

An aerial night photograph of a city, likely New York City, showing a dense urban landscape with illuminated buildings and streets. A grid of overlapping squares in light blue and yellow is superimposed on the image. A dark teal rectangular box is positioned in the upper left, containing the title text. A green rectangular box is located in the lower right, containing the authors' names and the date. The Climate Xchange logo is in the bottom left corner.

REGIONAL CAP AND TRADE:

LESSONS FROM THE REGIONAL GREENHOUSE GAS INITIATIVE AND WESTERN CLIMATE INITIATIVE

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October 2018

CLIMATE **X**CHANGE



Our mission is to provide research, education, and advocacy to enhance climate resilience and move us towards a low-carbon economy through market-based mechanisms.

Climate XChange was founded in 2013 by a group of concerned citizens, frustrated by the lack of progress in the fight against climate change, and seeking effective and viable policy solutions to reducing carbon emissions.

Inspired by the great success of British Columbia's carbon pricing law, and by the support for carbon pricing among economists and popularity across the political isle, we decided to focus on market-based solutions to the climate crisis. Our starting point — researching the impact of carbon pricing on the Massachusetts economy and writing legislation to implement it in the state.

We have since grown from an organization of two working around a kitchen table to something much bigger. Our offices now occupy the second and third floors of Old West Church, a two-hundred-year-old revolutionary building located on the back side of historic Beacon Hill. As our organization has grown, so has our staff, our aspirations, and most importantly, our impact.

At a time when our federal government remains stagnant on climate action, states have the opportunity to make policy decisions that will bolster the well-being of communities and the economy. By providing policymakers and advocates the cutting-edge research and knowledge they need, we can work together to ignite a clean energy revolution and establish a stronger energy foundation for our economy.

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EXECUTIVE SUMMARY

TWO LARGE CAP-AND-TRADE SYSTEMS for carbon dioxide emissions (CO₂) exist in the U.S. — the Regional Greenhouse Gas Initiative (RGGI) that currently covers ten Northeast and Mid-Atlantic states; and the Western Climate Initiative (WCI), which now includes California and the Canadian province of Québec. Both of these programs, which launched in 2008 and 2012 respectively, were created in the absence of a comprehensive federal policy to reduce carbon pollution.

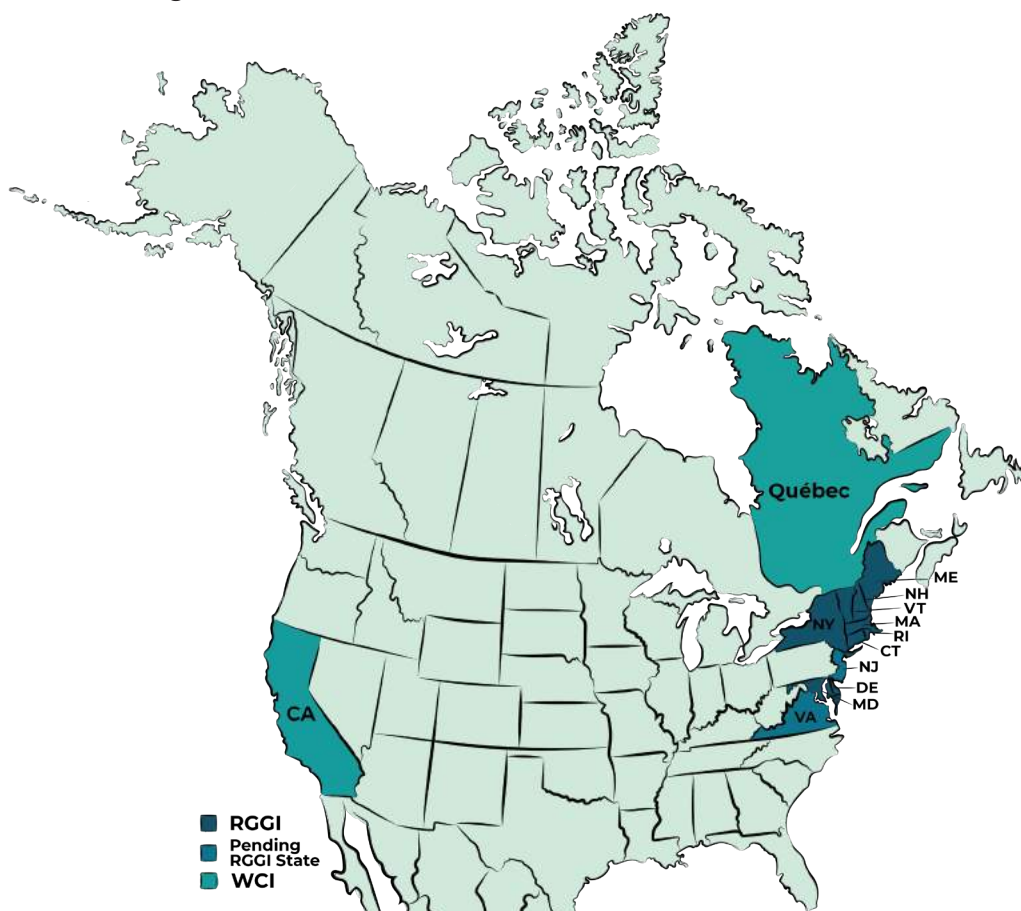
The two systems have functioned effectively to date, demonstrating that sub-national jurisdictions can unify their environmental aspirations and collaborate on carbon pricing program design. However, the majority of emissions reductions have come from market forces and other clean energy policies in the electricity sector, not from the emissions caps. If cap-and-trade is to have a major impact on cutting emissions in the future, these policies must be far stronger than current designs.

While electricity-sector reductions in both systems have exceeded expectations thus far, emissions in other sectors will likely be far more difficult to cut. The recommendations outlined in this report would prepare these programs to stay on target through 2030 without overburdening their economies.

POLICY RECOMMENDATIONS

Expand RGGI beyond electricity

To have a larger impact RGGI must follow WCI in expanding to other polluting sectors such as transportation, heating fuel, and industrial activity. Alternatively, the states should institute direct carbon pricing in the form of pollution fees. Most RGGI states have a long-term emissions target in place for 2050, usually an 80% reduction below 1990 levels. Some have targets for earlier years, such as Maryland's 40% and Connecticut's 45% reduction mandates for 2030. While most RGGI states have other substantial policies to cut emissions, they will not be able to reach the



deep cuts in future decades that science tells us are necessary without carbon pricing. Expanding beyond electricity would likely necessitate higher allowance prices to spur GHG abatement.

Tighten future cap levels and limit banking

WCI and RGGI need downward cap adjustments and tighter control over loopholes in order to be more effective. Due to overestimated emissions in early years combined with unrestricted banking, WCI's current program design risks overshooting 2030 emissions goals.

Both RGGI and WCI are over allocated, such that there is a large gap between actual emissions and what the cap allows. When firms are allowed to purchase surplus allowances and save them indefinitely, the program's long-term annual emissions goals are jeopardized.

Carbon pricing theory emphasizes banking as a necessary component of a stable carbon market. But in practice, WCI participants are accumulating allowances worth hundreds of millions of tons of CO₂, which can be used to meet their compliance in future years. Ensuring the future success of the program will necessitate either adjusting the cap trajectory downward to account for these banked allowances, or imposing new restrictions that reduce the banked allowance pool over time.

Use rebates to protect the economy from potentially high allowance prices

Among other cost containment mechanisms, policy-makers have imposed "price collars" in carbon markets — a minimum price below which allowances will not be sold and a maximum at which more allowances will be issued.

The maximum exists to ensure that allowance prices remain within a price range that is economically and politically acceptable. But this could allow emissions to rise above the cap level, so that the program fails to meet its environmental goal.

Alternatively, these programs could employ rebate requirements, such that at various price points an increasing amount of revenue is returned to residents and employers in an equitable manner. This would enable the allowance price to continue to rise to whatever level is necessary, yet ensure that the ultimate economic impacts of the program are not excessive.

INSTEAD OF
IMPOSING PRICE
CEILINGS, AS
ALLOWANCE
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THE PROGRAMS
COULD PROVIDE
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REBATES TO
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EMPLOYERS IN
AN EQUITABLE
MANNER.

UNDER RGGI,
THE MAJORITY
OF EMISSIONS
REDUCTIONS
HAVE COME FROM
EXTERNAL FACTORS.
THESE INCLUDE
THE SHARP DROP
IN NATURAL GAS
PRICES AND LARGE-
SCALE PUBLIC
FUNDING OF
ENERGY EFFICIENCY
PROGRAMS, MOST
OF WHICH HAS NOT
COME FROM RGGI
REVENUES.

REGIONAL GREENHOUSE GAS INITIATIVE

RGGI covers only electricity generation, while WCI has covered nearly all sources of fossil fuel combustion since 2015. In part, both were designed to demonstrate that a cap-and-trade system could operate smoothly without damaging the economy.

Initially, RGGI policymakers were concerned that adding a cost to carbon, when most other states and countries do not have one, would risk putting local industries at a competitive disadvantage and imposing undue burdens on residents. As a result, intended impacts under RGGI were modest — the emissions limit was expected to produce only a 10% cut in electricity emissions by 2018.¹

The reality has been much more favorable. Due primarily to other factors, including a boom in natural gas supply and the effectiveness of other clean energy policies, capped emissions in the RGGI region fell by nearly 40% between 2009 and 2017, far more than the cap required.

RGGI acts as an excellent “proof of concept” — it has both reduced emissions and produced positive economic effects. However, these impacts are small in relation to total emissions, and to the overall size of the economy. If RGGI is tightened and expanded to other sectors, it could yield substantial reductions after 2020.

RGGI Emissions Impact

Current discourse tends to credit RGGI as the main cause of massive emission reductions in the electric sector. One econometric study, which covers the program from 2009 to 2012, found that RGGI was responsible for close to half of all electricity reductions in this timeframe. More up-to-date econometric studies need to be conducted.

Our analysis suggests that RGGI has been responsible for a much smaller share of the emissions drop, possibly below 10%. RGGI cuts emissions in two ways:

- 1 | Most of the revenue has been used to fund energy efficiency programs, and these programs are effective in cutting electricity consumption. We find that approximately 20% of emissions reductions experienced in the

¹ | RGGI's original Memorandum of Understanding, 2005. https://rggi.org/sites/default/files/Uploads/Design-Archive/MOU/MOU_12_20_05.pdf

region since the program's launch were due to \$12 billion of public funding for efficiency. But only 11% of this funding came from RGGI, as opposed to other charges on utility bills.²

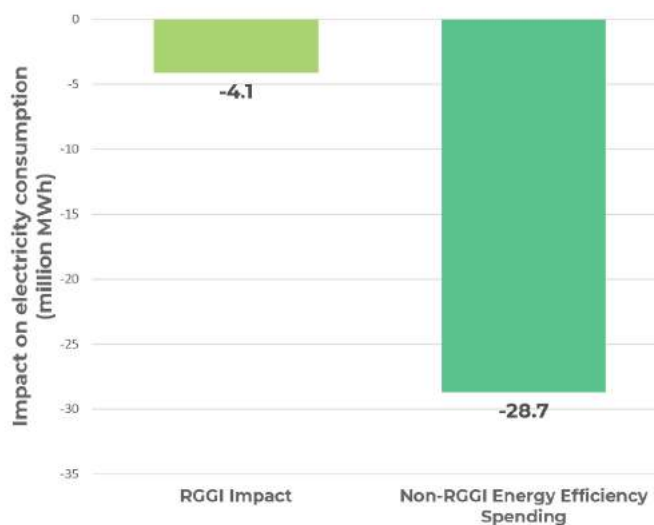
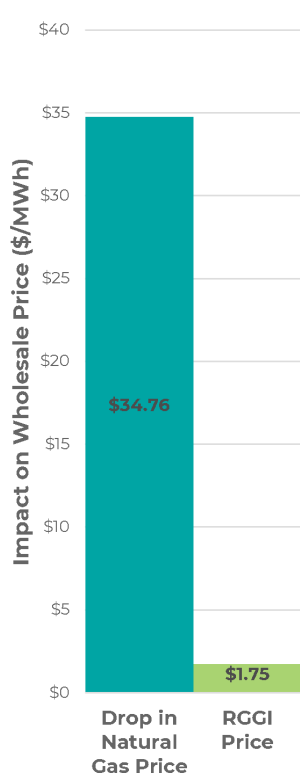


Figure ES-1: RGGI vs non-RGGI Impacts on Electricity Consumption



2 | RGGI adds a cost to CO₂ emissions associated with electricity generation. This cost can be reduced by switching from coal to gas, or entirely avoided by switching to renewables. However, this incentive is far outweighed by plummeting natural gas prices, which began prior to RGGI and continued after its launch.

Figure ES-2: Relative impact of RGGI vs falling natural gas prices in favoring gas over coal-fired generation³

Increases in natural gas supply have caused gas-fired electricity prices to drop drastically. This trend, which began prior to RGGI and continued after its launch, far outweighs RGGI's impact on coal prices. Canadian imports, which are dominantly hydroelectricity, have also replaced a significant portion of coal-fired generation in the RGGI region. But these changes are more likely due to competitive pricing and clean energy policy than the RGGI program.

This is not to say that RGGI has failed. Rather, other factors have significantly cut emissions, hence reducing the need for an aggressive program thus far. For most of its history allowance prices have been even lower than forecasted. Sharply reducing the cap in 2014 has led to somewhat higher allowance prices, hence increasing its potential impact. But allowance prices still remain very minor compared to the external factors previously outlined.

Economic Impact

RGGI has benefitted the region's economy, primarily due to the use of revenues for energy efficiency programs. The region imports almost all of its fossil fuel, which ends up sending energy payments to out-of-region entities. Efficiency programs cut such losses, and create jobs in the labor-intensive businesses that install efficiency measures. Studies suggest that every dollar invested by the program in efficiency through 2017 will create \$2.75 in lifetime benefits.

