JULY 2017 | NUMBER 015

THE CENTER FOR
INTERNATIONAL
ENVIRONMENT &
RESOURCE POLICY

CLIMATE POLICY LAB
THE FLETCHER SCHOOL
TUFTS UNIVERSITY

# Carbon Pricing In Practice: A Review of the Evidence

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**Acknowledgements**
Although responsibility for the final product rests with us authors, we wish to thank Patrick Verkooijen of the World Bank and Ms. Neydi Cruz Garcia from Mexico's SEMARNAT for encouraging us to review the evidence on carbon pricing in practice. Ms. Cruz Garcia was also supportive in helping us to research the Mexican experience. We are also grateful to Nat Keohane from the Environmental Defense Fund and Dirk Forrester of IETA for their suggestions on scoping. Finally, we would like to thank Joseph Aldy, Ottmar Edenhofer, Christian Flachsland, Ulrike Kornek, and Gilbert Metcalf for their valuable suggestions and comments.

We gratefully acknowledge financial support from BP International, Energy Foundation China, and The William and Flora Hewlett Foundation.

# Abstract

This paper performs a descriptive analysis of carbon pricing policy implementations in twelve regions (California, British Columbia and Quebec in Canada, Ireland, Norway and EU ETS, Mexico, Chile, Japan, India, South Korea, and China ETS Pilots) that have implemented an emissions trading scheme (ETS), a carbon tax or a hybrid of both. The paper synthesizes some key findings and knowledge gaps on what is working, what isn't and why when it comes to implementing explicit carbon pricing policies. Institutional learning, administrative capacity, and appropriate carbon revenue management are identified as key ingredients for a successful pricing regime. Recent implementations of ETS in regions such as California, Quebec and South Korea indicates significant institutional learning from prior implementations like the EU ETS, with these regions implementing robust administrative and regulatory structures suitable to handle unique national/sub national opportunities and constraints. Cases show that carbon tax, in addition to being a standalone policy, may also serve as a good first step towards building an emissions inventory and administrative capacity necessary for countries interested in adopting an ETS in the future. Cases also show that there is potential for a "double dividend" in emissions reduction even with a modest carbon price, provided the policy allows for a gradual increase in carbon price over time and a portion of the revenue to be reinvested towards other emissions reduction activities. Knowledge gaps exist in understanding what factors makes a particular carbon pricing policy suitable to a socio-political-economic context and whether governments decide on a policy based on such factors. Knowledge gaps also exist in understanding the interaction of pricing instruments with other climate policy instruments and how governments manage these policies to achieve optimum emissions reductions.

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**A note to readers:** This discussion paper is being published in order to solicit comment. Feedback and suggestions for improvement are welcome and should be sent to Easwaran Narassimhan in the Center for International Environment and Resource Policy at The Fletcher School at easwaran.narassimhan@tufts.edu

# 1. Introduction

The scope and urgency of dealing with climate change is abundantly clear. After the Paris Agreement was finalized in December 2015, nations realized that to meet their ambitious national emissions reduction targets, they must quickly ramp up policies to achieve decarbonization. Most experts agree that the most economically-efficient way to reduce greenhouse gas emissions is through the use of carbon pricing policy instruments (e.g. Metcalf and Weisbach 2009, Aldy 2015, Edenhofer et al. 2015, Schmalensee and Stavins 2017). Many firms, including ExxonMobil, Royal Dutch Shell, Total, and BP, have also expressed a preference for carbon pricing policies in lieu of regulatory approaches (Carroll 2017; BP 2015). In September 2014 more than 1,000 companies, including large oil and gas companies, signed the World Bank's Put a Price on Carbon Statement (World Bank 2014). Accompanying the December 2015 Paris Agreement was the launch of the Carbon Pricing Leadership Coalition (CPLC) under the leadership of the World Bank (Jungcurt 2015). The Coalition brings together 21 nations and numerous states and provinces from the United States and Canada (Carbon Pricing Leadership Coalition 2016). Currently, there are approximately 40 national carbon pricing mechanisms, along with more than 20 in cities, states, provinces, and other sub-national jurisdictions, covering approximately 7 gigatons of carbon dioxide equivalent (GTCO$_2$-e), roughly 13 percent of global emissions (World Bank 2016: 11).

More than 100 INDCs submitted before Paris included some carbon pricing proposal, accounting for roughly 58 percent of global emissions. China is currently piloting 7 municipal and regional carbon trading schemes with the expectation of rolling out a national policy in 2017. In October 2016, Canada finalized efforts for a comprehensive plan to implement some kind of carbon pricing in all provinces and regions by 2018. Mexico will launch a national carbon pricing mechanism in 2018, with a goal of linking emissions reductions with other North American carbon markets (World Bank 2016). All of this activity points to growing international political momentum to achieve global emissions targets through cost-effective pricing mechanisms in the near future. For this reason, the efficacy of carbon pricing policies is of utmost interest to many national and sub-national governments.

Carbon pricing mechanisms fall into three main categories; cap-and-trade, carbon tax, or a hybrid mechanism that combines elements of both. Other indirect carbon pricing strategies include the use of a social cost of carbon in government regulatory decisions and voluntary use of a shadow carbon price by private companies in firm level decisions. Each carbon pricing mechanism has strengths and weaknesses, and works well in some respects and falters in others.

This paper reviews existing evidence on how carbon pricing policies work in practice, highlights similarities between the different policies and details implementation issues with cap-and-trade and carbon tax policies. Second, the paper provides an overview of select national and sub-national policies, including a discussion of noteworthy features and constraints in each country's policy. Third, the paper discusses common features and issues that exist across the reviewed country cases for cap and trade, carbon tax and hybrid systems. Finally, the paper summarizes key findings, identifies knowledge gaps and lays out a plan for further research.

## 2. Basics of Cap-and-Trade

First conceived of by John H. Dales in 1970 in his book, *Pollution, Property and Prices: An Essay in Policy-Making and Economics,* cap-and-trade policies (also known as emissions trading schemes, or ETS) have been in use for decades, most notably since the first national program implemented in the early 1990s, when the U.S. EPA introduced cap-and-trade as a part of the Acid Rain Program (Ellerman et al. 2003). Since then, cap-and-trade pricing mechanisms have spread to more than 35 national and sub-national jurisdictions, and include a wide range of global warming pollutants.

A cap-and-trade system may establish a cap either on total emissions or on emissions intensity, as measured by emissions per unit of GDP. The latter is less common when compared to a cap- and- trade system based on total emissions. India, with its Perform Achieve and Trade (PAT) scheme, currently regulates fossil intensive sectors like cement, steel and textiles for their emissions intensity. Similarly, some regions in China have opted for an intensity-based emissions cap (Zhang et al. 2014). Irrespective of whether the cap is on total emissions or emissions intensity, a cap-and- trade system can include emissions from all greenhouse gases or just one, such as carbon dioxide. Governments then provide allowances, either freely or through an auction, equal to the level of the cap (Aldy and Stavins, 2012). A hybrid approach of both auctioning and freely allocating part of emission allowances is seen in some ETS markets. Firms then trade allowances before or during a specified compliance period, after which they are surrendered to the government. Firms with lower abatement costs will sell their allowances in secondary markets to firms with higher abatement costs, and overall, emissions reductions are achieved at least cost.

Key design considerations for a cap-and-trade program include determining which emissions and sectors will be regulated under the cap, at what point of regulation emissions will be measured (upstream or downstream), the stringency of the cap (or the total allowable emissions), permit revenue distribution, monitoring, measurement, and verification of emissions and allowances, and addressing international competitiveness concerns. Additional considerations for cap- and- trade include policies for banking and borrowing credits from future compliance periods, creation of an allowance reserve, creation of new trading registries to monitor and track carbon allowance markets, and accounting for carbon offsets.

Carbon offsets are a crucial market mechanism that can play a role in cap-and-trade markets. A carbon offset is a tradeable certificate on the avoided emissions that result from environmentally focused investment decisions such as landfill methane capture, reforestation, renewable energy development, energy efficiency upgrades, and destruction of dangerous and harmful pollutants such as HFCs and PFCs. Offsets are generally required to meet certain requirements such as additionality of the carbon emissions reduction in the absence of the investment project. In addition, emissions reductions must be quantifiable, long-term, and verifiable by a third-party auditor (Schmidt 2009). The largest offset market, the Clean Development Mechanism (CDM), was established under the Kyoto Protocol. In 2017, the CDM had registered 7,700 projects, representing a 1.8 billion tons of carbon offsets (UNFCCC – CDM 2017). However, there has been a marked decrease in CDM project activity since 2013. Firms in cap-and-trade markets can buy offsets generated from verified CDM projects and count those emissions reductions toward their emissions obligation, however, because the cap-and-trade program's aim is to limit local pollution as well, there are generally limits to the total number of global offsets that a regulated firm can buy in order to meet its emissions obligations.

Finally, there is the possibility of international linkage of carbon pricing markets, with either cap-and-trade or carbon tax approaches. In a bilateral linkage, total allowable emissions would be the aggregate of the two regions. Allowances would be tradable between covered entities in both regions, and allowance prices would likely be very similar between the two regions. Similar reporting, monitoring, and verification standards would exist between them. International carbon pricing linkage addresses three potential market flaws with carbon pricing schemes. First, in a world without linked markets there are potential efficiency losses between regions with higher carbon prices than those with lower carbon prices. This is due to varying marginal emissions abatement curves in different regions. Second, the possibility of carbon leakage from high priced carbon regions to low or no priced carbon regions is a significant economic and political concern. Third, the overall size of a carbon market in an unlinked system maybe small and lack liquidity, thereby increasing price and trading volatility. Linking cap-and-trade and carbon tax schemes across varying jurisdictions could potentially reduce all of the above inefficiencies (Metcalf and Weisbach 2010). As this paper will show, international linkage of carbon markets is happening and has been shown to be successful.

# 3. Basics of Carbon Tax

A carbon tax represents a quintessential Pigouvian tax (Mankiw 2009). The private market produces emissions at a certain level where marginal private cost equals marginal private benefit. However, greenhouse gas emissions incur external public costs in the form of increased pollution, including both ambient and global warming pollution, health and environmental effects, and a myriad number of other impacts of climate change. Because the private market does not internalize the public costs, the market overproduces pollution beyond what is socially optimal (Metcalf and Weisbach 2009). A carbon tax would ideally internalize these unaccounted public costs to arrive at a socially optimal level of emissions. The key difference between a cap-and-trade and a carbon tax pricing mechanism is that the former sets a quantity on allowable emissions and a carbon price is indirectly derived from the interaction of supply and demand of emission allowance units in secondary markets, while the latter sets a direct price on emissions or on the carbon content of a fuel. A carbon tax on the carbon content of a fuel is a type of excise tax (Metcalf and Weisbach 2009). Because different fuels emit different amounts of carbon dioxide in relation to the energy they produce, a carbon tax would create a higher effective price for carbon-intensive fuels such as coal and a lower price for less carbon-intensive fuels like natural gas.

Determining the appropriate size of the tax based on the principal of maximizing total social welfare is nearly impossible to do with certainty due to a lack of consensus on what is the socially optimal level of emissions (Mankiw 2009). This lack of consensus arises due to uncertainty over the potential economic damages of climate change, the cost of mitigation, and normative judgments over discounting future damages and time-inconsistent preferences. In recent years, many efforts have been made to determine the social cost of carbon, both globally and at the country level. In terms of specific carbon tax recommendations, William Nordhaus (2007) suggested a $30 per ton and the 2006 Stern Report recommended a tax of over $300 per ton (Stern 2007) globally. Aldy (2016) recommended a tax starting at $25 per ton for the United States with a 5 percent annual escalator to reach the desired social cost of carbon by 2030. In 2017, a carbon pricing effort led by former U.S. conservative politicians, advocated for a carbon dividend approach with a tax starting at $40 per ton and escalating annually from there (Climate Leadership Council 2017).

