Before the
Joint Senate Committee on Environment and Natural Resources
and
House Committee on Energy and Environment

Prepared Remarks of Northwest & Intermountain Power Producers Coalition and International Emissions Trading Association
on
SB 557, SB 748, HB 2135, HB 2468 and LC 1242 relating to limiting Greenhouse Gas Emissions.
March 1, 2016

Chair Dembrow, Chair Helm, and Joint Committee Members:

The Northwest and Intermountain Power Producers Coalition[1] ("**NIPPC**") and the International Emissions Trading Association[2] ("**IETA**" and jointly with NIPPC, the "**Joint Coalition**"**)** appreciate this opportunity to submit testimony in support of SB 557 and the adoption of a greenhouse gas ("**GHG**") emissions cap and trade program for Oregon.

The Joint Coalition represents a variety of economic interests that will be directly and indirectly affected by any carbon pricing adopted in Oregon. Coalition members include a broad range of commercial and industrial businesses, including independent power producers, large investor-owned utilities, major oil and gas interests, banks, clean project developers and a variety of other entities. The Joint Coalition and its members have extensive experience both operating and investing in jurisdictions with existing cap and trade programs and have informed the development of such programs around the world. A number of Joint Coalition members, with significant employees, operations and emissions in Oregon and along the Pacific Corridor, will be directly impacted by any carbon pricing mechanism that may be adopted. **As directly affected businesses, the Joint Coalition submits that a market-based cap and trade system -- one capable of aligning and linking with broader markets[3] – is far and away the best option for Oregon to achieve certainty of carbon reduction at the least cost to participants and the Oregon economy. As such, we urge Oregon to adopt SB 557 as a cornerstone climate policy measure.**

Oregon's ambitious climate targets will require significant, economy wide accelerations in deep GHG reductions. ***It therefore becomes vital to the Oregon economy that emissions reductions be achieved***

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[1] NIPPC is a member based advocacy group representing electricity market participants in the Pacific Northwest. Membership includes a diverse cross section of entities across the electricity value chain in the region. NIPPC is committed to facilitating cost effective electricity sales, offering consumers choice in their energy supply, and advancing fair, competitive power markets. Learn more about NIPPC at www.nippc.org.

[2] IETA is the world's leading business voice on the design, evaluation, and expansion of carbon pricing solutions and climate finance. IETA's 150+ member companies include some of the world's largest power, industrial, manufacturing, assurance and financial corporations. Learn more about IETA at www.ieta.org.

[3] "Linking" refers to an emissions program where some or all of the emission credits from one jurisdiction may be used to meet compliance obligations in another jurisdiction. For example, Quebec and California currently are part of a "linked" market managed by the Western Climate Initiative ("WCI").

at the lowest possible cost. Review of carbon pricing mechanisms throughout the world demonstrate that the best mechanism to achieve these goals is a fulsome cap and trade system, including the flexibility to meet compliance obligations through purchase of offsets, and ensuring efficiencies and cross border market and program alignment.

The premise of a cap and trade program is simple: Regulations establish an absolute cap on total emissions based on existing output, and set that cap to decline over time in order to reduce overall emission output. Entities subject to the cap must either reduce their emissions, or purchase tradable compliance units to meet their compliance obligation. An entity that exceeds its emission reduction targets can sell excess units to other entities, and parties not subject to the program can participate by developing projects that reduce atmospheric carbon (e.g., capturing methane from dairy production, improved forestry practices etc.) to create offsets. The cap guarantees with certainty that actual carbon reductions will occur, while the market finds the lowest cost price to achieve that goal.

This Testimony addresses the following issues:

- The current status of carbon markets in North America and around the globe;
- Evidence demonstrating that cap and trade programs are substantially more effective than carbon tax or "cap and permit" programs for reducing carbon emissions at the lowest cost to the economy;
- The ability of a cap and trade program to address competitiveness issues in a manner that can reduce leakage[4] and enhance economic opportunities across Oregon;
- The vital role that carbon offsets can play in driving down compliance costs, while driving-up clean investment, innovation and employment (including across agriculture, forestry and other non-regulated sectors);
- The support of industrial, commercial and societal interests in moving forward with a carbon cap and trade program.

This testimony also includes as attachments additional educational materials that provide background on carbon markets, the benefits of offsets, and similar issues that can help provide a common vocabulary for discussions going forward. A selection of other materials, reviewing the effectiveness of cap and trade programs historically, have also been attached for supplementary reading.

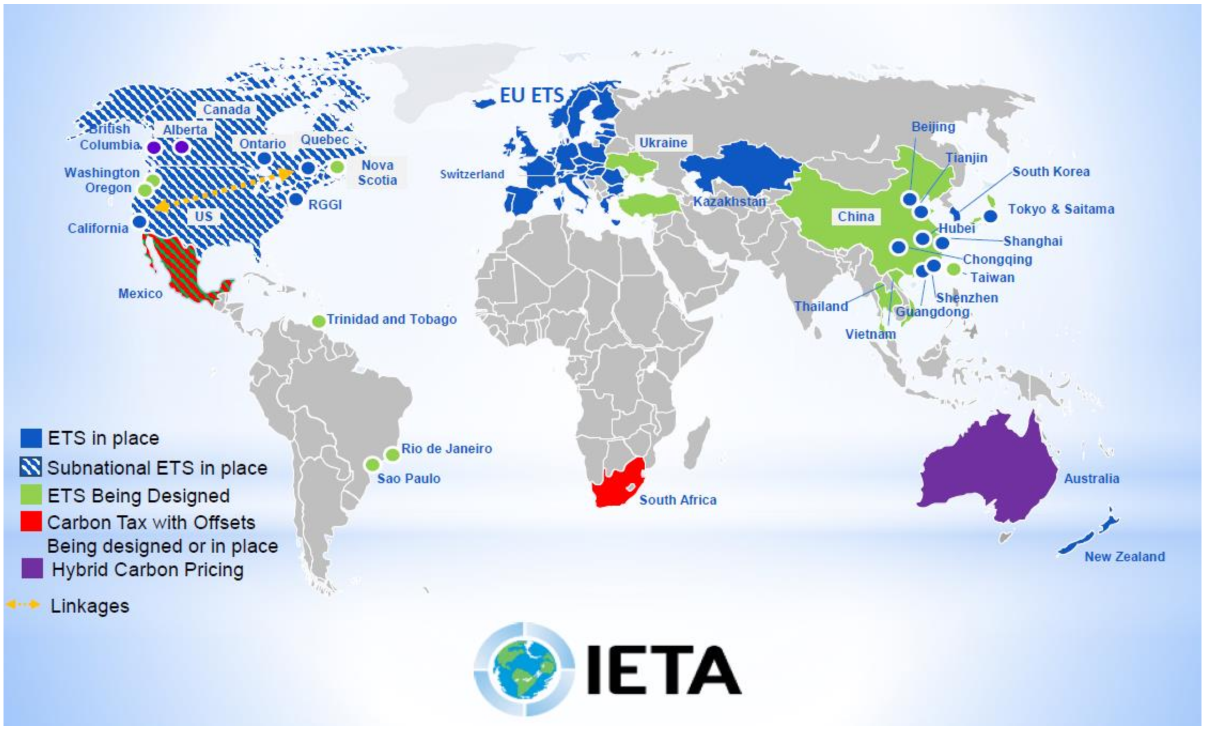
1. **Most jurisdictions – and many of Oregon's economic import/export partners - are moving towards flexible, market approaches for carbon pricing.**

The Joint Coalition urges Oregon to move forward with SB 557 and legislate development of a full GHG emissions trading program that is capable of linking with broader markets. Oregon is not alone when it comes to consideration of mechanisms to achieve reductions of GHG emissions. Throughout the world, jurisdictions are working towards putting a price on carbon, with the vast majority electing to move towards cap-and trade style emissions trading systems rather than other alternatives. As illustrated in the carbon pricing map below, over 40 national and 34 subnational jurisdictions –

[4] "Leakage" refers to the potential for economic activity to relocate from a jurisdiction that places a price on carbon emissions to a jurisdiction without a price on carbon emissions, resulting in a reduction of carbon emissions within the first jurisdiction but no net reduction globally.

representing about 50 percent of the world's GDP -- will be covered by a carbon trading system this year.[5] The inclusion of market based programs contemplating carbon trading was a key driver in spurring the international UN Paris Climate Change Agreement,[6] and adoption of cap and trade programs throughout the world is poised to grow to 2020 and beyond.

Global Carbon Pricing Map



Stated simply, market mechanisms, and specifically cap and trade programs, have become the primary policy tool to tackle climate challenges. This is true because jurisdiction throughout the world are reaching the same conclusion: cap and trade mechanisms can produce real, verifiable reduction in emissions at the least cost to the underlying economy, and are simply more effective and efficient than either a carbon tax or a cap and permit carbon mechanism.

Many of Oregon's largest import/export trading partners – both intrastate and internationally – are now subject to carbon cap and trade programs. Adopting a program that allows Oregon to participate in a broader market, such as the joint California/Quebec (and soon Ontario) WCI program, will provide

[5] *See* the International Carbon Action Partnership (ICAP)'s "Status Report 2017" https://icapcarbonaction.com/en/?option=com_attach&task=download&id=447. The Executive Summary of the Status Report 2017 is attached hereto and included as part of this written testimony The Joint Coalition asks that the full report be made part of the legislative record for these bills.

[6] *See* UNFCCC Paris Agreement, Article 6 https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf. Detailed considerations about the implementation of Article 6 are shared in IETA's May 2016 report, "A Vision for Market Provisions of the Paris Agreement" and IETA-EDF's April 2016 Joint Report, "Carbon Pricing: The Paris Agreement's Secret Ingredient" available via the IETA homepage www.ieta.org and incorporated herein by reference.

Oregon the benefits of least-cost compliance and market stability through participation in a larger market, provide opportunities to attract foreign capital into the state, reduce potential concerns regarding leakage and competitiveness, take advantage of existing compliance and systems infrastructure, and accomplish all of this while putting the state in position to meet its climate goals.

2. **Data demonstrates that cap and trade systems are more effective at achieving climate goals, and do so at a lower cost, than alternative carbon pricing systems.**

Existing carbon pricing programs provide data demonstrating that carbon cap and trade systems are more effective and efficient at meeting carbon reduction goals than carbon taxes and/or "cap and permit" systems, such as contemplated in SB 748.

Successful emissions trading systems have been in place for decades. Examples of successful programs that have been subject to detailed evaluation include the sulfur dioxide (SO2) allowance trading program under the Clean Air Act Amendments of 1990; the Regional Clean Air Incentives Market in southern California; NOx trading in the Eastern United States; the Regional Greenhouse Gas Initiative ("RGGI") in the northeast United States; California's AB-32 cap-and-trade system; and the European Union Exchange Trading System ("EU-ETS" - all textbook cap-and-trade systems.[7] The SO2 allowance trading program (also known as the "acid rain" program) is a good example. This potentially catastrophic environmental problem of acid rain was virtually eliminated after adoption of the cap and trade program. The cap created the requirement that emissions be reduced; the initial cost spurred permanent changes in technology, and the trading allowed those entities that could create emission reduction at the least cost to the economy to do so, avoiding disruptions to critical industries. The emissions of SO2 have fallen so low that most people don't recall the significance of the problem. The complete elimination of acid rain as a significant environmental issue provides empiric evidence that cap and trade programs work extremely well to resolve air emission concerns.