WESTERN CLIMATE INITIATIVE

WCI currently includes California and Québec. While they have a joint emissions cap and the same prices for allowances, the initiative's emissions impacts have been markedly different for each jurisdiction to date. The program is still young, but preliminary findings suggest that almost all emissions reductions have occurred in California's electricity sector. Like in RGGI, these reductions are primarily due to clean energy policy and market forces, rather than the cap-and-trade program.

California's emissions caps were set in conjunction with their legislated long-term targets. As a result, California's caps are much stricter and affect a broader set of emissions than do RGGI's, requiring a return to 1990 emission levels by 2020, a 40%

2 | Author's calculations using data from "The Investment of RGGI Proceeds 2016", September 2018; ACEEE State Energy Efficiency Scorecards, 2009-2017.

3 | Denotes Henry Hub Spot Price drop in 3-year average of natural gas prices between 2006-2008 and 2013-2015. RGGI Impacts calculated using data from RGGI.org and the U.S. Energy Information Administration.

reduction below 1990 by 2030, and an 80% cut below 1990 by 2050.

California Emissions Impact

In California emissions caps were imposed as an add-on to a suite of complementary policies, which were anticipated to produce the vast majority of emissions reductions through 2020. The emissions cap was designed primarily as a backstop in case other policies were repealed or underperformed.

This need not be regarded as a failure of California's cap-and-trade system, but rather as a testament to the strength of its other policies, to federal policies, and to market factors.⁴ The state has already met its emissions target for 2020 due to reductions in the electricity sector — increased solar and wind generation, as well as a rebound in hydro power in 2016, are largely responsible for this progress, although questions remain regarding how emissions from imported electricity are measured.

Whether progress can be sustained after 2020, and to what degree cap-and-trade is responsible, remains to be seen. In a recent speech, outgoing Governor Jerry Brown stated that while carbon pricing was important, it accounts for only 20% of the state's emissions reduction strategy.⁵

There are two important concerns about the effectiveness of California's policies. First, to some degree the 28% cut in electricity-sector emissions from 2012 to 2016 may be inflated due to "leakage" of emissions to other states; 10% of California's electricity is supplied by imports from unknown generation sources, leaving the door open for uncounted emissions.⁶ Additionally, fossil fuel imports that previously went to California may be diverted to surrounding states while low-emission sources are shifted to California. In this scenario, California can claim substantial reductions without any real changes to the regional grid. The extent of such leakage is unclear, but if California continues to aggressively pursue in-state renewable deployment, then this issue should diminish over time.

Second, California's oversupply of allowances and lack of banking restrictions jeopardize the program's 2030 target. In part due to the recession, and electricity market transformations described above, more allowances have been auctioned than necessary. As a result, polluters are purchasing hundreds of millions of allowances and "banking" them for future years. Carbon pricing literature has emphasized banking as a vital mechanism for maintaining a stable allowance market, but in practice these allowance banks are growing large enough to threaten future market integrity.

Without an expiration date, these cheaply acquired surplus allowances allow polluters to avoid cutting their emissions when the cap becomes more restrictive. Independent analysis indicates two possible scenarios for California in the next decade. First, if polluters are able to bank enough allowances, they can use them to meet their compliance obligation through 2030 instead of reducing emissions in the current year, leading California to overshoot 2030 goals by up to 30%.⁷ In a second scenario, banked allowances dissipate as the cap tightens, leading to a rapid increase in allowance price and prompting California to expand the allowance supply. To do so would sacrifice the environmental integrity of the program in order to ensure prices remain politically acceptable.

California Economic Impact

California administers its allowances in four ways:

CLOSE TO HALF have been auctioned by the government, with funds invested in state programs to reduce emissions.

ABOUT 35% of allowances have been "consigned" to electric and gas utilities. The utilities are required to pass along revenue primarily to residential consumers, with about a quarter of revenue assisting vulnerable industries and small businesses.⁸

ABOUT 15% of the allowances have been given at no cost to particular industries that

⁴ | California has historically had stronger auto fuel-efficiency standards than the federal standards; but the two standards were "harmonized" during the Obama administration.

⁵ | Remarks by Governor Jerry Brown, keynote speaker at "Carbon pricing: delivering climate ambition," sponsored by the State of California, the Government of Canada, and the European Commission, San Francisco, September 11, 2018.

⁶ | California Energy Commission, 2017 Total System Electric Generation. <http://www.energy.ca.gov>.

⁷ | California Legislative Analyst's Office, "Cap-and-Trade Extension: Issues for Legislative Oversight" December 2017.

⁸ | The money given to residential utility customers is now being delivered almost entirely via a flat payment, regardless of consumption, in order not to decrease the incentive to reduce fossil fuel use.

the state regards as energy-intensive and trade-exposed (EITE). Most of this has gone to petroleum refiners, with a small portion given to select manufacturing industries.

ABOUT 5% has been held in reserve by the state, for release as needed if allowance prices rise higher than desired.

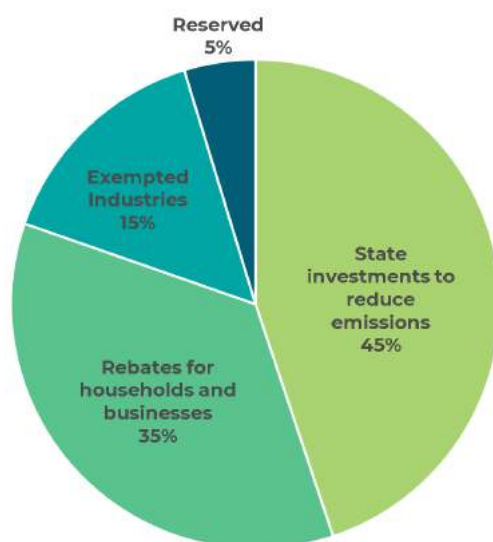


Figure ES-3: California's Distribution of Allowance Revenue 2015-2018⁹

Allowance prices have raised gasoline prices between 11 and 14 cents per gallon.¹⁰ This represents about 4% of average gasoline prices in the state, but is a far smaller impact than external factors such as fluctuations in crude oil prices on the global market.

Between the moderate prices for allowances, and the revenue returned both to households and to vulnerable business sectors, it would appear that allowance costs have only had a small impact on living costs, particular industries, and the overall economy.

The use of close to half the revenues for investment purposes should provide positive economic impacts. To the degree that net imports of fossil fuels are reduced via energy efficiency, renewable energy, and more energy-efficient transportation, then in-state economic activity should increase. As of California's 2018 Investment Report, \$6 billion has been allocated

to Climate Change Investments, \$2 billion of which has been implemented. An in-depth study of the economic impacts from California's investment programs has not yet been conducted.

Québec

Due to different levels of available data and literature, our analysis of Québec is preliminary. However, our analysis suggests that due to disparate emissions profiles, WCI has had a lower impact on Québec than it has on California. As Québec's electricity supply is dominated by hydropower, it is necessary to cut emissions in other sectors in order to reduce emissions.

Québec's emissions from mandatory reporting regulations (MRR), which form the basis of cap-and-trade compliance, have decreased 1.7% since 2012, as opposed to 6.7% in California. This discrepancy is likely due to California's deep cuts in electricity emissions. However, preliminary findings indicate that emissions from Québec's large facilities have decreased 8.8%.¹¹

There are challenges with linking programs between jurisdictions with different emissions profiles. With California's electricity sector driving allowance prices downward, Québec's sources of emissions are unlikely to experience a price impact high enough to spur significant abatement. In the same vein, any other design choices in California that drive down allowance prices, such as a high cap trajectory or complementary policy, can also limit emissions reductions in Québec. These concerns require further investigation in order to fully estimate their impacts. ■

⁹ | Data from International Carbon Action Partnership and CARB.

¹⁰ | See Legislative Analysis Office, letter to Assembly Member Lackey, 2016. <https://lao.ca.gov/reports/2016/3438/LAO-letter-Tom-Lackey-040716.pdf>

¹¹ | According to Mandatory Greenhouse Gas Reporting Regulation data, 2013-2016.

REGIONAL GREENHOUSE GAS INITIATIVE

ECONOMIC IMPACT

Key Findings

Service and information industries have dominated RGGI's economic growth, which is conducive to reducing GHG emissions without hindering economic growth.

States have invested most of their RGGI revenue in energy efficiency, which studies estimate have produced \$2.75 in benefits for every dollar spent.

RGGI has produced additional benefits by suppressing wholesale electricity prices, reducing payments for out-of-region fuel imports, and improving public health.

These impacts are small in relation to the size of RGGI's economy. But the benefits would likely grow if the program were tightened and expanded.

Much of this growth is driven by New York, Massachusetts, and Maryland, which collectively represent over 80% of RGGI's economy and have grown 37.6%.³

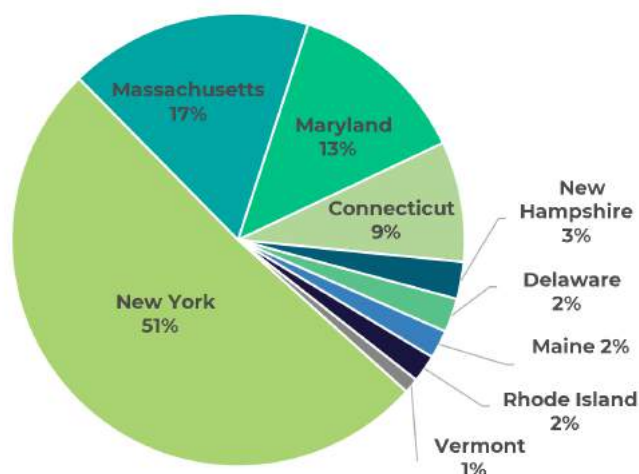


Figure 1: Relative economic size of RGGI states, Annual GDP 2017⁴

Regional Economic Trends

Were the RGGI region to be considered a nation, it would have the 5th largest national economy in the world.¹ Currently, the program consists of nine states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New York, New Hampshire, Rhode Island, and Vermont. New Jersey withdrew from the program in 2012, but is currently in the process of setting a cap trajectory and re-joining the market along with Virginia. As such our historical analysis focuses on the nine other states that have remained committed since program launch. As RGGI covers such a large economic region, it is imperative to rigorously examine the economic outcomes of its cap-and-trade system.

The region has experienced above-average economic growth compared to the rest of the US. While this growth is attributable to market forces far beyond the cap-and-trade program, RGGI's experience supports the notion that climate change policy can be implemented without hindering the economy significantly. RGGI's economy has grown by nearly 34% since 2008, as opposed to just over 31% in the rest of the US.²

New York, Massachusetts, and Maryland also constitute over 75% of electricity emissions in the region.⁵ As such the economic shifts and complementary policies in these states in future years will have large implications for the economic and emissions performance of the region.

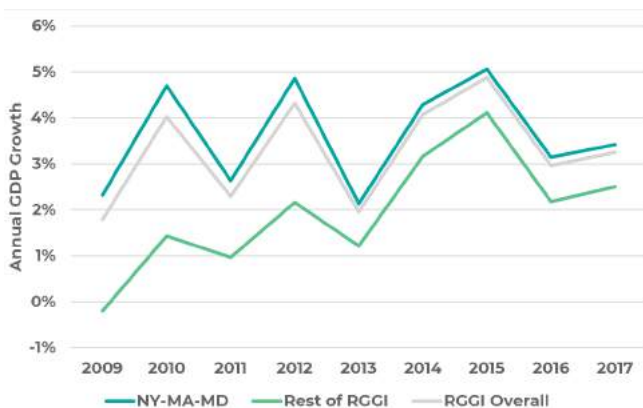


Figure 2: Annual GDP Growth in RGGI States 2009-2017

¹ | GDP data from Bureau of Economic Analysis & World Bank. Accessed August 2018.

² | GDP data from Bureau of Economic Analysis (BEA).

³ | Bureau of Economic Analysis (BEA).

⁴ | Original GDP data provided by Bureau of Economic Analysis.

⁵ | RGGI CO₂ Allowance Tracking System (COATS), Accessed August 2018. Climate XChange | 131 Cambridge Street | Boston MA 02114

The regional shift to a service economy is also worth noting. Industries such as finance, insurance, real estate, information, and professional services together constitute nearly half of RGGI's total economic output, compared to 36% in the rest of the US. Meanwhile energy intensive industries have been on the decline. Agriculture, extractive industries, utilities, construction, and manufacturing together only constitute 12% of RGGI's output, compared to 22% in the rest of the US.⁶ From the perspective of energy intensity, most of RGGI's industries are well positioned to thrive, even within an aggressive carbon pricing program.

Prospective carbon pricing regimes must take these industrial patterns into consideration to inform design, particularly around industry protections. As RGGI's major industries are not energy-intensive, only a small fraction of the region's economy faces risks from higher electricity prices. In addition, since the allowance price has remained low since RGGI began, the price change has close to negligible impacts on the overall costs of even electricity-intensive industries.

RGGI's benefits far outweigh costs

Current literature agrees that RGGI has produced net economic benefits for the region that far outweigh program costs. By reducing customer bills through energy efficiency investments and encouraging spending in the local economy, RGGI's positive impacts exceed the negligible increase in electricity prices. The program has raised \$2.7 billion in auctions through 2017, which is only 0.6% of the \$450 billion spent by customers on electricity over the same timeframe.⁷

RGGI is first and foremost an emissions reduction program. But if scaled up, the program could also act as a tool in economic development. The Analysis Group estimates that RGGI's first three compliance periods will ultimately produce lifetime net benefits of \$4.7 billion, primarily due to savings from energy efficiency projects, or \$2.75 in benefits for every dollar in program costs. This means that even if the program ended in 2017, it would continue to provide an average of \$250 million in annual net benefits through 2027.⁸

These benefits are largely caused by energy efficiency investments, which provide long-term cost savings, suppress electricity prices, stimulate job growth, and redirect money into the local economy.

