254] Starting in 2005, the refinery's hydrogen factory began capturing at least 170,000 metric tons of waste CO_2 per year.[255] By 2010, the carbon capture had doubled to more than 350,000 tons of CO_2 per year.[256]

Five hundred large Dutch greenhouses are fertilized with recycled carbon dioxide from Europe's largest oil refinery, which processes and transports the gas through a formerly abandoned oil pipeline.

"The debate about CO_2 is changing. You can either fight it—which is useless—or you can see it as a business opportunity."

–Jeroen van der Veer, the former chief executive of Shell, discussing the Pernis refinery in a *The New York Times* interview

The CO_2 stream is cleaned, compressed, and transported through a formerly abandoned oil pipeline[257] and a new infrastructure to 500 large greenhouses.[258] The greenhouses use the CO_2 as a fertilizer, avoiding the need to import and burn natural gas to generate fertilizer. Although some natural gas must still be burned in the winter to generate heat for the greenhouses, the use of recycled CO_2 replaces the burning of 95 million cubic meters of natural gas per year,[259] at half the cost.[260] In addition, the CO_2 arrives in a purer form than it would from burning natural gas, without polluting traces of ethane and NO_x, and the concentration of CO_2 is higher, making the method more profitable for both the greenhouses and the refinery.[261]

This technology for capturing CO_2 has been known for years, but it became economical only when the EU ETS put a price on CO_2 emissions.[262] The project was profitable for Shell in part because it could sell the surplus EUAs generated by capturing, rather than emitting, CO_2. As Jeroen van den Veer, the former chief executive of Shell, said in an interview about the Pernis refinery: [263] "The debate about CO_2 is changing. You can either fight it-which is useless-or you can see it as a business opportunity." Even though ETS rules on credits for the project have changed since 2008, the innovative project and its emission reductions continue.

Case study #5: Waste heat for salt production

In the eastern Netherlands, near the city of Hengelo, the regional waste company Twence incinerates 550,000 metric tons of waste per year at 900 degrees Celsius, producing a constant stream of 200 tons of steam per hour.[264] Twence captures more than 20% of the steam and uses it to generate power.

In 2011, Twence and the neighboring Akzo Nobel salt factory created an innovative business partnership to reduce energy use and CO_2 emissions covered by the EU ETS. Under the agreement, Twence transports much of the steam it produces through a 2.5 km pipeline network to Akzo's salt factory. Akzo uses the steam to produce salt by evaporating brine from a mine below the factory.

Previously, Akzo burned natural gas to produce steam. As a result of the partnership with Twence, Akzo has reduced its need for natural gas by 40 million cubic meters per year and has cut its annual emissions of CO_2 by 72,000 tons. This represents one-fifth of its allocated emissions allowances under the EU ETS and saves Akzo approximately $687,000 (€504,000)

Twence

A pipeline transports steam produced by the Twence waste incinerator to the neighboring Akzo Nobel salt factory, which uses the steam to produce salt from a mine below the factory, avoiding the need to burn 40 million cubic meters of natural gas every year.

annually, based on a CO_2 allowance price of $9.55 (€7) per ton. The project allows Akzo's business to continue to grow "without affecting [Akzo's] environmental footprint."[265]

The steam produced by Twence incineration is converted to electricity at an efficiency rate of 25%, while the direct use of steam in Akzo's production of salt is more than twice as efficient.[266] Thus, in addition to reducing CO_2 emissions, the partnership doubles energy efficiency. The award-winning project is expected to deliver annual energy savings equivalent to the total natural gas consumption of all households in the city of Hengelo (80,000 inhabitants).[267]

The financial benefits of the project are shared 50% between Twence and Akzo, making the project beneficial for both companies while reducing CO_2 emissions.[268] The Twence/Akzo partnership provides a "shining example" of the process innovations that occur when entrepreneurs look for opportunities created by cap-and-trade policies such as the EU ETS.[269]

APPENDIX B

The U.S. sulfur dioxide (SO_2) emissions trading program

The successful U.S. SO_2 cap-and-trade program, on which the EU ETS is modeled, provides instructive parallels for evaluating the success of the ETS. Since its inception in the mid-1990s, the U.S. Acid Rain Program for SO_2 has achieved unprecedented environmental protection at unmatched cost efficiency.

SO_2 emissions reductions: The Acid Rain Program reduced SO_2 concentrations in the air by 76% from 1980 to 2009. In addition, from 1989 to 2009, regional decreases in wet deposition of sulfate averaged 43% for the eastern United States (see Figure B1).[270]

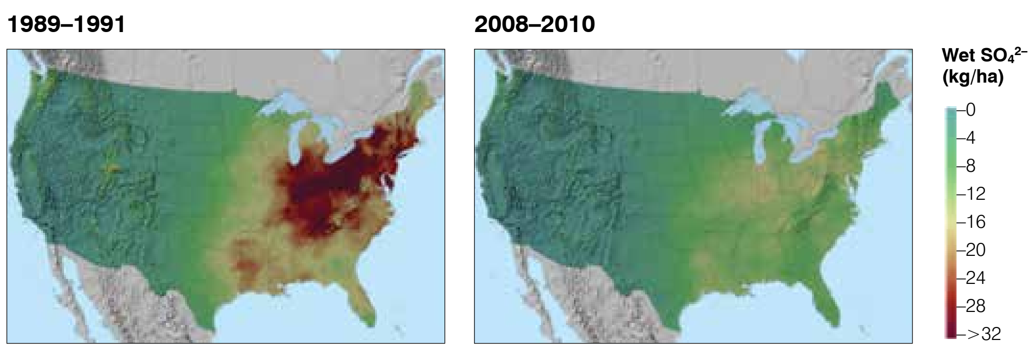
Cost: The program has achieved these significant reductions at a fraction of projected costs. At the end of 2009, the price for traded allowances was $61 per ton, which was near the market low during the first year of the program and far below the pre-program cost estimates of $579–$1,935 per ton of SO_2. In the early years of the program, allowance prices ranged from a low of $66 per ton to a high of approximately $200 per ton.[271]

The U.S. SO_2 program is instructive in evaluating the ETS experience for at least three reasons:

1. It demonstrates that starting a cap-and-trade program with somewhat generous caps and then ratcheting those caps down is a reasonable way of achieving political agreement on what will be an environmentally effective outcome. The program also demonstrates that providing broad flexibility on how to comply with caps, and pairing that flexibility with tough automatic

FIGURE B1

Three-year mean wet sulfate deposition, U.S.

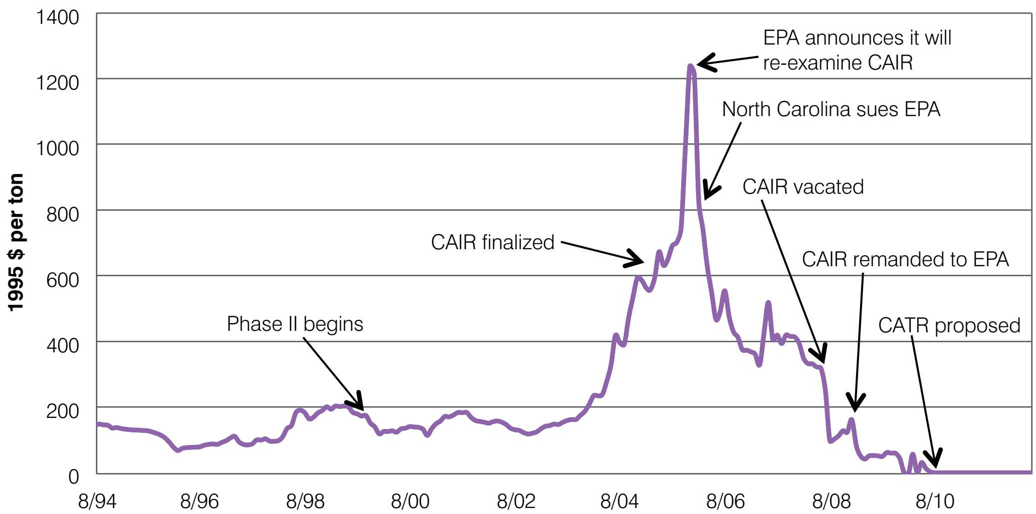


Areas of red indicate higher deposition levels and areas of green indicate lower deposition levels.