Significantly, cap and trade programs offer a number of distinct and quantifiable benefits as compared to either a carbon tax approach and a "cap and permit" approach. The hallmark feature of cap and trade is certainty related to environmental outcomes (*i.e.* achieving GHG target and pollution reductions). The "cap" effectively represents the program's overall "emissions budget," or the total number of allowances that are available to covered entities. This fixed sum of emissions will not exceed a given limit and will ratchet down over time. In contrast, a carbon tax simply cannot guarantee, nor is it capable of timely measuring, GHG reduction outcomes in order to help inform forward looking climate policy.[8]

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[7] See "Lessons Learned from Three Decades of Experience with Cap and Trade," R. Schmalensee and R. Stavins, prepared for the *Review of Environmental Economics and Policy, November, 2016*

[8] With a carbon tax, the outcome of actual emissions needs about a year to be accurately known. Further, to sustain any reductions, the tax must continually increase to meet the rising cost of additional emission reductions. Haites, Erik, Margaree Consultants, Inc., 2016. Carbon Pricing Options for Canada, pp. 5.

Emissions trading The combination of an absolute cap on the level of emissions permitted and the carbon price signal from trading helps firms identify low-cost methods of reducing emissions on site, such as investing in energy efficiency – which can lead to permanent productivity gains.

Trading incentivizes innovation and identifies the lowest-cost solutions to make businesses more sustainable. Trading reduces the overall costs of meeting GHG reduction goals by allowing all emitters to take advantage of the least-cost options for reducing emissions. As a simplified example: assume two manufacturing facilities each need to reduce emissions: Company A has the ability to do so at $8/ton through new technology, but the technology would only be cost effective if amortized over a larger amount of emissions than needed for Company A's compliance. Company B, by contrast, cannot reduce their own emissions for less than $20/ton – a rate that could put them out of business, with the concomitant loss of Oregon jobs. Allowing Company A to "trade" additional allowances beyond its need would save Company B – and Oregon - $12/ton of carbon, *while still meeting the very same carbon reduction goals*. Moreover, historic price data shows that flexible pricing systems respond to economic downturns with lower prices on carbon – this ability to respond to economic shocks is unique to emissions trading.[9] Unlike the politicized nature of a tax, enabling the open market to set the price of carbon allows for better flexibility and avoids price shocks and other undue burdens.

With a tax or fee approach, by contrast, the "price" will be nothing more than a guess made by the legislature. If the price is too low, it will be simply ineffective at reducing actual emissions; if the price is too high, it will likely place a substantial drag on the economy and lead to permanent relocation of industry. Further still, it is politically very difficult to modify a carbon price once it is set, regardless of whether it was set at an appropriate point initially or whether economic changes require revisions.

Evidence bears this out: California has been subject to the carbon cap and trade market operating since 2013. In that time, California has exceeded its carbon reduction goals while continuing to have one of the countries fastest growing and strongest economies each year. Importantly, California has managed its carbon reduction with a carbon price hovering near the market floor, currently set at $13.57/ton. In contrast, British Columbia has adopted a carbon tax, with a current tax rate of Can$30/ton – yet actual carbon emissions continue to increase.[10] In fact, between 2011 and 2014, GHG emissions rose by the equivalent of 1.8 million ton in the province, and the jurisdiction is projected to see **a 39% increase** in GHG emissions by 2030. Without additional climate action, British Columbia will fail to meet its legislated 2020 GHG emission reduction target.[11] Because British Columbia's mechanism does not allow trading, emitters can not bring down the cost of compliance by finding the cheapest way to create carbon reductions, reducing opportunities for permanent innovation. Instead, the high fixed price simply is passed on to consumers. The net result is that British Columbia's economy is paying a far higher price for each ton of carbon reduced then in other jurisdictions, and is still not meeting its goals.

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[9] Historic price and market data across existing emissions trading programs is available at https://www.edf.org/climate/worlds-carbon-markets

[10] BC's tax rate was originally set to increase each year, but the increases were frozen in due to political pressure.
[11] *http://www.pembina.org/reports/bc-emissions-backgrounder-2016.pdf*

A cap and permit approach, such as proposed in SB 748, may offer a slight improvement over a straight "tax" approach by virtue of having a cap – but failure to allow for trading will ensure that the system will be more expensive for compliance, and will place a drag on the Oregon economy not present with cap and trade. Moreover, to the extent a cap and permit mechanism such as proposed in SB 748 relies on a regulatory body to reprice a key economic input each year, that regulatory body will face enormous political pressure to keep prices lower than what the market would bear, as happened in British Columbia.

3. **A Cap and Trade Market can address competitiveness issues in a manner that can reduce leakage and preserve – if not enhance - economic opportunities across Oregon**

Any price on carbon creates a risk of "leakage" under which economic activity relocates from an area subject to carbon pricing to a jurisdiction without carbon pricing. This concern is at its height with respect to certain identifiable carbon-intensive, trade exposed industries. A cap and trade program offers policy tools that can mitigate these risks.

As addressed above, cap and trade programs allow emitters to meet their obligations at the lowest cost. This fact alone makes a cap and trade program better suited for Oregon than any of the other alternatives under consideration. Further, to the extent Oregon participates in a market "linked" with other jurisdictions, such as the California/Quebec/Ontario WCI Market, leakage and competitiveness concerns are further reduced because all competitors within linked jurisdictions will face the same costs, preserving a level playing field.

A cap and trade system also would provide Oregon with significant regulatory tools to protect carbon-intensive, trade exposed industries through issuance of free allowances, which can be adjusted based on changing circumstances.

Finally, as addressed below, participating in a cap and trade system would allow Oregon to encourage economic development through creation of offset programs, including forestry, dairy, and other types of offsets opportunities abundant in the state, many of which could provide an influx of international and out-of-state revenue and creating jobs and economic opportunity locally. The existing Ontario and Quebec cap and trade markets are prime examples of markets where low-cost carbon reduction projects for covered entities largely do not exist. In a linked cap and trade market, capital from these jurisdictions can flow into Oregon, funding local emissions reductions and economic development opportunities – often in rural counties -- that would not otherwise occur.

4. **Carbon Offsets Play a Vital Role in Meeting Emission Goals on a Cost Effective Basis.**

One of the significant benefits of a cap and trade program is that it allows participants to utilize offsets to reduce compliance costs. An offset represents the real and verifiable reduction, removal or avoidance of GHG emissions, measured in metric tons of CO2 equivelent. Offsets are often the least expensive, and fastest way, to generate carbon reductions. If it is economically more efficient to create that reduction through an offset project than, for instance, through more expensive on-site plant modifications, that economic benefit is realized across Oregon's economy in the form of lower overall program and compliance costs, without sacrificing the climate goal. For example, if an electric utility is able to fund creation of an offset for the equivalent of $8/ton, rather than invest in plant modifications at $20/ton, utility ratepayers receive the benefit of that $12/ton cost savings.

Offsets also offer an opportunity to spread the incentive for emission reductions to sources not directly covered by the cap and trade program, such as agriculture (e.g. dairy) and forestry industries, many of which reside in economically disadvantaged and rural communities. Notably, to the extent Oregon offsets are useable in linked jurisdictions, they can provide an engine for economic growth by allowing generation of in state revenue to support climate goals in other jurisdictions.

Oregon will need to determine the types of offset protocols usable for compliance with its program. However, Oregon need not undertake this process from scratch. Offsets in various forms are utilized in carbon markets throughout the world. Offset protocols have also been developed for use in markets in California, Quebec, Ontario, the RGGI market; various European carbon markets (the EU ETS, Switzerland, Norway); the Alberta Specified Gas Emitters Regulation ("SGER") market; and emerging markets throughout Asia, including China, Korea, and Japan.[12] A wealth of robust offset quantification methodologies, protocols, consultation mechanisms and third-party registry experience is also available across today's sophisticated voluntary market. Notably, within linked jurisdictions, such as the WCI program, different jurisdictions can choose to allow creation of different types of offsets, based on economic development opportunities within their own jurisdiction; once created, though, these offsets can be used to meet compliance obligations in the other jurisdictions.

5. **Commercial and Industrial Support for Cap and Trade.**

Finally, the Joint Coalition reiterates their strong support for Oregon to move forward with a carbon cap and trade system such as that outlined in SB 557. Some members of the Joint Coalition have substantial assets, and substantial emissions, in Oregon, and any carbon pricing mechanism will directly affect such members, increasing their costs. Nonetheless, we strongly support Oregon moving forward with a carbon cap and trade program because it is by far the best – and least cost – option for Oregon to meet its climate goals. As businesses, Joint Coalition members are subject to market prices for many commodities; we routinely evaluate market risks, create hedges and take other actions within the market to mitigate costs and price risks.[13] As long as the system allows for trading, and prices set by

[12] On 21 December 2016, the Governments of Ontario and Quebec jointly launched an Offset Protocol Adaptation Project for "**Ontario, Quebec and Other Potential Jurisdictions**". In 2017, 13 selected protocols, from WCI and non-WCI programs, will be reviewed and adapted to Ontario-Quebec. This timely project, led by the Climate Action Reserve (CAR), could help inform future thinking and program design considerations under Oregon's future market. More project details are available http://climateactionreserve.org.

[13] Joint Coalition notes that other industry groups such as the Western States Petroleum Association, which has long-opposed environmental regulations such as the low carbon fuel standards, are now on record as fully supporting cap and trade programs. See https://www.wspa.org/blog/post/wspa-well-designed-cap-and-trade-program-%E2%80%9Cprudent-approach%E2%80%9D-meeting-state%E2%80%99s-climate-change.

market forces (with proper protections if appropriate), rather than government edict, businesses will be able to adapt and thrive. By contrast, imposing a straight carbon tax, or another mechanism that does not allow for emission trading will, have a negative impact on the state economy.

Attachment 1

Excerpts from IETA Emission Trading Library

BENEFITS OF EMISSIONS TRADING

Emissions trading achieves the environmental objective – reduced emissions – at the lowest cost.

Cap and trade is designed to deliver an environmental outcome – the cap must be met, or there are sanctions such as fines. Allowing trading within that cap is the most effective way of minimising the cost – which is good for business and good for households. Determining physical actions that companies must take, with no flexibility, is not guaranteed to achieve the necessary reductions. Nor is establishing a regulated price, since the price required to drive reductions may take policy-makers several years to determine.

Emissions trading is better able to respond to economic fluctuations than other policy tools.

By allowing the open market to set the price of carbon allows for better flexibility and avoids price shocks or undue burdens. For example, as seen in Europe, prices will fall during a recession as industrial output, and thus emissions, fall. A centrally-administered tax does not have the same flexibility.

Emissions trading incentivizes innovation and identifies lowest-cost solutions to make businesses more sustainable.

The combination of an absolute cap on the level of emissions permitted and the carbon price signal from trading helps firms identify low-cost methods of reducing emissions on site, such as investing in energy efficiency – which can lead to a further reduction in overheads. This helps make business more sustainable for the future. Imposing technology on business does not allow for creativity and can actually lead to higher costs as companies look merely to comply with regulations.

Cap and trade has proven to be an effective policy choice.