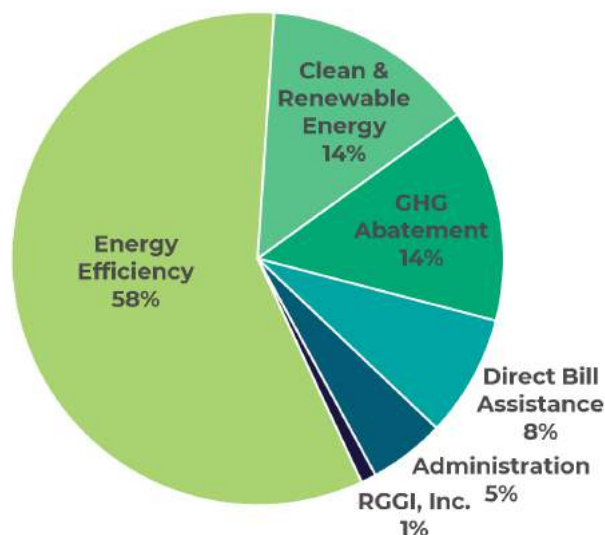


Figure 3: Cumulative RGGI Investments by Category, 2016

Many energy efficiency projects are already cost-effective absent of the carbon pricing program. Especially in regions with historically high energy prices, these investments can pay themselves off in as short as 1-2 years. However, due to lack of information and access to upfront capital, consumers tend not to pursue these projects on their own accord.

RGGI's investments attempt to counteract these obstacles by undertaking extensive awareness campaigns and marketing for energy efficiency programs, as well as in some cases providing the upfront capital necessary for these projects. But more research is needed into how these investments are utilized across demographic groups to ensure that program benefits are distributed in an equitable manner.

RGGI provides indirect benefits as well

As the RGGI region has little indigenous fossil fuel resources, much of the region's electricity spending is directed to out-of-state entities. Reducing electricity consumption can provide multiplicative effects by directing expenditures to the local economy. In their

⁶ | Data on industry-level GDP by state provided by Bureau of Economic Analysis.

⁷ | RGGI Auction Results, rggi.org; Energy Information Administration (EIA).

⁸ | Analysis Group, April 2018. "The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine North-east and Mid-Atlantic States".

analysis of the 2015–2017 period, the Analysis Group estimates that lifetime electricity savings will direct an additional \$1.37 billion into the local economy as opposed to extra-regional fossil fuel producers. This is a substantial additional gain from energy efficiency projects and a major contributor to the estimated \$2 billion in lost revenue for fossil fuel companies due to RGGI between 2009 and 2027.⁹

Customers who utilize RGGI-funded energy efficiency and renewable energy programs enjoy direct savings from reduced electricity consumption. However, the rest of the grid also enjoys suppressed electricity prices due to reduced demand. This is because of how the deregulated wholesale electricity market functions.

In a deregulated system, the Independent System Operator (ISO) facilitates the purchase of electricity from various generators throughout the day. The cheapest generation source is selected first, followed by the next most cost-effective, until all electricity demand on the grid is satisfied. However, after this process is complete, every selected generator is paid the same wholesale price. This price is determined by the most expensive (i.e. last) generator needed to satisfy demand. Therefore, when energy efficiency projects reduce the overall load on the electric grid, the ISO can fulfill that demand without resorting to the most expensive generators. This leads to a lower overall wholesale price and additional economic savings for consumers.

The Analysis Group estimates an additional \$725 million in lifetime savings across all three RGGI-region electricity grids due to price reductions (“suppression”), or \$38 million per year. Some states have directed efficiency funds towards oil and gas consumption. While wholesale natural gas and oil markets operate differently than electricity markets, reduced demand in relation to supply still leads to regional price suppression. The Analysis Group estimates a lifetime benefit of \$264 million in natural gas and oil price savings, or approximately \$14 million per year.¹⁰ These benefits are minor in comparison to the program’s direct impacts, but nonetheless should be

highlighted as an additional benefit that carbon pricing can achieve in a deregulated market.

Closing coal plants produces major public health benefits

The RGGI region has enjoyed extensive benefits to public health as well, primarily due to coal plant retirements. While GHG’s have no direct impact on local public health, co-pollutants such as Sulfur Oxides (SOx) and Nitrogen Oxides (NOx) directly contribute to heart conditions, respiratory complications, and premature deaths. These co-pollutants are produced alongside CO₂ at petroleum refineries and coal plants, meaning that reductions in GHG’s at these plants results in massive health benefits for the surrounding community.

A study by Abt Associates finds that RGGI produced \$5.7 billion in public health benefits between 2009 and 2014. The majority of these impacts came from coal retirements in Maryland, which lead to reduced premature deaths and illness across state lines (including states near RGGI such as Pennsylvania). It is debatable to what extent RGGI can be credited with coal retirements (many were and still are uneconomic in the region), but even Abt Associate’s lowest estimate of \$2.4 billion of in-region benefits are well above the \$1.9 billion in allowance costs through the same time period.¹¹ Our own analysis suggests that RGGI may have played less of a role in coal retirements than indicated by this report, but the trend is still noteworthy for prospective carbon pricing states — that retiring coal generators will produce extensive co-benefits for surrounding residents.

New research suggests that high levels of local air pollutants can significantly impede cognitive ability and productive value as well. A 2018 study of arithmetic and language performance in China found that the cognitive harm of co-pollutants such as SOx and NOx can equate to losing an entire year of education.¹² This impact is even greater for older populations. While RGGI and the rest of the US have better air quality than China, this research suggests that public health benefits from coal retirements may be more extensive than Abt Associate’s study would indicate.

9 | Analysis Group, April 2018.

10 | Analysis Group, April 2018.

11 | Abt Associates, January 2017. “Analysis of the Public Health Impacts of the Regional Greenhouse Gas Initiative, 2009–2014”.

12 | Xin Zhang, Zi Chen, and Xiaobo Zhang, August 2018. “The impact of exposure to air pollution on cognitive performance”.

The delay between costs and benefits

Much of these benefits are yet to be felt as the returns from current energy efficiency and clean energy investments continue to roll in over the next ten years. In addition, there was a short window at program launch where benefits had not yet outweighed costs. This is due to delay in both the spending of RGGI revenue as well as the slow accrual rate of energy efficiency savings.

Some energy efficiency investments, such as lighting, only take 1–2 years for energy savings to surpass the initial installation cost. Other efficiency investments can take up to 4 or 5 years. Prospective studies of carbon pricing programs suggest that when investing significant auction revenue into energy efficiency, it can take 3–5 years for economic benefits to outperform allowance costs.¹³ These studies do not account for co-benefits such as public health.

RGGI's price impacts are very small, and were likely recuperated within 2–3 years. We estimate RGGI investments from the first compliance period reduced yearly consumption by about 1 million MWh, producing \$1.5 billion in retail electricity savings. This far surpasses the \$952 million raised by RGGI in the same timeframe.¹⁴

This, however, does not capture the delay between auctions and the implementation of revenue dollars, which can significantly extend the window where negative impacts prevail.

In RGGI, the carbon price is too low to be a significant issue. But in future programs with higher allowances prices or a stricter RGGI cap, the short-term losses to consumers could be more pronounced. To offset these, a portion of funds could be earmarked to protect vulnerable populations, businesses, and key industries during the “negative window” of the program.

To conclude, RGGI has demonstrated that a cap-and-trade program can create significant net economic benefits in relation to allowance costs. This is currently happening on a small scale — \$250 million per year in net benefit is less than 0.008% of RGGI's total GDP. What is more important to observe are the trends behind the programs benefits, and how they could apply to a more ambitious environmental

program. Especially in a region characterized by high energy costs and out-of-region fuel production, energy efficiency investments are an excellent way to provide lasting benefits to consumers whilst also further contributing to emissions reductions. As long as the “delay” in benefits is considered, future programs should continue to seek these investment strategies.

RGGI'S EMISSIONS IMPACT

Key Findings

Emissions from electricity generators in the RGGI region have dropped greatly - nearly 40% since 2009.

External factors have caused the majority of these reductions:

Almost a third of reductions come from natural gas generators replacing coal generators, which is largely due to plummeting natural gas prices.

About one-fifth of reductions were caused by increased availability of Canadian hydroelectricity.

Between 12% and 15% of reductions are due to reduced electricity consumption. This was caused substantially by states in the RGGI region investing heavily in energy efficiency, but only 11% of the funding for these projects came from RGGI.

The higher cost of RGGI allowances for coal has caused some increase in gas use relative to coal, resulting in lower emissions. This change is small, but has likely increased since the program's cap trajectory was lowered in 2014, leading to higher allowance prices.

Additionally, it is possible that RGGI influenced investment decisions by instilling a sense of “regulatory anticipation” in power producers, both leading up to and following the program's launch.

To the extent that RGGI has caused increases in natural gas use, the GHG impact of methane gas leakage could be significant, and should be subtracted from the emissions gains due to RGGI (see Policy Recommendations).

¹³ | ICF, December 2017. “RGGI Program Review: REMI Modeling Results.” 2016 RGGI Program Review, RGGI.org.

¹⁴ | American Council for an Energy-Efficient Economy (ACEEE) State Report Cards; RGGI Inc; and author's calculations.

In the RGGI region, we find the majority of emissions reductions of the past decade to come from external factors. Transitions from coal to natural gas and renewables are the product of larger market forces that began years before RGGI was implemented. This transition has produced a far larger reduction in GHG emissions than RGGI's high cap and low allowance price could produce. A secondary, but still substantial, driver of emissions reductions has been energy efficiency programs, which are largely funded by non-RGGI charges on utility bills.

The dynamic and competitive nature of the wholesale market, however, leaves open the opportunity for RGGI to create incremental changes in the dispatch of electricity. Additionally, the large impacts of efficiency projects from non-RGGI sources highlights an opportunity for RGGI investments to have a deeper impact if the program became more ambitious.

At the time RGGI was designed and implemented, it was not expected that external factors such as hydrofracturing to obtain natural gas would lead to an extremely low cost of GHG abatement. An emissions cap necessarily reflects these costs, leading to allowance prices lower than was forecasted when RGGI was designed and the annual caps were set.

This is not to say that RGGI is unsuccessful. Cap-and-trade is a flexible carbon pricing mechanism — when emissions reductions are going faster than expected, the rigor of the program is reduced in the form of lower allowance prices. As such, RGGI's experience provides valuable insight into 1) what drives the majority of reductions in the electricity sector; 2) how cap-and-trade interacts with these market forces; and 3) what design choices can best prepare the program for future market uncertainty.

There are also several ways in which RGGI's impact may have been higher than what we have measured. Due to the competitive nature of the wholesale power

market, even small allowance prices have the potential to sway dispatch order and the long-term planning of power plant owners in ways that are difficult to measure. Additionally, we do not have access to a dispatch model to estimate the incremental changes to dispatch that a carbon price creates. As such we cannot definitively conclude that RGGI's impact has been negligible.

We can, however, break down the various components of RGGI to better understand how cap-and-trade can best reduce emissions in the electricity sector. Reductions in the RGGI region must be retrospectively examined in order to inform program design for the coming decade.

Current Discourse on RGGI

At face-value, regional trends in power sector emissions would suggest that RGGI has been a massive success. The original Memorandum of Understanding drafted in 2005 committed to a 10%

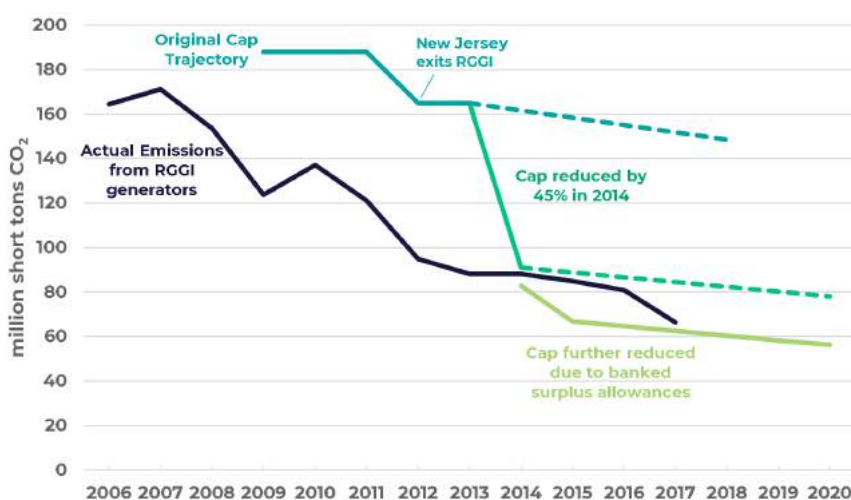


Figure 4: RGGI's Cap Trajectory and Covered Emissions

reduction in power plant carbon pollution by 2018,¹⁵ but the region already achieved 40% reductions by 2016, compared to a 20% reduction in the rest of the United States.¹⁶ 2016 also marked the sixth consecutive year of power-sector emissions declines, reaching 8.4% below the emissions cap.¹⁷

Public-facing documents on RGGI's performance tend to focus only on the downward trend of RGGI-covered

¹⁵ | Regional Greenhouse Gas Initiative Memorandum of Understanding, 2005. RGGI.org.

¹⁶ | Acadia Center, September 2017. "Outpacing the Nation: RGGI's Environmental and Economic Success".

¹⁷ | Acadia Center, June 2017. "RGGI on the World Stage: States Acting on Climate Constitute 3rd Largest Global Economy".

sources as opposed to a more comprehensive review of all electricity serving the RGGI region. Additionally, these articles tend to speak about the downward trend in emissions as a product of RGGI itself.

