



International Carbon
Action Partnership

Benefits of Emissions Trading

Taking Stock of the Impacts of Emissions Trading Systems Worldwide

Alexander Eden, Charlotte Unger, William Acworth, Kristian Wilkening, Constanze Haug

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This paper has been drafted in response to a request from ICAP members to provide a consolidated overview of theory and empirical evidence on the benefits of emissions trading systems (ETS). Its goal is to provide robust arguments in favor of ETS that can be used to communicate and to support decision-making on an appropriate climate change mitigation strategy. The paper is based on research conducted by the ICAP Secretariat, surveying official information, grey and academic literature for evidence of the effects of ETS across the currently operating systems around the world. The findings and opinions expressed in this paper are the sole responsibility of its authors. They do not necessarily reflect the views of ICAP or its members.

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Executive summary

The last decade has seen worldwide growth of emissions trading systems (ETS) for climate change mitigation. In 2017, there are 19 systems in operation, at the supra-national, national, state, provincial, and city level, and several others are under consideration. In 2018, the combined value of ETS worldwide (not including the Chinese National ETS) is estimated to be more than USD 34 billion, while jurisdictions with an operating ETS now generate more than 50% of global gross domestic product (GDP).

As experience with ETS continues to grow, so too does the body of literature which attempts to measure empirically its impacts. Drawing on academic literature and official reports, this paper reviews the theory and empirical evidence for the benefits of ETS under three broad categories: the environmental benefits of ETS targeting emissions reductions, the economic benefits of ETS as a cost-effective market-based mechanism, and the potential for ETS to support broader public policy objectives. A summary of the evidence to date on the benefits of ETS is provided in Table E.S.1 at the end of this section.

ETS ensures environmental effectiveness

ETS targets emissions reductions. Evidence from existing systems shows ETS policy has driven emissions reductions, even when accounting for external factors. Estimates of emissions reductions attribute the EU ETS with 3% of aggregate emissions in Phase I. During the beginning of Phase II (2008-2010) when the policy was at its most influential, covered firms in Germany reduced emissions 25-28% more than comparable non-covered firms. For the RGGI states, modelling results indicate that emissions from covered entities would have been 24% higher in the absence of an ETS. Similar reductions from baseline emissions have been achieved under the Tokyo ETS (26%); however, not all of these can be attributed solely to the ETS.

ETS enables clear emissions reduction paths. The quantity-based approach of ETS ensures emissions remain at or below the specified emissions cap across the covered sectors. Jurisdictions implementing ETS have aimed to adopt progressively declining, credible caps in line with national climate targets, providing a clear emissions reduction path over the mid- to long-term.

ETS makes economic sense

ETS delivers cost-effective abatement. In OECD countries, studies have determined ETS to be a highly cost-effective mitigation option. A recent OECD study found that compared to other instruments, ETS (and broad-base carbon taxes) incurred the lowest costs per ton of abated emissions.

ETS provides flexibility. ETS allows firms to choose where and when to reduce emissions. The cheapest abatement options are selected first. Moreover, participants can abate emissions when it is most cost-effective to do so. Furthermore, the price signal created through an ETS automatically adapts to changing economic conditions, making emission reductions cheaper when the economy slows and more expensive during periods of growth.

ETS encourages low-carbon development, decoupling emissions from economic growth. ETS facilitates the transition to a low-carbon economy and supports countries in breaking away from a carbon-intensive development path. Many jurisdictions with an ETS are already trending towards less carbon-

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intensive economies. For example, the carbon intensity of California's economy has fallen 33% since it peaked in 2001, while during the same period the state's economy has grown by 37%. From 2012-2015, emissions in the state steadily declined, while GDP, population and employment grew. Between 2008 and 2015, the RGGI states reduced CO₂ emissions from the power sector by 30%, while the regional economy grew by 25%. Analysis also shows that during the first nine years of operation (2009-2017), the RGGI program led to 44,700 new job years.

ETS promotes the deployment and innovation of low-carbon technology. ETS establishes a carbon price, which changes market conditions to favor low-carbon production processes, products, and technologies, and provides an incentive for innovation. Evidence shows that ETS contributes to the deployment of market-ready low-carbon technology, as well as technological innovation close to the market. For example, research indicates that from 2005-2007, the EU ETS constituted a main driver for small-scale investments with short amortization times in covered firms in Germany. Studies also show that ETS is driving innovation. According to recent research, the EU ETS increased low carbon patenting of regulated firms by 10% compared to otherwise similar firms.

ETS supports further public policy objectives

ETS generates revenues. Through auctioning allowances, ETS can generate an additional source of government revenue, which may then be used to invest in further climate action, lower other taxes, or compensate low-income households or adversely impacted groups. By the end of 2017, ETS jurisdictions have raised nearly USD 35 billion from auctioning. This figure is set to grow as the coverage of ETS and the share of auctioned allowances increase. From when auctioning was introduced until the start of 2018, the EU ETS raised more than USD 25.8 billion, RGGI USD 2.8 billion, California USD 6.4 billion and Québec USD 1.6 billion in auctioning revenues.

ETS produces emissions data and facilitates information sharing. The monitoring, reporting, and verification (MRV) systems underpinning an ETS generate emissions data. This information allows jurisdictions to take stock of economy-wide emissions, identify the abatement potential of covered sectors, and track progress towards mitigation targets. Evidence from the EU ETS suggests that participating in an ETS helps to raise awareness about climate change issues at the management level of firms and facilitates information exchange among key stakeholders. Likewise, knowledge sharing between the regulator and covered entities has been a key element of the emission reductions achieved under Tokyo's ETS. MRV systems are currently being established in Mexico, Thailand, Vietnam, Turkey, and Russia.

ETS creates substantial co-benefits. ETS can have positive synergies with public health, energy security, job creation and land-use change objectives. In particular, it has the potential to generate long-term public health benefits by reducing local air pollution. From 2009-2017, the reduction in hazardous pollutants in RGGI states has led to an estimated more than USD 10 billion in health savings from avoided illness, hospital visits, lost work days, and premature deaths.

ETS can be adapted to country-specific contexts. The jurisdictions of the 20 ETS currently in operation display notable geographic, political, and economic differences. The ability to adapt the ETS framework means that the policy can be designed to accommodate domestic priorities and fulfill different roles in a jurisdiction's policy mix.

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ETS is politically feasible. Implementing an ETS has proven politically feasible across a range of jurisdictions. ETS is shown to be compatible with new and existing policy frameworks. Stakeholder concerns can be accommodated, for example, through targeted rules on allocation and revenue use, helping build support among domestic interest groups.

ETS allows for linking with other systems, fostering international climate action. ETS policy enables distinct systems to be linked through the mutual recognition of emissions allowances. Linking reduces overall compliance costs, increases market liquidity, promotes market stability, and reduces the risk of leakage. There are already precedents for successful linking. For California and Québec, modelling studies indicate that linking cuts overall compliance costs by one-third compared to achieving the same targets unilaterally.

Table E.S.1: Summary table outlining the evidence for the benefits of ETS

Benefit	Jurisdictions	Summary of evidence	Sources
Emissions reductions	EU, RGGI, California, Tokyo	<p>ETS has driven emissions reductions, even when accounting for external factors:</p> <ul style="list-style-type: none"> • EU ETS impacts range from an estimated 3% of aggregate emissions to 25-28% at the firm level, with the impact on emissions being greatest during the beginning of Phase II (2008-2010) • Based on modelling, RGGI contributed to around 50% of the emission reductions achieved in the energy sector of RGGI participating states between 2009 and 2012, and emissions would have been 24% higher in the absence of the ETS. <p>California and Québec verified emissions have remained below the cap Tokyo achieved a 26% reduction below baseline emissions</p>	European Environment Agency (2017) ⁴ , Martin et al. (2014) ⁵ , Abrell et al. (2011) ⁶ , Petrick and Wagner (2014) ⁷ , Bel and Joseph (2014) ⁹ , Murray and Maniloff (2015) ¹¹ , ARB (2015) ¹⁴ , ARB (2017) ¹⁵ , Tokyo Metropolitan Government (2018) ¹⁶
Cost-effective abatement	Global (OECD countries)	ETS (and broad-based carbon taxes) achieve lowest-cost abatement when compared with other instruments	OECD (2013) ²⁴
Decoupling emissions from growth	California, EU, RGGI	<p>Jurisdictions with an ETS demonstrate an overall trend towards decreasing carbon intensity (not directly attributable to ETS)</p> <ul style="list-style-type: none"> • From 1990 to 2016, emissions' intensity of the EU economy was reduced by around 50%, and decoupling occurred in all member states. • The carbon intensity of California's economy has fallen 33 percent since it peaked in 2001, while the state's economy has grown by 37 percent. From 2012-2015, emissions in the state steadily declined, while GDP, population and employment grew. Between 2008 and 2015, the RGGI states reduced CO2 emissions from the power sector by 30%, while the regional economy grew by 25%. During the first nine years of operation, the RGGI program led to over 44,700 new job years 	European Environment Agency (2017) ⁴ , European Commission (2016) ⁴¹ , Denny Ellerman et al. (2016) ⁴² California Air Resources Board (2017) ⁴⁰ , Stutt et al. (2016) ¹³ , RGGI (2015) ⁴³ , Hibbard et al. (2018) ⁴⁴
Deployment and innovation of low-carbon technology	EU, Tokyo	<p>ETS promotes the deployment and innovation of low-carbon technology and processes close to the market. ETS has a small but positive effect on patenting of low-carbon technology in covered firms.</p> <ul style="list-style-type: none"> • The EU ETS increased low carbon patenting of regulated firms by 10% compared to otherwise similar firms. At the aggregate level, the EU ETS has resulted in a 1% increase in low carbon patents compared to the counterfactual. • For covered firms in Germany, from 2005-2007 the EU ETS constituted a main driver for small-scale investments with short amortization times. <p>Tokyo's ETS has resulted in energy efficient low-carbon technologies in the building sector (particularly LED lights and efficient air conditioning units).</p>	European Commission (2015) ⁴⁵ , Tokyo Metropolitan Government (2015) ⁴⁶ , Martin et al. (2012) ⁴⁹ , Martin et al. (2012b) ⁵⁰ , Hoffman (2007) ⁵¹ , Borghesi et al. (2012) ⁵² , Anderson et al. (2011) ⁵³ , Delarue et al. (2008) ⁵⁴ , Cael and Dechezlepetre (2016) ⁵⁵ , Nishida et al. (2016) ⁴⁷
ETS generates revenues with various uses	EU, Germany, California, Québec, RGGI, Australia	<p>By the end of 2017, ETS jurisdictions had raised around USD 37 billion from auctioning emission permits. This revenue is used for various purposes, including furthering climate action and compensating low-income households. Revenues to the end of 2017:¹</p> <ul style="list-style-type: none"> • EU ETS – USD 25.8 billion since 2008; 	European Union (2009) ⁶⁹ , RGGI (2017) ¹⁰ , RGGI (2018) ⁷⁰ Hsia-Kiung and Morehouse (2015) ⁷¹ , Gouvernement du Québec (2018) ⁷³ , Centre for Climate and Energy Solutions (2011) ⁷⁵