Cap and trade has proven its effectiveness in the US through the acid rain program, where it quickly and effectively reduced pollution levels at a far lower cost than expected. The EU Emissions Trading System has shown that cap and trade can be extended to carbon, and in doing so creates a price on carbon that drives emissions reductions. Reductions in pollution that industry feared would be excessively costly were achieved at a fraction of the original estimates. The International Carbon Action Partnership's 2015 status report found that **40% of the world's GDP is now subject to emissions trading**, with systems active in South Korea, China, California and Kazakhstan, among several others.

Emissions trading can provide a global response to a global challenge.

Cap and trade provides a way of establishing rigour around emissions monitoring, reporting and verification – essential for any climate policy to preserve integrity. Allowing for the use of offsets, which lowers compliance costs, can help involve other jurisdictions in the fight against climate change – and may even inspire them to establish their own emissions trading system, as the Clean Development Mechanism offset program inspired China.

As emissions trading spreads around the world, there are a number of opportunities to link systems, which enhances their effectiveness and reduces costs.

Connecting emissions trading systems, as California and Québec have done, widens the pool of participants to trade with, which reduces costs. This can allow for even greater emissions reductions to be achieved at a lower cost than previously.

Revised March 2015 | For more information, contact northamerica@ieta.org | www.ieta.org

IETA

CAP AND TRADE: THE BASICS

Cap and trade program overview

A cap-and-trade system places a limit on the amount of greenhouse gas emissions that industry can emit in a single year. Emissions of gases such as Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) are measured by industry and reported to the government or regulator who monitors emissions and runs the cap and trade program. In order to control emissions, the government sets a cap on emissions of these gases. It does this by giving or selling companies "allowances" (or permits).

Allowances are distributed via allocation and/or auctioning. The free allocation of allowances helps to reduce cost and competitiveness burdens to affected industries, especially those competing with regions not subject to regulatory carbon constraints. Companies that are required to reduce emissions are called regulated entities. They must demonstrate that they comply with the cap and trade program every year.

What industry sectors are covered under cap and trade?

Most existing cap-and-trade systems apply to the power sector and heavy industry (e.g., cement manufacturers, metals, chemicals, the oil and gas industry, ceramics, pulp and paper, mining, etc). An increasing number of programs - including **California, Québec, China pilots and Korea** - also cover transport fuels, **New Zealand's** covers forestry, and the **European Union Emissions Trading System** now applies to flights within the bloc. **China** will also consider including aviation under its national program, set to launch in 2016 and building-on experience gleaned from its seven existing pilot cap-and-trade programs. The **US Regional Greenhouse Gas Initiative (RGGI)** is the only existing cap-and-trade program that only applies to the region's power sector.

How does a regulated entity comply?

At the end of the compliance cycle (eg, calendar year, financial year etc), regulated entities covered by the cap-and-trade program must submit a verified emissions report, developed by independent third parties. Companies will then have to surrender emissions units - allowances or, if permitted, offsets - equal to their emissions; by acting to reduce their emissions, regulated entities can reduce their carbon liability.

Those which have reduced their emissions could also potentially end up with surplus emissions units, which can be sold to those which have exceeded their expected emissions; this can typically be done via exchange or intermediary.

How does Cap and Trade achieve the environmental objective?

The cap typically declines each year, gradually phasing-down towards the emissions reduction goal. **This is essential in ensuring the environmental outcome is met at lowest cost.**

Where have emissions trading systems been implemented?

Jurisdictions accounting for **around 40% of global GDP** have implemented an emissions trading system, according to ICAP's Emissions Trading Worldwide Status Report 2015. This includes China, South Korea, Kazakhstan, the EU, 10 US states (including California and New York) and Tokyo. Other systems are being considered in Brazil, Chile, Mexico, Washington State, Russia, Ukraine and Thailand, among others. These global climate markets and finance developments are further showcased and analysed in IETA's 2014 Greenhouse Gas Markets Report.

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OFFSETS: THE BASICS

What are offsets?

An offset represents the reduction, removal or avoidance of greenhouse gas emissions, measured in tonnes of CO2 equivalent (tCO2e). Offsets are important not only in environmental terms, but also in providing improved prospects for linking of emissions trading systems in the future. Offsets provide a vital cost-containment tool or safety valve for each system - and each system can implement the filters it deems necessary, according to predefined criteria.

Offsets achieve real emission reductions.

Governments can encourage emission reductions from specific activities, such as forestry, agriculture and waste management, which are outside the cap. Emissions reductions from these activities can be used to generate offsets that can be sold and used to comply with an emissions trading system.

Offsets help lower costs for business and households.

Offsets are an effective way to reduce emissions in an efficient cost-effective manner. Allowing the use of offsets in a cap-and-trade system will lower the cost of emission reductions throughout the market and provide a financial incentive to reduce greenhouse gas emissions..

Offsets can help cut emissions faster while encouraging innovation.

Offsets generate the greatest emissions reductions in the least time at the lowest cost. Maximum environmental benefit is gained by eliminating the greatest quantity of emissions as quickly as possible. The use of offsets provides an efficient means of reducing greenhouse gas emissions in the near-term. The revenue generated from the sale of offsets can be used to develop and implement transformative technologies that will achieve longer-term reductions.

Offsets help maintain domestic competitiveness in the regional and global marketplace.

Offsets help business stay competitive by keeping both energy and compliance costs down. By keeping costs down, offsets help help companies become greener and better stewards of the environment. Offsets provide economic certainty that companies want. This means that companies can flourish, generating more jobs and money for the communities they operate in.

Offsets promote innovation and cooperation, both domestically and internationally.

Offsets allow key actors - including foresters, farmers, and other clean project developers - to earn revenue for the greenhouse gas emission reductions they achieve, while at the same time stimulating innovation in areas that are outside a cap.

Offsets can link markets together to achieve even greater reductions.

Especially in today's bottom-up climate policy world, sub-national and national climate policy coordination, harmonization and innovation is more important than ever. The use of robust, eligible offsets for these actors to fully or partially link their bottom-up programs (ie, via offset linkages and trading) will become an increasingly critical step towards putting a real and lasting dent in the climate challenge.

OFFSETS: THE BASICS

Essential Offset Criteria:

Offsetting must demonstrate actual emission reductions compared to what would have otherwise happened, ensure emissions are not simply released at a later date, or are displaced elsewhere. Some of the consistent essential criteria used in existing greenhouse gas offset progams include:

- **Real**: offsets must represent real emission reductions that have already occurred (ie, the reduction is not projected to occur in the future)
- **Additional**: offsets must represent emission reductions that are in addition to what would have occurred otherwise
- **Permanent**: offsets must represent emission reductions that are non-reversible or must typically be sequestered for X number of years in the case of carbon bio-sequestration projects.
- **Verifiable**: sufficient data quantity and quality must be available to ensure emission reductions can be verified by an independent auditor against an established protocol or methodology
- **Quantifiable**: emission reductions must be reliably measured or estimated, and capable of being quantified
- **Enforceable**: offset ownership is undisputed and enforcement mechanisms exist to ensure that all program rules are followed and the program's integrity is maintained

GREENHOUSE GAS MEASUREMENT, REPORTING AND VERIFICATION (MRV)

Overview

MRV is a general term describing the process of measuring and collecting data on greenhouse gas (GHG) emissions or mitigation actions, compiling and reporting this information to a respective program, and then subjecting this reported data to a third-party review and verification.

The MRV process is applied to: 1) the reporting of GHG emissions by an entity or facility; and 2) the generation of carbon offset credits through the development and implementation of GHG offset projects.

Entity & Facility-Level Reporting & Measurement

A variety of GHG reporting programs exist at the entity level and facility level. Typically, entity-level reporting is voluntary and facility-level reporting mandatory. Current mandatory reporting programs for facilities in North America include:

- Alberta
- British Columbia (WCI)
- Ontario (WCI)
- Québec (WCI)
- Saskatchewan
- California (WCI)
- Massachusetts

Common Features

Programs have many similarities, but do have some differences in their structure and criteria. The basic criteria for GHG measurement and reporting include:

- **GHGs reported**
  - CO_2, CH_4, N_2O, SF_6, HFCs, PFCs, biogenic
- **Reporting Thresholds**
  - The most common thresholds for who has to report GHGs are either 10,000 metric tonnes carbon dioxide equivalents (tCO_2e) or 25,000 tCO_2e on an annual basis. Program thresholds can range from a low of 5,000 to 50,000 tCO_2e.
- **Sectors Included**
  - A wide variety of industrial sectors are included in programs including power generation, refineries, gas & electric utilities, manufacturing, mining & minerals, chemical production, metals production, fuel distribution and upstream oil/gas.
- **Reporting Timing**
  - Programs usually require entities/facilities to report their GHG emissions for the previous year within 6 months of the end of the previous year, with verifications completed within 6-12 months of the end of the previous year.
- **Emission Factors**
  - Programs use a variety of emission factors for different GHG sources and fuels that can be updated over time with the release of new data. Emission factors are typically published by governmental agencies (e.g. Environment Canada, U.S. EPA) or GHG registries (e.g. The Climate Registry).
- **Specific Calculation Methodologies**
  - Most programs provide reporters with specified methodologies for the calculation of their GHG emissions, especially for common and large sources of GHGs, and for certain energy-intensive industries.

GREENHOUSE GAS MEASUREMENT, REPORTING AND VERIFICATION (MRV)

Carbon Offsets Reporting & Measurement

Similar to GHG reporting, a variety of carbon offset programs exist as part of compliance programs or for voluntary purposes. Compliance offset programs present in North America include:

- Alberta
- British Columbia (WCI)
- Québec (WCI)
- California (WCI)
- Regional Greenhouse Gas Initiative (RGGI)

While each program allows a specific list of offset projects to be eligible for credits, many of the same project types are eligible across multiple programs. Examples of offset project types found across several North American compliance programs include:

- Capture and destruction of methane at livestock operations
- Destruction of ozone depleting substances
- Forestry
- Landfill gas capture and destruction

Specific offset methodologies (protocols) are developed for each offset project type. Protocols can be developed on a project-specific basis or use a standardized approach (performance-based or activity-based). Performance-based and activity-based protocols each have their own pros and cons.

Offset projects must follow the accepted protocols, which ensure that each project meets the essential offset criteria (real, additional, permanent, verifiable, quantifiable, enforceable). An important component of any protocol is the methodology and equations to calculate the amount of emissions reductions generated by an offset project.

Verification - GHG Reporting and Carbon Offsets

Verification Bodies (VBs or Verifiers) are third-party companies that are either accredited or approved to review the submitted reports of GHG reporters or carbon offset projects. The concept of verification has been present since the first GHG programs initiated in the 1990s. VBs assess whether the submitted reports meet all requirements of the GHG reporting or carbon offset program as well as the applicable protocol. Typical verification criteria include program-specific requirements, a reasonable level of assurance, and 5% materiality thresholds.

In most programs, VBs are required to be accredited to the International Organization for Standardization (ISO) standards of 14065, 14064-3 and 14066. VBS are certified to these standards by an appropriate accreditation body.

In North America, the American National Standard Institute (ANSI), Standards Council of Canada (SCC) and the Mexican Entidad Mexicana de Acreditación (EMA) are accreditation bodies for VBs. Accreditation of VBs is an important aspect of any GHG program, ensuring that the VBs are conducting the reviews in a uniform manner and that the verification team members are competent and able.