Source: EPA, "Clean Air Interstate Rule, Acid Rain Program, and Former NO_x Budget Program 2010 Progress Report," June 2012, available at epa.gov/airmarkets/progress/ARPCAIR10_02.html.

FIGURE B2

SO_2 allowance prices and the regulatory environment, 1994–2012 (1995 $ per ton)



Significant price volatility starting in 2004 has been attributed to regulatory uncertainty. CAIR and CATR refer to SO_2-related U.S. Environmental Protection Agency regulatory programs.

Source: Richard Schmalensee and Robert N. Stavins, "The SO_2 Allowance Trading Scheme: The Ironic History of a Grand Policy Experiment," Discussion Paper 2012-53, Harvard Project on Climate Agreements, August 2012, at 14 (citing Power & Energy Analytic Resources (PEAR) Inc., Cantor Fitzgerald, and ICAP United), available at belfercenter.ksg.harvard.edu/publication/22245/SO_2_allowance_trading_system.html.

penalties for failure to comply, can deliver superior environmental results at low cost. In 2002, *The Economist* hailed the U.S. SO_2 trading program as "probably the greatest green success story of the past decade."[272]

2. The success of the SO_2 trading program also indicates that high and consistent allowance prices are not requirements for cost-effectively achieving emissions targets. As Figure B2 illustrates, prices for SO_2 allowances ranged widely, from approximately $60 per ton to almost $1,400 per ton and back again. More recently, according to the U.S. Energy Information Administration (EIA), the combination of a growing bank of existing "saved" allowances, knowledge that allowances likely will cease to have value under future regulatory programs, and increased use of natural gas for power generation have brought SO_2 allowance prices to historic lows.[273]

3. Regulatory uncertainty over the possibility that the Acid Rain program would be replaced by the Clean Air Interstate Rule (CAIR) caused a spike in allowance price volatility from 2005–2006 (see Figure B2). The spike underscores how important regulatory certainty is to the stability of allowance markets.

APPENDIX C

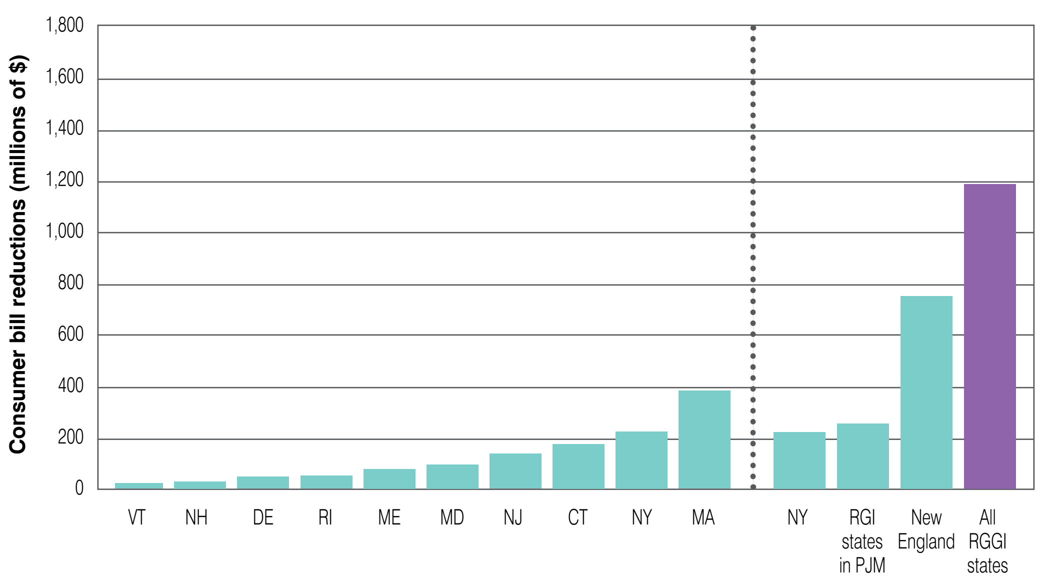
The Regional Greenhouse Gas Initiative (RGGI)

In 2009, the Regional Greenhouse Gas Initiative (RGGI), comprising 10 Northeastern and Mid-Atlantic states, became the United States' first market-based system for reducing CO_2 emissions from power plants.[274] RGGI states represent approximately one-fifth of the country's GDP and one-sixth of the population. The program has already generated significant economic and environmental benefits for the region.[275]

Starting in 2012, the RGGI cap for CO_2 emissions from the power sector is 165 million short tons per year.[276] State caps are apportioned based on emissions from included sources (fossil fuel power plants with generating capacity of 25 megawatts or more). After 2014, the cap will decline by 2.5% annually, so overall emissions by the end of 2018 will be 10% lower than in 2012. The vast majority of allowances are dispersed via a centralized auction.

FIGURE C1

Geographic distribution of consumer benefits from the Regional Greenhouse Gas Initiative (RGGI)

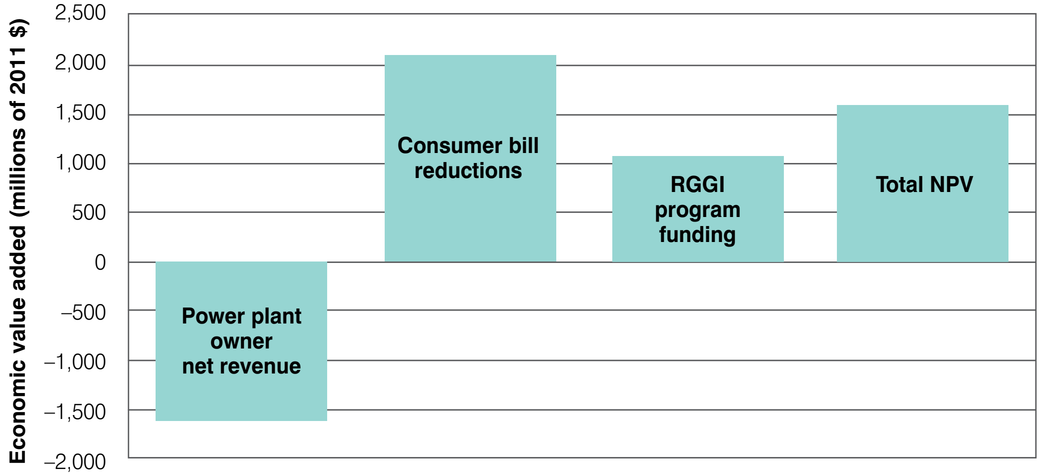


Bill reduction totals for the three electricity regions within RGGI are shown on the right side of the chart: New York, PJM (Delaware, Maryland, New Jersey), and New England, along with the cumulative total for all RGGI states (purple).

Source: Paul J. Hibbard et al., "The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States," The Analysis Group, November 15, 2011, at 4, available at analysisgroup.com/uploadedFiles/Publishing/Articles/Economic_Impact_RGGI_Report.pdf.

FIGURE C2

Net economic impact to states in the Regional Greenhouse Gas Initiative (RGGI) region



Source: Paul J. Hibbard et al., "The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States," The Analysis Group, November 15, 2011, at 3, available at analysisgroup.com/uploadedFiles/Publishing/Articles/Economic_Impact_RGGI_Report.pdf.