An econometric study completed by Brian Murray in 2015 finds that RGGI was responsible for nearly 50% of electricity-sector CO₂ reductions in the region between 2009 and 2012. The study argues that emissions would be 24% higher over the study period had RGGI not existed.¹⁸ This is the most commonly cited document on RGGI's impact. But since its release, far more empirical data has been accumulated regarding electricity market behavior in the region. As such, it is worth comparing Murray's econometric results to what has since been observed.

RGGI's Electricity Monitoring Report

RGGI's Electricity Monitoring Report states that annual electricity sector emissions averaged over 2013-2015 decreased by 51 million short tons CO₂ compared to the average of 2006-2008.¹⁹ Multi-year averages form the basis for our analysis, as it better captures durable trends over time as opposed to yearly fluctuations. At a fundamental level, emissions can only decrease in two ways – overall electricity consumption declines (electric load), or fossil fuel power generators are replaced with cleaner sources (generation mix).

Activity	Emissions Impact (short tons CO ₂)	% of Emission Reductions
Emission Reductions	-51 million	100%
Changes in Consumption	-6.3 to -7.5 million	11% to 15%
Changes in Generation Mix	-45.5 million	89%

Figure 5: Change in 3-year average annual emissions, 2006-2008 to 2013-2015²⁰

The impact of electric load depends on the assumptions used and their interaction with generation mix, which is why the two factors add up to greater

than 100%. The more important takeaway is that the majority of emissions reductions are coming from cleaning the energy grid rather than reducing overall consumption.

We consider four influences on reduced electric load:

- RGGI investments into energy efficiency.
- RGGI price impacts on consumption behavior.
- Non-RGGI funded investments into energy efficiency programs.
- All other non-RGGI impacts, i.e. economic growth patterns, weather, and complementary clean energy policies

Activity	Impact on electric consumption	CO ₂ impact as % of overall reductions
All RGGI factors	-4.1 million MWh	2.8%
All non-RGGI factors	-14.2 million MWh	9.6%
Net change in reduced load	-18.3 million MWh	12.5%

Figure 6: Impact of RGGI vs non-RGGI factors on annual electric load, 2006-2008 to 2013-2015

Meanwhile, we consider the following factors for changes in generation mix:

- Non-RGGI influences on generation mix, i.e. fuel switching to natural gas due to lower gas prices, changes in generation capacity, and RPS standards.
- Direct changes in generation mix due to RGGI's price signal.
- Indirect influence of RGGI on electricity market decisions (political forecasting).
- Emissions leakage from RGGI-covered emitters to uncovered sources, such as small generators and electricity imported from outside the RGGI states.

18 | Brian Murray & Peter Maniloff, August 2015. "Why Have Greenhouse Emissions in RGGI States Declined? An Econometric Attribution to Economic, Energy Market, and Policy Factors".

19 | RGGI Inc., April 2018. "CO₂ Emissions from Electricity Generation and Imports in the Regional Greenhouse Gas Initiative: 2015 Monitoring Report".

20 | Derived from 2015 Electricity Market Report. Includes all sources of electricity serving the RGGI region, including imports and other uncovered sources.

RGGI impacts on generation mix are far more challenging to quantify, and as such we do not provide an exact breakdown. However, we will examine each of these factors and use the best evidence available to evaluate their role in the sharp decline of RGGI emissions since program launch. Since RGGI's Electricity Market Report 2015 serves as the foundation of our empirical data, we will keep our analysis within the 2008-2015 timeframe.

Changes In Electric Load

We find that RGGI produced minor impacts on electric load. The majority of calculated reductions came from non-RGGI state energy efficiency spending, which is ten times larger than RGGI-sourced energy efficiency spending. Other non-RGGI factors include economic growth, weather, and complementary policy.

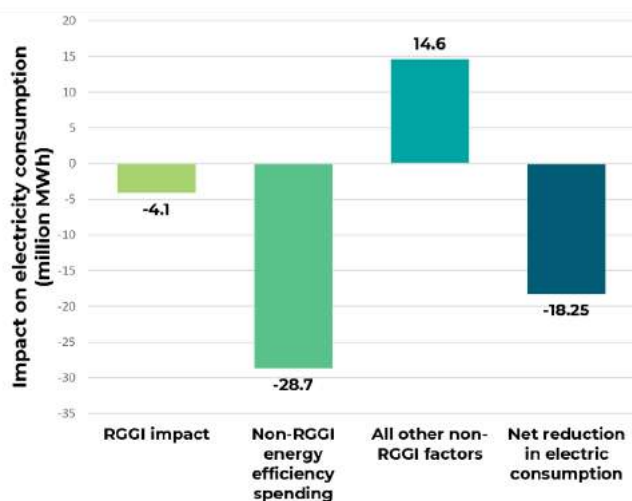


Figure 7: Impact of identified factors on annual electric load, 2006-2008 to 2013-2015

Note that the sum of RGGI and state energy efficiency investments significantly exceeds observed changes in consumption. This suggests that while efficiency spending was reducing electric load, economic growth and possibly weather changes were

canceling out some of these reductions. Below is a detailed breakdown of RGGI and non-RGGI factors.

1 | RGGI allowance prices have had only a small impact on electricity prices.

Due to RGGI's low allowance prices, we do not calculate it to play a significant role in discouraging energy consumption. According to the EIA, total electricity sales between 2008 and 2015 totaled about \$400 billion, compared to the \$2.4 billion raised by RGGI allowance auctions within the same timeframe. As such, the allowance price impact represents about 0.6% of total electricity sales, or 0.08 cents on the average electricity bill of 14.78 cents per kilowatt hour.²¹

We estimate this price increase reduced annual consumption by 1.1 million MWh, which translates to 400,000 short tons of CO₂ mitigated.²² This is less than 1% of total emissions reductions observed during the study period.

2 | RGGI funds are a small fraction of total utility energy efficiency funding, and therefore emissions reductions, in the region.

According to state-level data collected by ACEEE, total utility energy efficiency spending in the region during the 2006-2015 timeframe amounted to \$11.9 billion and 31.5 million MWh of reduced yearly consumption.²³ This translates to over 11 million short tons of CO₂ reductions, or 22% of the 50 million short tons CO₂ reductions over the same timeframe. This would suggest that utility energy efficiency investments played an important secondary role in regional emissions reductions.

However, of the \$10.9 billion invested in energy efficiency between 2008 and 2015, only about 10% came from RGGI funds.²⁴ Thus RGGI efficiency funding is only responsible for about 2% of overall emissions reductions in the region.

²¹ | Data from Energy Information Administration.

²² | Changes in consumption due to changes in price can be estimated using "price elasticities of demand," which give the percentage in sales due to a percentage change in prices. We use a weighted price elasticity of -0.49 based on the relative size of the residential, commercial, and industrial sector. Price elasticities used here were obtained from the Carbon Tax Assessment Model (CTAM), which is available at www.commerce.wa.gov.

²³ | This number is the sum of incremental yearly savings reported by ACEEE. The number is likely lower, as some efficiency projects implemented have since expired. Source: ACEEE State Report Cards.

²⁴ | This is based on RGGI's Investment of Proceeds 2015, which indicates that 60% of the \$1.77 billion raised through 2015 went to energy efficiency projects. Although RGGI did not launch until 2008, utility energy efficiency spending from 2006 and 2007 is included as it influences the empirical reductions provided by RGGI's electricity market report.

RGGI's "Investment of Proceeds 2015" report supports this finding, estimating that all RGGI investments since program launch produce a lifetime reduction of 30.3 million MWh.²⁵ Using Analysis Group's average assumed lifetime of 10 years for energy efficiency projects, we find a reduction of approximately 1 million tons of CO₂ per year, similar to ACEEE's data.

3 | Changes in consumption due to other factors.

Literature commonly cites several other factors that may have affected electricity-sector emissions in the region — overall economic growth patterns, the decline of energy-intensive industries in the region, weather patterns, and complementary policies. Precisely measuring the impact of these factors is beyond the scope of this report. However, our other calculated measures allow us to roughly infer their net impact on consumption through 2015.

As previously stated, RGGI's Electricity Market Report 2015 measures an 18 million MWh decrease in average annual consumption since program launch, which is far lower than the calculated reductions of RGGI and other energy efficiency spending. Thus, by adding up the calculated savings of RGGI and state energy efficiency investments, we can infer the difference to be the net change in consumption due to all other factors.

This comes out to approximately 14.6 million MWh, or a net increase of 5.1 million short tons of CO₂. If this number is accurate, then almost half of the reductions achieved from state energy efficiency measures have been offset by external factors.

Particularly in service-based economies such as RGGI, economic growth and GHG emissions are decoupling. This statement is true in the sense that emissions reductions can be achieved without harming economic growth. However, fluctuations in economic growth still directly impact annual emissions. This relationship was most important in the 2008–2009 economic crash, when both GDP and emissions declined in the region for the first time since 1990.

Brian Murray's study estimates that the recession was responsible for approximately 28% of decreased emissions between 2009–2012. This econometric study result accords with the expectation that reduced economic activity and employment brings about reduced energy consumption.

²⁵ | This includes strategies not captured in ACEEE data, such as natural gas projects and behind-the-meter renewable installations. As such, it may be showing a greater impact than the ACEEE method.

²⁶ | Data from Energy Information Administration.

This may be a key contributor to the large disparity between the cap (188 million allowances) and RGGI-covered emissions (122 million short tons) at program launch. However, since then, the region's unemployment rate and GDP growth has largely recovered. Thus, while early reductions in the program were certainly influenced by the recession, we suspect that those impacts have largely been negated by recent strong economic growth.

More research is needed into external factors, such as weather patterns and the decline of manufacturing in the region. These trends are important to understand when forecasting future business-as-usual scenarios that inform cap trajectories.

Changes In Generation Mix

As indicated in RGGI's Electricity Market Report 2015, generation mix changes are responsible for the large majority of real GHG reductions since program launch. Reports indicate that the emissions intensity of RGGI's electricity grid is dropping rapidly.

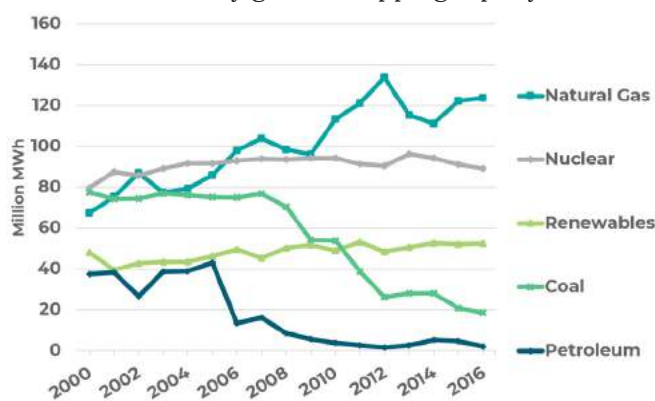


Figure 8: Electricity generation in the RGGI region by source²⁶

The electricity market has undergone massive changes since RGGI program launch, most notably the downfall of coal and explosive growth of natural gas. Due in part to advancements in hydraulic fracturing technology and exploitation of new supply in Pennsylvania, natural gas has become the dominant electricity generation fuel source.

Note that Figure 8 depicts only in-region generation. A more comprehensive understanding of the generation mix is captured in the RGGI Electricity Market Report, which includes the emissions of all electricity sources serving the RGGI region

(including imports and in-region uncovered sources). Together, the emissions intensity of all these sources has decreased 26%.²⁷

Assessing the impact of RGGI on generation mix is far more difficult than assessing impact on electric load. The story behind each generation source's trends involves dozens of intersecting factors outside of RGGI's price impact and requires complex modeling to estimate. For example, the decline of coal played a large role in decarbonizing the electricity mix; however, the decision to close a given coal plant is at an owner's discretion and is due to a combination of various factors.

The most accurate way to do so is by running dispatch models, which simulate how the selection of generators on the competitive wholesale market changes with or without a carbon price. Analysis Group hypothesized RGGI's impact using the PROMOD dispatch model, while ICF has completed occasional predictions of future RGGI impacts using their Integrated Planning Model (IPM).

Due to the competitive and dynamic pricing of wholesale electricity, there is potential for even small allowance prices to create incremental shifts in the dispatch order. However, the dispatch model fails to capture all aspects of behavior change from the perspective of a power producer. For example, "regulatory anticipation" of RGGI may have led power producers to close plants and otherwise reduce emissions ahead of program launch.²⁸ Meanwhile, times of political uncertainty in the Western Climate Initiative have produced profound hesitance to comply with the program.²⁹ This is all to suggest that durable political signals can influence investment decisions.

However, this effect has not been separated out from larger market forces that were already reducing emissions prior to program launch. NYSERDA completed a RGGI-commissioned study in 2010 to assess why electricity sector annual emissions dropped by over 60 million tons of CO₂ between 2005 and 2009. They found the primary factors to be:

31% due to changing fuel prices, leading to fuel switching from coal and petroleum to natural gas.

24% due to changing weather patterns.

21% due to changes in generation capacity (i.e. closing coal plants, increased nuclear, solar, and wind).

12% due to energy efficiency and behind-the-meter renewables.

4% due to economic downturn.

Many of these patterns continued during RGGI launch. The Henry Hub price for natural gas fell nearly 70% between 2008 and 2015, suggests that changing fuel prices and consequent fuel switching remained the dominant force in emissions reductions through 2015.