Another critical consideration is the flexibility of the tax rate to change in light of new information. Governments could opt for a regular, pre-set escalating tax rate (plus the rate of inflation) unless they determine through a review process that the escalator is not needed. Such an approach would be less susceptible to political pressures than a carbon tax policy where the tax rate must be continually renegotiated among political entities (Aldy 2017). Deciding which government agency or body will set and change the tax rate is often a major challenge. Governments could be susceptible to industry lobbying and rent-seeking behavior for reductions or exemptions from the tax.

Ensuring emissions reduction certainty is another concern for carbon taxes. In the absence of imperfect information, a carbon tax and cap-and-trade scheme would yield the same total amount of emissions reductions. However, a carbon tax, at the outset, may not be set at the appropriate level and may result in emissions above the optimal level. One approach found in the literature details a design structure that sets interim emissions benchmarks and final emissions targets. The tax rate is then periodically revaluated at the interim benchmark periods and either adjusted upwards or downwards in order to ensure that a jurisdiction is on track to meet its final emissions targets (Hafstead et al. 2016). Some economists worry that this approach risks increasing business uncertainty, as individual businesses may have to adjust long-term investments to idiosyncratic increases in tax rates. An alternative approach found in the literature would be to implement a tax schedule, that considers expert government opinion, say every 5 years, on the effects of climate change, probability of reaching carbon emissions reduction goals, economic effects of the tax, and the role of the tax in meeting international mitigation efforts. The executive branch would then recommend either an increase, decrease, or no change in the carbon tax rate and this would be voted on by the legislature. This approach has the benefit of taking into account more than just whether or not a country is on track to meet its emissions benchmarks and its final target (Aldy, 2017).

Carbon taxes vary widely in terms of sectoral coverage. Carbon taxes can apply to specific sectors and products such as liquid fuels like Finland's liquid fuels tax, or specific industries such as the oil and gas sectors similar to how Norway taxes emissions (World Bank 2016). Finally, carbon taxes could apply to just carbon dioxide emissions (which make up roughly 76 percent of global emissions), or could be expanded to include all greenhouse gases, including methane (IPCC 2014).

For true economic efficiency, a carbon tax would ideally cover all emitting sources at either the production (upstream) or consumption (downstream) stage. Taxing upstream, with the exception of natural gas, is generally considered to lower the transaction costs of implementing and collecting the tax, as well as ensuring wide sectoral coverage (Metcalf and Weisbach 2009). A downstream tax requires applying and collecting the tax at the broader retail level, rather than on a smaller subset of fuel extractors, producers, and users. However, a downstream tax on natural gas at the consumer or final producer level, would likely cover more of the natural gas sector at lower administrative costs (Metcalf 2017). This is due to the fact that only two-thirds of dry natural gas is processed by a processing facility in the United States. It is more feasible and would cover more natural gas emissions if a tax on natural gas was applied at the local distribution company- level for residential, commercial and industrial natural gas use (Metcalf 2017).

A crucial design consideration for carbon taxes is the allocation of revenue generated from the tax. A carbon tax has the potential to be regressive, with large tax shifts falling onto lower income populations due to consumption patterns (Metcalf and Hassett 2007). Revenue can be allocated in ways that compensate lower-income populations. A revenue neutral carbon tax or "swap" is one that returns all carbon tax revenues to citizens and/or corporations through reduced income or corporate taxes. A cash dividend distribution scheme recycles the revenue back to each citizen in the form of equal portioned direct cash transfer. Finally, governments can use revenue to invest in infrastructure, clean energy projects, R&D, climate change adaptation, or any other fiscal priority (Metcalf and Weisbach 2009).

There is a rich literature on the prospects of a "double dividend" arising from a carbon pricing policy, especially carbon taxes, although it is possible under a cap-and-trade scheme as well. The basic idea behind the potential for a double dividend arising from a carbon pricing scheme is that revenue could be used to reduce distortionary taxes on labor and capital and yield increased economic growth. Thus, there is a double dividend from a carbon pricing policy that leads to reduced emissions and increased economic productivity (Bovenberg 1999). By reducing non-environmental distortions in the tax structure, a carbon tax could raise overall societal welfare by reducing regressive taxes on labor and capital. However, research into the reality of a double dividend is inconclusive at best.

Finally, a national or sub-national carbon tax policy may expose a country to international trade pressures. A carbon tax that is not harmonized across national borders raises the marginal cost of production in the region with the carbon tax and thus creates a competitive disadvantage for that country. A number of carbon pricing experts have proposed border carbon adjustments that would serve to equilibrate prices of carbon-intensive goods across regions that do and do not have carbon pricing schemes (Flannery 2016). Industries within a region with a carbon tax that are exporting carbon intensive goods to a region without a carbon tax would receive a rebate, and vice versa, importing goods into a region with a carbon tax from regions without a carbon tax would be subject to an import tax (Metcalf and Weisbach 2009). Border carbon adjustments also serve to discourage carbon-intensive industries from leaving regions that have a carbon tax for regions that do not have a tax. Indeed, addressing potential carbon leakage is a concern for any carbon pricing mechanism (Flannery 2016).

# 4. Hybrid Approaches

As this paper illustrates, there is increasing evidence that countries find advantage in employing both carbon taxes and cap-and-trade schemes, or devising policy instruments that employ elements of both approaches. Some governments may prefer a carbon tax for political purposes in order to publicly demonstrate their commitment to reduce emissions. Conversely, some governments may consider new taxes a political liability and therefore adopt a cap-and-trade system for certain sectors. Finally, some countries or states/provinces that participate in emissions-trading regimes at higher governance levels (e.g. supranational regime) also apply carbon taxes domestically.

Four different hybrid approaches have been observed in existing carbon pricing regimes. First, countries that impose a carbon tax in some sectors and cap-and-trade in other sectors without significant overlap. Norway and Ireland are two examples discussed in this paper where a carbon tax is imposed on sectors not fully covered under the EU ETS. Second, countries with cap-and-trade and a price collar. A cap-and-trade approach that imposes a price "collar" (with minimum and maximum permit prices) is a hybrid because it creates an effective carbon tax at the minimum and maximum price (Schmalensee and Stavins 2017). The United Kingdom is a good example of an ETS with price collars. Third, countries that impose both cap-and-trade and a carbon tax without coordination among the instruments. In such scenarios, the simultaneous signaling from both policies may lead to cost inefficiencies. Fourth, programs where a jurisdiction with a carbon tax scheme is linked with a jurisdiction with a cap-and-trade scheme. There are currently no instances of hybrid international linking between a carbon tax and cap-and-trade program (Metcalf and Weisbach 2010).

# 5. National & Sub-National Policies: Cap-and-Trade

In this section, we detail the design and implementation features, constraints and other issues faced by the EU ETS, California cap-and-trade, Quebec cap-and-trade, Republic of Korea ETS and China's provincial ETS. We selected these initial cases to cover cap-and-trade implementation at the supranational, national, and subnational levels. In addition, these cases represent diverse geographies and span across time, allowing us to identify learning and spillover of knowledge, if any, from older to newer implementations. Since we evaluate information based on what is available in the existing literature and government documents, the cases described in the following sections vary in terms of the depth of information covered. We hope to provide more equal coverage in the next phase of our research through in-depth surveys and interviews of several cases where there are knowledge gaps in the existing literature.

## 5.1. EU ETS

The European Union's emissions trading scheme (ETS) was the first and remains the largest GHG pricing program in the world. Begun in 2005, the EU ETS is the result of the Union's attempt to meet its Kyoto Protocol emission reduction goals by using an innovative trading scheme. The EU has strong complementary carbon reducing policies, but GHG emissions were expected to increase by more than 300 $MMTCO_2$-e above the EU's Kyoto-target in the absence of a carbon pricing policy (Ellerman and Joskow 2008). While there have been a number of challenges with the EU ETS, including over allocation of allowances, price volatility, data transparency issues, and slowness to reform the system, the EU ETS illustrates valuable program and policy design considerations. In addition to the EU ETS, both Ireland and Norway have instituted a domestic carbon tax, which effectively creates a hybrid carbon pricing system that is examined below.

Inaugurated in 2005, the EU ETS now operates in 28 EU member states, plus Iceland, Liechtenstein, and Norway. The EU ETS covers roughly 11,000 entities accounting for roughly 45 percent of EU-wide GHG emissions (1,988 MMT $CO_2$-e), including carbon dioxide, nitrous oxide, and perfluorocarbons emissions. The sectors covered are power and heat generation, energy intensive industry sectors[1], commercial flights operating within the European Economic Area (EEA), aluminum production, and nitric, adipic and glyoxylic acids and glyoxal production (European Commission 2017).

The first three-year trading period (2005-2007) was a pilot phase of "learning by doing." During this phase only $CO_2$ emissions from power generation and energy-intensive industries were covered and applied to EU countries only. Most allowances were allocated for free based on estimated needs. Emissions permits were over-allocated, which caused the price to fall to zero in 2007. In addition to this challenge, the member states set individual caps at the national level. These caps were too high and led to an over-allocation of allowances (Schmalensee and Stavins 2017). Finally, the prohibition on carrying credits from one compliance period to another effectively made allowances worthless toward the end of the compliance period. During the second phase (2008-2012), Iceland, Norway and Liechtenstein joined the ETS, the number of allowances was reduced by 6.5 percent (compared to 2005 levels), nitrous oxide from nitric acid production and aviation sectors was included, and 10 percent of allowances were allocated through auctioning. The 2008 economic crisis led to a decline in emissions and thus to a surplus of unused allowances, keeping the price low (European Commission 2016). During the third trading period (2013-2020) major reforms took effect. The initial 27 individual caps set by member states at the national level were aggregated to create an EU-wide cap (Ellerman and Joskow 2008). In addition, each member state had its own registry to track the trading, selling, and overall number of allowances within that country; today, trading of allowances between member states

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[1] Including oil refineries, steel works and production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals.

is monitored and tracked by the European Union Transaction Log (EUTL), an EU-wide central registry (Frunza 2013). Also, a progressive shift towards auctioning of allowances in place of free allocation started during this phase. For the fourth trading period (2021-2030), a legislative proposal for reforming the EU ETS to address its major challenges is being negotiated (European Commission 2016).

Since Phase 2, banking and borrowing (restricted to one year) of European Union Allowance units (EUAs) is allowed within a trading period but not from other trading periods. Offsets are allowed, primarily through the Clean Development Mechanism and Joint Implementation, and up to 50 percent of total emissions reductions can be met through these facilities, with certain project restrictions in place. Finally, in case of non-compliance the entity responsible has to pay a fine of 100 euros for each excess ton of regulated emissions and must purchase allowances to make up the shortfall (European Commission 2016).

### Noteworthy features

The allowance cap at the beginning of phase 3 stood at 2.18 billion EUAs, and is designed to decrease at a rate of 1.74 percent each year. Thanks to the decreasing cap, the number of allowances that can be used by fixed installations to cover emissions will be 21 percent lower in 2020 than in 2005 (European Commission 2017). Today there is a new reform proposal for the EU ETS on the table that, if approved, will set the cap declining at the rate of 2.4 percent per year, which would contribute to an additional GHG reduction of 556 million tons or 43 percent below 2005 levels by 2030 (Meadows 2017).

To address over allocation concerns, a Market Stability Reserve (MSR) was agreed to in 2015 and will be implemented in 2019 (EC 2017). The MSR aims to better align the demand and supply of allowances by placing surplus allowances into the MSR, from which they can be released in case of a shortage. Additionally, 900 million allowances will be placed directly in the MSR to reduce the oversupply of allowances (European Parliament 2016). Under the reform proposal currently being negotiated, the capacity of the MSR would double to absorb the excess of allowances in the market (Meadows 2017).

Between 2012 and 2016, 3.45 billion EUAs were allocated freely, while 2.44 billion EUAs were auctioned. Revenues generated from the auctioning of 2.44 billion allowances between 2012 and 2016 exceeded €14 billion, with at least 50 percent of revenue distributed for climate and energy related purposes, with significant investment directed toward upgrading and retrofitting infrastructure (European Commission 2017). If the EU ETS proposed reforms are implemented, two new funds will be established: An Innovation Fund to extend existing support for the demonstration of innovative technologies to breakthrough innovation in industry, and a Modernization Fund to facilitate investments in modernizing the power sector and foster energy efficiency (Meadows 2017).