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		<ul style="list-style-type: none"> • RGGI – USD 2.8 billion since 2009, • California – USD 6.4 billion since 2012 and • Québec – USD 1.6 billion since 2013. 	
Data production and information sharing	Global, EU, Tokyo	Countries currently considering an ETS are developing MRV systems and gathering emissions data. ETS has also raised the issue of climate change to management boards of companies, and has facilitated information sharing among key stakeholders. MRV systems are currently being established in Mexico, Thailand, Vietnam, Turkey, and Russia.	Neuhoff (2011) ⁷⁶ , Laing et al. (2014) ⁷⁷ , Tokyo Metropolitan Government (2012) ⁷⁸
Co-benefits	RGGI, China, USA, Germany, New Zealand, Global	<p>ETS has the potential to create synergies with, e.g., public health, energy security, job-creation and land-use-change policy. In particular, public health savings from improved air quality could be substantial.</p> <ul style="list-style-type: none"> • Between 2009-15, the reduction in hazardous pollutants sulfur dioxide, nitrogen oxide, and mercury in RGGI states has led to an estimated more than USD10 billion in health savings from avoided illness, hospital visits, lost work days, and premature deaths; • A review of studies into the potential air-quality benefits of climate mitigation policy found estimates ranging from USD 2-196 /tCO₂ (average of USD 49 /tCO₂). • IMF estimates that a carbon price of USD 57 /tCO₂ will yield the same value of domestically accrued co-benefits <p>Significant ETS co-benefits were accrued from reforestation in New Zealand from 2008-2012.</p>	Stutt et al. (2016) ¹³ , Nemet et al. (2010) ⁷⁹ , Parry et al. (2014) ⁸⁰ , PBL (2009) ⁸¹ , Dong et al. (2015) ⁸² , Ma et al. (2013) ⁸³ , Thompson et al (2014) ⁸⁴ , BMUB (2015) ⁸⁵ , Hibbard et al. (2015) ⁴⁴ , New Zealand Government (2013) ⁸⁶
Adaptable to country-specific contexts	California, Global	Existing ETS vary in design, depending on context, as well as their intended role in the climate policy mix. ETS has also been established in jurisdictions with regulated energy prices.	ICAP (2017) ³ , ARB (2015b) ⁸⁸ Acworth et al. (2018) ⁹⁰
Politically feasible	EU	<p>Experience to date suggests that ETS is more likely to result in broad coverage and hence higher cost effectiveness compared to a carbon tax as industries lobby for a larger share of free allocation rather than exemptions.</p> <ul style="list-style-type: none"> • Evidence from the EU ETS supports this claim, finding that companies have lobbied for free allocation based on competitiveness concerns and that trade associations were found to have had a significant influence on this outcome. 	Fagan-Watson et al. (2015) ⁹⁴
Allows for linking with other systems	California, Québec, EU, Switzerland, Global	<p>Several jurisdictions have established direct links with each other, while many systems are indirectly linked through international carbon markets.</p> <ul style="list-style-type: none"> • Modelling results indicate that over the period 2013-20, linking California and Québec reduced total compliance costs by one-third. • The UNFCCC estimates that through the EU ETS link to the CDM, compliance costs under the EU ETS were reduced by around EUR 1.2 billion in the four years of 2008-2011 	Purdon et al (2014) ⁹⁷ , ARB (2013) ¹⁰⁰ , ICAP (2017) ³

Notes: ¹ EU auction revenues exclude aviation. Californian auction revenues exclude auctions of consigned allowances.

1. Introduction

As the world looks to mitigate the risks of climate change, a broad range of policy tools have been discussed and implemented. Among these, emissions trading, also referred to as cap-and-trade, is an increasingly popular choice for climate change mitigation policy around the world.¹ Emissions trading systems (ETS) have been successfully implemented in a diverse range of economic and political contexts. There are currently 20 systems in operation, at the supra-national, national, state, provincial, and city level, and several others are either scheduled or under consideration. In 2017, the combined value of ETS worldwide is estimated to be more than USD 34 billion, while the combined value of all carbon pricing instruments (ETS and carbon tax) is estimated at USD 52 billion.^{a, 2} Furthermore, with the launch of a national ETS in China, jurisdictions with an operating ETS now generate more than 50% of global gross domestic product (GDP).³

This trend reflects the growing understanding of the benefits of ETS, being one type of market-based carbon pricing policy (other instruments include carbon taxes and crediting schemes), all of which aim to make emitters internalize the external costs of their greenhouse gas (GHG) emissions. ETS policy establishes a carbon price via a quantity-based approach. The government distributes a limited number of tradable allowances, and then obliges participants to surrender allowances to match their emissions. The market for allowances generates a carbon price in response to supply and demand, and each participant is free to react to this carbon price as is individually appropriate. The quantity-based approach of ETS thereby retains the benefits of a carbon price while also ensuring that emissions are limited to a desired level.

Alongside an overview of the theoretical arguments for ETS, the main aim of this study is to provide a review of evidence from scientific studies and official reports from existing systems, which is summarized in Table App.1 at the end of this document. As ETS for climate change mitigation is a relatively new instrument, the empirical evidence mainly centers on the longest running and most well-established system, the European Union Emissions Trading System (EU ETS), which has been operating for over 10 years. There are some studies of the North American cap-and-trade programs, but systems in the Asia-Pacific region are under-represented, even though ETS in this region is currently growing the fastest.

Both the environmental and economic effects of ETS are well-covered in the literature, and are addressed in the first two sections of this paper. The environmental effectiveness of the instrument is appraised regarding its demonstrated effect on emissions reductions and the benefits that stem from setting a progressively declining cap. The economic benefits of ETS, in particular, the cost-effectiveness of the instrument, its effect on economic growth, and the potential for ETS to drive the uptake and development of low-carbon technology, are then examined. The third section of this paper identifies how ETS reaches beyond direct environmental and economic benefits to support a range of broader public policy objectives. This section outlines the benefits of ETS relating to revenue generation and use, the production of quality measurement, reporting, and verification (MRV) information, and the typical synergies with other public policies that ETS presents. Furthermore, the adaptability and political feasibility of ETS are discussed, as well as the potential for ETS to be linked to other carbon markets

^a The estimated total value for ETS markets is based on the allowance volume of each ETS for 2017, or the latest year available, multiplied by the allowance price. In the prior State and Trends of Carbon Pricing 2015 report, the World Bank estimated the combined value of carbon pricing instruments in 2015 to be nearly US\$50 billion globally, of which almost 70 percent (about US\$34 billion) is attributed to ETS and about 30 percent to carbon taxes. This combined value grew to USD 52 billion in 2017.

2. ETS ensures environmental effectiveness

2.1 ETS targets emissions reductions

By setting an absolute cap, the maximum quantity of emissions under an ETS is clearly defined. Although there are a range of economic, political, and social factors that can influence emissions levels, the quantity-based approach of ETS ensures emissions remain at or below a specified limit across the covered sectors, as determined by the cap. Provided that ETS legislation is robust and stable over time, ETS therefore enables emissions reduction targets to be met with a high degree of certainty.^b By focusing on emissions reductions, the fixed cap of an ETS lends integrity to climate policy as the environmental outcome takes precedence.

Despite the broad array of factors affecting emissions, research on impacts from currently operating systems shows that not only have reduction targets been achieved, but ETS has also driven abatement with a measurable effect on emissions levels.