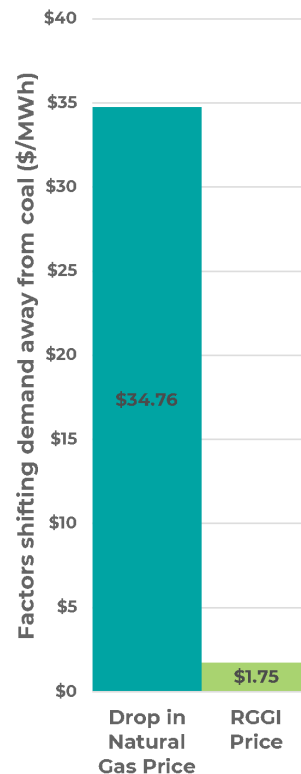


Figure 9: Relative impact of RGGI vs falling natural gas prices in favoring gas over coal-fired generation³⁰

²⁷ | RGGI Electricity Market Report 2015.

²⁸ | Brian Murray & Peter Maniloff, August 2015. "Why Have Greenhouse Emissions in RGGI States Declined? An Econometric Attribution to Economic, Energy Market, and Policy Factors"

²⁹ | In 2016, when the legality of California's cap-and-trade and its extension into the next decade was in question, large swaths of allowances went unsold at auction.

³⁰ | Denotes Henry Hub spot price drop in 3-year average of natural gas prices between 2006-2008 and 2013-2015. RGGI Impacts calculated using data from RGGI.org and the U.S. Energy Information Administration.

Average natural gas prices in 2006-2008 were extremely high. But by 2013-2015, natural gas prices dropped by \$35/MWh in terms of wholesale electricity prices. This drop is 20 times greater than the \$1.75/MWh incentive that RGGI creates to switch from coal to natural gas.

RGGI's Influence on electricity dispatch

While steep drops in natural gas price drove the majority of emissions reductions, there is still space for RGGI to incrementally influence dispatch.

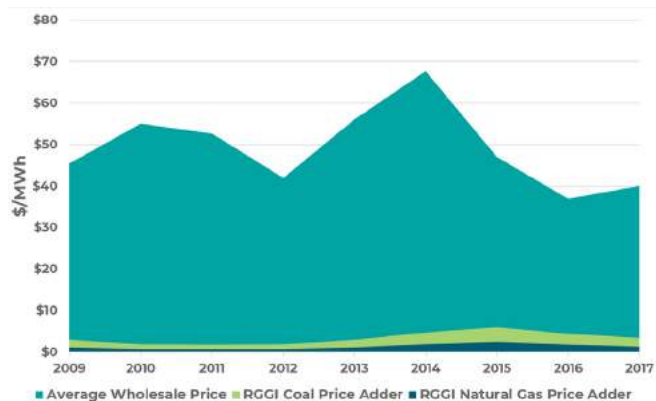


Figure 10: Average annual wholesale price vs RGGI's impact on coal and natural gas

Across all three grids, annual wholesale prices have ranged between \$28.94/MWh and \$70.37. This is more than a \$40/MWh wholesale fluctuation. Of that, RGGI's allowance cost has raised natural gas prices between \$0.78 and \$2.52/MWh, or between approximately 2% and 6% of the total fluctuation.

These numbers point to a larger learning lesson — that when natural gas prices are low, modest allowance prices have the potential to further reduce coal dispatch. The level to which allowance prices can reduce coal generation depends on whether periods of peak demand can be sufficiently met with sources that are cleaner and cheaper. The addition of more renewable and natural gas generation in the next two years³¹ should enhance the potential impacts of the allowance price by reducing reliance on coal and oil during periods of peak electricity demand.

Emissions Leakage

Carbon pricing systems bring about considerable worry that emissions will simply “leak” out of the system, such that an increasing amount of fossil fuel electricity will be sourced from adjacent jurisdictions

³¹ | ISO-NE Annual Report. See https://www.iso-ne.com/statistic-assets/documents/2018/02/2018_reo.pdf

NATURAL GAS
PRICES DROPPED
BY \$35/MWH
IN TERMS OF
WHOLESALE
ELECTRICITY
PRICES. THIS
DROP IS
GREATER THAN
THE \$1.75/MWH
INCENTIVE THAT
RGGI CREATES
TO SWITCH
FROM COAL TO
NATURAL GAS

with no price on carbon. This was a significant concern ahead of program launch.³²

This is an important question in RGGI, where imports have increased by nearly 40% between 2008 and 2015 and replaced more than half of lost fossil fuel generation in the RGGI region.³³ However, annual emissions from imports have decreased by 30%, suggesting that new imports are coming from renewable sources.

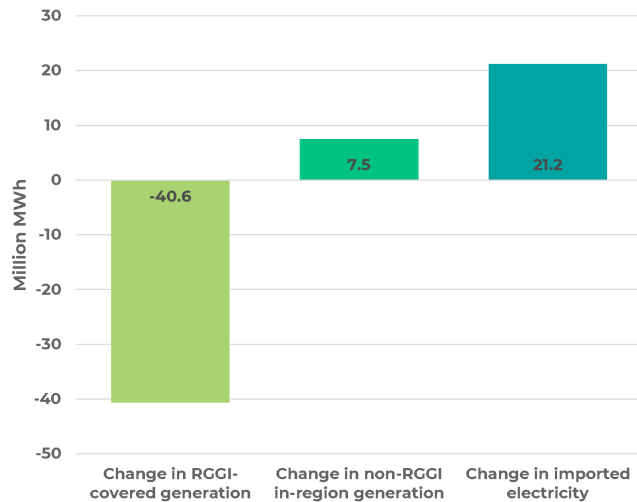


Figure 11: Change in generation of electricity serving RGGI region³⁴

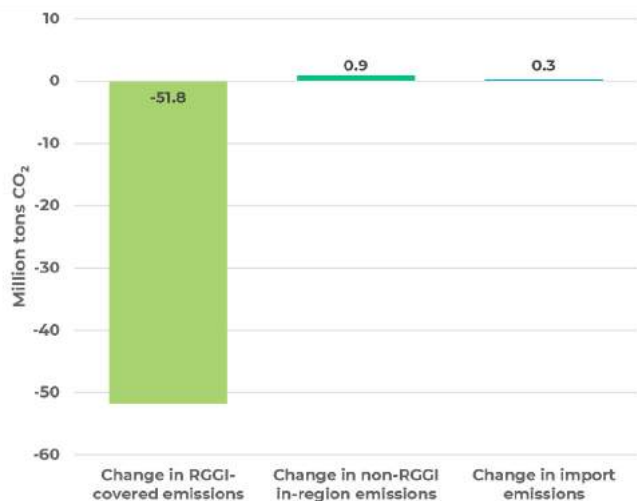


Figure 12: Change in CO₂ emissions of electricity serving RGGI region

This trend is primarily driven by hydroelectric imports from Canadian grids, which constituted 73% of added imports between 2008 and 2015. In fact, the replacement of RGGI-covered sources with Canadian imports is responsible for about 21% of all emissions reductions in the electricity supply, or the same effect as the nearly \$12 billion in utility-funded energy efficiency projects over the same time period.³⁵

This suggests that significant fossil fuel leakage is not occurring. Unlike California, RGGI does not assess a greenhouse gas rate on imported electricity. Thus, the dominance of hydro as a share of imports speaks to its price competitiveness relative to fossil fuel imports.

However, indirect forms of leakage can still occur. For example, if a RGGI utility signs a large-scale contract with a Canadian hydro generator, that generator may not be able to provide previous levels of electricity to non-RGGI regions. Thus while RGGI can claim the reduced emissions from a hydro contract, other regions may be increasing their generation from natural gas or coal to compensate for reduced hydro-electricity access.

There is little evidence to suggest this has yet occurred in RGGI, but it has not been fully studied. It is also a difficult issue to track – while California's cap-and-trade system covers imported electricity, it still cannot prevent more indirect forms of leakage. Such behavior will need to be monitored in RGGI over the next decade, particularly as allowance prices increase and alongside with it the incentive for leakage. Current literature indicates that expanding the program to a broader collection of jurisdictions is the only way to guarantee leakage is prevented.³⁶ ■

32 | See Burtraw, Kahn, and Palmer 2006. "CO₂ Allowance Allocation in the Regional Greenhouse Gas Initiative and the Effect on Electricity Investors"; Sue Wing and Dolodziej, 2008. "The Regional Greenhouse Gas Initiative: Emission Leakage and the Effectiveness of Interstate Border Adjustments"

33 | RGGI Electricity Market Report 2015

34 | Both figures depict changes between 2006-2008 and 2013-2015. Data from RGGI Electricity Market Report 2015.

35 | There are caveats to this data - the emissions intensity of imported electricity is usually calculated as the average emissions rate for the entire grid from which it is sourced. Thus, it is possible for the data to fail to capture significant contracts with fossil fuel generators that reside within clean grids. However, since the majority of new imported electricity comes from such as Québec and Ontario which primarily export hydro-power, there is little risk that this is the case.

36 | Schmalensee & Stavins, 2017. "Lessons Learned from Three Decades of Experience with Cap and Trade".

WESTERN CLIMATE INITIATIVE

ECONOMIC IMPACT

Key Findings

WCI has a wider scope and higher allowance price than RGGI, but overall economic impacts are still modest.

This is in part due to how both California and Québec distribute their allowances. Since 2015, WCI has dedicated 48% of total allowances to protecting residents and businesses from negative economic impacts.

California has dedicated 35% of their allowances to “consignment,” in which mainly residents, and secondarily businesses, are given rebates on their utility bills. This allows wholesale electricity prices to rise according to carbon content without hurting consumers.

California and Québec dedicate a portion of their allowances (15% and 30% respectively) to protect industries that are energy-intensive and trade-exposed.

The remaining allowances (about half) are sold at auction and revenue is invested in state projects that provide further GHG abatement and economic development.

Gasoline prices have increased 11 to 14 cents per gallon due to the program, which is modest compared to the impact of crude oil fluctuations and other factors on gas prices.

Economic evaluation of the Western Climate Initiative is vital considering its higher allowance prices and greater coverage of the economy compared to RGGI. However, we still find that its impacts are relatively small compared to larger economic transitions. California has made several design choices to extensively protect vulnerable industries, businesses, and consumers. What remains is a modest increase in the price of gasoline compared to other factors, such as crude oil fluctuations and federal and state taxes.

The implications for GHG reductions will be discussed later, but both California and Québec have directed revenue to a wide set of economic and environmental priorities. The potential economic returns of these investments are substantial, but many funded programs have slow lifetime return rates upwards of 50 years.

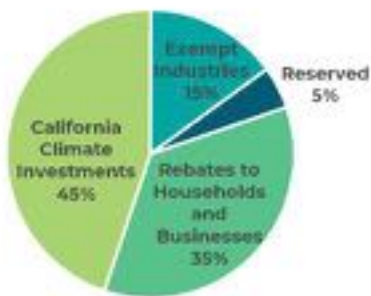
There is a need for comprehensive macroeconomic statewide analysis to capture the timing of these impacts. Such an endeavor is beyond the scope of this report.

However, we can still draw a similar narrative as RGGI — that strong economic growth and emissions reductions are not mutually exclusive. California's GDP has grown by 29% since program launch, compared to 19% growth in the rest of the US. WCI's approach shows that in an economy-wide cap-and-trade program, there is enough revenue to simultaneously protect vulnerable constituents and raise substantial capital for vital transformation projects.

Western Climate Initiative



California



Québec

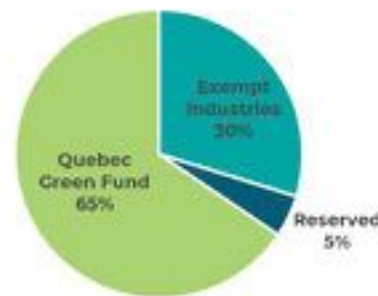


Figure 13: WCI's Allowance Distribution, 2015-2018

Economic Impact of Allowance Price

As previously noted, WCI is designed to cover approximately 85% of the economy. Nearly every ton of CO₂ involved in transportation, industrial processes, and electric power generation necessitates compliance with the program, with exemptions for several activities such as agriculture, aviation, and marine transportation.

But within covered sectors of the economy, allowances are distributed four different ways — auction, consignment, allocation, and reservation.

Since 2015, almost half of California's allowances have been distributed via standard auction, as opposed to two-thirds in Québec. Revenue raised through this process goes straight to the California Climate Investment Program (CCIP) or Québec's Green Fund.

An additional portion of California allowances are "consigned", or placed under utility ownership. These allowances are auctioned normally on the carbon market, but revenue is distributed to utilities, which are in turn required to pass along savings to consumers. This protects ratepayers from increased costs whilst still raising energy prices according to their carbon content. These "consigned" allowances have constituted 30% of WCI's total cap since 2015.

Finally, 17% of allowances have been freely allocated to industries, as opposed to 30% in Québec. These exemptions are determined by examining the energy-intensity and exposure of a given facility to global competition. The exemptions are occasionally benchmarked according to economic output as well.

A small portion of the annual cap is also placed in a reserve used for price control mechanisms. These allowances are withheld from auction until a certain price trigger point is met, after which a portion of the reserve is offered in auction. This helps contain costs, but thus far this mechanism has not been needed.

Auction, consignment, and allocation draw important distinctions in how they impact the economy. Both auctioned and consigned allowances introduce a price of carbon via the auction system, causing the price of goods and services to rise according to carbon content. However, both the consignment and allocation method negate some of the ways in which businesses and residents may experience these higher costs.

Protections through utility consignment and industry exemptions

The consignment mechanism effectively serves as a rebate to ratepayers — the majority of revenue is distributed as a "Residential Climate Credit" on utility bills.