CARBON PRICING & ADDRESSING COMPETITIVENESS

Carbon pricing – and the economics of policy decisions – should aim to preserve, if not enhance, a region's economic performance and competitiveness.
Addressing real or perceived competitiveness impacts to affected industries is a critical dimension to smart carbon pricing design.

Companies which are covered by carbon pricing programs and which compete with national or international firms that are not subject to carbon constraints **do not have the leeway to raise product prices or recoup compliance costs**. These companies, many of which are "energy intensive and trade exposed" (EITE), are vulnerable to 'carbon leakage' (ie, corporate decision to relocate production to jurisdictions where no carbon pricing program is in effect).

In contrast, regulated companies that have more captive, local consumers and therefore not subject to leakage concerns (eg, power generators, fuels) are typically mandated to purchase all rights to emit and meet compliance.

Unlike other carbon policy measures like taxation and command and control, **cap-and-trade programs can effectively address these competitiveness and carbon leakage concerns** linked to a domestic carbon pricing. Many existing cap-and-trade programs, including the EU, California, Québec and Korea, freely allocate allowances to identified EITE sectors based on an agreed-upon percentage of the company's regulatory compliance obligation.

Allowance allocation is the process of distributing allowances to covered entities in an emissions trading system (ETS). There are two basic options for allocation: allowances can be either given away (freely allocated) or sold at auction. **Because allowances have value, the allocation process is governed by rules to ensure their fair distribution.** A simple, transparent and credible process facilitates this politically contentious part of operating a trading scheme.

To address competitiveness concerns, a defined number of free allowance allocations is usually delivered to EITE sectors. The free allocation typically starts high, depending on the industry and susceptibility to leakage. Allocations then gradually decline (eg, 1-2% per year); this approach provides incentive to reduce emissions while lending incremental support to enable low-carbon transitions yet remain competitive in the global marketplace.

For example, in the EU ETS industry received 80% of its allocation for free in 2013 – but this will fall to 30% by 2020. Allocations are determined by benchmarks, set at the best available technology, ie so the most efficient plants in theory receive most of their allowances for free.

Some programs have also considered border carbon adjustments, whereby a carbon price is levied on imports of goods from outside the jurisdiction that are from a non-carbon constrained region. Such proposals are complex and open to legal and diplomatic challenges – as the EU experienced when it proposed including aviation in its ETS, and California has faced with efforts to level the playing field for fuel suppliers.

CARBON REVENUE & CLEAN TECHNOLOGY FUNDS

Overview

A clean technology fund ("tech fund") can be established to achieve a number of climate change and greenhouse gas (GHG) reduction goals. Typically, a fund may be one or more of the following:

- A financing and technology innovation mechanism;
- A compliance mechanism under a GHG reduction regulation; and/or
- A compensation mechanism (e.g., funding for climate adaptation or resilience, socio-economic support programs to offset carbon costs or climate impacts etc.)

The following focuses on these mechanisms in a regulatory compliance context, though it is important to note that non-regulatory funds and other financing initiatives can also hold important lessons and models for future tech fund design and implementation.

Alberta offers an important Canadian working model of a tech fund in the context of a regulatory compliance tool under provincial GHG regulations. Covered entities can choose to make a compliance payment into the tech fund at a specified price per tonne of CO_2e (currently set at $15/tonne). The fund is administered through the Climate Change and Emissions Management Corporation (CCEMC).

Saskatchewan has also developed a tech fund framework, with the intention of implementing the mechanism as compliance tool under its future provincial regulatory approach.

British Columbia has also signalled that a tech fund will likely be part of its new regulatory package for the province's growing Liquefied Natural Gas (LNG) sector.

Key Design Concepts

Collaboration, Harmonization, Innovation, Flexibility, Effective Access, Transparency, Shared Benefits

Pricing Structure

- The carbon price set for tech fund payments can impact both the use and the development of a GHG offset market (as another compliance option).
- Consistency in overall cost structures across jurisdictions could help encourage future.

Governance

- Funds are typically governed by Board of Directors – size and structure varies.
- Important to clearly define the intended goal(s) of the fund and shape board representation accordingly. Can include representation from government, industry or other stakeholders (community, NGOs, other sectors).

CARBON REVENUE & CLEAN TECHNOLOGY FUNDS

Access to Funding

- Efficient processes to choose projects and disperse funds improves timeliness of investment and outcomes
- Flexible limits on funding to ensure adequate funding provided relative to total capital required and associated risk
- If a goal is to drive in-sector reductions and to incentivize early use by covered entities, a phased approach to tech fund access over time may be beneficial.

Funded Activity Scope

- The overarching goal of a tech fund directly impacts the extent to which firms that have contributed to the fund can expect to potentially shape or benefit from its use.
- Tech Fund may include a portfolio of projects across the technology development and deployment chain. Diversified activities could have multiple benefits, including:
    - Improve the viability of certain abatement options by moving them along a firm's Marginal Abatement Cost Curve.
    - Incentivize additional investments in higher risk and early R&D activities that would not otherwise be invested in, but could have transformative impacts over time.
    - Ensure healthy project pipeline across the development chain to achieve:
        - 'Quick wins' and near term emissions reductions by commercializing new low-carbon technologies.
        - Longer-term emissions reduction potential, social license, and additional sustainable development co-benefits.

Outcomes Achieved

- As the concept of a tech fund is still relatively new, there is still a good deal of "learning by doing".
- Tech fund investments can help drive additional emissions reductions, but also valuable role for adaptation, land use and forestry projects to help achieve broad climate goals.
- Continuous improvement should be built into the design through established milestones and/or review triggers to increase certainty for industry and government. Consistent evaluation of outcomes against objectives is critical.

Cap-and-Trade Auction Revenue & Funds

Auctions are one way of distributing allowances – with the revenue accruing to the system's regulating authority.

Most cap-and-trade programs sell some, if not all, allowances at auction (rather than freely distribute 100% to covered entities). An analysis by Resources for the Future (RFF) on the use of auction revenues (published in IETA's 2014 GHG Market Report, Markets Matter) found that nearly all market systems studied invested some carbon revenue in low-carbon R&D and support, such as renewable energy and energy efficiency.

CARBON REVENUE & CLEAN TECHNOLOGY FUNDS

Smart use of auction revenues to support further mitigation and resilience projects.

Planned infrastructure investments that could lead to emission reductions or climate resilience (e.g. clean infrastructure funding, energy efficiency upgrades etc.) can be supported by auction revenues.

"Climate dividends" to support public buy-in for emissions trading and auctions.

Recycling auction revenue to consumers and business to incent greener choices or offset higher costs drives public support for carbon pricing. For example, RGGI uses a share of auction revenues to effectively provide a rebate on electricity prices.

Under the linked Quebec-California cap-and-trade models, allowance auction revenue channels into sub-nationally managed "green funds".

In **Quebec**, revenue generated by the carbon market is allocated to the province's Green Fund and re-invested for full implementation of Quebec's Climate Change Action Plan (CCAP 2013-2020). CCAP measures aim to reduce Quebec's GHG emissions, adapt to climate change impacts and accelerate the shift towards a "strong, innovative and increasingly low-carbon economy".

In **California**, the legislature and Governor appropriate auction proceeds for projects that support the goals of AB-32. Strategic investments are used to reduce state GHG emissions, providing net GHG sequestration, and support long-term transformative efforts to drive the state's clean energy economy. California's Legislative Analyst's Office (LAO) projects revenues from the state's allowance auctions in FY15-16 to be at least $2 billion – and potentially as high as $4.9billion.

OFFSETS IN CALIFORNIA'S CAP-AND-TRADE PROGRAM

What are offsets?

Under the California cap-and-trade program, there are two types of compliance instruments: allowances and offsets. Allowances are initially generated by the government and initially distributed to sources subject to the cap (regulated entities) via auction or allocation. In contrast, an offset is an alternative compliance instrument voluntarily generated by a non-Regulated Entity (a private market particpant) pursuant to a California Air Resources Board (ARB) rules, and sold to regulated entities through bi-lateral purchase agreements. Both allowances and offsets can be traded on the secondary market.

An offset represents the reduction, removal or avoidance of one tonne of greenhouse gas (GHG) emissions that would not have otherwise occurred and which is generated from an ARB-registered project. Regulated Entities can use offsets to fulfill up to 8% of their compliance obligation under the cap-and-trade program. The 8% limit ensures that 92% of emission reductions under cap-and-trade are made directly by regulated entities at sources subject to the cap and not just compensated by offsets. Offsets must be generated from projects developed based on rules (called offset protocols) adopted by ARB and administered by Offset Project Registries (OPRs) which assist ARB by reviewing projects and providing expertise on the protocols. ARB also approves offset projects which private market participants undertook before the effective date of the cap-and-trade program (called early action offset projects) if they meet certain regulatory requirements, including registration under one of the approved early action protocols.

Key criteria for offsets

- Real: offset must represent real emission reductions that have already occurred (i.e. the reduction is not projected to occur in the future)
- Additional: offset must represent emission reductions that are in addition to what would have occurred otherwise
- Permanent: offset must represent emission reductions that are non-reversible or must be sequestered for 100-years or more
- Verifiable: sufficient data quantity and quality must be available to ensure emission reductions can be verified by an independent third party auditor (verifier) against an established protocol
- Quantifiable: emission reductions represented by offsets must be reliably measured or estimated, and capable of being quantified
- Enforceable: offset ownership is undisputed and enforcement mechanisms exist to ensure that all program rules are followed.

Benefits of offsets

Offsets achieve completely voluntary GHG emission reductions at sources outside of the cap. And because ARB retains oversight of the offset approval process, it can encourage certain types of source reductions via approving offset protocols targeting selected uncapped sectors (e.g. forestry). Further, offsets can increase flexibility by giving regulated entities another option for compliance in addition to just allowances. Finally, and perhaps most importantly, offsets can help reduce compliance costs because reductions can often be generated outside of the cap less expensively than they could be within the capped sectors. Due to this and the risk of invalidation of offset credits (discussed below), offsets often sell at a discount to allowances. Less expensive emission reduction costs lead to overall lower compliance costs, this reduces the cost impact on consumers. Development of offsets can spur technology innovation in areas outside of capped sectors, and deliver economic benefit by creating new job opportunities for stakeholders involved in offset projects.

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OFFSETS IN CALIFORNIA'S CAP-AND-TRADE PROGRAM

Risks associated with offsets

Under the California program, offsets can be cancelled (or invalidated) for, inter alia, failure to comply with a given offset protocol even after offsets have been surrendered for compliance. This risk of cancellation is called "invalidation risk." If invalidation occurs, the entity which used the invalidated offset for compliance must surrender another valid offset or allowance, thus increasing the costs. The ability to review an offset's compliance with a given protocol after surrender for compliance ensures the environmental integrity of the compliance program, but makes offsets less attractive as a compliance instrument compared to allowances, which can never be invalidated. However, robust and efficient verification requirements and review by OPRs prior to issuance, as well as due diligence prior to purchasing offsets can reduce invalidation risk.

ARB Adopted Offset Protocols

ARB has adopted five protocols to date covering: U.S Forest Projects, Urban Forests Projects, Ozone Depleting Substances (ODS) Projects, Livestock Projects, and Mine Methane Capture (MMC) Projects. ARB is continuously working to adopt new offset protocols and is now assessing rice cultivation projects as another offset protocol type.