While attributing emissions reductions directly to the EU ETS is difficult due to the absence of a robust counterfactual and the existence of complementary emissions reducing policies, the available literature suggests annual emissions savings in the range of 40 to 80 MMT of $CO_2$-e per year is attributable to the EU ETS (Laing et al. 2014). According to the European Commissions, emissions have decreased by about 4.5 percent between 2011 and 2015 (European Commission 2017).

**Constraints**
The price for European Union Allowances (EUAs) has been marked by substantial volatility (Feng, Zou, and Wei 2010). Due to the over-allocation of free emissions allowances, based on historical emissions benchmarks, during the first and second compliance periods, there was a large oversupply of credits and little demand (Ellerman and Joskow 2008). Total demand for allowances was only 1.96 billion EUAs, leading to an over allocation of 220 million allowances.

Between 2008 and 2011, some firms tried to game the EU ETS, resulting in the loss of €5 billion in national tax revenues. Some EU governments impose a value-added (VAT) tax on the trade of EUAs, but not all. This situation opened the door for some companies to buy EUAs in countries without the VAT, sell them in countries with the tax (and therefore for a higher price), without returning the VAT to the relevant tax authority (Bierbower 2011). Once this fraudulent activity was discovered, the EU adopted a directive allowing member states to implement a VAT reverse mechanism. This means that the entity responsible for paying the VAT is now the entity purchasing the allowances. While this measure is considered to be sufficient to stop the fraud in theory, not all member states have implemented this mechanism and therefore the European Court of Auditors has stated that the EU ETS still "remains at risk to VAT fraud." (European Court of Auditors 2015). This highlights the challenges involved in transforming the politically palatable and decentralized EU ETS system with poor institutional oversight to a centralized market system that can be monitored and regulated effectively.

## 5.2. CALIFORNIA'S CAP-AND-TRADE

The California cap-and-trade program is the second largest emissions trading scheme in the world, after the European Union's Emissions Trading Scheme. The program has been in place since January 2013 and is now in its second three-year compliance period (C2ES 2014). The program's legal authority was granted to it by the state legislature when they passed the California Global Warming Solutions Act of 2006 (AB 32), requiring the state to reduce emissions to 1990-levels by 2020 (427 MMT). California must reduce emissions by roughly 80 million metric tons of carbon dioxide equivalent ($CO_2$-e) by 2020 as compared to a business-as-usual emissions growth pathway (507 MMT). California made addressing climate change a top political priority under the leadership of both Republican Governor Schwarzenegger and Democratic Governor Brown. The state has other complementary policies aimed at reducing GHG emissions, including a 50 percent renewable portfolio standard (RPS) by 2030, the low-carbon fuel standard (LCFS) that sets annual carbon intensity standards for transportation fuels, the carbon tailpipe standard that imposes stringent fuel economy standards for vehicles, the zero emission vehicle (ZEV) mandate and appliance efficiency standards (http://climatechange.ca.gov/).

The cap-and-trade program is multi-sectoral and applies to all industrial plants that emit 25,000 $MTCO_2$-e per year or more (California Air Resources Board 2011). The cap covers all six major GHGs, in addition to a number of other inorganic warming compounds. Regulated sectors under phase one, from 2013 to 2014, covered roughly 35 percent of California's total emissions, and under phase two, from 2015 to 2017, cover roughly 85 percent of emissions, approximately 395 $MMTCO_2$ (C2ES 2014).

Of particular note, the California cap-and-trade program covers emissions from transportation fuels, natural gas, and other fuels, in addition to electric generators and industrial emitters (CARB 2011). Covered entities must surrender allowances or offsets equal to 30 percent of annual emissions from their previous year's emissions total and the remainder at the end of the compliance period. The allowance allocation method varies depending on the type of the entity. For electric utilities, industrial facilities, and natural gas distributors, CARB allocated allowances freely, with a declining total over time. For other covered sectors, such as transportation, natural gas extraction, and other fuel sources, allowances must be purchased at auction or through the allowance trading platform (C2ES 2014).

CARB established an Allowance Price Containment Reserve that maintains an increasing amount of allowances to serve as a price stabilization mechanism (regulators can remove or add allowances as necessary to maintain a certain price level), as well as an emergency reserve. Ten percent of allowances are auctioned annually. The revenue has been subsequently appropriated by the state legislature to the Greenhouse Gas Reduction Fund, where the revenue is allocated to fund a number of projects within the climate change nexus. The allowance floor price was set at $10 in 2012, with a 5 percent annual escalator, plus inflation, and as of 2017, allowance prices were $13.50 a ton. (californiacarbon.info). Through fiscal year 2017, the state raised roughly $3.385 billion in revenue through auctions, and these revenues were spent on high speed rail, low-carbon transit, low-income weatherization, and conservation efforts (California Climate Investments 2017). GHG emissions from these investments projects outside of regulated sectors under the cap-and-trade policy are expected to reduce emissions by 15 MMT $CO_2$-e (California Climate Investments 2017).

A final notable feature of the California cap-and-trade program is its international linkage with the cap-and-trade pricing scheme in Québec beginning in 2014. California originally planned to expand its cap-and-trade program via the Western Climate Initiative, but so far this initiative has not materialized (Houle et al. 2015). Québec was motivated to link with the California market out of concerns about liquidity due its relatively small economy and already-low level of emissions. The systems were fairly easy to link due to transparent communication between the two governments, going as far back as 2008 (Benoit, J. and Cote, C. 2015). California and Québec created a common, electronic allowance registry to avoid gaming and potential double-counting. Strong verification and data accuracy safeguards were put in place to ensure the integrity of allowance credits, in addition to that of the offsets. To maintain price stability, the price floor is set at the highest minimum price of either region, in US dollars. Québec also maintains an allowance reserve, priced at the same value as California's, in the case of increased demand for allowances. There is little evidence to suggest that there is active or robust trading occurring between the two marketplaces so far due to the lack of reporting on international transactions. Currently, there is talk of Ontario joining the California and Québec carbon market, with Ontario's Premier Kathleen Wynne signaling that she intends to link up their markets in the coming years (Reuters 2015).

Developing strong public support for the cap-and-trade program was crucial to successful implementation. The California cap-and-trade legislation enjoys broad public support within the state, as seen by the failure of a 2010 ballot initiative that would have suspended the program if the state's unemployment rate rose above 5.5 percent (EDF & IETA 2014) In addition, a July 2016 poll found that 54 percent of state residents were in favor of the program, even if it raises consumer prices (Public Policy Institute of California 2016). Finally, in September 2016, Senate Bill 32 was approved, requiring CARB to pursue policies to reduce emissions by 40 percent below 1990-levels by 2030 (Senate Bill No. 32, Chapter 249, 2016). This ambitious legislative policy gives CARB and other state agencies the authority to drive emissions even lower than other legislated reductions, and beyond what the cap-and-trade program is designed to do.

The results of the California cap-and-trade experience indicate that the program is inducing emissions reductions in covered sectors. According to reported GHG emissions data, covered entities have steadily reduced emissions, with total emissions attributable to the cap-and-trade program being 9 percent under the 2014 cap (CARB 2017). Final data on phase two emissions reductions will not be available until after the compliance period ends in 2017.

### Noteworthy features

The cap-and-trade program is notable for its transparency, accountability, and rigorous monitoring of allowances, offsets, and actual emission reductions. CARB and the California Energy Commission ensure this transparency through careful monitoring and evaluation. The program allows for flexibility and price stability through a number of mechanisms. The use of offsets and international linkage with the Québec market increased the number of entities who could trade allowances, in addition to expanding potential offset markets. Price stability is ensured through the minimum allowance floor price, as well as the allowance price containment reserve. While allowance price volatility was more extreme prior to 2014, allowance auction prices have stabilized at around $13 per ton (Calcarbondash.org). Free allocation of allowances built political support in the initial stages of the program and allowed for greater allowance auctioning later (Schmalensee and Stavins 2017). In addition, California grants free allowances to energy-intensive, trade exposed industries in order to stem leakage and avoid competitive disadvantages.

**Constraints**

Legal challenges may undermine the success of the program and result in lower-than-expected auction proceeds and price volatility. A long-standing lawsuit by the California Chamber of Commerce claimed that CARB did not have the proper legislative authority, under AB 32, to raise revenue from the auctioning of allowances. They also claimed that auctioning allowances represented a tax and would require additional legislative approval. In April 2017, California's 3rd District Court of Appeals ruled that the cap-and-trade program does not represent an illegal tax and upheld the state's right to auction allowances (California Chamber of Commerce et al., v. State Air Resources Board et al. 2017). The decision could be appealed to the California Supreme Court and the litigants have indicated that they are considering that possibility (LA Times 2017). The second legal challenge is that the program must be reauthorized after 2020. The legislative authority for the program comes from the 2006 Assembly Bill 32, which only authorizes climate change mitigation efforts out to 2020. There is uncertainty about the legislative prospects of extending the program's authorization.

The issue of emissions leakage and utility resource shuffling are policy challenges that some believe threaten the integrity of the California cap-and-trade program (Cullenward 2014). Resource shuffling occurs when a regulated entity such as a utility, swaps a polluting resource with a cleaner resource and claims the emissions allowances as a reduction in overall emissions, when in fact, overall emissions have not fallen under the cap.[2] While initial CARB program policies banned the practice, after significant industry pressure, CARB allowed for special exemptions that allow for resource shuffling (Cullenward and Weiskopf 2013). California imports large amounts of electricity, roughly 33.5 percent in 2015 (much of it either coal or natural gas based), from other Western states that do not have carbon pricing mechanisms (California Energy Commission 2017). This practice allows regulated California utilities to switch from dirtier to cleaner electricity resources by rearranging ownership or contracts with out-of-state generators, and to then claim the difference in emissions as reductions in firm-level emissions. Estimates of the potential leakage range from 120 to 360 $MMTCO_2$-e in total measured emission reduction under the cap-and-trade program, a not insignificant amount in light California's overall emissions reduction goals (Bornestein et al. 2013).

Some experts have stressed that California's complimentary emissions reduction policies such as vehicle emissions standards, renewable portfolio standards, energy

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[2] Formally, CARB, in 2012, defined resource shuffling as ”any plan, scheme, or artifice to receive credit based on emissions reductions that have not occurred, involving the delivery of electricity to the California grid.” Cal. Code Regs., tit 17, § 95802(a)(250).

efficiency programs, and non-carbon GHG emissions reduction programs, undermine the proper functioning of the cap-and-trade scheme. This creates potential market uncertainty as regulated entities may not know if the state will meet it complimentary policy goals and obligations in the future, and what effect that will have on allowance prices (EPRI 2013). Other cap-and-trade programs, most notably the EU ETS program, have complimentary energy and environmental policies as well.

The final challenge identified is related to offsets. The California Air Resources Board allows for six distinct categories of emissions reducing projects that meet their eligibility requirements, to qualify as emissions offsets. The California cap-and-trade program allows for regulated entities to offset up to 8 percent of their emissions total through the use of approved carbon offsetting projects within the United States or Québec (C2ES 2014). This amount is larger than what is allowed for under the northeastern Regional Greenhouse Gas Initiative, but less than the use of offsets allowed under the European ETS. Some have argued that the challenges of additionality, evaluation, measurement, and verification posed by offsets can undermine the integrity of carbon pricing markets (GAO 2011).

## 5.3. QUÉBEC'S CAP-AND-TRADE

With the election of Prime Minister Justin Trudeau in 2015, Canada made carbon pricing central to its national and international climate change goals and commitments. In March 2016, Canada's Prime Minister and First Ministers issued a joint statement, the Vancouver Declaration, which established a comprehensive national policy and identified carbon pricing to be the favored policy approach (Vancouver Declaration 2016). Three Canadian provinces, Alberta, British Columbia, and Québec implemented different types of carbon pricing before the Vancouver Declaration and others have since announced plans to do so, starting with Ontario.