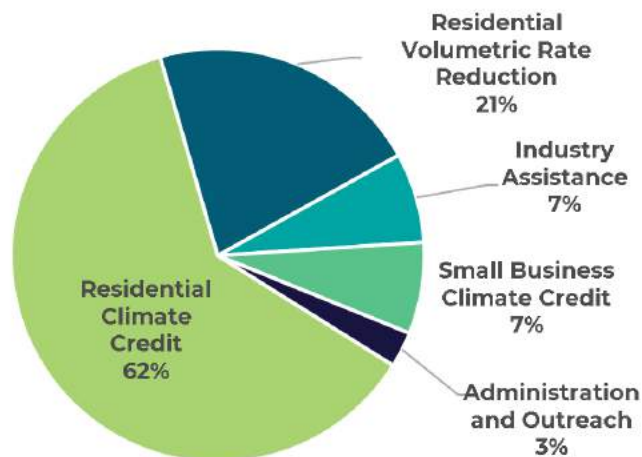


Figure 14: Use of revenue earned from consignment auctioning, 2014-2016³⁷

The Residential Climate Credit is an evenly distributed semi-annual flat payment across all residential ratepayers, whereas the Residential Volumetric Rate Reduction reduces the overall rates of electricity for consumers. From an environmental economic standpoint, the Residential Climate Credit is a more effective rebate system, for it more effectively encourages ratepayers to decrease their consumption. As of 2016, the Residential Volumetric Rate Reduction was discontinued and almost entirely replaced with a larger Residential Climate Credit.

The consignment mechanism has shown to be a superior mechanism as opposed to traditional exemption for two reasons. First, retail electricity prices are still allowed to rise according to carbon content, thus giving low-emission electricity generators a competitive advantage. Second, as consignments have made up 35% of WCI's entire allowance budget since program launch, exempting them entirely would considerably reduce the size and stability of the auction supply. Due to Québec's virtually clean energy grid, there is no need for utility consignment in their allowance budget.

³⁷ | Data from California Air Resources Board.

Another 17% of WCI's allowance budget has been freely allocated to industry. Both California and Québec use quantitative methods to determine the level to which a given industry is both energy-intensive and trade-exposed (EITE). By allocating free allowances to these industries, they prevent their own economic players from losing out to the competitive global market due to the carbon price.

In California, most of these allowances go to fossil fuel extraction and refinement. In 2018, these entities received nearly 30 million allowances, or 8.4% of California's total allowance budget. Another 3.1% of total allowances were allocated to targeted manufacturing industries.

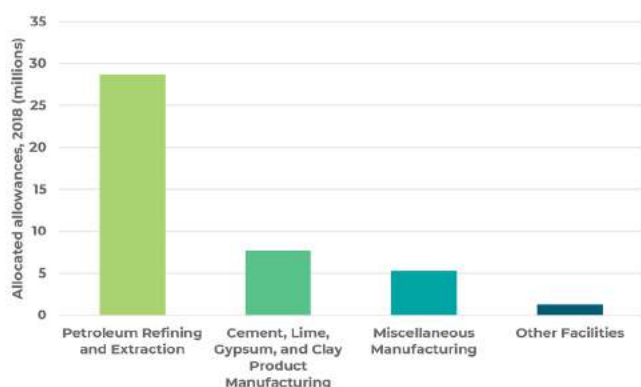


Figure 15: Free allowance allocation to California's major industries, 2018³⁸

Meanwhile, Québec allocated approximately 31% of their 2018 allowance budget to EITE industries.³⁹ Since Québec is a far smaller jurisdiction, the industry-specific breakdown of allowance allocation is not shared publicly in order to protect the financial information of individual facilities.

Impact of WCI on motor gasoline

The combination of utility consignment and industrial exemption leaves transportation fuel as the primary means by which the auction impacts are felt by consumers and businesses. We estimate that

retail gasoline accounts for approximately \$2 billion in allowance sales, or 72% of total auction revenue in 2016. Considering nearly 44% of California's sold allowances were consigned in 2016⁴⁰, and Québec's electricity sector has virtually no emissions, it appears that the overwhelming majority of consumer impacts from WCI are reflected in higher motor fuel costs.

California's 2016 GHG Inventory lists on-road transportation emissions to be 155 million metric tons of CO₂ equivalent. Multiplying by the average allowance price of \$12.73 in 2016 produces revenue of nearly \$2 billion. This aligns with LAO calculations, which also estimate \$2 billion in 2016 costs for California motorists due to cap-and-trade, or about \$75 per licensed motorist.⁴¹

WCI's allowance price has increased gas prices between 11 and 14 cents per gallon since program launch — 14 cents represents less than 4.2% of California's average retail gasoline price since program launch (\$3.36 per gallon). In Québec, the portion is even smaller — of the average gas price of approximately \$1.32 per litre in 2016, 3.6 cents is due to the cap-and-trade program, or 2.7% of total gas price.⁴²

This is a measurable impact, but is still far smaller than the impact of massive fluctuations in crude oil price, as well as other federal and state taxes. Crude oil prices, which on average determine about 60% of the final retail price in the US, have ranged between \$25 and \$105 per barrel since WCI launch. State and Federal taxes and fees clock in at 73 cents per gallon in California which is over 5 times greater than the allowance price. Meanwhile total gasoline taxes in Québec clock in between 51 and 55 cents per litre, compared to a 3.6 cent allowance price impact. In other words, state and local taxes on gasoline in WCI regions are 5 to 15 times greater than cap-and-trade impacts.

Overall, WCI follows a similar trend as other cap-and-trade schemes — the carbon price is too low, and there are too many protections in place for the

³⁸ | Data from California Air Resources Board. See <https://www.arb.ca.gov/cc/capandtrade/allowanceallocation/publicallocation.htm>.

³⁹ | Québec exemptions provided by the MDDELCC. For extensive carbon market documentation, see <http://www.mddep.gouv.qc.ca/changements/carbone/documentation-en.htm#regulations>.

⁴⁰ | Since consigned allowances are the first to sell, their share of total auction sales are inflated whenever an auction is undersubscribed, which is what happened multiple times in 2016. In more recent auctions, where auctions have been fully subscribed, consignments have constituted about 25 percent of sales.

⁴¹ | Data from California Legislative Analyst Office and California DMV.

⁴² | Author's own calculations using data from Energy Information Administration and Canadian Taxpayers Federation, May 2018. "20th Annual Gas Tax Honesty Report".

program to have a significant negative economic impact. This is good in the sense that consumers do not experience large increases in energy prices, but this may come at the price of substantial emissions reductions if maintained in the future.

Economic Impact of Invested Revenue

Revenue raised from California's allowances is directed towards California Climate Investments (CCI), such that the legislature appropriates funds to state agencies to administer specific programs. The Annual Investment of Proceeds report lists total allocations at \$6.1 billion through 2017, \$2 billion of which has been implemented.

Performing macroeconomic analysis of the long-term impacts of invested revenue is beyond the scope of this report and has not been completed at the state level. However, California extensively documents its investments annually, including expected project lifetimes and GHG reductions as well as benefits to disadvantaged communities. Methodologies to properly quantify additional macroeconomic benefits such as job-years and net impacts are still under development, but California's latest report claims that investing \$2 billion has attracted an additional \$8.2 billion of private capital. This results in \$4.10 leveraged from outside sources for every dollar invested from cap-and-trade.⁴³

If accurate, this may be in part due to California prioritizing long-term transformational projects that further develop communities while also facilitating GHG abatement. About half of all invested revenue is considered to "benefit" disadvantaged communities, with about 33% (\$660 million) taking place directly in such communities, as defined by California EPA. This does not include high speed rail, which has likely already created benefits through "thousands of direct and indirect jobs and promoting development in areas with high unemployment rates."⁴⁴

Evaluating the merits of each given project are beyond the scope of this paper and require extensive knowledge into the contextual development needs of the jurisdiction. However, it is important to highlight that California's investment approach creates additional political benefit for the program.

Using revenue for public-facing, highly visible and transformational projects can help solidify future

political support for the cap-and-trade program. While the slight increase in electricity prices caused by cap-and-trade goes unnoticed to most ratepayers, the Residential Climate Credit is visible twice yearly on electric bills. Auction revenue has funded hundreds of events aimed at raising awareness of climate policy and educating constituents on how to take advantage of offered programs.

This is not intrinsically an economic benefit, but it highlights why investing cap-and-trade auction revenue is politically attractive — the carbon costs are less apparent than a carbon tax approach, but the project investments are highly visible. More comprehensive research is needed into co-benefits and political advantages associated with the investment strategies of both California and Québec.

EMISSIONS IMPACT

Key Findings

California has achieved their 2020 emissions targets 4 years early, largely due to substantial reductions in electricity sector emissions. Like RGGI, the majority of electricity emission reductions are due to external factors; namely an increase in available hydroelectricity and falling prices for solar and wind generation.

Questions remain about the legitimacy of emissions reductions from imported electricity, but this issue will become less important over time as reliance on imports decreases.

The other major sectors have not yet experienced significant reductions, and transportation emissions continue to rise.

Due to their clean electric grid, Québec likely requires a higher allowance price than California in order to achieve the same rate of emission reductions. Québec has experienced a moderate decline in industrial emissions, although these reductions are negated by increasing transportation emissions.

California's emissions market is far larger than Québec's, and thus conditions in California, including complementary policies, tend to dominate emissions results in Québec. Future policy design should look closely at how to address this issue.

⁴³ | California Air Resources Board, 2018. "2018 Annual Report: Cap-and-Trade Auction Proceeds."

⁴⁴ | California Air Resources Board, 2018. "2018 Annual Report: Cap-and-Trade Auction Proceeds."

As WCI expanded to the transportation sector less than 4 years ago, and heavily interacts with a complex suite of economic changes and complementary policies, it is premature to perform quantified analysis with the same granularity as we have done for RGGI. However, the launch of WCI in both California and Québec presents an opportunity to investigate carbon pricing not unlike a scientific experiment – what happens when a comparable carbon pricing regime is applied across two different jurisdictions that differ in economic size and makeup, federal and local regulations, emission profiles, political forces, and civilian cultures?

For WCI to create similar results across these jurisdictions would suggest that there are fundamental lessons in policy design that persist across conditions. But if California and Québec diverge in their results as the program matures, they present an important opportunity to investigate underlying causes behind disparate program outcomes.

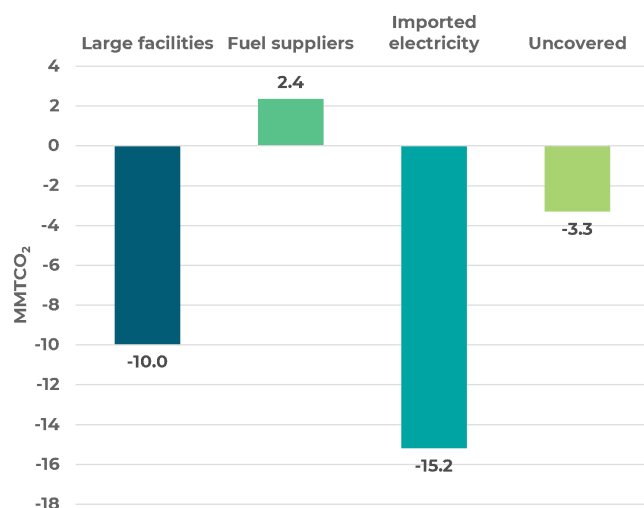


Figure 16: Changes in emissions reported for compliance in WCI, 2013-2016⁴⁵

Some of this work can be done preliminarily. California and Québec both rely on a Mandatory Reporting Regulation (MRR) to measure compliance obligations at the facility level. Between 2013 and 2016, annual emissions across WCI dropped nearly 23 million metric tons, nearly all of which happened in California's imported electricity and in-state fossil fuel electric power generation (within the large emitters category). Due to Québec having a dominantly hydro powered grid, these reductions

are overwhelmingly taking place in California. Early trends in WCI hence draw a strong similarity to RGGI, despite having expanded coverage and a higher allowance price – in that nearly all reductions are reported within the electricity sector, and are happening faster than expected.

California

California's recently released 2016 GHG Inventory indicates that the state has hit its 2020 reduction targets 4 years early.

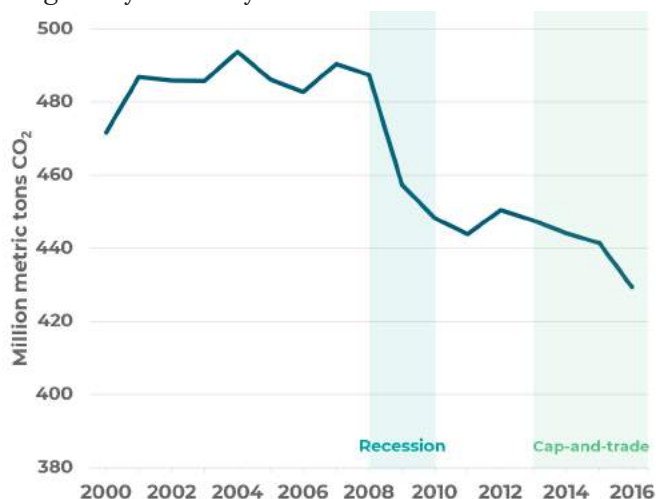


Figure 17: Annual emissions in California, 2000-2016

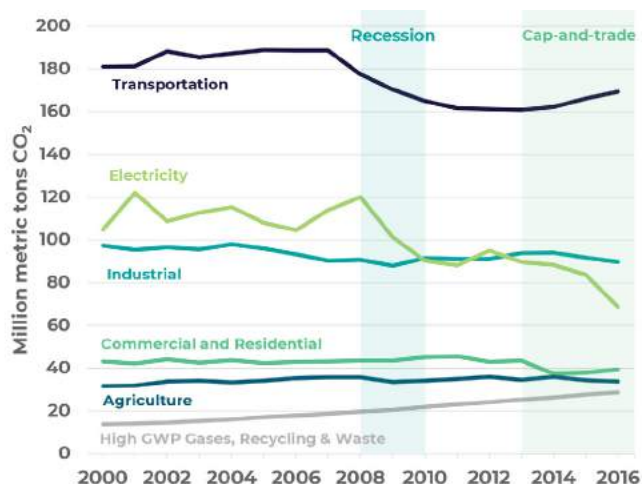


Figure 18: Annual emissions in California by sector, 2000-2016

California experienced a large decline in emissions during and following the economic recession, which reduced electricity and gasoline consumption. This is commonly cited as a reason for allowance oversupply

⁴⁵ | Data from California Air Resources Board and MDDELCC.

at program launch, as the cap was designed before the effects of the recession were fully experienced and measured.⁴⁶

But after a slight rebound in 2012, deep reductions in the electricity sector have persisted. Meanwhile, transportation emissions are slowly creeping upward towards pre-recession levels.⁴⁷

Deep Cuts in Electricity Sector

The emissions of electricity serving the California grid have decreased 28% since prior to program launch — 57% of this reduction occurred in 2016 alone. This draws striking similarity to the RGGI region, despite California's cap-and-trade program covering nearly the entire economy.