- From 2005 to 2015, emissions from sectors covered by the EU ETS decreased 24%.^{c,4} Several studies have sought to identify the main factors affecting emissions during this period and determine the role of the EU ETS in driving emissions reductions. Studies of Phase I (2005-2007) show that the EU ETS had a small but non-trivial effect, causing abatement of around 3% of total capped emissions.⁵ The EU ETS was still a major driver of abatement in the first part of Phase II (2008-2012), with the increase in stringency of Phase II particularly sparking abatement.⁶ Firm-level studies show that from 2008-2010 industrial facilities under the EU ETS in Germany were substantially driven by the policy, reducing emissions by 25-28% more than comparable non-covered firms.⁷ However, from about 2009, factors other than the EU ETS began to drive emissions reductions. In particular, the economic recession of 2009-2012 resulted in reduced economic activity, which caused a significant drop in emissions. Other factors include the effects of renewable energy and energy efficiency policies of the EU 2020 Climate and Energy Package.⁸ Nonetheless, the EU ETS has still been found to drive emissions reductions throughout this period (estimated at around 20% of the total abatement between 2005 and 2012).⁹
- In 2015, the average CO₂ emissions from power plants regulated by the Regional Greenhouse Gas Initiative (RGGI) were more than 45% lower than in 2005,¹⁰ with a substantial decline in the period after RGGI was introduced (2009-2012) - a trend not reflected in other U.S. states.¹¹ The 2012 RGGI program review showed that RGGI states consistently managed greater emissions reductions than expected, and the cap was consequently tightened in 2014.¹² In 2015, emissions once again fell 6.3% below the cap.¹³ Studies suggest that external factors, in particular the opening of shale gas reserves and the subsequent drop in the price of natural gas in the region, as well as the economic recession, have also likely played a role in reducing RGGI states' emissions. Nevertheless, it is estimated that the program was responsible for half of the region's emissions reductions in 2009-2012, and that emissions would have been 24% higher in the absence of the ETS.¹¹

^b Robust enforcement provisions are essential to maintaining the integrity of the cap. They ensure that participants fulfil their compliance obligations and ensure that emissions are accounted for. Non-compliance has not yet been a major issue in any ETS around the world. A further risk stems from the unrestricted use of offsets, which may expand the cap, or introduce allowances whose environmental integrity may be lacking. Checks and limits may be put in place to ensure the environmental integrity of offset credits.

^c In 2014, GHG emissions from stationary installations under the EU ETS reached their lowest level since 2005 (1800 Mt CO₂e) corresponding to a 24% reduction from 2005 to 2014. This level was maintained in 2015, and preliminary estimates indicate a 27% reduction from 1990 levels in 2016.

- The Californian Cap-and-Trade Program also maintained verified reductions in covered emissions in line with a steadily decreasing cap so far in each year of operation: the cap in 2015, with the inclusion of emissions from fuel suppliers, was set at 340.3 MtCO₂e.^{14,15}
- Tokyo's total emissions from covered facilities in 2016 (the 7th year of the Tokyo Cap-and-Trade Program) were 26% lower than base-year emissions (average of 2002-2007),¹⁶ although not all these emission reductions can be attributed directly to the ETS.

2.2 ETS enables clear emissions reduction paths

By setting a progressively declining cap, ETS enables a credible long-term policy signal and emissions trajectory in line with mid- to long-term targets. An example of how a declining cap can set a trajectory for emission reductions is shown for the EU ETS in Figure 1. Moreover, by focusing on emissions reductions (as opposed to setting a specific carbon price or efficiency standard), ETS follows the format of many national mitigation targets, which are usually defined as absolute quantity targets (tons of CO₂e). In many cases, this carbon budget approach also aligns well with the pledges countries have put forward in their Nationally Determined Contributions (NDC) under the Paris Agreement.

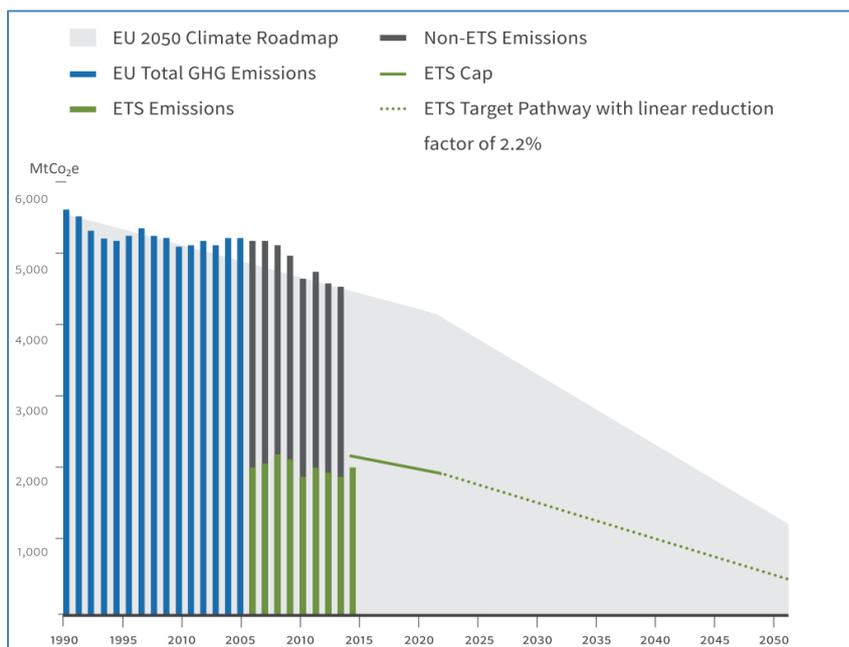


Figure 1: The EU climate plan showing emissions reduction targets and the role of the EU ETS. The green line indicates the progressively declining cap, with a linear reduction factor of 1.74% until 2020, and a proposed factor of 2.2% beyond then. Source: BMUB based on EEA data, published in the ICAP Status Report 2015.

Many ETS jurisdictions have adopted progressively declining caps corresponding to their short-term mitigation targets, some of which are listed in Table 1.

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Table 1: Cap reduction factors across different ETS

ETS Jurisdiction	Emissions cap, 2017	Annual linear cap reduction factor, %	Jurisdiction-wide mitigation target
EU ETS	1930.8* Mt CO ₂ e	1.74% until 2020, 2.2% 2021-2030	by 2020: 20% below 1990 GHG levels. by 2030: at least 40% below 1990 GHG levels. by 2050: 80–95% below 1990 GHG levels (not legislated).
Republic of Korea ETS	551.0 Mt CO ₂ e	1.9% until 2017	by 2020: 30% below BAU by 2030: 37% below BAU – (this represents a 22% reduction below 2012 GHG levels).
California Cap and Trade	370.4 Mt CO ₂ e	3% until 2020 -4% 2021-2030	by 2020: return to 1990 GHG levels. by 2030: 40% below 1990 GHG levels. by 2050: 80% below 1990 GHG levels.
RGGI	84.3 Mt CO ₂ e	2.5% until 2020	by 2020: 50% below 2005 GHG levels.
Québec Cap and Trade	61.1 Mt CO ₂ e	3% until 2018, 4% 2019-2020	by 2020: 20% below 1990 GHG levels. by 2030: 37.5% below 1990 GHG levels. by 2050: 80–95% below 1990 GHG levels.

*Note: * Excludes aviation sector (210 MtCO₂e) and does not account for adjustments related to backloading, the NER, or unallocated allowances.*

Source: International Carbon Action Partnership (ICAP) ‘ETS map’.¹

A clearly defined emissions reduction pathway provides predictability for economic actors, as it frames market expectations and sets a clear signal for necessary long-term investments.¹⁷ While this is important for driving investment and innovation among covered entities (see section 3.4 - ETS promotes the deployment and innovation of low-carbon technology), it also sends a signal for change across the broader economy. Participants and non-participants alike are encouraged to integrate climate mitigation into their corporate strategies and planning. However, the actual strategic response of participating firms greatly depends on whether they perceive the ETS policy to have long-term credibility. A number of studies have addressed this “commitment problem” in climate mitigation policy. They have found that factors such as the perceived future stringency of an ETS, as well as speculation about the future supply of allowances, affect the formation of the carbon price under an ETS and therefore influence the general response of firms.^{18, 19, 20, 21}

3. ETS makes economic sense

3.1 ETS delivers cost-effective abatement

ETS harnesses the allocative power of the market to deliver a fixed level of emissions reductions at the lowest possible cost to the economy. Under an ETS, trade in scarce emissions allowances on the carbon market generates a carbon price, which provides the incentives for a shift in consumption, production and investment decisions towards a low-carbon economy. Entities have the freedom and flexibility to respond to this carbon price as they see fit, and so long as costs can be passed through, the carbon price will be reflected in the price of goods and services across the economy.^{d, 22}

In response to the ETS carbon price, companies with cheaper abatement options have an incentive to abate more and sell allowances, while those with more expensive options abate less and purchase allowances when needed. This leads to an efficient allocation of abatement efforts across installations (also referred to as static efficiency), with the carbon price that emerges reflecting the marginal costs of abatement across the system.^{e, 23} ETS therefore ensures that no-regret options (with net negative costs) are taken first, followed by the lowest cost options. Furthermore, there is no need for regulators to dictate specific abatement actions or to try to prescribe an optimum carbon price. This is especially advantageous when targeted sectors have differing mitigation potentials and the regulator lacks information on the actual costs companies will face.