The Québec cap-and-trade program represents a collaborative regional, national, and international effort to implement a wide-ranging carbon pricing scheme. In 2009, the government of Québec adopted an emissions reduction goal of 20 percent below 1990 levels by 2020. This step, along with joining the Western Climate Initiative (WCI) in 2008, led to the adoption of an emissions trading scheme in 2011, with the program's first compliance period beginning in 2013. In 2014, the program formally linked with California's cap-and-trade system, creating the largest carbon market in North America, and the first sub-national carbon pricing programs to link internationally (EDF et al. 2015).

As already discussed, in many ways, the Québec cap-and-trade mirrors the California cap-and-trade program. Québec's cap was initially set at 23.2 MMTCO$_2$-e and increased in 2015 to 65.3 MMTCO$_2$-e when the program was expanded to include additional sectors. The cap is lowered at a rate of 4 percent a year in order to meet the province's 2020 emissions reduction goal (EDF et al. 2015). Similar to the California program, the Québec cap-and-trade program covers all six major GHGs. During the first compliance period (2014-2015), the program covered roughly 28 percent of provincial emissions. Coverage was expanded during the second compliance period (2015-2017) to cover approximately 85 percent of emissions from 132 entities emitting more than 25,000 tons of $CO_2$-e per year (International Carbon Action Partnership 2017).

Free allowance allocation during compliance period one was based on a regulated entity's historical emissions intensity from 2007 to 2010. During the second compliance period, the total amount of freely allocated allowances decreases by 1 to 2 percent per year. Remaining allowances are auctioned four times a year, with the price floor being the highest minimum price between the California and Québec carbon markets.

Again, similar to the California cap-and-trade, the Québec cap-and-trade has an allowance price containment reserve which holds an increasing percentage of un-auctioned allowances in order to serve as a price stabilizing mechanism. If allowance prices rise too quickly, then the reserve can sell allowances to regulated entities; the reserve also serves to manage the amount of unsold allowances in the market (Government of Québec 2015).

**Noteworthy features**

Stringent and transparent monitoring, reporting, and verification standards exists to ensure the integrity of the cap-and-trade program. Severe monetary and criminal consequences are possible for non-compliance, fraud, under-reporting, or failure to surrender credits (Environment Quality Act 2015).

Revenue raised from thirteen auctions, nine of which have been held jointly with California, goes to the Québec Green Fund, a dedicated fund to enhance carbon emission reductions. The cap-and-trade program is expected to raise $3.3 billion by 2020, with funds allocated to a number of environmental initiatives (EDF et al. 2015). While it is too early to know definitively how much the program has reduced provincial emissions by, 2013 estimates show a 7.5 percent decrease from 2005 levels (Second Biennial Report on Climate Change 2013).

**Constraints**

Due to the relatively small number of emitters in Québec, few attractive opportunities exist to reduce emissions from either the electric or manufacturing sectors. With fewer opportunities to reduce emissions, the marginal costs of complying with the emissions reduction cap is higher in Québec than in California. In the absence of linkage, allowance prices were estimated to be between $37- 43 a ton in 2013, almost three times the current price for tradable allowances (Purdon, Houle, and Laschapelle 2014). Linking with the California system allowed the Québec cap-and-trade market to increase its market liquidity through increased access to allowances, with analysis indicating that Québec could potentially purchase between 14.4 to 18.3 million allowances from California, based on projected demand for allowances (CARB 2012). Ontario, which recently inaugurated its cap-and-trade program, announced plans to link up with Québec and California in 2018, which will further increase the total number of tradable allowances and offsets (IETA 2017). This highlights the benefits of linking cap-and-trade markets for small markets that may not see high levels of trading due to low emissions and demand for allowances. By linking markets, low emitters, like Québec and Ontario, are able to further reduce emissions under the cap by purchasing cheaper allowances from high emitting markets, like California.

## 5.4. REPUBLIC OF KOREA'S ETS

In 2009, at the Copenhagen COP15, then- President Lee Myung-Bak announced a national emissions reduction target of 30 percent by 2020 under a business-as-usual scenario. This pledge became a symbol of Korea standing at the forefront of green-growth initiatives. Subsequently, the 2012 Act on "Allocation and Trading of Greenhouse Gas Emissions Allowance" first introduced an emissions trading scheme, set to begin operating in 2015. On January 1, 2015 Korea launched its nationwide emissions trading scheme (KETS). KETS covers about 573 million tons of $CO_2$-e, two thirds of  Korea's total emissions (Sopher and Mansell 2013) from 23 sub-sectors with 525 of the country's largest emitters regulated for direct emissions of six Kyoto gases as well as indirect emissions in the electricity sector (PMR 2015). In the electricity sector, KETS assigns allowance obligations both upstream at electricity generation and downstream at electricity consumption, requiring an accounting system and a cap number that accommodates two allowance units for each unit of emissions from electricity generation and consumption (PMR 2015). Allocations were entirely free and allowances were granted to firms based on their historical GHG emissions, except for the cement, refinery and domestic aviation industries, for which the government benchmarked historical activities to allocate permits.

### Noteworthy features

The Korean government followed a careful approach to the rollout of its ETS by legislating laws with clearly defined timelines, establishing a strategic governance architecture to make up for the weak position of the Ministry of Environment, creating a relatively independent Allocation Committee to oversee the market, imposing market stabilizing measures to maintain allowance price stability, and providing support to compensate for losses made by entities participating in KETS (Oh et al. 2016). KETS is to be rolled out in three phases 2015-2017; 2018-2020; 2021-2025 with annual compliance, unlimited banking, and 10 percent borrowing within phases. Phase 1 of the KETS allows for domestic offset (Certified Emission Reduction (CER) credits) of up to 10 percent of an entity's compliance obligation, from the CDM and carbon, capture and storage project implementation that occurred after April 2010. In Phase 1, the government allocated a total of 1,598 million KAUs (each Korean Allowance Unit equal to 1 ton of $CO_2$-e) to 525 entities, to be traded between 2015 and 2017, while holding 89 million KAUs as reserve to be deployed in the event of an overheated market (Song et.al 2015) or to provide to new entrants and entities that earned early action credits. KETS follows a detailed set of conditions under which the Allocation Committee can intervene in the market without requiring permission from the legislature. Prior to KETS, the Korean government launched a GHG and Energy Target Management System (TMS); a mandatory negotiated agreement aimed at curtailing energy use and GHG emissions, thereby easing firms in to the process of monitoring and verifying emissions data (Oh et.al 2016). KETS also imposes a non-compliance penalty of three times the average market price in a given compliance year or up to EUR €70 a ton (PMR 2015).

**Constraints**

There are three main concerns related to the successful operation of the existing KETS design. First, regulating emissions upstream and downstream in the electricity sector necessitates a complex accounting system that accommodates two allowance units for each unit of emissions reduced (PMR 2015). Although KETS is trying to circumvent its price-regulated power sector and transfer a part of the compliance cost to consumers, the process may run the risk of double counting emission reductions (Oh et.al 2015). Relatedly, because KETS requires downstream fleets in the transport sector to report fuel use, there is a risk of increased leakage from fleets shifting towards unregulated vehicles (PMR 2015). Second, allocations were calculated primarily in conjunction with the country's manufacturing businesses, excluding the views of civil society and environmental organizations, raising questions about whether the appropriate emission targets were set (Kim 2016). Lack of confidence in the system creates popular uncertainty as to whether KETS will help Korea achieve its NDC commitment of 37 percent emission reductions below BAU (i.e. 22 percent below 2012 levels) by 2030.

Finally, the KETS marketplace suffers from a lack of active trading. No transactions took place between January and October 2015 and the total volume in 2015 was only 0.3 million tons $CO_2$-e, representing a tiny share of the total 573 million tons $CO_2$-e cap. In spite of the government auctioning 0.9 million tons $CO_2$-e from the allowance reserve in June 2016, relaxing rules for entities to earn credits from emissions reductions achieved prior to joining KETS and increasing future borrowing limit to 20 percent (World Bank 2016), there has been little or no activity in the market place. In 2015 and 2016, the price threshold was around KRW 10,000 (EUR 7). The borrowing limit was increased from 10 to 20 percent and an additional nine million allowances were made available from auction at a reserve price of KRW 16,200 (EUR 12). As of June 2016, the allowance price was KRW 17,000 (EUR 14) with little or no transactions in the marketplace (ICAP 2016).

## 5.5 CHINA'S PROVINCIAL ETS PILOTS

In 2011, the Chinese government initiated seven pilot carbon emission-trading programs at the city or provincial levels. These pilots were required to launch by 2013 and fully initiate by 2015 (Zhang et al. 2014). In 2015, President Xi Jinping announced, as part of a joint statement with the United States, that China's central government would establish a national emissions trading program by 2017, after learning from these pilot programs. This paper draws lessons from the seven Chinese pilot programs, as the national program has yet to be transparently elaborated as of the time of this writing.

The seven pilot programs were in Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Guangdong, and Hubei and they all only capped carbon dioxide and no other greenhouse gases (Dong et al. 2016). The pilots' ETS designs varied widely, "reflecting diverse circumstances and priorities in the localities where they are implemented" and covered 7 percent of China's total emissions as of 2010 with 2,535 entities covered. Nearly all of the permits were given away for free rather than auctioned, except for a small number that were auctioned in Guangdong, Shenzhen, and Hubei (Guangdong was the only pilot to use auctioning — 5 percent — in the first compliance period) (Dong et al. 2016). All of the pilots accepted offsets generated through Certified Emissions Reductions outside the pilot regions (Zhang et al. 2014).

**Noteworthy features**

As of August 2014, the average trading price across the seven pilots was \$6.7/ton $CO_2$-e (Yu and Lo 2015). During the first compliance period the trading prices in the different pilots ranged between \$2.50 and \$11.50/ton $CO_2$-e (Dong et al. 2016).

**Constraints**

Problems identified with the pilots include, "poor GHG measuring and reporting practices, incomplete legal frameworks, noncompliance, ineffective enforcement, low penalties" as well as illiquidity with low trading volumes in some pilots (Yu and Lo 2015). The maximum allowable fine for non-compliance was only 100,000 RMB (\$14,459 at 2017 exchange rates) per enterprise, which is not seen as an effective deterrent (Zhang et al. 2014) and most of the pilot ETS programs imposed far smaller non-compliance fees (Dong et al. 2016).

Significantly, a survey of Chinese firms conducted in 2015 revealed that the carbon price failed to "stimulate companies to upgrade mitigation technologies" and that the majority of firms considered participation in the ETS pilots as a means of improving ties with governments and earning a good social reputation rather than as a cost-effective mechanism to mitigate greenhouse gas emissions (Yang et al. 2016).

# 6. National & Sub-National Policies: Carbon Tax and Hybrid Systems

In this section, we describe the design and implementation features, constraints and other issues faced by carbon tax systems in British Columbia, Mexico, Chile, Japan, India, Norway and Ireland. We selected these initial cases to cover carbon tax implementations that varied in their sectoral coverage (i.e. economy wide in British Columbia to partial coverage in Chile), taxation on carbon content of the fuel instead of direct carbon emissions (i.e. Mexico, Norway), taxation on one particular source of fuel (i.e. India), revenue redistribution (i.e. revenue neutral in British Columbia versus earmarking of revenue to clean energy investments in Japan and India) and the presence of a hybrid with cap-and-trade systems (i.e. Norway and Ireland). Similar to the cap-and-trade case studies, our carbon tax case studies represent diverse geographies and span across time, allowing us to observe learning and knowledge spillovers, if any, from older to newer policy implementations.