There are a few factors of varying significance that have driven electricity sector emissions downward.

Primary Factor 1 | The rebound of hydro

Hydro is perhaps the strongest contributor to reduced emissions in 2016. Yearly fluctuations in renewable energy generation are largely determined by hydroelectricity, whose sales have been inversely related to those of natural gas generation since 2000.

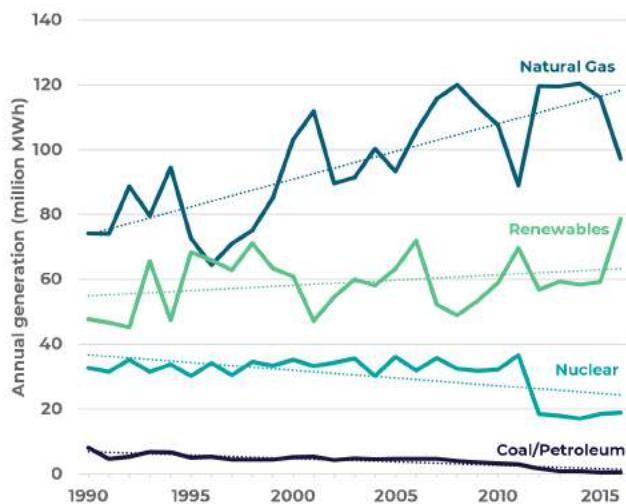


Figure 19: California in-region electricity generation by source, 1990-2016⁴⁸

In 2016, in-state hydro generation doubled (an increase of 15 million MWh) while natural gas generation significantly decreased (19 million MWh). If indeed 15 million MWh of natural gas generation was

replaced with hydroelectricity in 2016, then its recent rebound is responsible for mitigating approximately 8 million metric tons of CO₂ in a single year.

But this is not the entire picture. Drastic increases in hydroelectricity were only possible due to extremely low production in previous years; 2014 and 2015 boasted the lowest levels of hydro generation in California in over 20 years, which was primarily due to weather and snowpack conditions. In fact, annual hydroelectricity generation in 2016 was only 2 million MWh higher than 2012, and is still far below average generation between 2000 and 2010.

Recent history suggests that hydroelectricity will continue to fluctuate and drastically influence yearly emissions reductions, regardless of cap-and-trade design. However, the long-term replacement of natural gas is coming from a different renewable source.

Factor 2 | The new renewables on the block

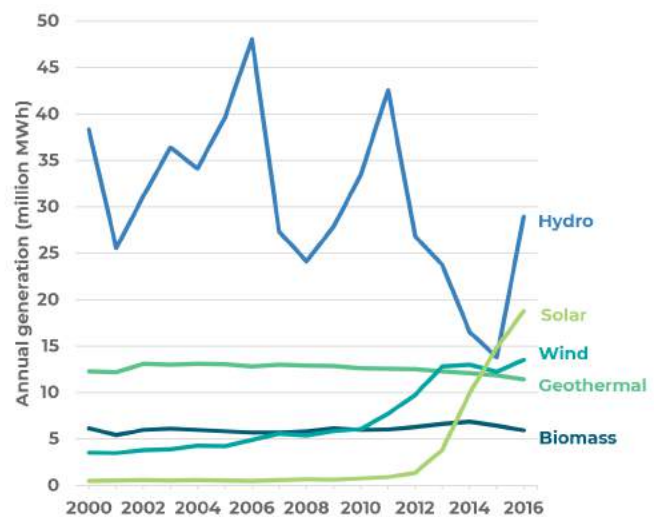


Figure 20: Renewable electricity generation in California, 2000-2016⁴⁹

Since 2012, solar generation has exploded by over 1,200% to become California's second largest source of renewable generation. This solar boom, along with contributions from increased wind generation, allowed renewables to reach a new high in 2016 despite hydroelectricity generation remaining below peaks experienced in 2006 and 2011.

⁴⁶ | Mac Taylor, February 2017. "The 2017-18 Budget: Cap-and-Trade." Legislative Analyst Office.

⁴⁷ | California Air Resources Board, July 2018. "2000-2016 GHG Emissions Trends Report."

⁴⁸ | Data provided by Energy Information Administration.

⁴⁹ | Data provided by Energy Information Administration.

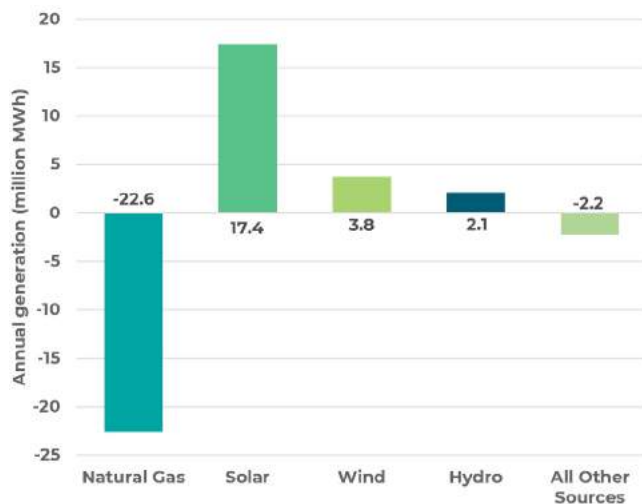


Figure 21: Net change in renewable electricity generation in California, 2012-2016⁵⁰

This trend suggests that non-hydro renewables, largely solar and wind, are replacing natural gas in the long-term. Under this assumption, we find that solar and wind growth has replaced almost 7 million metric tons of CO₂ since program launch, or about 26% of emissions reductions experienced in California's electricity grid.⁵¹

While WCI's price signal may have made minor contributions to this trend, it is predominantly due to the rapidly declining cost of solar hardware installation. Since 2010, residential and commercial solar installations have decreased about 65% in overall cost, while utility-scale costs have decreased nearly 80%.⁵² All costs considered, solar is the most competitive new generation source in California.

Factor 3 | Natural gas generation is down... temporarily

Unlike RGGI, California has virtually no petroleum or coal-based electricity generation. The only way for WCI to reduce in-state electricity emissions is by discouraging natural gas generation, and it is unlikely that cap-and-trade has played a large role in this regard.

As mentioned earlier, natural gas and renewable generation are historically inversely related. Due to a strong rebound of hydroelectricity, natural gas generation experienced a strong dip in 2016 despite gas reaching its lowest cost in nearly 20 years.⁵³ This dip could easily rebound in future years if hydroelectricity generation continues to fluctuate.

Creating deep and durable reductions in California's generation requires retiring natural gas plants in favor of renewables, and WCI has little to do with this trend. The decision to open or close a plant has to do with long-term market projections that far outweigh the \$5.45/MWh that WCI adds to the wholesale natural gas price. CAISO cites long-term contracting as the primary means for facilitating new generation investment.⁵⁴

There is, however, opportunity for even modest prices to facilitate investment into more efficient natural gas systems. CAISO's 2013 Electricity Market report cites the carbon price as a factor in facilitating more efficient combined-cycle natural gas generators, as opposed to simple-cycle generators that produce less electricity and more emissions with the same amount of natural gas.⁵⁵ The long-term contracting necessary for natural gas retirements or efficiency investment rely on stable lasting price signals, which WCI's price collar can help provide.

Factor 4 | The mystery of imported electricity

Since 2012, changes in imported electricity appear to be responsible for 68% of emissions reductions, as opposed to 32% from in-state generation. But the extent to which these reductions are legitimate is unclear.

A major concern in the electricity market is that emissions will "leak" into adjacent states and grids. California attempts to address this problem by adding a carbon price to imported electricity. If the generation source is specified, the purchaser is

⁵⁰ | Data provided by Energy Information Administration.

⁵¹ | Author's calculations using data from CAISO Annual Report 2016, Energy Information Administration, and California Air Resources Board.

⁵² | National Renewable Energy Laboratory, September 2017. "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017."

⁵³ | Data provided by Energy Information Administration.

⁵⁴ | CAISO Annual Report on Market Issues and Performance 2013.

⁵⁵ | CAISO Annual Report 2013.

charged at a rate according to the emissions intensity of that source. This electricity is purchased through the Energy Imbalance Market (EIM), which connects CAISO to surrounding grids in the Western US to exchange electricity in real time.

However, the generation source of imported electricity is not always specified. In these cases, the purchaser is assessed a carbon rate similar to that of an efficient natural gas plant. This previously has been a major source of concern – without tracking the original source of imported electricity, power purchasers are free to “shuffle” their resources. Contracts are rearranged to replace legacy coal power import contracts with “unspecified” electricity, allowing power purchasers to claim the difference in emissions without making any real changes to the grid.⁵⁶

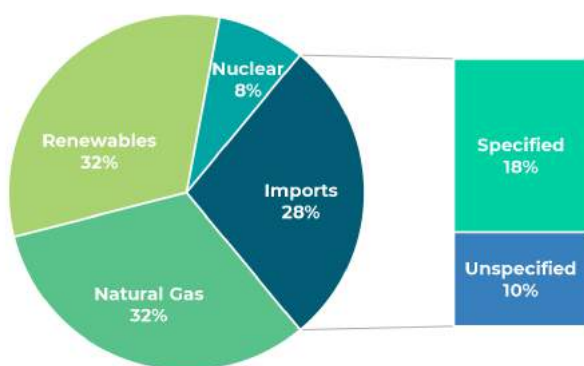


Figure 22: Sources of electricity serving California including imports, 2016⁵⁷

The impacts of unspecified imports are potentially substantial. As of 2016, one third of imported electricity is unspecified. Were all this electricity to originate from coal plants, it would leave approximately 14 million metric tons of CO₂ unaccounted for, which raises total electricity sector emissions by 20% and cancels out 53% of sector reductions since 2012.

These numbers represent the worst-case scenario for what unspecified imports could be responsible for. But the issue cannot be adequately assessed without access to data that EIM has not yet been able

to fully monitor. Neither RGGI nor California are set up to monitor the flow of electricity at the level of detail required for such analysis. The EIM is currently in talks with California and other member states in order to find market designs that address this issue without impeding the cost benefits that the current structure provides.

Fortunately, there is a limit on the extent to which resource shuffling can occur moving forward. When a power purchaser's electricity is unspecified, the only way to further reduce emissions is to switch to zero-emission sources. So even under a scenario where the majority of early program reductions are due to resource shuffling, the issue can be corrected by further reducing the cap, rather than dramatically restructuring the EIM.⁵⁸

More “natural” forms of leakage can also occur. When power purchasers replace their imported coal contracts with natural gas or renewables, coal plants may simply increase their sale of electricity to nearby states that don't have carbon markets. This also leads to perceived reductions in California without any real changes to the larger electricity grid.

Even future carbon pricing regimes that adequately track the source of imported electricity will not completely solve the issue of leakage on an increasingly interconnected grid. All forms of leakage cannot be prevented short of expanding carbon pricing to all connected grids.⁵⁹

Impact of Invested Revenue on Emissions

It is too early in the program for invested revenue to have a significant effect on emissions. Many of these projects have long-term GHG reduction lifetimes, extending as far as 50 years. Using data provided in California's 2018 Investment of Proceeds report, we estimate that investments were responsible for almost 700,000 metric tons of annual CO₂ reduction through 2016, which is 3% of observed reductions since program launch.

⁵⁶ | Danny Cullenward, September 2014. “How California's carbon market actually works.”

⁵⁷ | CAISO Annual Report on Market Issues and Performance 2016

⁵⁸ | Danny Cullenward, May 2015. “Resource shuffling continues in California's carbon market.”

⁵⁹ | Schmalensee & Stavins, January 2017. “Lessons Learned from Three Decades of Experience with Cap-and-trade.”



Figure 23: GHG emissions reductions from implemented projects in California⁶⁰

The durability of reductions from investment will depend on continued revenue in the future. Currently, committed funds will produce nearly 1.2 million metric tons of CO₂ reductions per year through 2026. Furthermore, currently committed projects will produce a cumulative reduction of 23.2 MMTCO₂, most of which will occur between now and 2035.

These projects have large savings potential but take a long time to implement and impact emissions. And there is significant uncertainty in what level of revenue the program will raise in the future. But if revenue collection and implementation strategies continue their current trends, they could help California achieve about 7% of their reduction goal between 2020 and 2030.