A recent analysis of emissions from the first phase of RGGI found that the program was "a standout success," achieving results faster than anticipated. From 2009 to the end of 2011, power plants in the 10-state region emitted an average of only 126 million tons of CO_2 per year, well below the original 10-state cap of 188 million tons.[277]

Important economic results from the program's first three years illustrate: 1) employment growth despite a lackluster economy, 2) consumer benefits through advances in energy efficiency, and 3) significant increases in well-balanced economic benefits throughout the region. Key findings include the following:

Net employment growth: RGGI resulted in 16,000 additional jobs in only its first three years. This gain is especially impressive because the region's labor force declined by 74,300 from September 2010 to September 2011, a loss that would have been even larger without RGGI.

Consumer benefit: Consumers in every RGGI state benefit from reduced power bills, as shown in Figure C1. Gains for electricity consumers are $1.1 billion net present value (NPV).[278] In the very early stages of the program, small price increases outweighed benefits, but electricity prices dropped quickly, as expected, because of investment in energy efficiency funded by state allowance auctions. From 2009 to 2021, residential consumers are projected to save a total of $25 per capita, commercial consumers save $181, industrial consumers save $2,493, and consumers of natural gas and heating oil save $174. Further, RGGI has helped reduce participating states' expenditures on fossil fuel imports by $765 million NPV.

Producer cost: The cumulative expenditure for emissions allowances has been $912 million during the first three years. Initially, power producers recovered those expenses from customers through price hikes, but as energy efficiency improved, customers used less energy. The expected cost to energy producers is $1.6 billion, spread over 2009–2021 (NPV).

State revenue and investment: In the first three years of the program, $912 million of producer allowance expenditures became state revenue. States invested RGGI proceeds in a variety of ways, including in energy efficiency measures, in community-based renewable energy projects, and in education and job training programs. The labor and expenses generated from these investments had net positive local and regional, direct and indirect multiplier effects.

Net impact: As shown in Figure C2, RGGI is producing net economic benefits for the ten-state region. From 2009 to 2021, RGGI is expected to produce a $1.6 billion net economic benefit for participating states.When spread across the region's population, the value added is $33 per person. Each state is projected to experience a net gain from the program.

Notes

[1] *See* A. Denny Ellerman, Frank Convery, and Christian de Perthuis, *Pricing Carbon*, Cambridge Press (2010), at 191. *See also* European Commission, "Climate change: Progress report shows EU on track to meet or over-achieve Kyoto emissions target," press release, Brussels, November 12, 2009, available at europa.eu/rapid/pressReleasesAction.do?reference=IP/09/1703&format=HTML&aged=0&language=EN&guiLanguage=en.

[2] *See* Karoline S. Roggea & Volker H. Hoffmann, "The impact of the EU ETS on the sectoral innovation system for power generation technologies—Findings for Germany," 38 Energy Policy 7639 (2010) (finding that "the EU ETS seems to have accelerated the innovation process in general"). *See also* Raphael Calel and Antoine Dechezlepretre, "Low CO_2 innovation is up, but not because of the EU ETS," LSE, May 1, 2012 (indicating that the EU ETS has spurred operational innovations, rather than technological changes), available at lse.ac.uk/GranthamInstitute/Media/Commentary/2012/May Low-carbon-innovation-EU-Emissions-Trading-Scheme.aspx.

[3] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 243. *See* "Europe's emissions trading forum has 'tiny' impact as companies prepare for auctions," ClimateWire, December 9, 2010, available at eenews.net/public/climatewire/2010/12/09/1. *See also* McKinsey and Company & Ecofys, "EU ETS Review: Report on International Competitiveness," European Commission, December 2006, available at origin.mckinsey.com/clientservice/sustainability/pdf/Report_on_International_Competitiveness.pdf; Julia Renaud, "Industrial Competitiveness under the European Union ETS," International Energy Agency, December 2004, available at 194.245.121.74/fileadmin/gruppen/bdz/Themen/Umwelt/IEA-Studie_11-2004.pdf.

[4] Unless otherwise specified, in this report the term "emissions allowance" means an allowance issued under the directives establishing the EU ETS, to emit one metric ton of carbon dioxide equivalent during a specified period. Under the directives, emitters are required to tender to governmental authorities one allowance for each ton of actual emissions, and allowances are transferable. Some commentators also use the terms "permits" and "quotas" to refer more generally to these types of allowances, and on occasion we use these terms as well. The full text of the directives establishing the EU ETS's Phase I and Phase II, linking the ETS to project-based mechanisms, expanding the ETS to cover aviation, and extending the ETS to Phase III, can be found, respectively, at: Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, L 275/32 EN Official Journal of the European Union (October 25, 2003); Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms, L 338/18 EN Official Journal of the European Union (November 13, 2004); Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, L 8/3 EN Official Journal of the European Union (January 13, 2009); and 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 scheme of the Community, L 140/63 EN Official Journal of the European Union (June 5, 2009).

[5] "Emissions impossible for CBI to stomach," The Guardian, March 20, 2004, available at guardian.co.uk/business/2004/mar/21/theobserver.observerbusiness10 ("industry ... issuing dire warnings to consumers. Households could face rises of 50 percent or more on their utility bills... ").

[6] Ben Schiller, "Europe's CO_2 Trading Scheme: Is it Time for a Major Overhaul?" Yale Environment 360, April 28, 2011 (quoting Michael Buick, Acting Director of Sandbag) available at e360.yale.edu/feature/europes_co2_trading_scheme_is_it_time_for_a_major_overhaul/2396/.

[7] For a review of several of these studies, *see* Christian Egenhofer, Monica Alessi, Anton Georgiev, and Noriko Fujiwara, "The EU Emissions Trading System and Climate Policy towards 2050: Real incentives to reduce emissions and drive innovation?" CEPS Special Report, January 2011, available at papers.ssrn.com/sol3/papers.cfm?abstract_id=1756736&. *See also* "Emissions from the EU ETS down 3% in 2008," New Carbon Finance, February 16, 2009, press release, available at bnef.com/Downloads/pressreleases/38/pdffile; Frank Watson, "EC CO_2 data shows that EU carbon trading is working: analysts," Platts, April 11, 2011, available at platts.com/NewsFeature/2011/emissionsdata/index; Ellerman et al., *Pricing Carbon*, *supra* note 1, at 191; Jan Abrell, Anta Ndoye Faye, and Georg Zachmann, "Assessing the impact of the EU ETS using firm level data," July 15 2011, at 9, available at bruegel.org/publications/publication-detail/publication/579-assessing-the-impact-of-the-eu-ets-using-firm-level-data/.

[8] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 191.

[9] *See* A. Denny Ellerman, European University Institute, "The EU ETS: Path to the Future or Dead-end?" Presentation, September 5, 2011, available at dors.dk/graphics/Synkron-library/Konference%202011/Abstracts/Ellerman.pdf.

[10] *See* Simon Rogers and Lisa Evans, "World carbon dioxide emissions data by country: China speeds ahead of the rest," The Guardian, January 31, 2011, available at guardian.co.uk/news/datablog/2011/jan/31/world-carbon-dioxide-emissions-country-data-co2. *See also* World Resources Institute, "Climate Analysis Indicators Tool (CAIT)," available at wri.org/project/cait/.

[11] Germany, Sweden, Poland, and Austria are among several EU ETS member states where economic growth has continued despite the economic recession. *See* Eurostat, "Real GDP growth rate-volume," available at http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&plugin=1&language=en&pcode=tec00115 (select Germany, Sweden, Poland, and Austria; then select "vertical bar graph" to display GDP growth in relevant years).

[12] *See* ClimateWire, *supra* note 3. *See also* Abrell et al., *supra* note 7, at 2.

[13] *See* McKinsey & Company and Ecofys, *supra* note 3. *See also* Renaud, *supra* note 3.