## 6.1. BRITISH COLUMBIA'S CARBON TAX

British Columbia has the longest running carbon tax policy in Canada, allowing for a robust analysis of the greenhouse gas reducing effects, as well as the economy-wide effects of its carbon pricing policy. Inaugurated in 2008, the Carbon Tax Act created a revenue-neutral carbon tax starting at $10 Canadian dollars per ton of $CO_2$-e, and increased $5 a year until it reached $30/ton in 2012, where it stands today (Government of British Columbia 2016). The tax covers 70-75 percent of all provincial GHG emissions from facilities that emit more than 10,000 tons of $CO_2$-e per year, including emissions from liquid fossil fuels, natural gas, coal, and other greenhouse gases such as methane, nitrous oxide, and land-use change emissions (Murray and Rivers 2015). One important caveat is that while the BC carbon tax covers the electric sector, almost 90 percent of the province's electricity comes from large hydroelectric power, and the electric sector accounts for less than 3 percent of total emissions (Carbon Tax Center 2015). Several sectors are exempt from the carbon tax, including fuels exported from BC; emissions from shipping and air travel; emissions from agricultural production; all non-fossil fuel GHG emissions from industrial processes, landfills, forestry, and agriculture; and methane leakage from the production and transport of natural gas.

### Noteworthy features

A defining feature of the BC carbon tax is that it was implemented as a revenue-neutral tax. This design decision won support from the business community. According to the Ministry of Finance, the total estimated carbon tax revenue collected between 2008 to 2015 was $7.3 billion, with revenue allocated toward low-income tax credits, a 5 percent reduction in the two lowest personal income tax brackets, direct cash transfers to Northern and rural residents, a reduction in corporate and small business tax rates, as well as an industrial property tax credit (Ministry of Finance).

Overall, data indicate that British Columbia's carbon tax has successfully reduced emissions, while having few negative effects on the economy as a whole (Murray and Rivers 2015 and Metcalf 2015). The 2008 Climate Action Plan estimated that the carbon tax would reduce emissions by 3 MMT of $CO_2$-e annually (Climate Action Plan 2008). An analysis of several different models shows that the carbon tax reduced emissions between 5 to 15 percent, absent any additional policy, when compared to a business-as-usual scenario (Murray and Rivers 2015). The province decreased per capita emissions by 12.9 percent by 2013 when compared to pre-carbon tax levels, more than three-and-a-half times more than the 3.7 percent per capita decline in the rest of the country (Metcalf 2015). All in all, the BC carbon tax reduced provincial emissions by an estimated 2.8 million metric tons as of 2015, when compared to the pre-tax period (Carbon Tax Center 2015). GDP growth in British Columbia was higher than the rest of country, with annual average growth between 2008 and 2013 of 1.55 percent compared to 1.48 percent in the rest of the country (Carbon Tax Center 2015).

### Constraints

Carbon pricing mechanisms have the potential to raise significant quantities of government revenue. The British Columbia carbon tax raised $7.3 billion in revenue between its inception and 2015. One potentially concerning development are exemptions, from 2014 onward, for particular sectors such as the agricultural and cement sectors (Murray and Rivers 2015). In one instance, the Cement Association of Canada secured a one-time, $22 million transition incentive for the BC cement industry (PRNewswire 2015). This may establish a precedent whereby economically threatened industries lobby for targeted subsidies and incentives, while maintaining their current level of emissions. Carbon tax favoritism could undermine popular support for the policy. To protect emissions-intensive, trade-exposed sectors like the cement industry, British Columbia could consider a border carbon adjustment that would help protect the competitiveness of BC manufacturing, while maintaining the integrity of the province's carbon tax.

## 6.2. MEXICO'S CARBON TAX

In 2013, as part of a broader fiscal reform effort, Mexico became the first Latin American country to establish a carbon tax. This carbon tax builds on the national climate change law approved by the Mexican Congress in 2012, with the goal of reducing greenhouse gas emissions by 30 percent by 2020 and 50 percent by 2050. The law mentioned carbon taxes as a potential instrument to achieve this goal (Mexico Congress 2012).

The primary goal of the carbon tax is to increase popular awareness of $CO_2$ emissions and to foster the use of cleaner fuels. It levies a tax rate on the sale and import of fossil fuels that varies depending on their carbon content as compared to the baseline emissions from natural gas. Therefore, the tax on natural gas is zero; additionally, fuel oil and jet fuel are exempt (IEPS Law 2013).

The original government proposal covered all fossil fuels — including natural gas, with an effective average tax rate of USD $5.70 per ton of $CO_2$-e. The Congress introduced changes in order to garner political support, establishing a new effective average tax of $3.21 per ton of $CO_2$-e and limiting the rates at a 3 percent of the sales price for each fuel (OECD 2014). The initial rates for taxed fuels ranged from $0.43 to $3.44 per ton $CO_2$-e (for the specific final tax rate for each fuel and a comparison with the rates initially proposed see Table 1) (Metcalf 2015).

Examining the administrative process of implementing the carbon tax, it is similar to a valued added tax (VAT) mechanism where the tax is paid at the production or import stages (upstream tax), not at the point of final sale, or the retail level. The Mexican revenue collection agency (SAT, by its Spanish acronym) is responsible for collecting and auditing the tax, as with other taxes (Muñoz Piña 2015). Additionally, the carbon tax design includes an offset compensation mechanism that allows for the use of "certified emissions reduction (CER) credits from Mexican projects for compliance" (IETA 2015) with the carbon tax. To this end, a voluntary carbon exchange (Mexi$CO_2$) was established in November 2013.

**Table 1: Mexico's Carbon Tax**

| Fossil Fuel | | Rate | | Carbon Price | |
|---|---|---|---|---|---|
| **Type** | **Units** | **Initial** | **Enacted** | **MEX$/ton $CO_2$** | **US$/ton $CO_2$** |
| Natural Gas | ¢/$m^3$ | 11.94 | 0.00 | 0.00 | 0.00 |
| Propane | ¢/liter | 10.50 | 5.91 | 39.78 | 2.93 |
| Butane | ¢/liter | 12.86 | 7.76 | 42.10 | 3.10 |
| Gasoline | ¢/liter | 16.21 | 10.38 | 45.26 | 3.33 |
| Jet Fuel & Kerosene | ¢/liter | 18.71 | 12.40 | 46.84 | 3.44 |
| Diesel Oil | ¢/liter | 19.17 | 12.59 | 46.42 | 3.41 |
| Fuel Oil (Heavy & Regular) | ¢/liter | 20.74 | 13.45 | 45.84 | 3.37 |
| Petroleum Coke | $/ton | 189.85 | 15.60 | 5.80 | 0.43 |
| Mineral Coal | $/ton | 178.33 | 27.54 | 10.92 | 0.80 |
| Other Carbon Fuels | Fuel Specific | | | 39.80 | 2.93 |

Source: Belausteguigoitia as cited in Metcalf 2015

### Noteworthy features

Mexico's price-setting regulation mechanism for gasoline and diesel negatively affects the effectiveness of the carbon tax. If world oil prices rise, the result is a subsidy on the retail price of these fuels. This illustrates the importance of fossil-fuel subsidy reform, along with post-tax energy subsidies, which reached $4.9 trillion globally in 2013 (IMF 2015). Mexico is in the process of liberalizing domestic fuel prices by 2018, which will eliminate the current fuel consumption subsidies. The proposed reform is estimated to lead to a 6 percent carbon emissions reduction annually over a business-as-usual trajectory (about 7 million tons of $CO_2$-e) (IMF 2015). Additionally, once the retail pricing reforms are fully implemented, the revenue implications would be significant, with the carbon tax and retail pricing reforms accounting for about 10 percent of total tax revenue (Metcalf 2015).

As a complementary measure to the carbon tax, a voluntary ETS may be established by the Mexican Government in 2018 with the expected participation of 60 national and international companies from the power, industry and transport sectors (Mexican Government 2016). In addition, Mexico advocated and actively fostered regional cooperation in carbon pricing: a North American carbon market linking the Mexican, California, and Québec markets is under discussion, while carbon pricing cooperation options in Latin American are currently ongoing in the context of the Pacific Alliance (comprised by Chile, Colombia, Peru and Mexico) (World Bank 2016). As these plans progress, the Mexican government needs to finalize sectoral and emissions coverage, regulatory and administrative framework, and carbon tax complementarity in the presence of a voluntary and potentially linked ETS regime.

The support of domestic think tanks and NGOs was crucial in the media and policy discussions about the need for a carbon tax. The initiative of taxing natural gas at zero by considering it the "greenest" option facilitated political acceptance of the tax by the Congress (Muñoz Piña 2015). The landmark Climate Change Law approved by the Congress in 2012 paved the way for the carbon tax by explicitly mentioning taxes as a means to achieve its goals. Likewise, the successful implementation of the carbon tax and the subsequent creation of a national emissions inventory registry have, in turn, paved the way for the development of a carbon market.

### Constraints

Since natural gas accounts for about 30 percent of Mexico's energy related carbon dioxide emissions and it is exempted, the carbon tax only covers about two-thirds of Mexico's fossil fuel-related emissions (Metcalf 2015). Additionally, the effective tax rate is the lowest among OECD countries (IMF 2015) and one of the lowest in the world (World Bank 2016). The annual revenues expected at this rate were about $1.1 billion, which represented less than one percent of total federal tax collections (Metcalf 2015). According to the Mexican Under-Secretariat for Revenues, however, the tax revenues collected in 2014 and 2015 added up to approximately $1.2 billion (Muñoz Piña 2015), which implies collection of only about $600 million per year, lower than the anticipated $1.1 billion. Despite the weakness of the price signal, a gradual rate increase over time was not considered in the tax design, and has not been discussed as a possibility for the future (although fuel rates are adjusted annually for general inflation).

According to Belausteguigoitia (Metcalf 2015), the low tax rate was expected to contribute to a modest $CO_2$-e emissions reduction of about 1.6 million tons of $CO_2$-e, representing just 0.33 percent of Mexico's total emissions. Tax revenues are not earmarked and contribute to the general funds (Carl & Fedor 2016) and are not used either for green spending or revenue recycling, which could contribute to the goal of shifting towards the use of cleaner fuels. In fact, since natural gas is exempted, it appears that the Mexican carbon tax encourages "moving to natural gas rather than green energy," particularly when this fuel "is often cheaper than renewable energy alternatives" (Waty 2015). An additional problem relates to the offset mechanism. The regulatory procedure for the use of certified emission reduction (CER) credits to comply with the carbon tax has not yet been developed (IETA 2015).

## 6.3. CHILE'S CARBON TAX

In 2014, Chile approved, as part of a general fiscal reform effort, a carbon tax that will enter into force in 2018. This tax is in line with 2010 Chile's commitment to take mitigation actions to reduce carbon emissions by 20 percent by 2020 as compared to 2007 levels (Benavides et al. 2015). The Chilean carbon tax applies only to the electricity sector and imposes a tax of $5 per ton of $CO_2$-e on emissions from fixed sources (boilers and turbines) with a thermal input greater than or equal to 50 MWT (thermal megawatts). Emitting sources using biomass energy are exempted (Gobierno de Chile 2014).

The main goal of the Chilean carbon tax is to reduce emissions by increasing the price of electricity, which in turn should lead to reductions in energy demand and foster a shift towards less carbon intensive fuels (Benavides et al. 2015). According to the Chilean Ministry of Environment, the tax will cover about 27 percent of the country's total $CO_2$-e emissions, primarily affecting big energy companies such as Endesa or AES Gener (CEPAL 2016). It is expected that the carbon tax will contribute to a $CO_2$ emissions reduction of 3 million tons by 2020 and 6 million tons by 2030, representing 6 percent and 11 percent respectively of total projected emissions from electricity generation. Additionally, the tax is expected to impose an additional cost of energy of about 3 percent, which would translate into approximately 2 percent of the current cost of the residential tariff (Borregaard 2014).

As for the administrative aspect of the carbon tax, the law mandates the creation of an inventory of the emissions from the sources affected by tax in 2017 prior to the tax entering into force. The Chilean internal revenue service (SII, by its Spanish acronym) will be the responsible agency for collecting the tax revenues, while the Environment Superintendence will be responsible of monitoring emissions and sanctioning non-compliance according to the fiscal general procedures (Ministerio del Medio Ambiente de Chile 2016).

Revenues are expected to be reinvested in education and modernizing the nation's electric grid to bring more renewable energy online (Villarreal 2016). However, the law does not mention earmarking, so it remains to be seen how the revenues will actually be allocated.