How many offsets have been issued?

ARB has issued over 17 million compliance offsets to date, far short of the supply needed to satisfy the maximum demand of 58 million offsets through 2015.

How do offset prices compare to allowance prices?

California Compliance Allowances: $12.50 - $13.00 | California Compliance Offsets: $9.00 - $11.00

More information

More information is available at: http://www.arb.ca.gov/cc/capandtrade/offsets/issuance/issuance.htm

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Attachment 2

Lessons Learned from Three Decades of Experience with Cap and Trade," R. Schmalensee and R. Stavins, prepared for the *Review of Environmental Economics and Policy, November, 2016*:

LESSONS LEARNED FROM THREE DECADES OF EXPERIENCE WITH CAP-AND-TRADE

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and

Robert N. Stavins

Prepared for

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Lessons Learned from Three Decades of Experience with Cap-and-Trade

Richard Schmalensee and Robert N. Stavins

ABSTRACT

This article presents an overview of the design and performance of seven major emissions trading programs that have been implemented over the past thirty years and identifies a number of important lessons for future applications of this important environmental policy instrument. A brief discussion of several other proposed or implemented emissions trading programs is also included.

Key Words: market-based instruments, cap-and-trade, leaded gasoline phasedown, Clean Air Act amendments of 1990, sulfur dioxide, acid rain, carbon dioxide, global climate change, European Union Emissions Trading System

JEL Classification Codes: Q540, Q580, Q400, Q480

Lessons Learned from Three Decades of Experience with Cap-and-Trade

Richard Schmalensee and Robert N. Stavins[1]

INTRODUCTION

Thirty years ago, many environmental advocates argued that government allocation of rights to emit pollution inappropriately legitimized environmental degradation, while others questioned the feasibility of such an approach (Mazmanian and Kraft 2009). At the time, virtually all pollution regulations took a command-and-control approach, either specifying the type of pollution-control equipment to be installed or setting uniform limits on emission levels or rates.

Today, it is widely recognized that because emission reduction costs can vary greatly, the aggregate abatement costs under command-and-control approaches can be much higher than under market-based approaches, which establish a price on emissions -- either directly through taxes or indirectly through a market for tradable emissions rights (called permits or allowances) established under a cap-and-trade policy. Market-based approaches tend to equate marginal abatement costs rather than emissions levels or rates across sources. This means that in theory, market-based approaches can achieve aggregate pollution-control targets at minimum cost.

In this article, we examine the design and performance of seven of the most prominent emissions trading systems that have been implemented over the past 30 years in order to distill key lessons for future applications of this environmental policy instrument. We focus on systems that are important environmentally and/or economically, and whose performance is well documented. We exclude emission-reduction-credit (i.e., offset) systems, which offer credits for emissions reductions from some counterfactual baseline, because while emissions can generally be measured directly, emissions *reductions* are unobservable and often ill-defined. It is worth noting, however, that offset systems have been fairly widely used, notably in the Clean Development Mechanism (CDM), an international offset system that is part of the Kyoto Protocol.

The seven emissions trading systems we examine are: the U.S. Environmental Protection Agency's (EPA's) phasedown of leaded gasoline in the 1980s; the U.S. sulfur dioxide (SO_2) allowance trading program under the Clean Air Act Amendments of 1990; the Regional Clean Air Incentives Market (RECLAIM) in southern California; the trading of nitrogen oxides (NO_X) in the eastern United States; the Regional Greenhouse Gas Initiative (RGGI) in the northeastern United States; California's cap-and-trade system under Assembly Bill 32; and the European Union (EU) Emissions Trading System (ETS). All these programs except the first are textbook cap-and-trade systems.[2] We review the design, performance, and lessons learned from each of the seven systems, and then briefly discuss several other cap-and-trade systems. In the final section we summarize key lessons for designing and implementing new cap-and-

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[2] See Appendix Table 1 for a brief overview of these programs.

trade systems and present our thoughts about the potential role of cap-and-trade in global climate change policy.

EXPERIENCE WITH U.S. NATIONAL CAP-AND-TRADE PROGRAMS

Beginning in the 1980s, the first emissions trading systems were developed and implemented at the federal level in the United States.

The Phasedown of Leaded Gasoline

In the 1970s, there was growing concern about the use of lead as an additive in gasoline. Although it was later documented that lead oxide emissions were a serious human health threat, the original concern was that these emissions were fouling catalytic converters, which were required in new U.S. cars (starting in 1975) to reduce emissions of carbon monoxide and hydrocarbons. In the early 1980s, in response to this concern, EPA began a phasedown of lead in gasoline to 10 percent of its original level.

In 1982, EPA launched a trading program aimed at reducing the burden on smaller refineries, which faced significantly higher compliance costs than large refineries. Unlike a textbook cap-and-trade program, in which a fixed quantity of permits is given or sold to compliance entities, there was no explicit allocation of permits. Instead, the system implicitly awarded property rights on the basis of historical levels of gasoline production (Hahn 1989). More specifically, if a refiner produced gasoline with a total lead content that was lower than the amount allowed, it earned lead "credits" that EPA allowed the refiner to sell. Under the program's banking provision, lead credits could also be saved for later use. This created an incentive for refineries to make early reductions in lead content to help them meet the lower limits that took effect over time.

Performance

Overall, the trading program was successful in meeting its environmental targets, although it may have produced some temporary geographic shifts in use patterns (Anderson, Hofmann, and Rusin 1990; Newell and Rogers 2007), and it resulted in leaded gasoline being removed from the market faster than anticipated. In each year of the program (until the lead phasedown was completed and the program was terminated at the end of 1987), more than 60 percent of the lead added to gasoline was associated with traded lead credits (Hahn and Hester 1989). This high level of trading far surpassed levels observed in earlier environmental offset markets under EPA's Emissions Trading Program in the 1970s. The level of trading and the rate at which refiners reduced their production of leaded gasoline suggest that the program was also relatively cost-effective (Hahn and Hester 1989; Kerr and Maré 1997; Nichols 1997). EPA estimated that the lead trading program resulted in savings of approximately 20 percent relative to approaches that did not include trading (U.S. Environmental Protection Agency, Office of Policy Analysis 1985). In addition, the program provided significant incentives for cost-saving technology diffusion (Kerr and Newell 2003).

Lessons

Three major lessons emerge from the design and implementation of this program. First, as the first environmental program in which trading played a central role, the program served as proof of the concept that a tradable emission rights system could be both environmentally effective and economically cost-effective.

Second, the program demonstrated that transaction costs in such a system could be small enough to permit substantial trade. In contrast, in the 1970s, EPA's Emissions Trading Program (a set of emission-reduction-credit systems) required prior government approval of individual trades, which hampered trading activity. The lack of such requirements was an important factor in the success of trading in the lead phasedown program (Hahn and Hester 1989).

Third, as in later programs, banking played a very important role. By enabling intertemporal substitution, provisions that allowed firms to bank permits contributed a significant share of the gains from trade.

The Sulfur Dioxide Allowance Trading Program

During the 1980s, there was growing concern that acid precipitation – due mainly to emissions of SO_2 from coal-fired power plants – was damaging forests and aquatic ecosystems (Glass, *et al.* 1982). However, because the costs of emissions reductions differed dramatically among existing plants, legislative proposals to use command-and-control approaches failed to attract significant support.

Title IV of the Clean Air Act Amendments of 1990 addressed this issue by launching the SO_2 allowance trading program. Phase I (1995–1999) required emissions reductions from the 263 most polluting coal-fired electric generating units (larger than 100 MW), almost all of which were located east of the Mississippi River. Phase II, which began in 2000, placed an aggregate national emissions cap on approximately 3,200 electric generating units (larger than 25 MW) — nearly the entire fleet of fossil-fueled plants in the continental United States (Ellerman *et al.* 2000). This cap represented a 50 percent reduction from 1980 levels.

The government *gave* power plants permits to emit (called "allowances") specific tonnages of SO_2 emissions; allocations were based primarily on actual fuel use during the 1985-1987 period.[3] If annual emissions at a regulated facility exceeded its allowance allocation, the owner could comply by buying additional allowances or reducing emissions – by installing pollution controls, shifting to a fuel mix with less sulfur, or reducing production. If emissions at a regulated facility were below its allowance allocation, the facility owner could sell the extra allowances or bank them for future use. EPA monitored emissions on a continuous basis and verified ownership of the allowances submitted for compliance.

This cap-and-trade system created incentives for facilities to reduce their SO_2 emissions at the lowest cost. Although government auctioning of allowances would have generated revenue that could have been used – in principle – to reduce distortionary taxes, thereby reducing the program's social cost (Goulder 1995), this efficiency argument was not advanced at the time. Because the entire investor-owned electric utility industry was subject to cost-of-service regulation in 1990, it was assumed that the value of free allowances would be passed on to consumers and thus not generate windfall profits for generators. Just as important, the ability to allocate *free* allowances helped to build significant political support for the program (Joskow and Schmalensee 1998). Since the equilibrium allocation of pollution permits (after trading has occurred) is independent of the initial allocation (Montgomery 1972) — barring particularly problematic types of transaction costs (Hahn and Stavins 2012) --- the initial allocation of allowances could be designed to maximize political support without compromising the system's environmental performance or raising its cost.

Performance

The program performed exceptionally well across all relevant dimensions. SO_2 emissions from electric power plants decreased 36 percent between 1990 and 2004 (U.S. Environmental Protection

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[3] In addition, the statute required EPA to withhold about 2.8% of all allocated allowances each year, sell them at an annual auction, and return the proceeds in proportion to firms from which allowances had been withheld (Ellerman *et al* 2000).

Agency 2011), even though electricity generation from coal-fired power plants *increased* 25 percent over the same period (U.S. Energy Information Administration 2012). The program delivered emissions reductions more quickly than expected, as utilities made substantial use of the ability to bank allowances for future use. With continuous emissions monitoring and a $2,000/ton statutory fine for any emissions exceeding allowance holdings, compliance was nearly 100 percent (Burtraw and Szambelan 2010).

Some worried that the geographic pattern of emissions would change so as to produce "hot spots" of unacceptably high SO_2 concentrations. However, the pattern of emissions reductions was broadly consistent with model predictions, and no significant hot spots were produced (Ellerman et al. 2000; Swift 2004).

The cost of the program was significantly reduced after the substantial deregulation of railroads in 1980, which caused rail rates to fall and thus reduced the cost of burning low-sulfur Western coal in the East (Keohane 2003; Ellerman and Montero 1980; Schmalensee and Stavins 2013). That said, cost savings were at least 15 percent and perhaps as great as 90 percent of the costs of various alternative command and control policies (Carlson et al. 2000; Ellerman et al. 2000; Keohane 2003). In addition, there is evidence that the program reduced costs *over time* by providing incentives for innovation (Ellerman *et al*. 2000; Popp 2003; Bellas and Lange 2011). However, for a variety of reasons, the program's costs were likely not as low as they could have been (Schmalensee and Stavins 2013).