[14] *See* Barry Anderson and Corrado Di Maria, "Abatement and Allocation in the Pilot Phase of the EU ETS," 48 *Environmental and Resource Economics* 83, 86 (2011) ("Most governments allocated EUAs relative to ex ante BAU projections, with past emissions strongly influencing the more detailed distribution of allowances ... [causing] a direct incentive to inflate actual emissions"), available at springerlink.com/content/4724437n37562rw1/fulltext.pdf?MUD=MP.

[15] Joseph E. Aldy and Robert N. Stavins, "The Promise and Problems of Pricing Carbon: Theory and Experience," The *Journal of Environment & Development*, October 2011, at 11, available at http://www.nber.org/papers/w17569.

[16] *See* Roggea and Hoffmann, *supra* note 2 (finding that the EU ETS has been particularly important in stimulating research and development in the coal-fired power sector).

[17] For a discussion of an alternative that would discount CDM credits earned from projects in advanced developing countries, *see* Kyle Meng and Jos Cozijnsen, "Viewpoint: Value-added CDM could stimulate more global reductions," CDM & JI Monitor, Point Carbon, September 5, 2007. *See also* Environmental Defense Fund, "Reforming the CDM: the Need for New Ways to Welcome Developing Countries into a Global Carbon Market," August 20, 2008, available at edf.org/sites/default/files/8303_CDMfinal_Ghana.pdf.

[18] In 2006, U.S. fraud loss on credit and debit card payments amounted to $3.72 billion. The total fraud loss rate on debit and credit card payments (per $100) was $0.092. Richard J. Sullivan, Federal Reserve Bank of Kansas City, "The Changing Nature of U.S. Card Payment Fraud: Issues for Industry and Public Policy," presentation at Harvard University, May 21, 2010, at 11, available at weis2010.econinfosec.org/papers/panel/weis2010_sullivan.pdf.

[19] Estimates of uncollected tax revenue lost to VAT fraud on EU ETS allowances range as high as $7.6 billion (€5 billion), but such estimates are disputed. *See* Alexandre Kossoy and Philippe Ambrosi, "State and Trends of the Carbon Market 2010," World Bank, Washington DC, May 2010, at 10, available at siteresources.worldbank.org/INTCARBONFINANCE/Resources/State_and_Trends_of_the_Carbon_Market_2010_low_res.pdf.

[20] *See* Oliver Sartor, "Closing the Door to Fraud in the EU ETS," Climate Brief No. 4, CDC Climat Research, February 2011, available at cdcclimat.com/IMG//pdf/11-02_climate_brief_4_-_closing_the_door_to_fraud_in_the_eu_ets.pdf.

[21] *See also* Ellerman et al., *Pricing Carbon*, *supra* note 1, at 185–191(providing examples of individual company actions to reduce emissions in response to the EU ETS); Abrell et al., *supra* note 7 (finding that the tightening of the EU ETS cap and of allocations to installations spurred significant emission reductions within individual firms, after controlling for production changes due to the global financial crisis).

[22] German Federal Environmental Ministry, "Renewably employed: Short and long-term impacts of the expansion of renewable energy on the German labour market," September 2010, at 8–9, 11, available at http://germany.info/contentblob/3179136/Daten/1346894/BMU_RenewablyEmployed_DD.pdf.

[23] 2011 was the 11th hottest year on record, and the hottest ever in a La Niña year, which has a cooling influence. World Meteorological Press Release No. 943, "WMO annual statement confirms 2011 as 11th warmest on record," March 23, 2012, available at wmo.int/pages/mediacentre/press_releases/pr_943_en.html.

[24] Evan Lehmann, "Temps and emissions on the rise, scientists say, as glaciers fall," ClimateWire, June 29, 2011, available at eenews.net/cw/2011/06/29/ (citing J. Blunden et al., Eds., "State of the Climate in 2010," Bulletin of the American Meteorological Society, Special Supplement, June 2011, at S59, available at ncdc.noaa.gov/pub/data/cmb/bams-sotc/2010/bams-sotc-2010-chapter2-global-climate-lo-rez.pdf). *See also* "Growth in Global Carbon Market Pauses Amid Uncertainty," World Bank Press Release No:2011/514/SDN, June 1, 2011, available at web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22928671~pagePK:64257043~piPK:437376~theSitePK:4607,00.html.

[25] European Commission, Climate Action, "Climate and Energy Package," available at http://ec.europa.eu/clima/policies package/documentation_en.htm.

[26] The size and global prominence of the EU ETS is reflected in the fact that the total value of the global carbon market was $176 billion in 2011, of which more than 90% came from the EU. *See* Alexandre Kossoy and Pierre Guigon, "State and Trends of the Carbon Market 2012," World Bank, Washington DC, May 2012 at 9, 37, available at siteresources.worldbank.org/INTCARBONFINANCE/Resources/State_and_Trends_2012_Web_Optimized_19035_Cvr&Txt_LR.pdf. *See also* "World Bank warns of 'failing' international carbon market," The Guardian, June 1, 2011, available at guardian.co.uk/environment/2011/jun/01/world-bank-failing-carbon-markets?CMP=twt_fd.

[27] European Commission, Climate Action, "Emissions Trading System (EU ETS)," available at ec.europa.eu/clima/policies/ets/index_en.htm.

[28] The 30 nations are the 27 EU nations, as well as Iceland, Liechtenstein, and Norway. *See* European Commission, "EU Action Against Climate Change: The EU Emissions Trading Scheme," 2009, at 6, 15, available at ec.europa.eu/clima/publications/docs/ets_en.pdf.

[29] *Id.* at 12.

[30] Aldy and Stavins, *supra* note 15.

[31] All cap figures are from Ellerman et al., *Pricing Carbon*, *supra* note 1, at 56. The ETS expanded its greenhouse gas coverage by 22% from 2005 to 2012 by adding more participating countries, sectors, and installations. *Id.* at 270. For instance, in 2012, the EU ETS expanded to include the aviation sector, capping CO_2 emissions from nearly all flights from, to, and within the EU. *See* European Parliament and Council, Directive 2008/101/EC, Art. 3, *supra* note 4.

[32] *See* European Commission, Climate Action, "Cap," available at http://ec.europa.eu/clima/policies/ets/cap/index_en.htm. *See also* Ellerman et al., *Pricing Carbon*, *supra* note 1, at 80.

33 *See* European Commission, "Emissions Trading System (EU ETS) FAQ," at 15, available at ec.europa.eu/clima/policies/ets/faq_en.htm.

34 IETA, "The EU's Emissions Trading System," available at ieta.org/index.php?option=com_content&view=article&id=324:the-eu-emissions-trading-system&catid=54:3-minute-briefing&Itemid=135.

35 *See, e.g.*, "Opportunities for innovation: The business opportunities for SMEs in tackling the causes of climate change," Shell Springboard/VividEconomics, October 2006, at 1 ("...emissions trading offers the largest emissions savings"), available at http://bit.ly/SOBFdo).

36 *See, e.g.*, Schiller, *supra* note 6.

37 For such an analysis, *see, e.g.*, Ellerman et al., *Pricing Carbon*, *supra* note 1.

38 *See* European Parliament and Council, Directive 2003/87/EC, Art. 1, *supra* note 4.

39 *See* Brad Plumer, "Around the world, cap-and-trade is still alive and kicking," Washington Post, June 5, 2012, available at washingtonpost.com/blogs/ezra-klein/post/around-the-world-cap-and-trade-is-still-alive-and-kicking/2012/06/05/gJQACSKVGV_blog.html.

40 *See* Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, U.N. Doc FCCC/CP/1997/7/Add.1, 37 I.L.M. 22 (1998), Art. 3 and Annex B, available at unfccc.int/resource/docs/convkp/kpeng.html.