- Among the available policies for greenhouse gas mitigation, ETS is considered to be highly cost effective at reducing emissions. A study published by the Organisation for Economic Co-operation and Development (OECD) found that ETS (and broad-base carbon taxes) incurred the lowest costs per ton of abated emissions in comparison to other instruments, including direct subsidies and feed in-tariffs.²⁴ Across the electricity sectors of OECD countries in 2013, the average effective carbon price (the cost to abate one ton of CO₂e) was estimated at USD 40/tCO₂e for renewable portfolio standards and certificate schemes, and USD 180/tCO₂e for feed-in tariffs and capital subsidies. In comparison, the majority of emissions covered by ETS in 2015 had a carbon price of less than USD 10.²⁵

The impact of a carbon price on firm performance is often prominent in debates surrounding carbon pricing policies. However, a recent empirical study of firms under Phases I and II of the EU ETS found that there were no negative, and even some positive effects on the economic performance of covered firms.²⁶ The study finds that firms reacted to the EU ETS by passing-through costs to their customers on the one hand and improving labor productivity on the other.

In the absence of a universal carbon price, some have referred to the risk that carbon-intensive and trade exposed industries may react to an ETS by shifting to regions with lower carbon prices. This process, termed carbon leakage, has implications for the economic efficiency and environmental effectiveness of carbon pricing and is discussed in Box 1.

^d For a comprehensive review of price formation and market behaviour under the EU ETS see Hintermann et al. 2015²²

^e For a detailed overview of the efficiency of pollution permits see Hasegawa and Salant 2015²³

Box 1: Carbon leakage – theory and practice

While ETS ensures emissions reductions are achieved at the lowest cost to the economy, covered entities still face a new cost factor under an ETS. This has often led to concerns that polluting industries will become less competitive and will therefore move to non-regulated and potentially more-polluting regions. The risk of “carbon leakage” has repeatedly been raised, with detractors arguing that ETS will displace emissions and push trade-exposed industries offshore. However, evidence suggests that these concerns have been largely overstated, with studies of ETS to date concluding a lack of any significant leakage effects.^{27, 28, 29, 30, 31, 32} In fact, ETS policy design can address these risks, for example, through the free allocation of some allowances to emissions-intensive, trade-exposed sectors, or through price equalization measures for imports of energy-intensive products.^{33, 34} Nonetheless, a more fundamental solution to carbon leakage would be to extend carbon pricing and price harmonization efforts to competitor regions, most effectively through the international linking of ETS.³⁵

3.2 ETS provides flexibility

The ETS policy framework features a range of measures that enhance the flexibility of the instrument, allowing participants to decide when and where to invest in abatement. These features foster a more stable carbon market and increase the overall cost effectiveness of the system.

Temporal flexibility allows market participants to make decisions about whether to abate now or at some point in the future. Allowances may be ‘banked’ to be used later or ‘borrowed’^f from future emissions budgets. Firms can then take advantage of future innovations, phase out old technology at a time that is cheapest for them, and abate more now if they expect future abatement costs to increase. Temporal flexibility allows participants to abate when it is most cost effective, ensuring emissions are reduced at least cost over the duration of the policy.^{g, 36}

External crediting systems that generate ‘offsets’, such as the Clean Development Mechanism (CDM), provide additional flexibility relating to where abatement takes place. Offsets allow certified emissions reductions to be made outside the scope of the ETS, expanding the range of abatement options available and driving down the cost of compliance. However, as the unrestricted use of offsets can pose a risk to the integrity of the ETS, limits on the quality and quantity of offsets are usually put in place.

Once implemented, a cap-and-trade mechanism is also inherently flexible, as it establishes a dynamic carbon price signal that automatically adapts to broader economic and political changes. ETS can be seen as a ‘breathing’ instrument that provides counter-cyclical economic feedback and promotes stability. In times of economic slowdown, lower than expected levels of economic output reduce demand for allowances and the carbon price therefore adjusts downward, reducing the economic burden of the policy. Then, during times of rapid economic growth, the carbon price rises, ensuring that more is abated when the economy is strong.

- In a study of price formation under the EU ETS, the authors concluded that “the trading scheme proved its flexibility with respect to changing economic conditions by reducing the carbon costs during a period of economic stress”.³⁷

^f While borrowing theoretically introduces intertemporal flexibility and hence improves efficiency, it also introduces a number of political concerns. Extensive borrowing reduces certainty over short term targets, locks energy systems into carbon intensive investments and creates a constituency that has an incentive to lobby for lower targets or scheme eradication.

^g For a detailed overview of how banking and borrowing are treated in existing ETS, see Step 5 of the ICAP and PMR, 2016. ‘Emissions Trading in Practice: A handbook on design and implementation’.³⁶

3.3 ETS encourages low-carbon development, decoupling emissions from economic growth

As economic growth has historically been tied to carbon emissions from energy generation, it is commonly assumed that reducing emissions will negatively impact the economy. While this may have been the case during the Industrial Revolution, it is not necessarily true today. As seen in Figure 2, many industrialized countries and regions are already trending toward decarbonization, with continual improvements in the carbon intensity of their economies (more economic output generated per ton of carbon emissions). This trend has many underlying drivers and reflects the increasing energy efficiency, productivity, and technological level of economies. By specifically targeting emissions, ETS can give a strong impetus to this transformation. It serves to help decouple carbon pollution from economic growth, and importantly, supports countries in breaking away from a carbon-intensive development path.

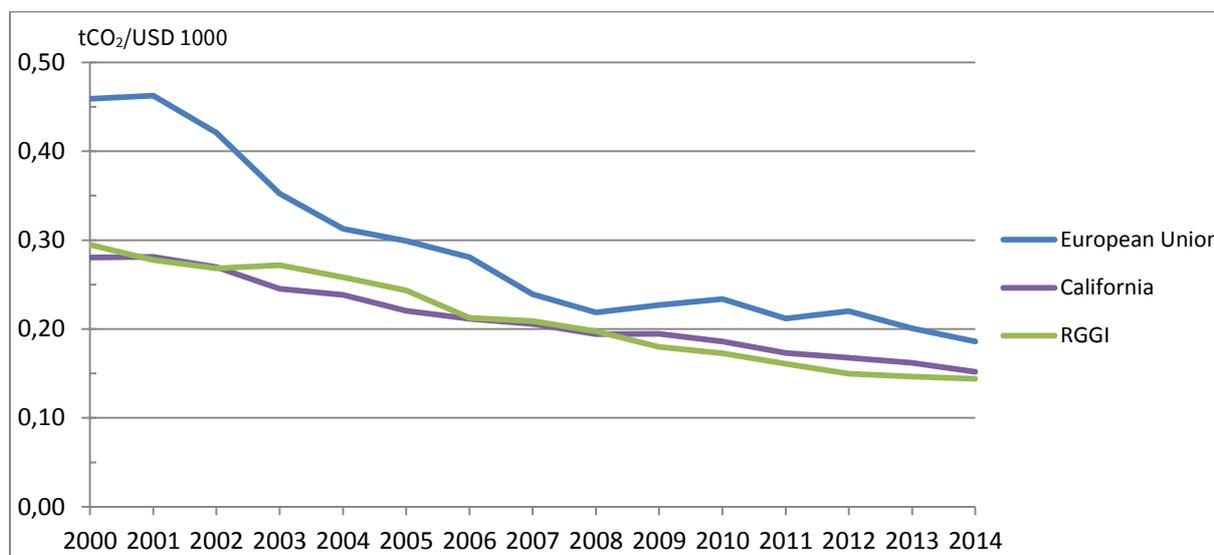


Figure 2: Carbon intensity of the economy shown in tons of CO₂ emitted per USD 1000 of GDP. Emissions include only CO₂ from the burning of fossil fuels, and exclude other GHG emissions, i.e., from construction (cement production), waste from landfill, agricultural emissions and LULUCF. GDP is normalized to 2015 USD. In the jurisdictions presented, CO₂ emissions from fossil fuels produced per USD 1000 of GDP have been decreasing (for every one ton of emissions, more economic output was generated), showing an improving carbon intensity of the economy. Over the short term, this trend can be influenced by many factors (e.g. changing coal/gas prices, economic shocks affecting specific sectors of the economy, weather patterns affecting energy use), however, over the long term the trend is toward a steady decoupling of emissions from economic growth. Sources: World Bank³⁸ and the US Energy Information Administration³⁹

Measuring the specific effect of an ETS on low-carbon economic development is generally hampered by the many external factors affecting the economy, as well as the effect of other policies supporting renewable energy and energy efficiency. Moreover, it is impossible to tell just how an economy would have developed in the absence of an ETS. However, evidence from existing systems shows that ETS is, in these cases, compatible with economic growth. In fact, several jurisdictions with an ETS have demonstrated robust growth while at the same time reducing emissions. For example:

- The carbon intensity of California’s economy has fallen 33% since it peaked in 2001, while during the same period the state’s economy has grown by 37%. From 2012-2015, emissions in the state steadily declined, while GDP, population and employment grew.⁴⁰
- In the EU emissions decreased by 4% in 2013-14, rose slightly in 2014-15, and then once again decreased in 2015-2016 (based on preliminary figures). More broadly, in the period 1990-2016, EU GDP grew by 53%, while total GHG emissions^h decreased by 23%. Over this period the

^h Excluding land use, land-use change and forestry (LULUCF) but including international aviation

GHG emission intensity of the EU economy was reduced by around 50%, and the decoupling of economic growth and GHG emissions occurred in all member states.⁴¹ This decoupling trend has continued in recent years; while 2010 saw both emissions and real GDP rebound after the global financial crisis, emissions have since declined and economic output has slightly increased.⁴²

- Between 2008 and 2015, the RGGI states have reduced CO₂ emissions from the power sector by 30%, while the regional economy has grown by 25%. Compared to other U.S. states without a comparable ETS, economic growth over the period was 3.6% greater and GHG emissions 16% lower.¹³ During the first few years of RGGI operation (2009-2013) participating states reduced emissions 2.7 times faster than other US states, while the RGGI economy grew 2.5 times faster.⁴³ Analysis also indicates that during the first nine years of operation (three compliance periods from 2009-11, 2012-14 and 2015-17), the RGGI program led to over 44,700 new job yearsⁱ, with each of the ten RGGI states recording net job additions.⁴⁴

3.4 ETS promotes the deployment and innovation of low-carbon technology

By establishing a carbon price signal, ETS changes market conditions to favor low-carbon production processes, products, and technologies. Furthermore, it provides an incentive for companies and entrepreneurs to engage in innovation activities. To distinguish the effects of a carbon price along the different stages of the innovation chain, from basic research in the laboratory to deployment in commercial markets, Figure 3 provides a simplified visualization of the innovation process, showing where ETS has a demonstrated effect. The clearest and best-known effects of an ETS on low-carbon technology are close to the market place.