### Noteworthy features

The tax specifically targets carbon emissions from the electricity sector, which is responsible for the highest proportion of emissions and more than doubled between 1990 and 2010. The electricity sector, along with the transport and industry sectors, represented 77.2 percent of total emissions in 2013 (Benavides et al. 2015).

While the current carbon tax might have a weak emissions-reduction effect, it should be noted that a senior official of the Chilean Ministry of Environment declared that it is possible that the carbon tax will be amended to ensure its effectiveness. Likewise, the potential establishment of an emissions trading system could be established to complement the carbon tax (Electricidad 2017). Furthermore, the Minister of Environment stated in 2015 that as the country builds its emissions monitoring, verifying, and reporting infrastructure as part of the carbon tax implementation process, a scale up of the tax or the establishment of an emissions trading system could be an option (CarbonPulse 2015).

### Constraints

The prevailing low tax rate represents a potential constraint for Chile to encourage companies to shift to cleaner fuels and invest in clean energy generation. It is believed that energy companies will simply pass the higher cost on to households and smaller companies (CEPAL 2016). A recent study concludes that a tax rate of about $26 per ton of $CO_2$ would be the optimal tax for Chile, and that it should be accompanied by a target to achieve a 50 percent carbon-free energy mix, which could be supported by investments using the tax revenues (López et al. 2016).

CEPAL (2016) recommends increasing the tax rate progressively in pre-defined stages in order to better reflect the social cost of $CO_2$ emissions, as well as to include other intensive emission sources, such as copper smelting and other industrial plants which currently are not covered. Likewise, an assessment of the interaction of the carbon tax with the electricity price-setting regulations is necessary to ensure the effectiveness of the tax. An emissions trading system including emitters not covered by the tax would be a potential complementary measure to contribute to the country's 2020 emission reductions goal.

## 6.4. JAPAN'S GLOBAL WARMING TAX

In 2010, the Japanese government passed the Basic Act on Global Warming Countermeasures (GW Basic Act), which established climate policy as a pillar of Japan's policymaking on par with energy and environmental policy. The major proposed policies were a carbon tax, a nationwide cap-and-trade system, and a feed-in tariff scheme. Subsequently, in October 2012, the Japanese government introduced the Global Warming Countermeasures Tax (GW Tax), an upstream environmental tax on fossil fuels that added surtax to existing taxes on petroleum, gas and coal products (Kuramochi 2015). Japan also introduced a feed-in tariff scheme as proposed in the GW Basic Act, but failed to introduce a nationwide cap-and-trade system.

The Ministry of Finance (MOF) is tasked with collecting the GW tax. Revenue is earmarked, through a dedicated fund, for the promotion of low carbon technologies and energy efficiency. The MOF subsequently disburses money to the Ministry of Environment (MOE) and Ministry of Economy, Trade and Investment (METI) to relevant projects (PMR 2017) as illustrated in table 2. The GW tax covers about 70 percent of Japan's GHG emissions with a low carbon price of about \$3 per ton of $CO_2$ as of 2017. The tax was phased in from 2012 to 2016 in three steps from JPY 95 per ton of $CO_2$ (USD 0.95) in October 2012 to JPY289 per ton of $CO_2$ (USD 2.89) by April 2016 (MOEa 2012), with no proposals to increase the tax rate any higher. Electric utilities are not exempt from the tax, but are allowed to pass the tax on to consumers through a fully distributed cost method, allowing utilities to recover additional expenses incurred from the tax (Kuramochi 2015). All fossil fuels that were exempted from the general Petroleum and Coal Tax before October 2012 continue to be exempt from the GW tax, including imported coal used for the production of iron and steel, coke and cement, and volatile oil feedstock for the production of petrochemical products (Kuramochi 2015). In addition, the agriculture, forestry, air, rail and maritime transport sectors are excluded from the GW tax. The MOE estimates that the tax would result in both a price induced and budget induced $CO_2$ reduction of 0.5 percent to 2.2 percent of the 1990 level emissions (i.e. from 6 to 24 million tons of $CO_2$) by 2020 (MOEb 2017).

**Noteworthy features**

In 2016, the special account received JPY 596 billion (USD 5.37 billion) and disbursed JPY 155 billion (USD 1.39 billion) to MOE and JPY 367 billion (USD 3.3 billion) to METI (MOEb 2017). Since introducing the GW tax, the Japanese government has efficiently used the earmarked funds to address distributional risks associated with the GW tax by offering subsidies to small and medium enterprises (SMEs) and individuals to reduce the simultaneous burden resulting from a tax and Feed in Tariff (FIT) surcharge. In addition, the government spent the earmarked revenue by funding energy saving and end-use energy efficiency programs, indirectly funneling revenue back to SMEs and individual consumers (see Table 2). Finally, the special tax fund has supported RD&D into low carbon technologies including for the increased efficiency of solar PV; RD&D for offshore wind technology and energy saving technologies (see Table 2).

**Table 2: Sample of investments from the special GW tax fund in 2017**

| METI projects | 2017 Funding Allocations (in million USD) |
|---|---|
| Subsidies for reducing FIT surcharge | 435 (in 2016) |
| Subsidies for energy saving projects | 102.7 |
| R&D for energy saving technologies | 86.5 |
| Energy saving manufacturing | 8.1 |
| Subsidies for fuel efficient vehicles | 126 |
| RD&D for more efficient solar PV | 69.3 (in 2016) |
| RD&D for offshore wind technology | 21.6 |

Source: METI 2017

### Constraints

Questions remain regarding whether Japan's existing tax rate and revenue use will help achieve emissions reductions necessary to realize its NDC goal of 26 percent emission reductions below 2013 levels by 2030 without compromising GDP growth. Some academics believe that if Japan uses the GW tax revenue to reduce taxes on labor and income, it may increase GDP while achieving the same emissions reductions, reinforcing the double dividend argument (Takeda et al. 2014; Kawase et al. 2003). Others suggest a combination of significant revenue recycling and some earmarking (Lee et al. 2012). The GW tax plan does not mention whether the tax of \$3 per ton of $CO_2$ will be increased in the future, showing that this modest tax rate is not coupled with the expectation of a rising tax over time. If taxes were scheduled to rise, firms might be induced to change their behavior or alter investment decisions in anticipation of higher future tax rates. Unlike the Scandinavian countries with ambitious carbon tax rates and revenue recycling to reduce income taxes, Japan's GW tax seems to neither maximize the price effect with high tax rates nor greatly accelerate significant emissions reduction through substantial use of tax revenues to invest in innovation of low carbon technologies.

Finally, after the Fukushima nuclear disaster, Japan's closure of nuclear power plants has increased the amount of imported coal use in electricity generation, making the GW tax even less effective in reducing the inelastic demand for imported coal. Pollitt et.al (2014) estimate that achieving 25 percent emissions reduction from 1990- levels with zero nuclear energy in the mix would require a very high carbon tax of \$506 per ton $CO_2$-e, much higher than the current \$3 per ton (Pollitt et. al 2014). Overall, questions remain as to whether there is the political willingness in Japan to increase the price ambition, recycle revenues effectively to achieve maximum emission reductions, and continue using nuclear power in Japan's energy mix.

## 6.5. INDIA'S COAL TAX

The government of India introduced an upstream tax on coal (aka. Clean Energy Cess) in 2010, with an initially assessed tax of Rs.50 (~USD $1 per ton of coal). Subsequently, the union government budget of 2014 and 2015 doubled and quadrupled the tax from its base rate first to Rs.100 ($2 per ton) and then to Rs.200 ($4 per ton) respectively. The tax was further increased to Rs.400 ($6 per ton) in the union budget of 2016-17 and was been renamed as "Clean Environment Cess" instead of "Clean Energy Cess" (MOF 2016).

**Noteworthy features**
Coal producers and importers are required to report the quantity of fuel mined or imported on a monthly basis. Excise officers are tasked with inspecting the premises of registered coal producers and auditing records for compliance. The penalty for non-compliance is three times the tax assessed on coal (i.e. $18 per ton of coal) (PMR 2017). The government does not exempt any coal producer except for coal mined by local tribes in the state of Meghalaya.

The coal tax revenue is allocated to the National Clean Environment Fund (NCEF) and earmarked for investments in both clean energy and environmental conservation. The NCEF is managed by an Inter-Ministerial Group (IMG), that consists of senior government officials representing the Ministry of Finance and the power, coal, fertilizers, petroleum and natural gas, new and renewable energy, and environment and forests sectors (Cottrell et.al 2013). Individuals and organizations in the public and private sector are allowed to apply for funding for projects that are related to clean fossil energy, renewable/alternative energy, energy infrastructure, or installation of energy-efficient technology (PMR 2017). Table 3 shows the amount of tax collected and disbursed for projects through NCEF since 2010 (MOF 2016).

**Table 3: Tax collected and disbursed out of the NCEF fund**

| **Year @ Tax $ per ton** (in million USD) | **Tax collected** | **Financed by NCEF** |
|---|---:|---:|
| 2010–2011 @ $1 per ton | 164 | 0 |
| 2011–2012 @ $1 per ton | 397 | 3.3 |
| 2012–2013 @ $1 per ton | 471 | 3.8 |
| 2013–2014 @ $1 per ton | 535 | 187 |
| 2014–2015 @ $2 per ton | 831 | 322 |
| 2015–2016 @ $4 per ton | 1947 | 808 |
| 2016–2017 @ $6 per ton | 4030 | N/A |
| **Total** | **8389** | **1392** |

Source: MOF 2016

**Table 4: Sample of projects that received funding from NCEF**

| Projects approved by IMG | Year | Approved Amount (in million USD/percent of total project cost) |
|---|---|---|
| Additional subsidy for solar lantern charging facility and rice husk based gasifier system in remote rural areas | 2011 | 2.06 / 100% |
| Installation of Solar Thermal Systems in 16 States | 2011 | 9.9 / 36% |
| Installation of Solar PV systems in 6 states | 2011 | 13.3 / 42% |
| Green India Mission – National Afforestation | 2016 | 16 / 100% |
| Ganga River Rejuvenation Plan | 2016 | 348 / 100% |

Source: MOF 2016; Panda and Jena 2012

### Constraints

It is unlikely that the current tax alone is high enough to support India's ambitious NDC goal of 40 percent non-fossil fuel energy mix by 2030. Although it is not practical to expect reaching 40 percent non-fossil target only with a coal tax, higher coal tax levels ($18 per ton) and recycling of revenues to solar, wind and agriculture could increase the share of renewables to at least 16 percent with a positive impact on GDP (Ghosh 2016). Second, there are concerns about the effectiveness of the current usage of tax revenue by NCEF. The lack of capacity to develop proposals, unclear eligibility criteria, and under provision for public-private partnerships seem to plague the NCEF mission. In addition, there are inconsistencies between the NCEF's stated objectives, operational guidelines, and actual implementation by the Inter Ministerial Group (IMG) (Pahuja et.al 2014). As per the fund's requirements, a project must be sponsored by a government department, be self-funded by the recipient individual/organization by at least 40 percent, and not received funding from another government agency, in order to be eligible for funding (PMR 2017). However, the IMG has followed an ad hoc approach to approving various projects under the NCEF (Panda and Jena 2012). In some instances, the IMG approved 100 percent funding for renewable deployment projects in remote rural areas, exceeding the 40 percent self-financing requirement (Table 4). As of 2013, half of the projects receiving full funding were deploying mature technologies, and only few projects were conducting research and development into new technologies (Cottrell et al. 2013). The self-financing requirement kept innovators from seeking NCEF money, as it is difficult for new, high risk innovations to raise the initial 40 percent requirement (Panda and Jena 2012).

Third, with the government changing the fund's name from "National Clean Energy Fund" to "National Clean Environment Fund" in 2016, the core NCEF mission of promoting clean energy investment and innovation has been further broadened to include environmental preservation and rejuvenation. In 2016, under this newly added objective, \$340 million was allocated towards Ganges river rejuvenation project (see Table 4). As of 2016, only 16 percent of NCEF revenue has been disbursed, however (see Table 3).