41 *See* A. Denny Ellerman et al., "Cap and Trade: Contributions to the Design of a U.S. Greenhouse Gas Program," MIT, 2004, at 4, available at web.mit.edu/ceepr/www/publications/DDCF.pdf.

42 European Environment Agency, "Greenhouse gas emission trends and projections in Europe 2011," EEA Report No. 4/2011, October 2011, at 9, available at eea.europa.eu/publications/ghg-trends-and-projections-2011/.

43 European Environment Agency, "European Union's total greenhouse emissions down 2.5% in 2011," September 7, 2012 (noting that official emissions data for 2011 will be available in mid-2013), available at eea.europa.eu/highlights/european-union2019s-total-greenhouse-emissions.

44 European Environment Agency, "Greenhouse gas emission trends and projections in Europe 2011," *supra* note 42, at 43.

45 For emissions and GDP data, *see* European Environment Agency, "The European Environment: State and Outlook 2010: Mitigating Climate Change," Copenhagen, November 2010, at 4, 20, available at eea.europa.eu/soer/europe/mitigating-climate-change. For manufacturing data, *see* European Commission, "Impact of the economic crisis on key sectors of the EU," October 29, 2009, Annex, Graph 1, at 10, available at ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=5509; *See also* European Commission, "The Economic Recovery in Industry," October 25, 2010, available at ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=6239.

46 *See* WWF, "Leading companies call for sharper EU carbon cuts," June 15, 2011, available at wwf.org.uk/what_we_do/press_centre/?unewsid=5012; Chris Huhne, Norbert Röttgen and Jean-Louis Borloo, "Europe needs to reduce emissions by 30%," Financial Times, July 14, 2010, available at ft.com/cms/s/0/08538a04-8f78-11df-8df0-00144feab49a.html.

47 Ellerman et al., *Pricing Carbon*, *supra* note 1, at 243.

48 McKinsey & Company and Ecofys, *supra* note 3.

49 Ellerman et al., *Pricing Carbon*, *supra* note 1, at 243. *See also* ClimateWire, *supra* note 3; Damien Demailly and Philippe Quirion, "European Emission Trading Scheme and competitiveness: A case study on the iron and steel industry," 30 Energy Economics 4, July 2008, available at ideas.repec.org/a/eee/eneeco/v30y2008i4p2009-2027.html; Abrell et al., *supra* note 7, at 14, 15.

50 Demailly and Quirion, *supra* note 49.

51 *See* Abrell et al., *supra* note 7, at 15.

52 *See* Abrell et al., *supra* note 7, at 14, 15 ("the overall conclusion is that participating companies did not experience any significant loss of competitiveness").

53 European Commission Staff Working Paper, "Analysis of options beyond 20% GHG emission reduction: Member State results," January 30, 2012, available at ec.europa.eu/clima/news/articles/news_2012013002_en.htm.

54 *See, e.g.,* COWI, "Competitiveness and EU Climate Change Policy," UNICE, October 2004, at 21 (predicting that "EU25 GDP is reduced 0.36% [to] 0.48%"), available at di.dk/SiteCollectionDocuments/Downloadboks%20-%20lokale%20filer/Downlads%20lokale%20filer%2005-08/UNICE-COWI%20report-Competitiveness%20and%20EU%20climate%20change%20policy.pdf; UNICE, "UNICE press conference on EU climate change strategy," press release, Brussels, October 7, 2004, at 1. ("8 big electricity-consuming sectors... could have to bear additional financial costs of between 85 million EURO and 2.3 billion EURO due to increases in the price of electricity"); Larry Elliott, "CBI 'plays up' CO_2 job threat," The Guardian, January 31, 2005, available at guardian.co.uk/society/2005/feb/01/environment.climatechange; "Slightly greener," The Economist, April 1, 2004, available at economist.com/node/2559016 ("Some industry lobbies have been screaming that the economic costs of action will be ruinous. Those representing the EU power industry claim that tackling carbon could cost €2 billion ($2.4 billion) a year."); and *supra* note 5.

55 *See* Nathaniel O. Keohane, "What Did the Market Buy? Cost Savings Under the U.S. Tradeable Permits Program for Sulfur Dioxide," Yale Center for Environmental Law & Policy, October 15, 2003, available at ucei.berkeley.edu/CSEM/pwrpubs cost_savings.pdf.

56 *See, e.g.*, Schiller, *supra* note 6, and Carbon Trade Watch, "EU Emissions Trading System: Failing at the third attempt," April 2011, available at carbontradewatch.org/publications/eu-emissions-trading-system-failing-at-the-third-attempt.html.

57 For a review of several of these studies, *see* Egenhofer et al., *supra* note 7. *But see*, e.g., Claudia Kettner, Angela Köppl, Stefan P. Schleicher, and Gregor Thenius, "Stringency and Distribution in the EU ETS: first evidence," 8 Clim Policy 41–61, 2008, available at uni-graz.at/karl.steininger/climate_policy.pdf ("it is rather unlikely that the EU ETS has already created incentives for abatement investments in the first trading years").

58 Ellerman et al., *Pricing Carbon*, *supra* note 1.

[59] *See* Eurostat, "Real GDP Growth Rate," available at epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tec00115.

[60] *See* Ellerman et al., Pricing Carbon, *supra* note 1, at 191-192.

[61] See, e.g., Egenhofer et al., *supra* note 7, at 9-10; Erik D. Delarue, A. Denny Ellerman and William D. D'haeseleer, "Short-term CO_2 abatement in the European power sector," MIT-CEEPR Working Paper, June 2008, available at web.mit.edu/ceepr/www/publications/workingpapers/2008-008.pdf; A. Denny Ellerman and Barbara Buchner, "Over-allocation or abatement: A preliminary analysis of the EU ETS based on the 2005-06 emissions data," Environmental and Resource Economics, 2008, available at ucei.berkeley.edu/PDF/seminar110207.pdf; Anderson and Di Maria, *supra* note 14.

[62] Anderson and Di Maria, *supra* note 14, at 83.

[63] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 191. *See also* Anderson and Di Maria, *supra* note 14, at 97 (estimating net abatement of 2.8%, or approximately 174 million tons); Egenhofer et al. *supra* note 7, at 9.

[64] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 191. *See also* Rogers and Evans, "World carbon dioxide emissions," *supra* note 10.

[65] Delarue et al., *supra* note 61, at 29.

[66] Egenhofer et al., *supra* note 7, at 10.

[67] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 168.

[68] Ellerman, A. D. and Feilhauer, S. M. "A Top-down and Bottom-up look at Emissions Abatement in Germany in response to the EU ETS," Working Paper, MIT Centre for Energy and Environmental Policy Research, 2008, at 13.

[69] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 170-171.

[70] Ellerman and Feilhauer, *supra* note 68, at 10.

[71] *See* Chapter 3, *infra.*

[72] A. Denny Ellerman and Paul L. Joskow, "The European Union's Emissions Trading System in perspective," Pew Center on Global Climate Change, May 2008, at 9, available at c2es.org/docUploads/EU-ETS-In-Perspective-Report.pdf.

[73] Egenhofer et al., *supra* note 7, at 4.

[74] Id.

[75] *See* Claudia Kettner & Daniela Kletzan-Slamanig & Angela Köppl, "ETCLIP – The Challenge of the European Carbon Market: Emission Trading, Carbon Leakage and Instruments to Stabilise the CO2 Price. The EU Emission Trading Scheme: Sectoral Allocation Patterns and the Effects of the Economic Crisis," WIFO Working Papers 408, 2011, at 3 (noting that in the post-Kyoto Phase III, national caps will be replaced by an EU-wide ETS cap).