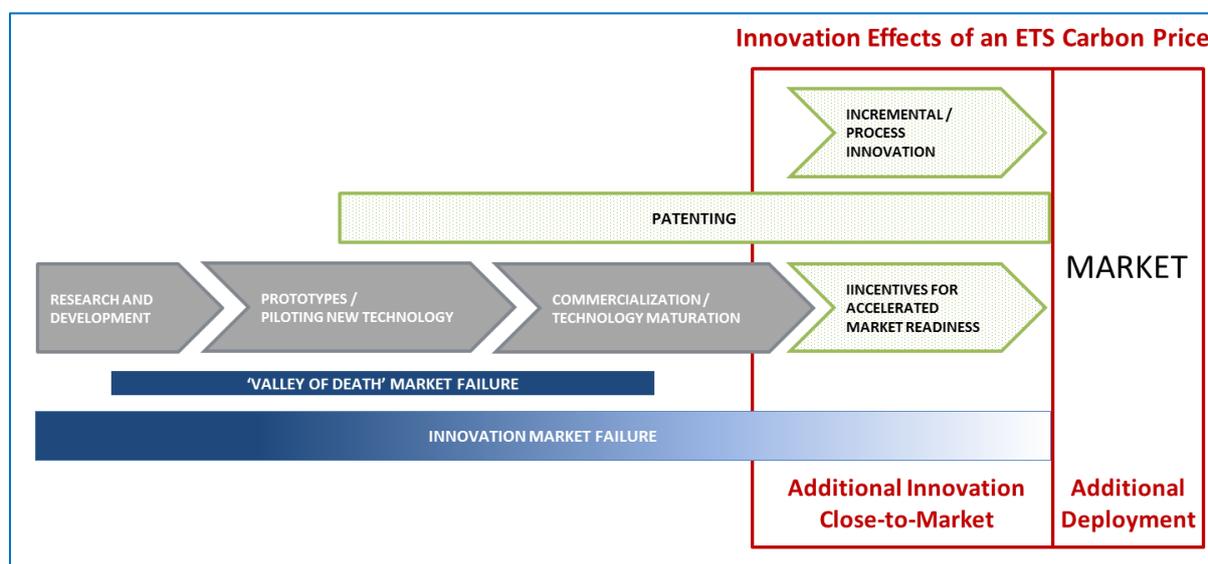


Figure 3: The effect of carbon pricing at different stages of the innovation process. ETS is shown to have an effect on the deployment of market-ready low-carbon technology, as well as technological innovation close to the market. Innovation processes with a demonstrated effect of ETS are lightly shaded, while processes with little or no demonstrated effect of ETS are darkly shaded. Market failures, according to innovation theory, are shown as dark blocks. The market failure relating to innovation increases at stages more distant to the market, as indicated by the gradual shading.

ⁱ One 'job year' equals one full time job for the period of one year. RGGI While some RGGI job impacts may be permanent full-time, others may be part-time or temporary. The total job years for the RGGI states is much greater (approximately 25 million in 2011), however, when compared to job losses in 2010-11 (approx. 73,400 job years), RGGI-generated employment is substantial. Jobs related to RGGI expenditures within the regional economy include, for example, engineers who perform efficiency audits; workers who install energy efficiency measures in commercial buildings; staff performing teacher training on energy issues; or the workers in state-funded programs that might have been cut had a state not used RGGI funds to close budget gaps.

Source: Adapted from Jenkins and Mansur 2011⁵⁹ and Grubb 2005⁵⁸

The price signal created by an ETS makes emerging low-carbon technologies more competitive, and thereby incentivizes short to medium-term investment in proven energy efficient products and processes. The greater deployment and diffusion of emerging technologies creates a larger and more competitive market, which in turn lowers technology prices and may accelerate learning curves and attract capital. A large and growing domestic market for low-carbon technology may also strategically place the economy in a technological leadership position.

- Case studies of covered entities across the EU have found that, in its early stages, the EU ETS played a supporting role in firms' decisions to invest in carbon efficient technologies.⁴⁵ In Asia, the Tokyo Cap-and-Trade Program has also fostered the deployment of energy-efficient, low-carbon technology in the commercial building sector, with entities responding to the ETS by installing energy-saving lighting systems, high-efficiency air conditioning units and electronic energy-saving controls.^{46, 47}

Beyond the increased deployment of otherwise uncompetitive low-carbon technologies, ETS has been shown to induce incremental innovation in production processes and inputs. Such changes are considered 'low-hanging fruit' in that the basic technologies already exist and even a modest carbon price (or the expectation of a higher price) is sufficient to induce change.⁴⁸

- For example, studies have identified a small but positive effect of the EU ETS on low-carbon innovation during the first two phases, with firms developing innovative processes.^{49, 50, j} Similarly, firms have repeatedly made small-scale investments with short amortization periods,⁵¹ and made incremental improvements, for example, relating to energy efficiency.⁵² Typically, investments have focused on the organizational innovation of the production process, for example, by fuel switching, installing of new equipment, streamlining procedures, and inducing behavioral changes, e.g., through training.^{53, 54}

Somewhat further from the market, but still far from breakthrough innovation is the patenting process. Through patenting, investors have the opportunity to realize the commercial benefits of developing new technologies, and the ETS carbon price is here shown to have an effect.

- In a recent comprehensive study of firm patenting behavior in the EU,⁵⁵ it was found that the EU ETS caused an increase of about 10% in low-carbon patents in regulated firms, as compared to otherwise similar firms. However, despite the significant innovation effect of the EU ETS on patenting in regulated firms, the effect on overall low-carbon patenting was small. This is because only a fraction of firms engaged in low-carbon patenting were covered by the EU ETS (regulated firms were responsible for less than 3% of all low-carbon patenting in the period 2005-2009). The results of the study are summarized in Figure 4.

^j The study (Martin et al. 2012b)⁵⁰ indicates an additional aspect. They found that companies that expected to receive less generous allocations of free permits in the third phase of the EU ETS had a tendency to innovate more. This suggests that a higher carbon price could lead to more innovation activity and that the expected stringency of the EU ETS is a key factor in firms' low-carbon investment decisions

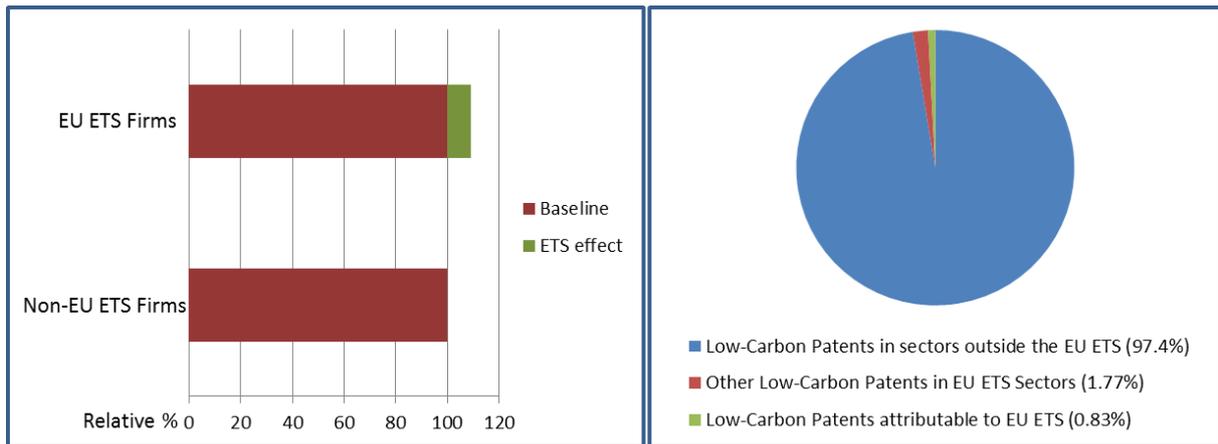


Figure 4: Effect of the EU ETS on low-carbon patenting in the EU 2005-2009 (based on Caeli and Dechezleprêtre 2016⁵⁵)
 Between 2005 and 2009, patenting activity increased by about 10% in EU ETS covered firms compared to similar firms not covered - an effect attributable to the EU ETS given that the studied firms are otherwise very similar.