### 6.6. NORWAY'S CARBON TAX WITH EU ETS — HYBRID

Following the publication of Brundtland report, Our Common Future, in 1987 the Norwegian government introduced an upstream carbon tax on oil and gas used for petroleum extraction activities in the continental shelf, HFC/PFC importers, and a midstream tax on oil, natural gas, and LPG fuel suppliers. Sectors such as pulp and paper, fishmeal, domestic aviation, domestic shipping of goods pays reduced rates per ton of $CO_2$. Except for a relatively high tax rate for "natural gas emitted to air" of \$432 per ton of $CO_2$-e, taxes across other fuels and sectors range between \$3.5 and \$64 per ton of $CO_2$-e. Sectors covered by the EU ETS, foreign shipping including oil and gas exports, fishing in Norway and in distant waters, and external aviation sectors are all exempt from the tax (Sumner et.al 2011). The carbon tax covers about 60 percent of Norway's GHG emissions while the EU ETS covers about 50 percent. In total, about 80 percent of Norway's GHG emissions are covered by EU ETS, carbon tax, or both (Bragadóttir et al. 2015). Although EU ETS sectors are exempt from the carbon tax, there seems to be significant overlap between the carbon tax and EU ETS covering the same base emissions in sectors such as electricity (58 percent), industry sector (54 percent) and off-road transport sector (30 percent) (OECD 2014).

Norwegian carbon taxes are authorized by two different laws: The Act concerning sales tax and The Act relating to $CO_2$ tax in the petroleum activity on the continental shelf (Bruvoll and Dalen 2009) and tax rates are reviewed annually. Norway imposes fines and up to three months of imprisonment for non-compliance and charges interest on late payments (PMR 2017).

**Table 5: Carbon tax by fuel and sector in Norway**

| Carbon Tax Sectors (Upstream and Midstream) | Tax on Fuel source (in NOK) | Tax per ton of $CO_2$ (NOK / USD) |
|---|---|---|
| Petroleum activities in the continental shelf – oil, gas, condensate (used in extraction) | 1.04 per liter or cubic meters | Gas – 554 / $64<br>Oil – 392 / $46 |
| Petroleum activities in the continental shelf – natural gas emitted to air (used in extraction) | 7.16 per liter or cubic meters | 3710 / $432 |
| Petrol (at consumption) | 0.97 per liter | 414 / $48 |
| Natural gas (at consumption) | 0.87 per cubic meters | 463 / $54 |
| LPG (at consumption) | 1.26 per kg | 479 / $56 |
| Oil (at consumption) | 1.2 per liter | 452 / $53 |
| Oil for Domestic Aviation (at consumption) | 1.1 per liter | 497 / $58 |
| Oil for Pulp and paper industry, Herring meal, fish meal industries (at consumption) | 0.32 per liter | 120 / $14 |
| Oil for fishing and catching in inshore waters (at consumption) | 0.29 per liter | 109 / $13 |
| Reduced rate for Natural Gas | 0.057 per cubic meters | 30 / $3.5 |
| Exempted sectors – Foreign shipping of oil and gas exports, fishing in Norway and in distant waters, external aviation, EU ETS sectors (except electricity, industry, transport all of which face both tax and EU ETS prices). | N/A | N/A |

Source: RMOF 2017; calculated with $CO_2$ conversion factors from www.eia.gov

## Noteworthy features

Norway has sustained an ambitious tax rate between $3 and $64 per ton of $CO_2$ in different sectors since 1991. In addition, the government also taxes non-$CO_2$ GHG emissions from NOx, SO2, and HFC/PFC. The government has maintained policy stability and created clear price signals for private sector companies willing to invest in clean energy technologies. In addition, the government has used the huge revenue stream to significantly reduce individual income and corporate taxes. In 2004, total energy taxes including revenues from EU ETS sectors made up 28 percent of the government's total tax revenues (Bye and Bruvoll 2008). The revenue from Norway's carbon tax is directed to the general budget to reduce income and capital taxes, reduce labor taxes, and provide pension plans for low-income citizens. With carbon tax revenue and revenue from offshore drilling licenses, Norway has financed a special pension fund that contained

$373 billion or nearly $80,000 for every Norwegian, at the end of 2007 (Turner 2008; Sumner et.al 2011). Traditionally, revenues from regional EU ETS sectors in Norway went towards green subsidies while the carbon tax revenue went towards the country's general budget. However, 2013 annual revenue data showed 30 percent of carbon tax revenue earmarked for green spending and the remaining 70 percent allocated to the general budget. The government earmarked 30 percent of the carbon tax revenue primarily to expand the capital base of its "Green Fund for Climate, Renewable Energy and Energy Efficiency Measures". Currently, the financial returns on this expanded capital base are used to subsidize green projects (Carl and Fedor 2016).

**Constraints**

A government report on environmental pricing in 2015 recommended a significantly higher tax rate on petrol and auto diesel in order to meet the EU target of 30 percent reduction in emissions in non-EU ETS sectors by 2030 (NOU 2015), but the increase has not materialized. Stiff political resistance to raising the tax rate has emerged, making policy changes unlikely in the foreseeable future. (PMR 2017).

Second, the Ministry of Climate and Environment estimated in 2014 that country's total emissions would have been 6-7 million tons $CO_2$-e higher than they were without the tax in place (PMR 2017). Academic scholars, however, are not in agreement about whether Norway's carbon tax policy has had any significant impact on its total emissions. Although Norway has achieved significant carbon emissions intensity reductions, total emissions have continued to rise. Between 1991 and 2008, total $CO_2$ emissions in Norway only increased by 15 percent while GDP grew 70 percent during the same period (Sumner et.al 2011). During that period, however, $CO_2$ emissions from petroleum and natural gas extraction increased 86 percent, while general emission growth was only 6 percent. With inelastic European demand for oil and gas extraction, which is taxed, exemptions for shipping exported oil and gas sold through pipelines, and a domestic energy mix already dominated by hydropower and renewables, the carbon tax does not seem to have created any significant domestic reduction of total emissions (Lin and Li 2011).

Norway's current GHG emissions are 63.5 million tons $CO_2$-e and Norway has a target to reduce emissions by 40 percent below 1990 levels by 2030. In 2016, the carbon tax rate in Norway ranged between $3.5 and $64 per ton of $CO_2$ across different fuel sources and sectors (see Table 5). The Green tax commission has recommended a single tax rate of USD 49 per ton $CO_2$ equivalent for all non-EU ETS sectors (World Bank 2016)

## 6.7. IRELAND'S CARBON TAX WITH EU ETS — HYBRID

In 2010, Ireland introduced a carbon tax on $CO_2$ emissions from most sectors not covered under the existing EU ETS (Irish Finance Act of 2010); including transport, heat for residential sectors, commercial buildings and small industry. However, waste and agriculture emissions were not included. As of 2011, the carbon tax comprised 38 percent of total emissions (Convery et al. 2013).

The carbon tax is levied on fossil fuels when they enter the country, and price increases are, theoretically, passed on to consumers at the point of purchase (Nadel 2016). An analysis of the carbon tax economic incidence found that indirect and direct household costs as a result of non-EU ETS carbon pricing increased expenditures by €182 to €286 a year (Farrell 2015) In addition, this analysis found that the Irish carbon tax was mildly regressive based on both income and household characteristics for home heating expenditures, while being progressively distributed across the income spectrum for electricity and petrol use (Farrell 2015). The tax initially applied to petrol, heavy oil, auto-diesel, kerosene, and liquid petroleum gas (LPG), fuel oil, and natural gas. In 2013, solid fuels (coal and peat) were included after concerns from the agriculture industry were addressed (Convery et.al 2013).

The carbon tax began at an average effective rate of €15 per ton of $CO_2$, and it was increased annually for different fuels until it reached a rate of €20 per ton, where it remains today. The Irish carbon tax rate was set under the assumption that the price of EUAs would stay in the €15-30 range. Therefore, all emitters would bear a similar price incentive to reduce emissions. However, this projection has proved incorrect since as of 2017, EUAs were trading around €5 a ton.

**Noteworthy features**

The carbon tax was also implemented during the global recession and during a time of austerity in Ireland. In November 2010, the European Commission, European Central Bank, and International Monetary Fund, imposed serious fiscal conditions on the country, including increased income taxes and spending cuts. While the overall contribution to government revenue was small (around €344 million in 2012), the carbon tax revenue represented about 12.4 percent of the cumulative tax increases required by the IMF between 2010 and 2012 (Convery et.al 2013). To date the carbon tax has generated over €2 billion in revenue.

**Constraints**

While the EU ETS and Ireland's carbon tax have certainly decreased emissions compared with business-as-usual, neither are delivering emission reductions that are on track to meet their own emissions reduction goals. Non-EU ETS covered emissions have decreased by 15 percent from 2008 to 2012 and while not all of these reductions can be attributed to the carbon tax, the Irish carbon tax has clearly decreased emissions further than the EU ETS would have alone (Convery et.al 2013). A government report, however, warns that Ireland is not on track to meet its decarbonization goals and may face added pressure when new emissions reduction obligations are imposed post-2020. There are concerns that non-ETS sectors will miss their 2020 target of twenty percent emissions reduction by 6 to 11 percent (EPA 2015) due to the difficulty of decarbonizing the agriculture and transport sectors, which collectively makeup three-fourths of all non-ETS emissions (EPA 2015). In the long-term, Ireland is not on track to meet its Climate Action and Low Carbon Development Plan. Additional policy initiatives in the agricultural and transport sectors are necessary if Ireland is to meet its goals.

# 7. Discussion

## 7.1. CAP-AND-TRADE SYSTEMS

From the five ETS designs reviewed in the paper (i.e. California, Québec, EU, Korea and China), we identify several design features that enable successful initiation and future management of the ETS marketplace. An ETS rolled out with free allowances appears to be more politically palatable, but auctioning of future allowances (e.g. California) ensures sufficient revenue generation. Revenue generated from auctioned allowances can then be used to achieve other goals (Schmalensee and Stavins 2017). Getting firms used to reporting data prior to the rollout of an ETS (e.g. Target Management System Pilot in Korea) may help the marketplace avoid over allocation in subsequent phases, as seen in ETS markets such as the EU ETS. Similarly, developing scenarios for future projections can also be useful in order to anticipate different types of events that could affect the system (e.g. the financial crisis).

A price floor/ceiling, or “collar,” creates a more stable market with less price volatility (e.g. Korea and California) and probably lowers compliance costs in the long run. Restricting banking of allowances (e.g. Korea) or not allowing banking between phases (e.g. EU ETS) may lead to a collapse in allowance prices at the end of a commitment period. Even in the presence of price collars, restricted banking and borrowing between phases could result in allowance price hitting the price floor. The presence of reserve allowances (e.g. California and Korea) creates the ability for the government to intervene quickly in the market (e.g. Korea’s pseudo independent Allocation Committee), which allows for the management of liquidity and administration of the price collar. Overall, managing the level of price caps, the percentage of banking and borrowing between phases, the amount of reserve allowances, and the ability to adjust these levers quickly could ensure a predictable marketplace with stable prices and sufficient liquidity. Finally, most countries that have implemented a carbon price have done so in the presence of complementary policies including renewable portfolio standards, fuel efficiency standards, feed-in-tariffs, and investments in innovation. The presence of complementary policies can achieve significant emission reductions but contribute to an overabundance of supply in the ETS market, which places downward pressure on the permit prices (Schmalensee and Stavins 2017).

Two knowledge gaps need to be addressed to better understand the functioning of an ETS market. First, what is the level and nature of management necessary for a well-functioning ETS market? From the five cases discussed in this paper, Korea may serve as a good case study to understand the level of management necessary for a successful ETS market. In spite of Korea’s careful rollout of its ETS with features necessary to avoid price volatility, over allocation and the ability to intervene in the market, the Korean ETS market suffers from a lack of liquidity and has experienced almost no transactions since its rollout in January 2015. Second, what is the interactive effect of ETS and other complementary policies aimed at emissions reductions? The

California cap and trade system and the EU ETS could serve as good case studies to understand the interactive effect of multiple environmental policies along with ETS on overall emissions reduction and cost. In particular, California could serve as a case to understand the effects, and attempts to stem carbon leakage due to neighboring subnational entities that do not have an explicit carbon price. Finally, with transportation added to California's cap and trade system in 2015 and Québec's ETS market comprising significant emissions from its transport sector, studying the effect of the recently linked California and Québec ETS on future transport emission reductions could be valuable.