Nevertheless, the SO_2 allowance-trading program's actual costs were much lower than under command-and-control regulation – if such an approach had been politically feasible. The program's goals were achieved with less litigation (and thus less uncertainty) than is typical for traditional environmental programs, because firms that found it particularly costly to reduce emissions had the option to buy allowances instead. Moreover, firms could not complain about EPA's exercise of administrative discretion because the law gave EPA very little discretion. That said, subsequent regulatory actions, court decisions, and regulatory responses led to the virtual elimination of the SO_2 market by 2010 (Schmalensee and Stavins 2013).

The SO_2 reductions achieved benefits that were a substantial multiple of the program's costs (Burtraw, *et al*. 1998; Chestnut and Mills 2005). However, the program's benefits were due mainly to the positive human health impacts of decreased local SO_2 and small particulate concentrations, not the ecological benefits of reduced acid deposition that were expected when the program was enacted (Schmalensee and Stavins 2013). Nevertheless, there were also significant ecological benefits (Banzhaf et al. 2006).

Lessons

Even though the conclusion of the leaded gasoline phasedown trading program preceded the beginning of the SO_2 allowance trading program by a decade, the SO_2 system was, and is still today, often celebrated as the first important cap-and-trade program. Some of the lessons from the SO_2 program reinforce lessons from the lead phasedown program.

First, putting final rules in place well before the beginning of the first compliance period provides regulated entities with some degree of certainty, which facilitates their planning and limits price volatility in early years. In the case of the SO_2 allowance trading program, this was done two years prior to the implementation of Phase 1.

Second, as with the lead trading program, the absence of requirements for prior approval of trades reduced both the uncertainty for utilities and the administrative costs for government, and it contributed to low transaction costs and substantial trading (Rico 1995).

Third, as with the lead trading program, banking of allowances was extremely important, accounting for more than half of the program's cost savings (Carlson et al. 2000; Ellerman et al. 2000).

Fourth, when combined with unrestricted trading and banking, a robust allowance market can be fostered through a cap that is significantly below business-as-usual (BAU) emissions.

Fifth, allocation of free allowances can be very useful in building political support.

Sixth, intra-sector emissions leakage from regulated to unregulated entities can be minimized, as it was in this program, by regulating all non-trivial sources.

Finally, high levels of compliance can be ensured through rigorous monitoring of emissions and significant penalties for non-compliance.

U.S. REGIONAL AND STATE PROGRAMS

Over time, action on emissions trading in the U.S. has shifted to sub-national programs, including the Regional Clean Air Incentives Market in southern California, the NO_x trading in the eastern United States, the Regional Greenhouse Gas Initiative in the northeast, and California's cap-and-trade system.

The Regional Clean Air Incentives Market

The South Coast Air Quality Management District, which is responsible for controlling emissions in a four-county area of southern California, launched the Regional Clean Air Incentives Market (RECLAIM) in 1993 to reduce emissions of nitrogen oxides (NO_x) and in 1994 to reduce SO_2 emissions from 350 affected sources, including power plants and industrial sources in the Los Angeles area that emitted four or more tons per year of either pollutant. RECLAIM replaced command-and-control regulations that were scheduled to bring the region into compliance with national ambient air quality standards (Ellerman, Joskow, and Harrison 2003).

RECLAIM Trading Credits (RTCs) were allocated for free, with initial allocations of NO_x and SO_2 RTCs based on historical peak production levels and set at 40 to 60 percent above actual emissions until the year 2000. The NO_x and SO_2 caps declined annually by 8.3% and 6.8%, respectively, until 2003, when the market reached its overall goal of a 70% emissions reduction (Hansjurgens 2011; Ellerman, Joskow, and Harrison 2003). The compliance period was a single year, and banking was not allowed. An interesting aspect of this program's design was its zonal nature: trades were not permitted from downwind to upwind sources.

Performance

RECLAIM was predicted to achieve significant cost savings via trade (Johnson and Pekelney 1996; Anderson 1997). And, by June 1996, 353 program participants had traded more than 100,000 tons of NO_x and SO_2 credits, with a value of over $10 million (South Coast Air Quality Management District 2016). Studies have found that emissions at RECLAIM facilities were some 20 percent lower than at facilities regulated with parallel command-and-control regulations; that hotspots did not appear; and that substantial cost savings were achieved (Burtraw and Szambelan 2010; Fowlie, Holland, and Mansur 2012).

In the program's early years, allowance prices remained in the expected range of $500 to $1,000 per ton of NO_X. During California's electricity crisis in 2000-2001, however, some sources of electricity were eliminated, which required generation at some RECLAIM generating facilities to increase dramatically. This caused emissions to exceed permit allocations at those facilities, and, in the absence of a pool of banked allowances, resulted in a dramatic spike in allowance prices -- to more than $60,000/ton in 2001 (Fowlie, Holland, and Mansur 2012). The program was temporarily suspended, and prices returned to normal levels (below $2,000/ton) by 2002, with all sources rejoining the program by 2007. As of December 2015, the twelve-month moving average of NO_X prices was $1,642/ton (South Coast Air Quality Management District 2016).

Lessons

Three lessons emerge from the RECLAIM program. First, because the RECLAIM system included an upwind and a downwind zone, with trades allowed in only one direction, the program demonstrated that appropriate design can accommodate a non-uniformly mixed pollutant and attendant concerns about potential hot spots.

A second lesson from RECLAIM, which later became important for several CO_2 cap-and-trade systems, is that an over-allocation of allowances eliminates a functioning spot allowance market. Third, provisions for the banking of allowances (along with other cost-containment elements, such as price caps) can be crucial for regulated entities to achieve compliance at a reasonable cost in years in which unanticipated circumstances cause emissions to be greater than expected.

NO_x Trading in the Eastern United States

Under EPA guidance, and enabled by the Clean Air Act Amendments of 1990, in 1999 eleven northeastern states and the District of Columbia developed and implemented the NO_x Budget Program, a regional NO_X cap-and-trade system. Given the significant adverse health effects of ground-level ozone (i.e., smog formed by the interaction of NOx and volatile organic compounds in the presence of sunlight), the goal of the program was to reduce summertime ground-level ozone by more than 50% relative to 1990 levels (U.S. Environmental Protection Agency 2004). Some 1,000 electric generating and industrial units were required to demonstrate compliance each year during the summer ozone season (May through September).

The region covered by the program was divided into upwind and downwind zones, and allowances were given to states to distribute to in-state sources. Sources could buy, sell, and bank allowances within limits reflecting the seasonal nature of the ozone problem. Upwind states were given less generous allowance allocations as percentages of 1990 emissions. However, trading across zones was permitted on a one-for-one basis, and the two zones made similar reductions from baseline emissions levels (Ozone Transport Commission 2003).

In 1998, the EPA issued the NO_x SIP (State Impementation Plan) Call, which required 21 eastern states to submit plans to reduce their NOx emissions from more than 2,500 sources. The Call included a model rule, which, if adopted by a state, would enable it to meet its emission reduction obligations by participating in an interstate cap-and-trade program, known as the NO_x Budget Trading Program. All affected states adopted the model rule, and the trading program went into effect in 2003, replacing the NOx Budget Program. As in the earlier program, states were given allowances to allocate to in-state sources. In 2009, the NO_X Budget Trading Program was effectively replaced by the Clean Air Interstate Rule (CAIR), and in January 2015, CAIR was replaced by the Cross State Air Pollution Rule (CSAPR).

Performance

At the outset, the NO_X Budget Program market was characterized by uncertainty because some trading rules were not in place when trading commenced. This resulted in high price volatility during the program's first year, although prices stabilized by the program's second year (Farrell 2000). Overall, under the NO_X Budget Program and the NO_X Budget Trading Program, NO_X emissions declined from about 1.9 million tons in 1990 to less than 500,000 tons by 2006, with 99% compliance (Butler, *et al.* 2011; Deschenes *et al.* 2012). For the 1999-2003 period, abatement cost savings were estimated at 40 to 47 percent relative to conventional regulation, which did not include trading or banking (Farrell 2000).

Lessons

Four lessons stand out from the NOx trading program. First, in order to avoid unnecessary price volatility -- which imposes unnecessary risk on affected sources and thus raises costs -- all of the components of an emissions trading program should be in place well before the program takes effect.

Second, a well-designed multi-state process with federal guidance can be effective in coordinating what are legally state-level goals.

Third, the history of NO_X trading in the eastern United States provides a precedent and model for expanding the coverage of a cap-and-trade system over time to include additional jurisdictions, such as neighboring states.

Fourth, states can be given the flexibility to allocate allowances among in-state sources without necessarily compromising environmental goals.

The Regional Greenhouse Gas Initiative

Nine northeastern U.S. states participate in the Regional Greenhouse Gas Initiative (RGGI), the first U.S. cap-and-trade system to address carbon dioxide (CO_2) emissions. RGGI is a downstream program that focuses only on the power sector. It began in 2009 with the goal of limiting emissions from regulated sources to 2009 levels through 2014. The emissions cap was then set to decrease by 2.5 percent each year from 2015 to 2019, when the cap would have declined to 10 percent below 2009 emissions. It was originally anticipated that meeting this goal would require a reduction of approximately 35 percent below business-as-usual emissions (13 percent below 1990 emissions).

Due to the recession and the drastic decline in natural gas prices relative to coal prices, the emissions cap quickly ceased to be binding, and it appeared unlikely to become binding through 2020. In response, in 2012, in a pre-planned review of the program, the RGGI states agreed to establish a lower cap for 2014, with 2.5% annual cuts thereafter to 2019. Reflecting these economic and policy changes, allowance prices fell from approximately \$3/ton of CO_2 at the first auction in 2008, to the floor price of \$1.86/ton in 2010, and rose to \$5.50/ton in 2015.

Under the RGGI program, participating states must auction at least 25 percent of their allowances and use the proceeds to invest in energy efficiency, renewable energy, and related efforts. Auctioning was required mainly to avoid the windfall profits that would generally result from free allocation of allowances in deregulated electricity markets (Sijm, Neuhoff, and Chen 2006). In practice, states have auctioned virtually all allowances.

There is a ceiling on allowance prices via a cost containment reserve, from which additional allowances sold when auction prices reach specified levels. There is also a price floor below which allowances are not sold at auction. Any unsold allowances are permanently retired after three years, thus automatically tightening the cap if there is a chronic allowance surplus. This combination of a price ceiling and a price floor serves as a price collar, thus making the RGGI program somewhat of a hybrid of a cap-and-trade system and a carbon tax.

Performance

Because the cap was not binding during the program's first compliance period (2009-2011), and has been barely binding since then, the direct impact of the RGGI program on power-sector CO_2 emissions has been small, at best. However, the program's auctions have generated more than $1 billion in revenues for the participating states. Some of this revenue has been used to finance government programs aimed at reducing energy demand and hence CO_2 emissions and the demand for allowances (Hibbard, *et al.* 2011)

Monitoring costs have been very low because U.S. power plants were already required to report their hourly CO_2 emissions under the federal SO_2 allowance trading program. The penalty for non-compliance is that entities must submit three allowances for each allowance they are short.

Because of the geographically-limited scope of the RGGI system, combined with interconnected electricity markets, emissions leakage has been a significant concern (Burtraw, Kahn, and Palmer 2006). One study found that if the program were fully binding, power imports from Pennsylvania to New York State could result in emissions leakage of as much as 50% (Sue Wing and Kolodziej 2008).