[76] Ellerman, "The EU ETS: Path to the Future or Dead-end?", *supra* note 9. *See also* Gernot Wagner, "Innovation is Not Enough: Why Polluters Must Pay," Yale Environment 360, March 12, 2012, available at e360.yale.edu/feature/innovation_is_not_enough_why_polluters_must_pay/2502/.

[77] *See* Barbara Lewis and Nina Chestney, "EU ETS emissions down in 2011, permit glut grows," Reuters, May 15, 2012, available at reuters.com/article/2012/05/15/us-eu-carbon-idUSBRE84E0SA20120515. *See also* European Environment Agency, "European Union's total greenhouse emissions down 2.5% in 2011," September 7, 2012, available at eea.europa.eu/highlights/european-union2019s-total-greenhouse-emissions. For 2011 GDP growth rates in Europe, *see* Eurostat, "Real GDP growth rate—volume, percentage change on previous year," (showing 2011 GDP growth of approximately 1.4% in the EU-27), available at epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tec00115.

[78] Egenhofer et al., *supra* note 7, at 10-12. *See also* Kettner et al., *supra* note 75, at 17 (finding that over both Phase I and Phase II of the EU ETS, "the EU on aggregate and especially the EU-15 countries [the original members of the EU before a 2004 expansion], exhibit an increasing decoupling of economic growth, energy use, and emissions. Compared to previous years the improvements have become larger.")

[79] Egenhofer et al., *supra* note 7, at 11.

[80] *See* Abrell et al., *supra* note 7, at 2 ("We find that the EU ETS induced emissions reductions in the second phase").

[81] New Carbon Finance, *supra* note 7.

[82] Interview with A. Denny Ellerman, April 29, 2011, unpublished manuscript on file with authors; *See also* Ellerman, *supra* note 9. For Egypt's emissions data, *see* Rogers and Evans, *supra* note 10.

[83] The steep decline in emissions during the 1990s—before the ETS—was driven by the collapse of the Soviet Union and economic restructuring in eastern European countries that are now part of the EU ETS. See, e.g., European Environment Agency, "Greenhouse gas emissions in Europe: a retrospective trend analysis for the period 1990-2008," 2011, at 108, available at eea.europa.eu/publications/ghg-retrospective-trend-analysis-1990-2008 ("A large part of this trend can be explained by the 'economic restructuring' following the collapse of the Soviet Union and its consequences in eastern Europe, which led in particular to the closure of heavily polluting industrial plants.... Across the energy, industry and agriculture sectors, the economic trends resulted in significant reductions in GHG emission levels [in the early 1990s].").

[84] Interview with A. Denny Ellerman, April 29, 2011, unpublished manuscript on file with authors; *See also* Ellerman, *supra* note 9.

[85] Rogers and Evans, *supra* note 10. *See also* World Resources Institute, *supra* note 10.

[86] "Emissions Trading: EU ETS emissions increased in 2010 but remain well below pre-crisis level," Europa press release, May 17, 2011, available at http://europa.eu/rapid/press-release_IP-11-581_en.htm.

[87] *See* Watson, *supra* note 7.

[88] *Id.*

[89] Egenhofer et al., *supra* note 7, at iii.

[90] *Id.*

[91] *See* Ellerman et al., *Pricing Carbon*, *supra* note 1, at 54–57.

[92] Ellerman and Feilhauer, *supra* note 68, at 20.

[93] Robert N. Stavins, "What Can We Learn from the Grand Policy Experiment? Lessons from SO2 Allowance Trading." 12 Journal of Econ. Perspectives 3, at 72 (1998), available at hks.harvard.edu/fs/rstavins/Papers/What%20Can%20We%20Learn%20from%20the%20Grand%20Policy%20Experiment....pdf.

[94] Aldy and Stavins, *supra* note 15.

[95] Id.

[96] Anderson and Di Maria, *supra* note 14.

[97] Aldy and Stavins, *supra* note 15.

[98] *See* U.S. EPA, "Acid Rain and Related Programs: 2009 Highlights," December 2010, available at http://epa.gov/airmarkt/progress/ARP09_4.html. *See also* Appendix B: The U.S. SO_2 emissions trading program, *infra*.

[99] Anderson and Di Maria, *supra* note 14.

[100] Annie Petsonk and Jos Cozijnsen, "Harvesting the Low-Carbon Cornucopia: How the European Union Emissions Trading System (EU ETS) is Spurring Innovation and Scoring Results," Environmental Defense, March 14, 2007, at 11, available at edf.org/sites/default/files/harvesting-the-low-carbon-cornucopia-march2007.pdf: Ellerman et al., *supra* note 1.

[101] *See* European Parliament, DG for Internal Policies, "Functioning of the ETS and the flexible mechanisms," March 2011, at 11, available at europarl.europa.eu/document/activities/cont/201203/20120301ATT39682/20120301ATT39682EN.pdf.

[102] European Commission, Climate Action, "Benchmarks for free allocation," June 18, 2012, available at http://ec.europa.eu/clima/policies/ets/benchmarking/index_en.htm.

[103] Richard Cooper, "Europe's Emissions Trading System," The Harvard Project on International Climate Agreements, August 2010, at 7 and 11, available at belfercenter.ksg.harvard.edu/files/CooperETSfinal.pdf.

[104] European Parliament and Council, Directive 2009/29/EC, Art. 9, *supra* note 4. *See also* Ellerman et al., *Pricing Carbon*, *supra* note 1, at 80.

[105] *See* European Commission, "Cap," *supra* note 32.

[106] *See, e.g.*, C. Jaeger et al., "A New Growth Path for Europe: Generating Prosperity and Jobs in the Low Carbon Economy," German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, June 2011, at 5, available at newgrowthpath.eu/wp-content/uploads/2011/06/A_New_Growth_Path_for_Europe__Final_Report.pdf.

[107] *Id*.

[108] *See* Jeff Coelho "Set-aside could send EU CO_2 to 20 eur/t-Pt Carbon," Reuters, March 27, 2012, available at reuters.com/article/2012/03/27/carbon-point-carbon-idUSL6E8ER4O320120327.

[109] *See* Dallas Burtraw and Sarah Jo Szambelan, "U.S. Emissions Trading Markets for SO_2 and NO_x," Resources for the Future, October 2009, at 9, available at rff.org/RFF/Documents/RFF-DP-09-40.pdf; U.S. EPA, "Allowance Markets Assessment: A Closer Look at the Two Biggest Price Changes in the Federal SO_2 and NO_x Allowance Markets," white paper, April 23, 2009, available at epa.gov/airmarkt/resource/docs/marketassessmnt.pdf.

[110] For discussion, *see* Alex Bowen and Nicholas Stern, "Environmental policy and the economic downturn," 26 (2) *Oxford Review of Economic Policy* 137, at 142–143 and 158 (2010).

[111] *See, e.g.*, Y. Chen and C.L. Tseng, "Inducing Clean Technology in the Electricity Sector: Tradable Permits or Carbon Tax Policies?" 32 Energy Journal 149–174 (July 2011), available at iaee.org/en/publications/ejarticle.aspx?id=2430; and *see* Wiener, J.B., "Global Environmental Reputation: Instrument Choice in Legal Context," 108 Yale Law Journal 677–800 (1999).

[112] *See* Y. Chen and C.L. Tseng, *supra* note 111.

[113] Current debates in the EU about taking action to reverse low allowance prices may signal a political commitment to maintain the relevance of the EU ETS to EU climate policy. To the extent that low prices may erode the political durability of the EU ETS, the angst in Europe over low carbon prices may be understandable. A clear lesson for other jurisdictions is to ensure the long-term political credibility—and durability—of a cap-and-trade system, including by ensuring long-term policy visibility, calibration of complementary climate policies, and some degree of flexibility to change the cap in extra-ordinary circumstances, in accordance with known-in-advance criteria.