## 7.2. CARBON TAX AND HYBRID SYSTEMS

From the five carbon tax (i.e. British Columbia, Mexico, Chile, Japan and India) and carbon tax — EU ETS hybrid systems (Norway and Ireland) discussed in this paper, we identify some key design features necessary for the efficient operation of a carbon tax system. Low tax rates per ton of $CO_2$ (e.g. Mexico, Chile, and Japan) with no mechanisms to increase the future tax rate may nullify the price effect of the tax on emission reductions over time. An ambitious tax rate per ton of $CO_2$ (E.g. British Columbia, Norway) is necessary for substantial emission reductions outcomes, but may not be sufficient if many exemptions are provided and/or the structure of the economy poses inelastic demand for sectors/fuels taxed (e.g. the oil and gas sectors in Norway). In addition, a clear, stable, and steady tax rate increase is necessary to drive deeper emission reductions, as well as to send transparent market signals to private actors that climate policy is a long-term, economy-wide policy. Exempting emission-intensive trade-competitive sectors (e.g. shipping in Norway; natural gas in Mexico; copper extraction in Chile) from carbon taxation undermines the purpose of a carbon tax. Exempting certain sectors may make the introduction of a carbon tax politically feasible, however. In such cases, combining the price effects of carbon taxes with investments through the earmarking of funds in clean energy technologies could result in more progressive emissions reduction, as seen in Japan. Earmarking funds from carbon taxes towards energy efficiency or renewable energy investments are only effective if a sound complementary policy framework for using the earmarked revenue exists (e.g. energy saving investments in Japan; green spending capital in Norway). Failure to define a consistent policy framework and adhere to it will result in carbon tax revenues not being dedicated to investments in innovation or emissions reductions (i.e. India's coal tax).

For systems that impose both a carbon tax and ETS across sectors, it is important to identify whether there is overlap of carbon tax and ETS on the same emissions base (e.g. the electricity and industrial sectors in Norway) and ensure that the overlap does not have distributional consequences or lead to increased, economically-inefficient abatement costs. Finally, taxing upstream at the point of fuel extraction (e.g. India, Norway) or emitting entities (e.g. Chile, British Columbia) reduces the complexity of a carbon tax design and enforcement, making it more palatable for LDC's with less developed administrative states.

A key knowledge gap in carbon tax and carbon tax-ETS hybrid systems is in understanding the emission outcomes and distributional consequences of sectorally differentiated carbon prices (e.g. Norway) versus economy-wide prices (e.g. British Columbia). In this regard, it would be helpful to compare the carbon tax systems of Norway and British Columbia. Another major knowledge gap is the relationship between the tax rate, allocation of revenue towards green investments or the general budget, and the overall structure of the economy. Improved understanding of this relationship would help determine which percentage of earmarking would lead to efficient emission-reduction outcomes, and this could be done by comparing the carbon tax policies of Japan and Norway.

# 8. Key Findings

**Countries are learning from each other** Each new carbon pricing policy implemented somewhere in the world shows evidence of learning from the prior experience of other countries. Korea, for example, made many design decisions based on the performance of the EU ETS.

**Each national context creates unique opportunities and constraints** No carbon pricing policy will ever be exactly the same, but certain types of pricing instruments lend themselves better to certain national circumstances.

**Carbon pricing leads to emissions reductions** While emissions reductions achieved from carbon pricing policies have thus far been modest in most cases, there is no instance where emissions increased as the result of carbon pricing.

**Administrative and regulatory structures for carbon pricing strategies appear to be robust in every carbon pricing system** Whenever administrative imperfections were identified, they appear to have been eventually rectified.

**So far, the price signals to the market from existing carbon pricing policies are modest** Because carbon prices (either direct through taxes on fuels or indirect through cap-and-trade) are relatively low, they do not appear to be inducing major changes in firm or consumer behavior (see Figure 1). Also, the signal to the market varies substantially because of the differing carbon intensity of the fuels (i.e. a modest carbon tax makes coal much more expensive than natural gas due to the higher carbon intensity of coal).

**Price ceilings are not being hit in any of the ETS regimes** It appears that either there is a surplus of supply of permits (over-allocation) or compliance costs are lower than anticipated by regulators.

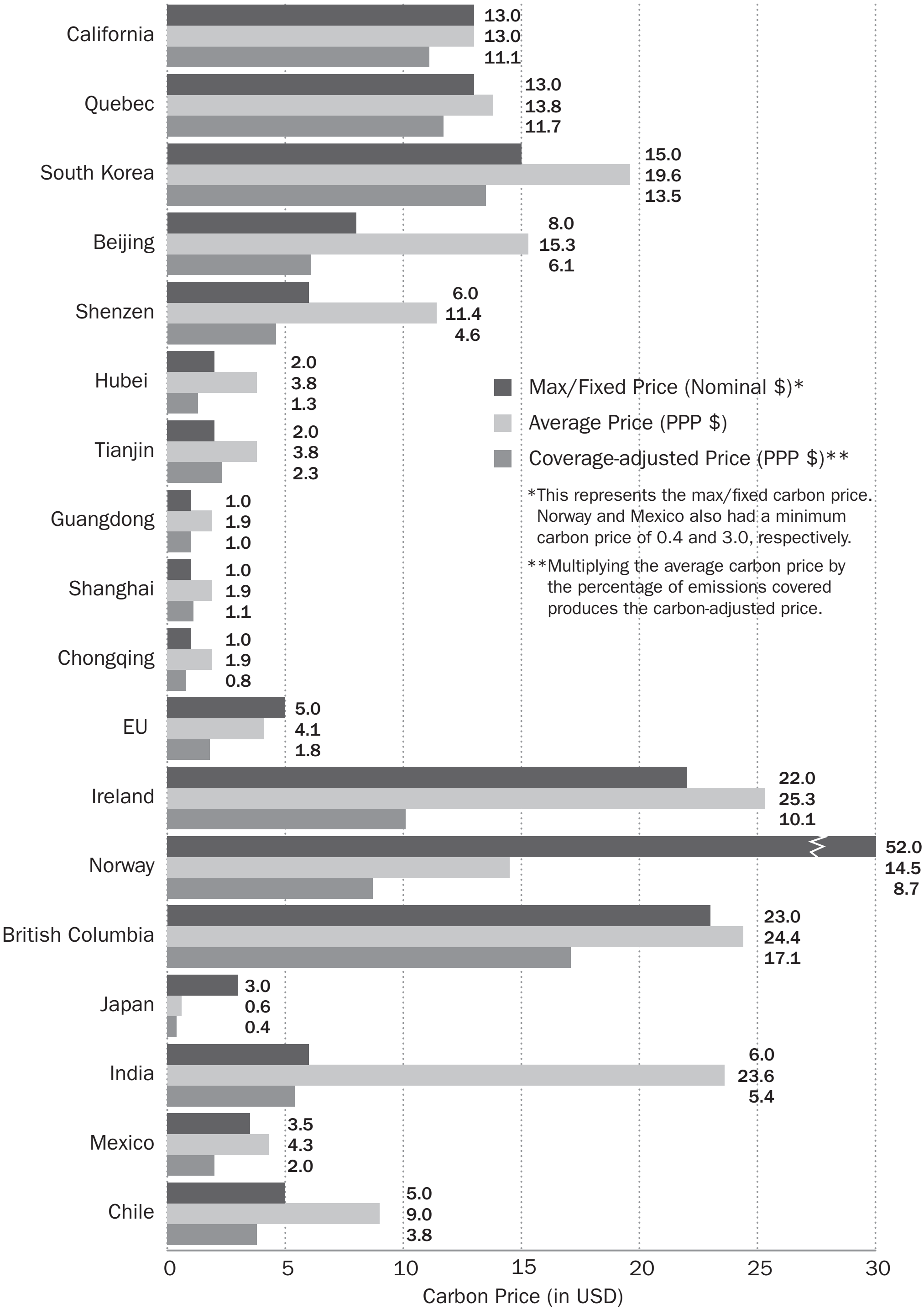
**Revenue generation from carbon taxes is often being used to meet (non-climate) societal needs** Most of countries employing tax policies use the revenues generated for non-climate purposes, such as general revenue to the treasury (e.g. Mexico, Ireland, Chile), or provision of pension funding to the population (e.g. Norway), thereby trying to reap a “double dividend” of emissions reduction and social good.

**A “double dividend” exclusive to emissions reductions may also exist** In cases where mitigation occurs as a result of the carbon pricing policy, the revenue from ETS auctions or carbon taxes may be invested in other emissions-reduction activities. This added benefit occurs even in the case of low carbon prices (e.g. India’s revenue directed to energy innovation investments or Japan’s revenue directed to energy efficiency deployments).

**Heterogeneity of carbon pricing mechanisms across fuels, industries or sectors may undermine cost effectiveness** Governments may be susceptible to intense lobbying by special interests (e.g. Mexico and Norway).

**The administrative burden for carbon taxes appears to be lower than for ETS** For those countries that ultimately are interested in adopting an ETS, establishing a carbon tax could be a good first step. At a minimum, both a cap-and-trade and a carbon tax policy would require establishing emissions inventories, reporting, monitoring, and verification procedures and oversight. Chile, Japan, Mexico, and Australia have all expressed a desire to evolve from a carbon tax towards an ETS.

**Figure 1: Carbon price per ton of GHG emissions in 2016**



*This represents the max/fixed carbon price. Norway and Mexico also had a minimum carbon price of 0.4 and 3.0, respectively.

**Multiplying the average carbon price by the percentage of emissions covered produces the carbon-adjusted price.

# 9. Future Research

A large body of empirical evidence already exists about the design and performance of existing carbon pricing policies around the world. However, we identify five main knowledge gaps in the existing literature:

1. How and why governments chose the type of carbon pricing policy?
2. How and why governments made specific design decisions for their policy?
3. How governments manage and maintain their existing climate pricing policies?
4. What makes a particular carbon pricing policy work in a particular socio-political-economic context?
5. How do carbon pricing policies interact with complimentary policy instruments in practice? What happens when there is mis-alignment?

To answer these questions, process-tracing methods through surveys and interviews would need to be utilized through field research to answer the first question, interviews would be required to answer the next three, and a combination of case studies, econometric analysis, and modeling to answer the last question. In the next phase of our research, we will enrich this analysis with descriptions of three additional cases, namely, The Regional Greenhouse Gas Initiative (RGGI) in the United States, Switzerland's ETS system and New Zealand's ETS system. Based on a program's ambition (i.e. price and emissions coverage), emissions reduction potential, potential for linkability and administrative challenges in implementation, we will then choose a few cases and perform in-depth analysis to test the key findings and knowledge gaps identified in this paper.

Finally, two emerging cases are not evaluated in this paper because the performance of these systems cannot yet be ascertained: China's national ETS and Ontario's ETS, both of which are scheduled to launch in 2017. Although their performance cannot be soon evaluated, design choices could be clarified through interviews. Similarly, although we attempted to analyze Chile's carbon tax design, in-depth interviews would shed additional light on this emerging regime.

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**The Center for International Environment and Resource Policy (CIERP)** was established in 1992 to support the growing demand for international environmental leaders. The Center provides an interdisciplinary approach to educate graduate students at The Fletcher School. The program integrates emerging science, engineering, and business concepts with more traditional subjects such as economics, international law and policy, negotiation, diplomacy, resource management, and governance systems.

**The Climate Policy Lab (CPL)** convenes teams of scholars and practitioners to evaluate existing climate policies empirically and works with governments contemplating new climate policies. The main questions the Lab seeks to answer are: Which climate policies work in practice? Which don't work? Why? Under what conditions would they work elsewhere? The scope of the Lab is global while remaining highly attuned to state, national, and bi-lateral policy processes. It has a particular emphasis on international comparative policy analysis.