Lessons

Three lessons have emerged from this program. The first, which has not been lost on policy makers, is that a cap-and-trade system that auctions its allowances can generate substantial revenue for government, whether or not the system has much effect on emissions.

Second, the leakage problem is potentially severe for any sub-national program, particularly a power-sector program, because of the interconnected nature of electricity markets (Burtraw, Kahn, and Palmer 2006).

Third, a changing economy can render a cap non-binding (causing allowance prices to fall) or drive allowance prices to excessive levels. This suggests an important role for price collars. In the case of RGGI, an effective price floor was established through the use of a reservation price in allowance auctions. The price ceiling has not been tested, however, and may be less effective because of the limited size of the cost containment reserve.

California's Cap-and-Trade System

In 2006, California enacted Assembly Bill 32 (AB-32), which required the California Air Resources Board to establish a program to cut the state's greenhouse gas (GHG) emissions to 1990 levels by the year 2020. The program includes: energy efficiency standards for vehicles, buildings, and appliances; renewable portfolio standards that increase renewables' share of electricity supply from 20% to 33%; a low carbon fuel standard that requires refineries to reduce the carbon content of motor vehicle fuels; and a cap-and-trade system (California Environmental Protection Agency 2014).

The AB-32 cap-and-trade system began in 2013, covering all electricity sold in California, no matter where it was generated[4], and large-scale manufacturing. The program was expanded to include fuels in 2015, thereby covering 85% of the state's emissions. The cap declines annually until 1990

[4] California imports much of its electricity from out of state. The possibility of reshuffling the contracts involved may enable substantial leakage (Bushnell, Peterman, and Wolfram 2008).

emission levels are achieved in 2020. Initially, most allowances were distributed for free, with greater use of auctions over time. Banking is allowed, and regulated entities may use approved offsets from emissions reductions from forestry, dairy digestion, and ozone-depleting substances reduction to account for up to 49% of their emissions reductions.

A price ceiling is established by releasing allowances from a reserve when auction prices reach specified levels. A price floor is created through an auction reservation price, with unsold allowances held until the reservation price is exceeded for six consecutive months. This combination produces an effective price collar, creating a hybrid cap-and-trade and carbon tax system. In addition, the program addresses competitiveness concerns in energy-intensive, trade-exposed (EITE) industries by granting free allowances in proportion to production levels in previous periods.

In 2014, California's system was linked to a very similar system in Quebec (Kroft and Drance 2015), with mutual recognition of allowances for trading and compliance and joint allowance auctions.

Performance and Lessons

Because California's cap-and-trade system was only launched in 2013, it is too early to assess its performance, other than to note that the auction mechanisms and other design features have functioned as anticipated. Thus, the lessons from the AB-32 cap-and-trade system are related to its design, rather than its performance.

First, the California system has demonstrated that using an initial free allowance allocation to build political support can transition over time to greater auctioning of allowances.

Second, the California experience is a reminder of the political pressures not to use auction revenues to reduce distortionary taxes. As of May 2015, the AB-32 auctions had generated over $2 billion and were expected to generate nearly $4 billion by the end of 2016 (California Legislative Analyst's Office 2015). Assembly Bill 1532 (2012) requires that these funds "be used to reduce GHG emissions and, to the extent feasible, achieve co-benefits such as job creation, air quality improvements, and public health benefits."

Third, as the first CO_2 (or GHG) cap-and-trade system to be essentially economy-wide[5], California's AB-32 system has demonstrated that this approach is as feasible as less efficient approaches that treat different sectors differently.

Fourth, the AB-32 system greatly limits price volatility by employing an effective price collar. As noted earlier, although emissions levels are less certain under such hybrid systems, lower price volatility reduces compliance costs.

Fifth, California has employed an effective mechanism to address concerns about competitive impacts on EITE sectors. Granting free allowances to firms in specific sectors in proportion to their production levels in a previous time period subsidizes production and thus directly affects competitiveness. Of course, this subsidy of EITE sectors introduces its own inefficiencies. On the other

[5] Since 2010, New Zealand has had an economy-wide (except for agriculture) CO_2 emissions trading system linked to international allowance markets under the Kyoto Protocol, but domestic emissions are not capped.

hand, simply granting extra allowances to firms in EITE sectors (as in the European Union's Emissions Trading System) has no effect on competitiveness because marginal production costs are not affected.[6]

Sixth, California's strong interest in linking its cap-and-trade system with those in other jurisdictions (including its recent linkage with Quebec) illustrates the desirability of using such linkages to reduce abatement costs, price volatility, and market power (Ranson and Stavins 2013).

Finally, although policies that address energy-related market failures can reduce costs, California's AB-32 system illustrates that some "complementary policies" are more likely to increase costs with no effect on emissions. For example, the state's Low Carbon Fuel Standard (LCFS) requires that California refineries produce fuel with, on average, no more than a set amount of life-cycle carbon content. But refineries and transportation fuels are already covered by the cap-and-trade system, so the LCFS cannot reduce emissions in the short run unless it makes the allowance price floor binding. Because the LCFS is a binding constraint on refiners, refiners achieve additional CO_2 emission reductions beyond what would be achieved through the cap-and-trade system alone. However, unless the price floor becomes binding, this "complementary" policy – the LCFS – will produce 100% leakage to other sectors when allowances are sold. In any case, marginal abatement costs are not equated across sectors and sources,[7] so aggregate abatement costs will increase. In addition, allowance prices will be depressed, raising concerns about the ability of the cap-and-trade system to encourage technological change --- except in the refinery sector. In short, the LCFS is a "complementary" policy that mainly increases abatement costs and lowers allowance prices (Goulder and Stavins 2011). Many other so-called complementary policies have similar perverse effects.[8]

THE EUROPEAN UNION EMISSIONS TRADING SYSTEM

The European Union Emission Trading System (EU ETS), a cap-and-trade system focused on CO_2, is the world's largest and first multi-country emissions trading system (European Commission 2012). The EU ETS was adopted in 2003 and covers about half of EU CO_2 emissions in 31 countries[9] (Ellerman and Buchner 2007). More than 11,000 entities are regulated, including electricity generators and large industrial sources. Competitiveness concerns were largely addressed by the allocation of free allowances to a long list of selected sectors. The EU ETS excludes most sources in the transportation, commercial, and residential sectors, although some aviation sector emissions were brought under the cap in 2012.

The EU ETS was designed to be implemented in phases: a pilot Phase I from 2005 to 2007, a Kyoto Phase II from 2008 to 2012, and a series of subsequent phases that are now being extended through 2030. Penalties for violations increased from €40 per ton of CO_2 in the first phase to €100 in the second phase. The first phase allowed trading only in CO_2, but the second phase broadened the program to include some other GHGs.

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[6] For a review of the literature on the competitiveness benefits and the efficiency costs of output-based updating of allowance allocations, see Fowlie (2012).

[7] As of January 2016, LCFS credits were selling for an average of $105/ton of CO_2 (California Environmental Protection Agency 2016), while the cap-and-trade allowances were selling for about $13/ton of CO_2 (Climate Policy Initiative 2016).

[8] In fact, the requirement that auction revenues from the cap-and-trade system be used to further the goals of the statute (AB-32) virtually guarantees this perverse interaction between "complementary policies" and the cap-and-trade system.

[9] All 28 EU countries plus Iceland, Lichtenstein, and Norway.

The allocation process was initially decentralized (Kruger, Oates, and Pizer 2007), with each member state responsible for proposing its own national cap, subject to approval by the European Commission. This created incentives for member states to set high caps (Convery and Redmond 2007).

Performance

The EU ETS has performed as might have been anticipated. In January 2005, the Phase I allowance price per ton of CO_2 was approximately €8; by early 2006, it exceeded €30, reflecting anticipated increases in demand. However, once it became clear that the generous allocation of allowances in 2005 had exceeded actual emissions, the allowance price fell by about half during one week in April 2006, fluctuated and soon returned to about €8, and then collapsed to zero in 2007 (Convery and Redmond 2007). This volatility was attributed to the absence of good emissions data at the beginning of the program, a surplus of allowances, and energy price volatility; and the collapse was attributed to the inability to bank allowances from Phase I to Phase II (Market Advisory Committee 2007).

The first and second phases of the EU ETS required member states to distribute almost all of the emissions allowances for free. However, since 2013, member states have been required to auction increasing shares of their allowances. The initial free distribution of allowances led to complaints about "windfall profits" for electricity generators when electricity prices increased significantly in 2005. But higher fuel prices also played a role in the electricity price increases, and some generators' profits reflected their ownership of low-cost nuclear or coal generation in areas where the market electricity price was set by higher-cost natural gas plants (Ellerman and Buchner 2007).

The system's cap was tightened for Phase II (2008-2012), and its scope was expanded to cover new sources in countries that had participated in Phase I as well as countries that joined the EU in 2007 and 2013. In addition, three non-member states -- Norway, Iceland, and Liechtenstein -- joined the EU ETS in 2008. Allowance prices in Phase II increased to more than €20 in 2008, and then fell when the recession reduced energy demand, thus reducing demand for allowances. Demand also declined because of the heavy use of offsets produced under the Kyoto Protocol's CDM. By the fall of 2011, prices had fallen to €10 and have remained in the €5 to €10 range since then.

The EU ETS has been extended through its Phase III (2013-2020) with a more stringent, centrally determined cap (20% below 1990 emissions), auctioning of a larger share of allowances, tighter limits on the use of offsets, and unlimited banking of allowances between Phases II and III. Free allocation of allowances continues in Phase III for EITE sectors (Sartor, *et al.* 2015).

There continues to be concern in the EU regarding low allowance prices (Löfgren, *et al.* 2015). These prices reflect the weak European economic recovery and the lack of a price floor. In addition, other binding EU policies, particularly renewable generation and energy efficiency standards, reduce emissions under the cap. As noted earlier, in the absence of a binding price floor, such "complementary" policies raise costs and reduce allowance prices without affecting total emissions.

Lessons

Five main lessons have emerged from our experience with the EU ETS thus far. First, the availability of good data is important for sound allowance allocation and cap-setting decisions. Had such data been available in Phase I of the EU ETS, it might have been possible to avoid the over-allocation that occurred.

Second, to avoid an artificial price collapse at the end of a compliance period, it is necessary to allow for banking from one period to the next. Because the EU ETS did not allow banking in Phase I, it was hardly surprising that Phase I allowance prices fell to zero at the end of Phase I.

Third, like the AB-32 California system, the EU ETS illustrates the perverse outcomes that result when "complementary" policies are applied to reduce emissions that are also covered under the cap, particularly in the absence of a price floor. Unless such complementary policies apply to sources *outside* the cap or address other market failures, they relocate emissions, drive up aggregate abatement costs, and depress allowance prices.

Fourth, although granting free allowances can help address distributional concerns as well as serving other political purposes, it is ultimately insufficient for dealing with international competitiveness concerns, because unless allocations are linked to *production*, they do not affect marginal production costs.

Finally, the history of the EU ETS again shows that it is possible to move over time from a regime of generally free allowances to one in which most allowances are auctioned.