While evidence shows that ETS provides a basic incentive for the deployment of existing technologies, as well as incremental innovation and patenting, there is no evidence of ETS driving more fundamental innovation. This is in line with current innovation theory,⁴⁸ which identifies several market failures relating to innovation – simply put, research and development is often too removed from the market to be affected by a price incentive. Several studies have suggested that, in order to stimulate the innovation of breakthrough low-carbon technologies, ETS should be complemented by other policy measures.^{56, 57, 58}

Furthermore, the demonstrated innovative effect of an ETS is shown to be dependent on the perceived stringency of the instrument, most notably via the actual and expected future carbon price. Studies of the EU ETS show that factors such as an oversupply of allowances, and perceived policy instability have muted the innovation effect of the EU ETS.^{59, 60} Measures to promote long-term price stability and reduce oversupply of allowances are currently being implemented. While we can expect that these measures will strengthen the price signal and therefore the innovative effect of the EU ETS, further empirical studies will be needed to evaluate their effectiveness in this regard.

Beyond generating a carbon price incentive, ETS policy provides at least one further possibility to induce low-carbon innovation. The revenue generated by ETS allowance auctioning can potentially be “earmarked” to fund targeted research and development of low-carbon technology,⁶¹ as is already practiced to some extent in the EU and RGGI systems. This option is discussed further in section 4.1 - ETS generates revenues.

4. ETS supports further public policy objectives

4.1 ETS generates revenues

Through the auctioning of allowances, ETS can generate fiscal revenue, similar in effect to a carbon tax. Depending on the jurisdiction’s legal requirements, the regulator can put this revenue to a variety of uses, such as earmarking revenues for research and development or direct climate action, enacting tax reform, and/or insulating low-income households from higher energy costs. By the end of 2017, ETS worldwide had raised around USD 37 billion.

Earmarking – governments may dedicate a share of ETS revenues to specific uses, and thereby complement broader climate and energy policy and contribute to lowering the long-run costs of

decarbonization. For example, revenues may be earmarked to fund research and development of low-carbon technologies. Revenues may also be dedicated to increasing adaptive capacity or resilience to climate damages, both domestically and in other countries. Earmarking auction revenues to fund further climate action has considerable political appeal, as a clear link is made between funds raised and government spending.^k

Tax reform – auctioning revenue can be ‘recycled’ to reduce existing distortionary taxes, such as labor and capital taxes, thereby making the overall tax system more efficient. Economists have postulated that if the efficiency improvements of the tax reform outweigh the cost of carbon pricing, emissions reductions could even be achieved at zero or negative cost. This idea is often referred to as the ‘double dividend’ hypothesis,^{62, 63, 64} and is still largely debated. Although there are not yet any cases of ETS revenues being recycled to tax reforms, the basic approach has been implemented, for example, in Germany with an ‘environmental tax’ on particular fossil fuels, and in British Columbia, where proceeds from the revenue-neutral carbon tax are recycled into broad-based tax cuts.

Protecting low-income households – the poorest households will be the least equipped to adjust to increasing carbon costs. To counter this, carbon pricing revenues can be used to compensate poor households. The amount of assistance required will be dictated by local economic circumstances, energy markets, and political considerations. However, recent studies indicate that for the United States 11-12% of total carbon pricing revenues would be sufficient to compensate the poorest one-fifth of households.^{l, 65, 66, 67, 68}

Examples from established ETS systems that auction permits illustrate how ETS revenues can be generated and used.

- In Europe, Member States themselves decide how to use their auctioning revenues, but the EU ETS Directive mandates that at least 50% should be used for additional domestic or international climate change action.⁶⁹ In Germany, for example, 100% of the revenue goes into a special fund^m that finances additional climate change action. From 2012-2017 (auctioning was introduced in 2012), allowance auctions in the EU raised a total of USD 25.2 billionⁿ (EUR 21.2 billion).
- RGGI states invest auctioning revenues into programs under four main categories: energy efficiency, clean and renewable energy, direct bill assistance, and GHG abatement. By the end of 2015, RGGI states had invested around USD 1.77 billion of the cumulative revenues from 2008-2015.^o Around 14% of cumulative investments (ca. USD 248 million) were rebated as direct bill assistance to electricity consumers, mostly through small credits on their energy bills. Investments in GHG abatement (ca. 7%) fund such programs as the research and development of advanced energy technologies. Clean and renewable energy programs received 14% of investments over the 2008-2015 period, while energy efficiency projects received 60%.¹¹ In 2017, RGGI auctions generated around USD 198 million (compared to USD 265 in 2016), with a cumulative total from 2008-2017 of around USD 2.83 billion.⁷⁰

^k However, there is no specific link between auction revenues raised and the appropriate level of spending on research and development or adaptation. Thus, earmarking is unlikely to be economically efficient (see Morris and Mathur, 2014)⁶⁵.

^l For a good overview of use of auction revenues to offset the burden on low income households, see Kaufman and Krause, 2016⁶⁸.

^m Called ‘Sondervermögen Energie- und Klimafonds’

ⁿ All auctions up to November 2017. Calculation by ICAP, based on data of EEF and ICE: <https://www.eex.com/en/market-data/environmental-markets/auction-market/european-emission-allowances-auction#/2017/11/13> and <https://www.theice.com/emissions/auctions> Retrieved 13.11.2017 Euro Value converted to US Dollars, exchange rate at 13.11.2017. Bundesverband Deutscher Banken.

^o Although the first RGGI trading period (control period) began in 2009, two preparatory auctions were held already in 2008.

- In California, auctioning revenues go to the Greenhouse Gas Reduction Fund (GGRF) for investments in projects that aim to “achieve even greater emissions reductions, while creating jobs, improving communities, and slashing other harmful pollutants”.⁷¹ At least 35% of the fund must be used to benefit disadvantaged communities and/or low-income households disproportionately affected by climate change and pollution.^p By the end of 2017, USD 2.0 billion worth of projects had been implemented, of which 50% are to benefit disadvantaged communities.⁷² In the financial year 2015-2016, USD 1.8 billion of auction revenues was deposited into the GGRF. By the end of 2017, the cumulative proceeds from 2013-2017 totaled more than USD 6.4 billion.^{q,r}
- In Québec, auctioning revenues go to the Québec Green Fund that finances further climate change mitigation actions as defined by the Climate Change Action Plan of the Government of Québec.⁷³ In 2015, CAD 830 million (USD 652 million) were deposited into the Fund. By September 2017, the program had raised a total of CAD 1.8 billion (USD 1.4 billion) in auction revenue.⁷⁴
- In the (now repealed) Australian Carbon Pricing Mechanism, over 50% of the revenue generated through the program was designed to be used to compensate households, particularly low-income households. The assistance was to be provided through general tax reform and not as a rebate on electricity bills. On average, households were expected to be marginally better off under the Carbon Price Mechanism given the tax reform.^{s,75}

4.2 ETS produces emissions data and facilitates information sharing

Implementing and operating an ETS requires comprehensive data on covered sources and their emissions in order to function properly. As companies comply with reporting requirements, extensive and detailed emissions data are generated, which may otherwise be difficult to obtain. This can help governments, researchers, and civil society organizations take stock of economy-wide emissions, identify the abatement potential of covered sectors, and track progress towards mitigation targets. Participating companies may also make use of this data, which can be applied to long-term investment decisions and to identify cost-effective emissions reductions options. Participating in an ETS further facilitates information sharing among key stakeholders.

In many regions of the world, the planning or prospect of an ETS has motivated countries to establish a reliable MRV system to account for emissions. Reliable accounting systems are not only an essential step in the implementation of a domestic ETS, they are also important in the international context, as they facilitate countries’ participation in international carbon markets. The robust and transparent reporting required by ETS also lends credibility to international mitigation claims, thereby building trust amongst parties, which will become ever more important in the future under the approach of the Paris Agreement.

- Currently, several countries considering implementing an ETS are developing national MRV systems. These include Mexico, Thailand, Vietnam, Turkey, and Russia.³

^p For a detailed outline of legislative requirements for GGRF funding, see ‘Cap-and-Trade Auction Proceeds Implementing Legislation’ at <https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/implementinglegislation.htm>. Retrieved 05.12.2017

^q Information on auction proceeds available from California Air Resource Board website at <https://www.arb.ca.gov/cc/capandtrade/auction/auction.htm#proceeds>. Retrieved 13.11.2017

^r Total proceeds do not include revenues from consigned auction allowances, as these revenues are not deposited in the GGRF

^s The average cost-of-living impact as a result of the carbon price was expected to be AUD 9.9 per week; average assistance received would have been worth AUD 10.10 per week.

Furthermore, participating in an ETS helps to spread knowledge and awareness about climate change issues, and gives impetus to information sharing activities among stakeholders.

- Studies have found that the EU ETS has helped to raise the issue of carbon emissions to the management boards of companies, thereby influencing investment and innovation patterns.^{76,77}
- The Tokyo Cap-and-Trade Program (covering mainly emissions from large residential, industrial and commercial buildings), explicitly aims to bring together stakeholders across the building sector (both landlords and tenants) in order to discuss and discover potential carbon savings.⁷⁸

4.3 ETS creates substantial co-benefits

While the primary objective of ETS policy is to reduce GHG emissions, a well-designed ETS will work in concert with domestic public policy objectives to deliver additional environmental and social co-benefits. The range of these benefits is diverse, and depending on ETS design and context for implementation, ETS is likely to create positive outcomes for public health, energy security, job creation and land-use change. In particular, the long-term health benefits from a reduction in local air pollution through climate mitigation policies have received much attention.