[114] Gerard Wynn and Nina Chestney, "Analysis: Polluters winners from carbon scheme," Reuters, June 23, 2011, available at reuters.com/article/2011/06/23/us-eu-carbon-market-idUSTRE75M3VI20110623. *See also* Schiller, *supra* note 6.

[115] Jeff Coelho, "EU capped emissions down 2.4 pct in 2011," Reuters, April 2, 2012, available at reuters.com/article/2012/04/02/eu-emissions-idUSL6E8F22GT20120402.

[116] *See* id. *See also* Schiller, *supra* note 6 (noting that a low carbon price may "lessen the downward pressure on emissions").

[117] *See generally* Robert N. Stavins, "A U.S. Cap-and-Trade System to Address Global Climate Change," JFK School of Government, Harvard University, RPP-2007-04 (2007) (an examination of the efficacy of a long-term carbon price in the U.S.).

[118] Prices accessed at ICE, "Daily Volumes for ICE ECX EUA Futures, " available at theice.com/marketdata/reports ReportCenter.shtml?reportId=10&contractKey=20#report/10/reportId=10&contractKey=20.

[119] See*, e.g.*, Roggea and Hoffmann, *supra* note 2.

[120] Wagner, *supra* note 76.

[121] *See* Allen Chen, "New Research Suggests Cap and Trade Programs Do Not Provide Sufficient Incentives for Energy Technology Innovation," Lawrence Berkeley National Laboratory, March 15, 2012, available at newscenter.lbl.gov/feature-stories/2012/03/15/cap-and-trade-programs-do-not-provide-sufficient-incentives/ (reaffirming that the cap-and-trade programs studied "exhibited lower-than-expected allowance prices, in part because program participants adopted an unexpected range of approaches for reducing emissions sources in the lead-up to trading").

[122] Mark Lazarowicz, "Global Carbon Trading: A Framework for Reducing Emissions," The Stationary Office 2009, at viii, available at streitcouncil.org/uploads/GlobalCarbonTradingaframeworkforreducingemissions.pdf.

[123] Harrison Fell and Richard D. Morgenstern, "Alternative Approaches to Cost Containment in a Cap-and-Trade System," Resources for the Future, April 2009, at 1, available at rff.org/RFF/Documents/RFF-DP-09-14.pdf.

[124] *See* Figure 3, page 16.

[125] *See* EU Climate Action, Presentation at the IMO Side Event, "Experience with the EU ETS and the carbon market," (March 29, 2011). Oranges and rice data come from IMF Commodity Price Index, available at imf.org/external/np/res/commod/index.aspx (Excel spreadsheet accessible at the "monthly data (CSV file)" hyperlink).

[126] EUA spot price data come from Thomson Reuters Point Carbon, accessed March 2012. Other commodity data from IMF Commodity Price Index, available at imf.org/external/np/res/commod/index.aspx (Excel spreadsheet accessible at the "monthly data (CSV file)" hyperlink). The IMF provides three natural gas price indexes; we use the American natural gas price index, from Henry Hub in Louisiana. Black-Scholes calculations for historical financial volatility conducted by the authors.

[127] *See* Wynn and Chestney, *supra* note 114. Wynn and Chestney also suggest the fall in prices may be linked to the forward sale of 300 million EU ETS allowances from the 2012–2020 trading period to raise money for clean energy projects. However, that sale was announced in November 2010. Had that announcement itself caused fears of a price drop, we should have seen that drop long before June 2011.

[128] "EUAs fall to lowest since April 2009," Commodities Now, June 24, 2011, available at commodities-now.com/news/environmental-markets/6806-euas-fall-to-lowest-since-april-2009.html.

[129] Joshua Chaffin, "Carbon trading: Into thin air," Financial Times, February 14, 2011, available at ft.com/cms/s/0/368f8482-387d-11e0-959c-00144feabdc0.html.

[130] "EC says new law to cut CO_2 years away as EUAs rebound," Point Carbon, June 27, 2011, available at pointcarbon.com/news/1.1553179.

[131] Borrowing is not formally allowed in the EU ETS, but the compliance period deadlines for surrendering allowances follow the issuance of the next year's allowances, so there is effectively year-ahead borrowing within trading periods. *See* Christina Hood, "Reviewing Existing and Proposed Emissions Trading Systems," OECD/IEA, November 2010, at 88, available at iea.org/papers/2010/ets_paper2010.pdf.

[132] *See* Cécile Goubet and Anaïs Delbosc, "Design of multi-sector emissions trading systems: a comparison of European and American experiences," CDC Climate Research, May 2011, at 29, available at cdcclimat.com/IMG/pdf/11-05-31_climate_report_28_design_of_multi-sector_ets_us_and_eu_ets_experiences.pdf.

[133] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 126.

[134] Andrew Aulisi et al., "From Obstacle to Opportunity," EDF, September 2000, at 5, available at cleartheair.edf.org/documents/645_SO2.pdf.

[135] Id.

[136] A deficit of available EUAs in Phase I would have been met by CER offsets from CDM projects or by paying a fine for non-compliance of \$58.40 (€40)/tCO_2. During Phase I, primary CER prices ranged from \$7.30–14.60 (€5–10) per ton of CO_2 equivalent, but because CER projects take time to implement, the supply of CERs during Phase I was limited. *See* Ellerman et al., *Pricing Carbon*, *supra* note 1, at 275.

[137] Ellerman and Joskow, *supra* note 72, at 13. The Phase I price for allowances peaked at \$36.48 (€30/EUA) in early 2006. This coincided with rising gas prices, which incentivized a switch to coal power production, and thus increased the power sector's emissions and demand for allowances. However, given that only the power sector was actively trading in this period, market participants wrongly assumed that there was an overall shortage in the supply of allowances. This resulted in the EUA price declining considerably following the release of verified emissions data in April 2006. The restriction in trading between the first and second periods exacerbated the decline of the price of EUAs in Phase I. *See* Egenhofer et al., *supra* note 7.

[138] New Carbon Finance, *supra* note 7.

[139] *See* "EUA price seasonality to dissipate: Socgen," Point Carbon, April 27, 2011, available at pointcarbon.com/news/1.1531547 (registration required).

[140] New Carbon Finance, *supra* note 7 ("some CO_2 reductions in 2008 were driven by a desire to bank credits into the post-2012 market, when the scheme is expected to be much tighter").

[141] *See* European Parliament, DG for Internal Policies, *supra* note 101, at 11.

[142] Petsonk, Annie. Statement to the House, Subcommittee on Energy and Air Quality, Committee on Energy and Commerce. Climate Change—International Issues, Engaging Developing Countries, Hearing, March 27, 2007, available at apps.edf.org/documents/6278_PetsonkMarch27Testimony.pdf.

[143] California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms, 17 Cal. Code Regs. § 95870(a) (2011). *See also* Sandbag Briefing, "California's carbon set-aside proposals," Sandbag, February 2012, available at sandbag.org.uk/site_media/pdfs/reports/California_set_aside_briefing.pdf.

[144] 17 Cal. Code Regs. § 95911 (4)(a) and (6)(a) (2011). *See also* Sandbag Briefing, *supra* note 143.

[145] Ellerman and Joskow, *supra* note 72, at iv.

[146] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 326. This profit does not include Ellerman's so-called "type II rents," which represent the value of the information possessed by large recipients of allowances. In Ellerman's view, individual companies that receive large allocations of EUAs have more information about the market than other market participants and can use this insider knowledge to their advantage. "Type II" rents are difficult to estimate and are highly dependent on theoretical assumptions.

[147] Global Business Insights, "The Top 10 European Utility Companies," June 2009, at 3, available at globalbusinessinsights.com/content/rben0211m.pdf.

[148] Ellerman, interview, *supra* note 9.