OTHER CAP-AND-TRADE SYSTEMS

Other cap-and-trade systems have been implemented, planned, or at least contemplated in many nations. Under the 1987 Montreal Protocol, several countries implemented systems of tradable rights for ozone depleting substances (ODS) during the ODS phasedown from 1991 to 2000 (Klaassen 1999; U.S. Environmental Protection Agency 2014). In addition, an international CO_2 cap-and-trade system has nominally operated since 2008: countries with emissions reduction commitments under the Kyoto Protocol (the "Annex I countries") that have ratified the Protocol can, in effect, sell emission reductions that go beyond their compliance obligations to other Annex I parties that have outstanding compliance obligations. However, because the trading agents are nations rather than firms, not surprisingly there has been little activity (Hahn and Stavins 1999). There has been more international private sector activity in emissions offsets under the Kyoto Protocol's CDM.

Currently, there are CO_2 cap-and-trade systems at various stages of development in a number of countries around the world, including Japan (Sopher and Mansell 2014a), South Korea (Park and Hong 2014), Kazakhstan (Kossoy *et al* 2014), and Switzerland (Sopher and Mansell 2014b). Most importantly, China began municipal and provincial pilot trading systems in 2013 (Kossoy et al 2014), and on September 25, 2015, President Xi Jinping announced that in 2017 China will launch a national CO_2 cap-and-trade system covering key industries (Cunningham 2015).

Cap-and-trade systems have also been proposed in other countries at levels of governance that range from sub-municipal to national (Kossoy, *et al.* 2014; Organization for Economic Cooperation and Development and World Bank Group 2015). Notably, the government of Ontario (Canada) recently announced a CO_2 cap-and-trade system to be linked to Quebec's system, and thus to California's system (Government of Ontario 2015). Finally, in August 2015, the United States finalized the Clean Power Plan (CPP), which is aimed at CO_2 emissions from electricity generators and both enables and encourages state-level and multi-state emissions trading (U.S. Environmental Protection Agency 2015). However, on February 9, 2016, the U.S. Supreme Court halted implementation of the CPP, pending the resolution of legal challenges to it, and thus its ultimate fate is unclear.

SUMMARY AND CONCLUSIONS

This article has examined thirty years of experience with emissions trading systems. Overall, we have found that cap-and-trade systems, if well designed and appropriately implemented, can achieve their core objective of meeting targeted emissions reductions cost-effectively. But the devil is in the details, and design as well as the economic environment in which systems are implemented are very important. Moreover, as with any policy instrument, there is no guarantee of success.

Based on the lessons we have identified in our discussion, several design and implementation features of cap-and-trade programs appear critical to their performance.

Key Features for System Design and Implementation

First, it is important not to require prior approval of trades. In contrast to early U.S. experience with emissions offset systems, transactions costs can be low enough to permit considerable efficiency-enhancing trade if prior approval of trades is not required. Second, it is clear from both theory and experience that a robust market requires a cap that is significantly below BAU emissions. Third, to avoid unnecessary price volatility, it is important for final rules (including those for allowance allocation) to be established and accurate data supplied well before commencement of a system's first compliance period. Fourth, high levels of compliance in a downstream system can be achieved by ensuring there is accurate emissions monitoring combined with significant penalties for non-compliance. Fifth, provisions for allowance banking have proven to very important for achieving maximum gains from trade, and the absence of banking provisions can lead to price spikes and collapses. Sixth, price collars are important. A changing economy can reduce emissions below a cap, rendering it non-binding, or a growing economy can increase emissions and drive allowance prices to excessive levels. Price collars reduce price volatility by combining an auction price floor with an allowance reserve. The resulting hybrid systems will generally have lower costs (as more stable prices facilitate investment planning) at the expense of less certain emissions reductions. Finally, economy-wide systems are feasible, although downstream, sectoral programs have been more commonly employed.

Political Considerations that Affect Cap-and-Trade Design

Thirty years of experience with cap-and-trade also indicate the importance of political considerations for the design of cap-and-trade programs. First, because of the potentially large distributional impacts involved, the allocation of allowances is inevitably a major political issue. Free allowance allocation has proven to help build political support. And, under many circumstances, the equilibrium allowance distribution, and hence the aggregate abatement costs of a cap-and-trade system, are independent of the initial allowance allocation (Montgomery 1972; Hahn and Stavins 2012). This means that the allowance allocation decision can be used to build political support and address equity issues without concern about impacts on overall cost-effectiveness.

Free allowance allocation does forego the opportunity to cut overall social costs by auctioning allowances and using the proceeds to cut distortionary taxes. On the other hand, experience has shown that political pressures exist to use auction revenue not to cut such taxes but to fund new or existing environmental programs or relieve deficits. Indeed, cap-and-trade allowance auctions can and have generated very significant revenue for governments.

Second, the possibility of emissions leakage and adverse competitiveness impacts has been a prominent political concern in the design of cap-and-trade systems. Of course, virtually any meaningful environmental policy will increase production costs and thus could raise these concerns, but this issue has been more prominent in the case of cap-and-trade instruments. In practice, leakage from cap-and-trade systems can range from non-existent to potentially quite serious. It is most likely to be significant for programs of limited geographic scope,[10] particularly in the power sector because of interconnected electricity markets. Attempts to reduce leakage and competitiveness threats through free allocation of allowances does not *per se* address the problem, but an output-based updating allocation can do so.

[10] For this and other reasons, linkage between cap-and-trade systems and other types of policies in other jurisdictions is likely to become increasingly important in the future because such linkage can reduce abatement costs, leakage, price volatility, and market power.

Third, although carbon pricing (through cap-and-trade or taxes) may be necessary to address climate change, it is surely not sufficient. In some cases, abatement costs can be reduced through the use of complementary policies that address other market failures, but the types of "complementary policies" that have emerged from political processes have instead addressed emissions under the cap, thereby relocating rather than reducing emissions, driving up abatement costs, and suppressing allowance prices.

Identifying New Applications

Cap-and-trade systems are now being seriously considered for a wide range of environmental problems. Past experience can offer some guidance as to when this approach is most likely to be successful (Stavins 2007).

First, the greater the differences in the cost of abating pollution across sources, the greater the likely cost savings from a market-based system – whether cap-and-trade or tax -- relative to conventional regulation (Newell and Stavins 2003). For example, it was clear early on that SO_2 abatement cost heterogeneity was great, because of differences in ages of plants and their proximity to sources of low-sulfur coal (Carlson *et al.* 2000).

Second, the greater the degree of mixing of pollutants in the receiving airshed (or watershed), the more attractive a market-based system, because when there is a high degree of mixing, local hot spots are not a concern, and the focus can thus be on cost-effective achievement of aggregate emissions reductions. Most cap-and-trade systems have been based on either the reality or the assumption of uniform mixing of pollutants. However, even without uniform mixing, well-designed cap-and-trade systems can be effective (Montgomery 1972), as illustrated by the two-zone trading system under RECLAIM, at the cost of greater complexity.

Finally, since Weitzman's (1974) seminal analysis of the effects of cost uncertainty on the relative efficiency of price versus quantity instruments, it has been well known that in the presence of cost uncertainty, the relative efficiency of these two types of instruments depends on the pattern of costs and benefits. Subsequent literature has identified additional relevant considerations (Stavins 1996; Newell and Pizer 2003). Perhaps more importantly, theory (Roberts and Spence 1976) and experience have shown that there are efficiency advantages of *hybrid* systems that combine price and quantity instruments in the presence of uncertainty.

Implications for Climate Change Policy

Two lessons from thirty years of experience with cap-and-trade systems stand out. First, cap-and-trade has proven itself to be environmentally effective and economically cost-effective relative to traditional command and control approaches. Moreover, less flexible systems would not have led to the technological change that appears to have been induced by market-based instruments (Keohane 2003; Schmalensee and Stavins 2013) or the induced process innovations that have resulted (Doucet and Strauss 1994). Second, and equally important, the performance of cap-and-trade systems depends on how well they are designed. In particular, we have emphasized the importance of reducing unnecessary price volatility and argued that hybrid designs offer an attractive option if some variability of emissions can be tolerated, since substantial price volatility generally raises costs.

These lessons suggest that cap-and-trade merits serious consideration when regions, nations, or sub-national jurisdictions are developing policies to reduce GHG emissions. And, indeed, this has happened. However, because any meaningful climate policy will have significant impacts on economic activity in many sectors and regions, proposals for such policies have often triggered significant opposition.

In the United States, the failure of cap-and-trade climate policy in the Senate in 2010 was essentially collateral damage from a much larger political war that has decimated the ranks of both moderate Republicans and moderate Democrats (Schmalensee and Stavins 2013). Nevertheless, political support for using cap-and-trade systems to reduce GHG emissions has emerged in many other nations. In fact, in the negotiations leading up to the Paris conference in late 2015, many parties endorsed key roles for carbon markets, and broad agreement emerged concerning the value of linking those markets (codified in Article 6 of the Paris Agreement).

It is certainly possible that three decades of high receptivity to cap-and-trade in the United States, Europe, and other parts of the world will turn out to have been only a relatively brief departure from a long-term trend toward reliance on command and control environmental regulation. However, in light of the generally positive experience with cap-and-trade reported here, we remain optimistic that the recent tarnishing of cap-and-trade in US political debates will itself turn out to be a temporary departure from a long-term trend of increasing reliance on market-based environmental policy instruments.

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APPENDIX TABLE 1

Summary of Major Cap-and-Trade Systems

System	Geographic Scope	Coverage & Sectors	Time Period	Allowance Allocation Method	Cost Containment Mechanisms	Environmental and Economic Performance
Leaded Gasoline Phasedown	USA	Gasoline from Refineries	1982-1987	Free	Banking	Phasedown completed successfully, faster than anticipated, with cost savings of $250 million/year
Sulfur Dioxide Allowance Trading	USA	SO_2 from Electric Power	1995-2010	Free	Banking	Cut SO_2 emissions by half, with cost savings of $1 billion/year; but market closed due to judicial actions
Regional Clean Air Incentives Market (RECLAIM)	South Coast Air Quality Management District, CA	NO_x & SO_2 from Electric Power & Industrial Sources	1993-present	Free	---	Emissions lower than with parallel regulations; un-quantified cost savings; electricity crisis caused allowance price spike and temporary suspension of market
NOX Trading in the Eastern United States	12-21 U.S. States	NO_x from Electric Power & Industrial Sources	1999-2008	Free	---	Significant price volatility in first year; NO_x emissions declined from 1.9 (1990) to 0.5 million tons (2006); cost savings 40-47 percent
Regional Greenhouse Gas Initiative	Nine northeastern U.S. States	CO_2 from Electric Power	2009-present	Nearly 100% Auction	Banking, Cost Containment Reserve, Auction Reservation Price	Cap non-binding then barely binding due to low natural gas prices; has generated more than $1 billion for participating states
AB-32 Cap-and-Trade	California, USA	CO_2 from Electric Power, Industrial, & Fuels	2013- 2020	Transitions from Free to Auction	Banking, Allowance Price Containment Reserve, Auction Reservation Price	Covers 85% of emissions; reduces competitiveness effects w/output-based updating (OBU) allocation; linked with Quebec cap-and-trade system
European Union Emissions Trading System	27 EU Member States plus Iceland, Lichtenstein, & Norway	CO_2 from Electric Power, Large Industrial, & Aviation	2005-	Transitions from Free to Increased Use of Auctions	Banking after 2008, previous use of offsets from CDM	Over-allocation by member states in pilot phase; suppressed allowance prices due to "complementary policies," CDM glut, slow economic recovery