- Evidence from RGGI shows that declining CO₂ emissions have been accompanied by an even more significant decline in the hazardous pollutants sulfur dioxide, nitrogen oxides, and mercury. Between 2009 (the start of the RGGI program) and 2015, this reduction has led to an estimated more than USD 10 billion in health savings from avoided illness, hospital visits, lost work days, and premature deaths.^{14, t}
- On climate mitigation policies more broadly, a review of studies into the potential air-quality benefits of climate mitigation policy found monetized estimates ranging from USD 2-196 /tCO₂ (average of USD 49 /tCO₂), with the highest co-benefits in developing countries.⁷⁹ A more recent study of the top twenty emitting countries estimates that on average a carbon price of USD 57.5 /tCO₂ will yield the same value of domestically accrued co-benefits, reflecting mainly the value of reduced air pollution from coal power plants.⁸⁰ Globally, it is estimated that reducing GHGs to 50% of 2005 levels by 2050 can reduce the number of premature deaths from air pollution by 20-40%.⁸¹
- Several studies identify the potential co-benefits of climate mitigation policy in China, with benefits coming in the form of synergies with air pollution policy, as well as improved water quality and water conservation.^{82, 83}
- Highly developed countries also stand to benefit. A recent study in the USA projected that the savings in public health spending from improved air quality, resulting from the implementation of a national ETS, could more than outweigh the costs of the ETS policy.⁸⁴

If an ETS stimulates changes in the way energy is produced and used, then ETS policy can also support strategic macroeconomic objectives aimed at enhancing national energy security and supply.

- In Germany, for example, the EU ETS is considered a key supporting instrument of the German energy transition policy (*die Energiewende*) wherein an explicit objective is to enhance energy security and stabilize energy costs by reducing dependence on fossil energy imports. While

^t The analysis draws on emissions information from the EPA Air Program Markets Data and the EPA's benefit-per-ton metrics for specific pollutants. For more information, see: http://acadiacenter.org/wp-content/uploads/2015/07/Appendix_Monetized-Benefits-of-Avoided-Emissions.pdf. Retrieved 13.11.2017

not the main policy instrument of the *Energiewende*,^u the EU ETS still contributes to this objective by lowering the demand for fossil fuels, particularly in the electricity and heat generation sectors.⁸⁵

The inclusion of specific sectors or offsets in an ETS (e.g., the forestry, agriculture, or waste sectors) can further support local or regional environmental objectives such as the improvement of soil and water quality, the reduction of deforestation, and the restoration of biodiversity and habitats.

- In New Zealand, for example, environmental objectives related to forestry (e.g. soil erosion control, water quality, biodiversity) were explicit goals of New Zealand's ETS (NZ ETS), and evidence shows that over the five years following its implementation (2007-2012), new forest area increased and the deforestation rate decreased.⁸⁶ After 2012, however, the collapse of the carbon price together with policy uncertainty undermined the forestry outcomes of the NZ ETS.⁸⁷ While most forestry participants manage timber plantations of fast-growing exotic species, there is also the possibility for private landowners to earn NZ ETS units (NZUs) for the re/afforestation of new native forests (post 1989) with high conservation values both under the NZ ETS and the NZ Permanent Forests Sink Initiative.

4.4 ETS can be adapted to country-specific contexts

ETS policy can be tailored to fit a variety of national and subnational circumstances. The jurisdictions currently operating ETS display wide geographic, political, and economic differences.^v For instance, there are city-wide systems, such as in Tokyo, characterized by few industrial facilities but many large buildings with high energy consumption. The EU ETS as a supra-national system covers facilities in 31 countries with markedly different circumstances and economic profiles. In China, pilot systems were implemented in very heterogeneous regions, including large, commercial cities such as Beijing and Shanghai, the industrial centers of Tianjin and Guangdong, and the more rural province of Hubei, to prepare for the implementation of a national cap-and-trade system in 2017. Finally, New Zealand's emissions profile is strongly characterized by land-use, land-use change and forestry, and its ETS has been designed with these circumstances in mind.

The ability to adapt the policy framework means that ETS can be designed to accommodate domestic priorities and objectives. Existing systems vary significantly in their design.

- For instance, while RGGI covers only power installations, New Zealand is the only ETS that directly includes the forestry sector. Systems also differ in terms of allocation, GHG coverage, price control measures, and offset provisions.³

ETS can be designed to fulfil different functions in a jurisdiction's overall climate policy mix.

- In California, for example, the California Cap-and-Trade Program is one of several complementary instruments comprising the state's overall climate change mitigation and clean-energy policy,^w which includes a feed-in tariff for renewable energy sources, renewable portfolio standards, strict building codes, the Low-Carbon Fuel Standard, and the Advanced Clean Air Program.⁸⁸ In the EU on the other hand, the EU ETS is considered as a cornerstone of

^u The German Energy Transition (*Energiewende*) comprises a raft of policy instruments, including the planned phase-out of nuclear power plants, the feed-in tariff program *Renewable Energy Act (Erneuerbare-Energien-Gesetz - EEG)*, and policy measures targeting energy efficiency, such as the *Energy-Conservation Ordinance (Energieeinsparverordnung - EnEV)*.

^v See, e.g., the ICAP ETS Map: <https://icapcarbonaction.com/ets-map>.

^w As determined by the California Global Warming Solutions Act of 2006.

European climate change mitigation policy,⁸⁹ and is responsible for a major part of the emissions reductions needed to fulfil the EU climate targets.^x

ETS has also been implemented in jurisdictions where price incentives traditionally play little role.

- For example, ETS has been implemented in the Republic of Korea, and regions in China where there are government controls on electricity prices. By also including indirect emissions from electricity consumption, these jurisdictions have created a demand-side incentive for emission reductions while retaining government control over electricity prices.⁹⁰

4.5 ETS is politically feasible

ETS policy has proven to be politically tenable, as demonstrated by the number and variety of jurisdictions that have chosen ETS as their primary mitigation instrument. While successful implementation is still contingent on political will, the flexibility of an ETS, both in the freedom that it gives firms and the various design options, makes it compatible with new and existing policy frameworks and allows it to gain broad political acceptance.

Furthermore, ETS can be designed to address particular concerns of different stakeholder groups. For example, the free allocation of some allowances to especially energy-intensive and trade-exposed sectors as an initial and transitional allocation method may help to overcome concerns of industrial groups regarding carbon leakage or competitive distortions. At the same time, the use of auction revenues to compensate households for rising energy costs may win over consumer groups. The ability to address issues of allocation and revenue use through negotiations at the design stage, while still ensuring the policy achieves a set level of emissions reductions, means ETS policy can work well in achieving consensus among domestic interest groups.^{91,92}

- The final design of the EU ETS was the result of intense negotiations between stakeholder groups and political institutions, which resulted in the concerns of various groups being successfully incorporated. For example, free allocation was introduced as a mechanism to counter the competitiveness concerns of some industrial sectors,⁹³ and trade associations were found to have had a significant influence on this outcome.⁹⁴

4.6 ETS allows for linking with other systems, fostering international climate action

In order to effectively fight global climate change, it is crucial to coordinate international efforts and to link different measures. The nature of ETS policy means that distinct systems can be linked through the mutual (or unilateral) recognition of emissions allowances for compliance. Linking systems creates a larger carbon market, which can reduce overall compliance costs, increase market liquidity and promote market stability.^{95,96}

- Based on official projections of allowance prices, abatement costs, and trade volumes in California and Québec, one study estimates that both jurisdictions will be significantly better off by linking systems, as compared to a situation where they operate alone. By linking markets, Québec is expected to reduce compliance costs by 52-57% (USD 387-532 million) by 2020. While compliance costs are expected to rise in California, income from the sale of allowances is expected to more than compensate these additional costs, with the net gains

^x Under the '2030 climate & energy framework', in order to meet 2030 emissions reduction targets, EU ETS sectors (currently ca. 45% of EU emissions) would cut emissions by 43% and non-ETS sectors would cut emissions by 30% below 2005 levels. See the European Commission website for more details - https://ec.europa.eu/clima/policies/strategies/2030_en. Retrieved 13.11.2017

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from trade estimated to be USD 284-442 million for California. Overall, as a result of the link, aggregate compliance costs are estimated to be reduced by 28-33%.⁹⁷

Other potential benefits include a reduction of competitiveness distortions between linked regions related to ‘carbon leakage,’ as well as administrative benefits stemming from information sharing and cost-savings from shared infrastructure such as auction administration and registries.⁹⁸ Linking systems also allows jurisdictions to display political leadership in the fight against climate change by coming together in a joint effort to reduce GHG emissions.⁹⁹

Several jurisdictions have already proven that linking systems is feasible.