[149] J.P.M. Sijm et al., "The impact of the EU ETS on electricity prices. Final report to DG Environment of the European Commission," ECN, December 19, 2008, at 14, available at ecn.nl/docs/library/report/2008/e08007.pdf.

[150] *See* Egenhofer et al., *supra* note 7, at iii.

[151] *See, e.g.*, Mike Sandler, "Rebate Debate Over Utility-Sector Cap & Trade Revenues," Huffington Post, January 30, 2012, available at huffingtonpost.com/mike-sandler/rebate-debate-over-utilit_b_1240769.html.

[152] *See* Ellerman, "Cap and Trade", *supra* note 41, at 15 (describing the "political necessity" of free allocation) and 19.

[153] European Commission, "Benchmarks for free allocation," *supra* note 102.

[154] UK Department of Energy and Climate Change, "EU ETS Phase III," available at decc.gov.uk/en/content/cms/emissions/eu_ets/phase_iii/phase_iii.aspx.

[155] *See* Point Carbon Advisory Services, "EU ETS Phase II—The potential and scale of windfall profits in the power sector," March 2008, at 19, 22.

[156] For an example of such a revenue requirement report, *see* California Public Utilities Commission, "Gas and Electric Utility Cost Report," April 2010, available at cpuc.ca.gov/NR/rdonlyres/28894AA0-7C8A-4470-B342-53A84734DBF4/0/FinalCostReportwithErrata2009AB67.pdf.

[157] Ellerman and Joskow, *supra* note 72, at 25. *See also* Revenue Procedure No. 1992-91, Internal Revenue Service (IRS), October 29, 1992, "Examination of returns and claims for refund, credit, or abatement; determination of correct tax liability"; and *see* GAO "Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives: Air Pollution Allowance Trading Offers an Opportunity to Reduce Emissions at Less Cost," December 1994, GAO/RCED-95-30, text available at gao.gov/products/RCED-95-30 ("In 1992, the IRS issued guidance requiring the use of the historical cost of SO_2 allowances for purposes of tax calculation. [Citation omitted.] The IRS also said that EPA's allocations of allowances to utilities would not be taxable. In effect, these allocated allowances would be treated as having no value. *If the allowances are sold by the utility receiving them, almost one-third of their sale price would be taxed as a capital gain.*" (Emphasis added.)).

[158] For an extended discussion of the economics of marginal cost plants, *see* Ellerman et al., *Pricing Carbon*, *supra* note 1, at 323.

[159] According to Point Carbon, low-emitting sources such as hydro and co-gen set the prevailing electricity price in Spain around 35% of the time. *See* Point Carbon Advisory Services, "EU ETS Phase II—The potential and scale of windfall profits in the power sector," *supra* note 155, at 15.

[160] Id.

[161] Id. at 23

[162] Jos Sijm, Karsten Neuhoff and Yihsu Chen, "CO_2 Cost pass-through and windfall profits in the power sector," 6 *Climate Policy* 49, at 60–61, available at faculty.ucmerced.edu/ychen/climate_policy_2006.pdf.

[163] California Energy Commission Almanac, "2010 Total System Power in Gigawatt Hours," available at http://energyalmanac.ca.gov/electricity/total_system_power.html.

[164] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 326.

[165] See, e.g., Elisabeth Rosenthal and Andrew W. Lehren, "Profits on Carbon Credits Drive Output of Harmful Gas," New York Times, August 8, 2012, available at nytimes.com/2012/08/09/world/asia/incentive-to-slow-climate-change-drives-output-of-harmful-gases.html?_r=1.

[166] *See* European Commission, "EU Action Against Climate Change: The EU Emissions Trading Scheme," *supra* note 28, at 23. Some jurisdictions implementing cap-and-trade systems do not currently allow CERs to be used for compliance with emissions caps. See, e.g., Point Carbon, "International Offsets to Play Limited Role in California CO_2 Market: official," April 11, 2012, at 3, available at pointcarbon.com/news/1.1824919 (registration required).

[167] Kossoy and Ambrosi, "State and Trends of the Carbon Market 2010," *supra* note 19.

[168] Environmental Defense Fund, "The Clean Development Mechanism: Flawed tool needs updating: Two key criteria for reform," available at edf.org/climate/clean-development-mechanism/.

[169] *See* "High Level Panel on the CDM Policy Dialogue," available at cdmpolicydialogue.org. New market-based mechanisms that can stimulate low-carbon investments in developing countries are being considered for adoption at the 2012 UN climate negotiations in Qatar. The institutional knowledge gained from the CDM experience can inform the improved development of these new mechanisms, particularly as some advanced industrializing nations begin the transition to true cap-and-trade systems applicable to some or all sectors of their economies.

[170] UNFCCC, Report of the Conference of the Parties on its seventeenth session, Durban, 28 November to 11 December 2011, at para 79, UN Doc. FCCC/CP/2011/9/Add.1, available at unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf.

[171] For discussion, *see* Kyle Meng and Jos Cozijnsen, *supra* note 17. *See also* Environmental Defense Fund, "Reforming the CDM," *supra* note 17.

[172] Kossoy and Guignon, "State and Trends of the Carbon Market 2012," *supra* note 33, at 9, 37.

[173] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 50.

[174] Id. at 272.

[175] Joint implementation is a second carbon market mechanism created by the Kyoto Protocol that creates emission reductions credits for projects among countries with emission caps. Unlike the CDM, JI credits are monetized as emissions allowances which a selling party must subtract from its allowance pool at the time of transfer. *See* Kyoto Protocol, *supra* note 40, Articles 3.10, 3.11 and 3.12.

[176] Ellerman et al., *Pricing Carbon*, *supra* note 1, at 59.

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[190] *See* World Bank Carbon Finance Unit, "Addressing Carbon Reversal Risks from LULUCF Activities," December 2011, at 2, available at wbcarbonfinance.org/docs/WB_duke_flyer_11-29-11web.pdf; Arthur A. van Benthem & Suzi C. Kerr, "Bigger Is Better: Avoided Deforestation Offsets in the Face of Adverse Selection," Stanford Program on Energy and Sustainable Development (PESD), March 2011, at 26, available at pesd.stanford.edu/publications/23144 ("Although baseline deforestation is difficult to predict, the errors fall relative to small scale prediction").

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273 U.S. Energy Information Administration, "Average prices for spot sulfur dioxide emissions allowances at EPA auction set new lows." Today in Energy, available at www.eia.gov/todayinenergy/detail.cfm?id=1330.

274 The ten original member states are Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. New Jersey ended its participation in RGGI as of January 1, 2012, which was the start of the second RGGI control period. *See* State of New Jersey, Department of Environmental Protection, "RGGI Withdrawal: Frequently Asked Questions," February 24, 2012, available at nj.gov/dep/sage/ce-rggifaq.html.

275 Unless otherwise indicated, all information and data for this case study come from Paul J. Hibbard et al., "The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States," The Analysis Group, November 15, 2011, available at analysisgroup.com/uploadedFiles/Publishing/Articles/Economic_Impact_RGGI_Report.pdf.

276 The RGGI cap is measured in short tons (2,000 lbs), while the EU ETS cap is measured in metric tons (also referred to as a "tonne," and equivalent to 1,000 kg, or approximately 2,204 lbs).

277 Point Carbon, "RGGI phase one CO_2 emissions 33 pct below cap," June 4, 2012, available at pointcarbon.com/news/1.1912808?&ref=searchlist. From 2009 through the end of 2011, the cap for the 10-state region was 188 million tons. With New Jersey's withdrawal from RGGI at the end of 2011, the cap as of January 1, 2012 is 165 million tons per year for the nine-state region. *See* Regional Greenhouse Gas Initiative, "The RGGI CO_2 Cap," available at rggi.org/design/overview/cap.

278 All Analysis Group references to net present value (NPV) are cumulative for 2009–2021, and are discounted at a rate of 3%.

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