- In 2014, California and Québec successfully linked their systems.¹⁰⁰ Ontario linked its cap-and-trade program (since repealed) to the systems of California and Québec in January 2018¹⁰¹ and the three jurisdictions conducted their first joint auction the following month. .
- In 2017, the EU and Switzerland signed an agreement to link their systems. The link will likely become effective from 2020 onward.¹⁰² Previously, the EU ETS had already been expanded to include Iceland, Norway, and Liechtenstein.¹⁰³

Some systems have also established indirect links by accepting credits from international offset mechanisms such as the CDM or domestic offset programs such as the China Certified Emission Reductions (CCER) program.³

- The UNFCCC estimates that through the EU ETS link to the CDM, firms under the EU ETS saved around €1.2 billion on compliance costs in the period 2008-2011.¹⁰⁴

Conclusion

This paper provides a comprehensive review of the theoretical arguments and empirical evidence of the benefits of ETS for climate mitigation. Given the short timeframe of existence of some ETS, it is not surprising that a large share of the scientific studies and official reports evaluating the performance of ETS focus on Europe and North America. Overall, however, there is a growing body of evidence supporting the arguments presented in this paper, and the benefits of ETS are being realized around the world.

Research on the effects of ETS has so far concentrated on the environmental benefits and cost effectiveness of the instrument, and the available evidence generally supports these main arguments. Beyond these aspects, this paper has highlighted several areas in which ETS may help to achieve broader public policy objectives, particularly public health benefits associated with improved air quality.

Currently, evidence is drawn largely from the European and North American experiences. This highlights the need for further research, but also reflects the fact that ETS in most regions is still a young instrument. Looking ahead, we expect evidence for the benefits of ETS to strengthen over the coming years, with more comprehensive data and new research becoming available.

Around the world, ETS policy is put into practice differently depending on the political and economic conditions in which it is implemented. Therefore, although this paper can show the range of potential benefits that are possible with an ETS, not all of the benefits outlined in this paper will be equally relevant across jurisdictions. In order to incorporate the full range and value of ETS benefits into policy decisions, policymakers will need to first uncover the drawbacks, advantages, and potential synergies presented by the implementation of ETS in their region.

Appendix 1. Summary table of evidence

Table App.1: Summary table outlining the evidence for the benefits of ETS

<u>Benefit</u>	<u>Jurisdictions</u>	<u>Summary of evidence</u>	<u>Sources</u>
Emissions reductions	EU, RGGI, California, Tokyo	<p>ETS has driven emissions reductions, even when accounting for external factors:</p> <ul style="list-style-type: none"> • EU ETS impacts range from an estimated 3% of aggregate emissions to 25-28% at the firm level, with the impact on emissions being greatest during the beginning of Phase II (2008-2010) • Based on modelling, RGGI contributed to around 50% of the emission reductions achieved in the energy sector of RGGI participating states between 2009 and 2012, and emissions would have been 24% higher in the absence of the ETS. <p>California and Québec verified emissions have remained below the cap Tokyo achieved a 26% reduction below baseline emissions</p>	European Environment Agency (2017) ⁴ , Martin et al. (2014) ⁵ , Abrell et al. (2011) ⁶ , Petrick and Wagner (2014) ⁷ , Bel and Joseph (2014) ⁹ , Murray and Maniloff (2015) ¹¹ , ARB (2015) ¹⁴ , ARB (2017) ¹⁵ , Tokyo Metropolitan Government (2018) ¹⁶
Cost-effective abatement	Global (OECD countries)	ETS (and broad-based carbon taxes) achieve lowest-cost abatement when compared with other instruments	OECD (2013) ²⁴
Decoupling emissions from growth	California, EU, RGGI	<p>Jurisdictions with an ETS demonstrate an overall trend towards decreasing carbon intensity (not directly attributable to ETS)</p> <ul style="list-style-type: none"> • From 1990 to 2016, emissions' intensity of the EU economy was reduced by around 50%, and decoupling occurred in all member states. • The carbon intensity of California's economy has fallen 33 percent since it peaked in 2001, while the state's economy has grown by 37 percent. From 2012-2015, emissions in the state steadily declined, while GDP, population and employment grew. Between 2008 and 2015, the RGGI states reduced CO2 emissions from the power sector by 30%, while the regional economy grew by 25%. During the first nine years of operation, the RGGI program led to over 44,700 new job years 	European Environment Agency (2017) ⁴ , European Commission (2016) ⁴¹ , Denny Ellerman et al. (2016) ⁴² California Air Resources Board (2017) ⁴⁰ , Stutt et al. (2016) ¹³ , , RGGI (2015) ⁴³ , ·Hibbard et al. (2018) ⁴⁴
Deployment and innovation of low-carbon technology	EU, Tokyo	<p>ETS promotes the deployment and innovation of low-carbon technology and processes close to the market. ETS has a small but positive effect on patenting of low-carbon technology in covered firms.</p> <ul style="list-style-type: none"> • The EU ETS increased low carbon patenting of regulated firms by 10% compared to otherwise similar firms. At the aggregate level, the EU ETS has resulted in a 1% increase in low carbon patents compared to the counterfactual. • For covered firms in Germany, from 2005-2007 the EU ETS constituted a main driver for small-scale investments with short amortization times. <p>Tokyo's ETS has resulted in energy efficient low-carbon technologies in the building sector (particularly LED lights and efficient air conditioning units).</p>	European Commission (2015) ⁴⁵ , Tokyo Metropolitan Government (2015) ⁴⁶ , Martin et al. (2012) ⁴⁹ , Martin et al. (2012b) ⁵⁰ , Hoffman (2007) ⁵¹ , Borghesi et al. (2012) ⁵² , Anderson et al. (2011) ⁵³ , Delarue et al. (2008) ⁵⁴ , Calel and Dechezlepetre (2016) ⁵⁵ , Nishida et al. (2016) ⁴⁷

BENEFITS OF EMISSIONS TRADING

ETS generates revenues with various uses	EU, Germany, California, Québec, RGGI, Australia	By the end of 2017, ETS jurisdictions had raised around USD 37 billion from auctioning emission permits. This revenue is used for various purposes, including furthering climate action and compensating low-income households. Revenues to the end of 2017: <ul style="list-style-type: none"> • EU ETS – USD 25.8 billion since 2008; • RGGI – USD 2.8 billion since 2009, • California¹ – USD 6.4 billion since 2012 and • Québec – USD 1.6 billion since 2013. 	European Union (2009) ⁶⁹ , RGGI (2017) ¹⁰ , RGGI (2018) ⁷⁰ Hsia-Kiung and Morehouse (2015) ⁷¹ , Gouvernement du Québec (2018) ⁷³ , Centre for Climate and Energy Solutions (2011) ⁷⁵
Data production and information sharing	Global, EU, Tokyo	Countries currently considering an ETS are developing MRV systems and gathering emissions data. ETS has also raised the issue of climate change to management boards of companies, and has facilitated information sharing among key stakeholders. MRV systems are currently being established in Mexico, Thailand, Vietnam, Turkey, and Russia.	Neuhoff (2011) ⁷⁶ , Laing et al. (2014) ⁷⁷ , Tokyo Metropolitan Government (2012) ⁷⁸
Co-benefits	RGGI, China, USA, Germany, New Zealand, Global	ETS has the potential to create synergies with, e.g., public health, energy security, job-creation and land-use-change policy. In particular, public health savings from improved air quality could be substantial. <ul style="list-style-type: none"> • Between 2009-15, the reduction in hazardous pollutants sulfur dioxide, nitrogen oxide, and mercury in RGGI states has led to an estimated more than USD10 billion in health savings from avoided illness, hospital visits, lost work days, and premature deaths; • A review of studies into the potential air-quality benefits of climate mitigation policy found estimates ranging from USD 2-196 /tCO₂ (average of USD 49 /tCO₂). • IMF estimates that a carbon price of USD 57 /tCO₂ will yield the same value of domestically accrued co-benefits <p>Significant ETS co-benefits were accrued from reforestation in New Zealand from 2008-2012.</p>	Stutt et al. (2016) ¹³ , Nemet et al. (2010) ⁷⁹ , Parry et al. (2014) ⁸⁰ , PBL (2009) ⁸¹ , Dong et al. (2015) ⁸² , Ma et al. (2013) ⁸³ , Thompson et al (2014) ⁸⁴ , BMUB (2015) ⁸⁵ , Hibbard et al. (2015) ⁴⁴ , New Zealand Government (2013) ⁸⁶
Adaptable to country-specific contexts	California, Global	Existing ETS vary in design, depending on context, as well as their intended role in the climate policy mix. ETS has also been established in jurisdictions with regulated energy prices.	ICAP (2017) ³ , ARB (2015b) ⁸⁸ Acworth et al. (2018) ⁹⁰
Politically feasible	EU	Experience to date suggests that ETS is more likely to result in broad coverage and hence higher cost effectiveness compared to a carbon tax as industries lobby for a larger share of free allocation rather than exemptions. <ul style="list-style-type: none"> • Evidence from the EU ETS supports this claim, finding that companies have lobbied for free allocation based on competitiveness concerns and that trade associations were found to have had a significant influence on this outcome. 	Fagan-Watson et al. (2015) ⁹⁴
Allows for linking with other systems	California, Québec, EU, Switzerland, Global	Several jurisdictions have established direct links with each other, while many systems are indirectly linked through international carbon markets. <ul style="list-style-type: none"> • Modelling results indicate that over the period 2013-20, linking California and Québec reduced total compliance costs by one-third. • The UNFCCC estimates that through the EU ETS link to the CDM, compliance costs under the EU ETS were reduced by around EUR 1.2 billion in the four years of 2008-2011 	Purdon et al (2014) ⁹⁷ , ARB (2013) ¹⁰⁰ , ICAP (2017) ³

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