Figure 24: Potential Investment Impact on emissions in California through 2030

Figure 24 uses a snapshot of California's revenue streams and spending strategies through 2017 to project possible emissions impacts through 2030. This is a simplistic scenario of what current investment practices could accomplish — in reality, there is large uncertainty surrounding changes in allowance price, emissions, and implementation strategy. Additionally, we assume that California implements all of their revenue in a timely manner, whereas in reality, two thirds of allocated revenue is yet to be spent. But it does illuminate a larger point — that at the current pace cap-and-trade investments could reduce emissions by nearly 13 million metric tons by 2030, which is 7% of the reductions necessary to achieve the 2030 target.⁶¹

While we highlight the dangers of unrestricted banking in other sections of this report, we recognize its utility as well. The investment strategy of California requires consistent and robust revenue streams to fund large-scale projects that transform California's infrastructure and reduce emissions over the long term. Meanwhile, they also earmark a significant portion for equity-focused projects, which tend to have lower GHG reductions per dollar spent. Banking allows California to sell-out auctions despite an allowance supply that far outweighs actual emissions. This creates the revenue needed to get large-scale programs started, but means that a large quantity of banked allowances overhangs the system.

It is too early for WCI investments to produce significant emissions reductions, and more research is needed into what will spur substantial reductions in the transportation sector. However current literature suggests that investing in infrastructure and public transportation will be an important component of any decarbonization strategy, particularly in congested states such as California, New York, and New Jersey. It is likely that the RGGI states, and many other North American regions, will need to undertake similar projects in their own territory in order to facilitate the reductions necessary in the transportation sector.

Québec

Even more so than California, it is too early to draw hard conclusions on cap-and-trade's impact on emissions in Québec. Québec's official emissions inventory is only available through 2015, offering one year of

⁶⁰ | California Air Resources Board, 2018. "2018 Annual Report: Cap-and-Trade Auction Proceeds."

⁶¹ | Author's calculations using data from California Air Resources Board, 2018. "2018 Annual Report: Cap-and-Trade Auction Proceeds."

final emissions figures since WCI expanded beyond electricity. We can, however, use preliminary data to compare jurisdictional outcomes through 2016.

Referring to figure 25, most emissions reductions reported in WCI’s mandatory reporting system are occurring in California. While California’s emissions have decreased 6.7% since 2012, Québec’s emissions have decreased 1.7%.

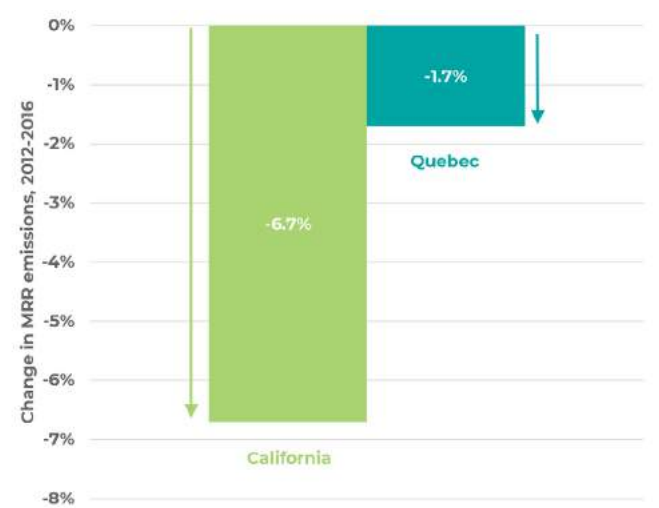


Figure 25: Change in WCI reported emissions for compliance by jurisdiction, 2013-2016

This speaks to a larger trend across all cap-and-trade systems in question, that we are still in the “electricity phase” of abatement. The most economically efficient ways to reduce emissions across both WCI and RGGI have been to replace uncompetitive coal plants with efficient natural gas power, increase hydroelectricity supply, and deploy cost-competitive solar and wind generators. Québec has not had the opportunity to reduce emissions in these ways because approximately 95% of its power comes from hydro-electricity.

However, there may be real impacts underway in Québec’s industrial sectors. According to national reporting data, emissions from manufacturing are down 7%, including a 6.4% decrease in emissions from petroleum refining. Altogether, emissions from large facilities are down 8.8% from 2012.

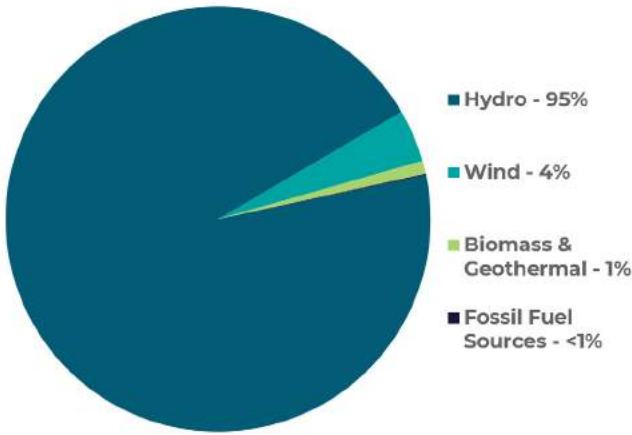


Figure 26: Generation mix of Québec electricity, 2016

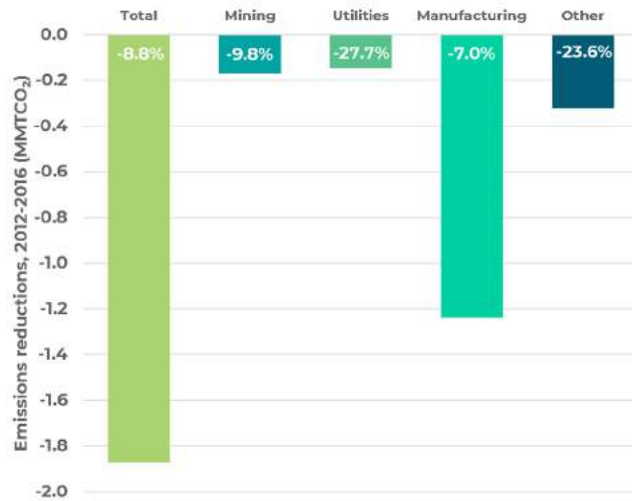


Figure 27: Percent change in Québec emissions by reported source, 2013-2016⁶²

Figure 27 includes facilities that emit at least 50,000 metric tons of CO₂ per year. Attributing the downward trend in facility emissions in Québec to cap-and-trade requires further investigation into the causes of these changes.

Linking with California has delayed reductions in Québec

In the short term, California can continue to reduce emissions in the electricity sector at a fairly low allowance price. But Québec is a different story – since their electricity market is already clean, their reductions will likely be slower than California until an adequate allowance price is reached to spur abatement in more difficult sectors.

⁶² | Data from MRR reporting system, provided by California Air Resources Board and MDDELCC.

California's allowance supply outweighs Québec's by a factor of about 6 to 1. Thus, the design choices made by California largely dictate outcomes in Québec as well. Linkage has been an important step for Québec, as it significantly increases their allowance liquidity and fosters a stable carbon market.

But this choice has downsides — as long as Québec is linked to larger jurisdictions with unclean electricity, their own emissions reductions may be delayed.

When two jurisdictions are linked, their allowance supply is pooled together at auction. The resulting price is expected to reflect the lowest cost of GHG abatement, regardless of which jurisdiction those reductions take place in. As the reductions in California's electricity market have driven allowance prices downward, Québec has not reached the allowance price necessary to reduce emissions at a similar rate. Such will be the case until either California runs out of GHG abatement opportunities in the electricity sector, or the program is adjusted to facilitate higher allowance prices.

Further research is needed into Québec's emissions performance, as well as the impacts of linkage with California. ■

DISCUSSION & POLICY RECOMMENDATIONS

A key lesson from our examination of RGGI and WCI is that the limitations of what cap-and-trade systems have achieved to date are not inherent in their concept or fundamentals. Rather, they are limited by the specific design features and emissions targets that have been included in each system. In turn, these features are in large part a function of economic and political concerns, such as how operating a system in one geographic area will affect that area in comparison with its neighbors and the rest of the world. The limitations to date have largely been intentional, not accidental. This is apparent in the original planning documents of both systems.

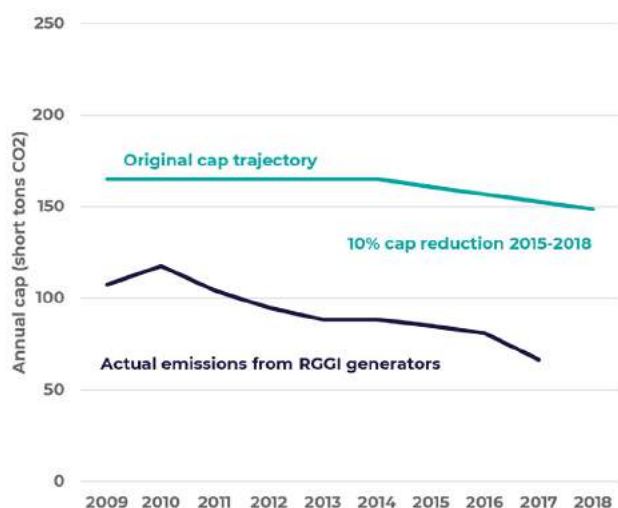


Figure 28: Original RGGI cap trajectory vs actual emissions

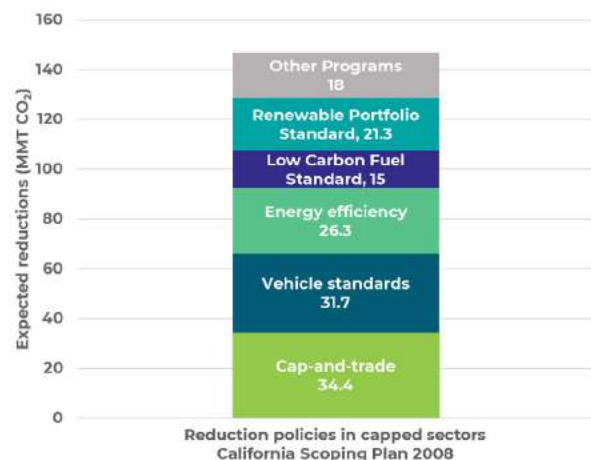


Figure 29: Expected contributions of California policies to 2020 emissions goal

In part, policymakers and advocates had the goal of demonstrating that cap-and-trade could work well, without disrupting the economic system, even if emissions reductions were relatively small. However, since their inception, the current and projected impacts of climate change, as well as the emissions reductions targets set by state governments, have changed. Governor Brown punctuated this shift in September 2018 by introducing an executive order to achieve a carbon-neutral economy by 2045.⁶³

These programs must become more ambitious in order for these jurisdictions to hit their long-term targets. At a fundamental level, carbon pricing regimes can be more effective with higher allowance prices, greater sector coverage, and increased geographic scope.

Our recommendations highlight why stricter design and increased scope will be needed in the next decade, as well as provide adjustments to market design that might make a more impactful program economically and politically feasible.

While this discussion focuses on RGGI and WCI, our recommendations can help any jurisdiction establish a program that mitigates political and economic obstacles without compromising environmental integrity. At the end of the day, political restrictions will determine how ambitious these programs can get.

Most importantly, RGGI needs to expand beyond the electricity sector. The recommendations we make below pale in comparison to the necessity that other sectors of the economy be covered, and that carbon pricing systems spread across North America. As such, our technical recommendations tend to most directly apply to WCI, however, these lessons can also be applied to build an expanded RGGI program that is environmentally ambitious and politically feasible.

Oversupply threatens long-term emissions targets

Due to overestimated emissions in early years combined with unrestricted banking, WCI's current program design risks failing to meet 2030 emission goals.

⁶³ | State of California, "Executive Order B-55-18 to Achieve Carbon Neutrality." See <https://www.gov.ca.gov/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf>

When cap-and-trade systems are overallocated (as has been the case in virtually all implemented programs to date), firms are heavily incentivized to purchase and save large amounts of unused allowances for future years when they will likely be more expensive. Thus, when the cap becomes more restricted, firms can use their banked allowances to avoid making any substantial changes to their emissions profile, or can sell them on the secondary market for profit. California's Legislative Analyst Office (LAO) finds that California could miss their 2030 target by as much as 30% due to unrestricted banking and unsold allowances.⁶⁴

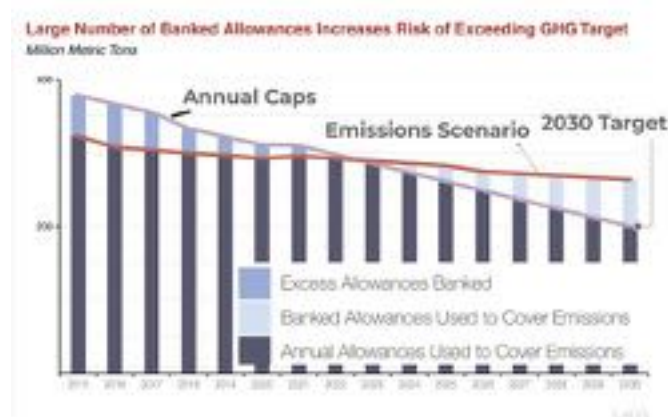


Figure 30: Potential emissions trajectory in California due to banked allowances

Other independent analysts have used CARB's own data to highlight a different scenario in which the cap becomes increasingly restrictive while emissions lag behind, prompting bank allowance pools to dry out. At this time, CARB may be forced to sell unlimited allowances at their price ceiling, sacrificing the cap trajectory to avoid political fallout due to runaway prices.⁶⁵ CARB outwardly contests these findings, but given the level of uncertainty surrounding future emissions and carbon market behavior, these scenarios cannot be ignored.

The fundamental challenge here is that unrestricted banking prioritizes cumulative emissions targets over annual emissions targets. For example, in the scenario outlined in figure 30, California severely misses 2030 annual targets, yet cumulative emissions between 2015 and 2030 remain under what the

cap allows. If the cap trajectory was instead designed based on a cumulative emissions goal, there would be no apparent downside to unrestricted banking. But California's mandated targets are incompatible with the temporal flexibility that current program design provides.

Business-as-usual (BAU) predictions, which are a primary determinant in forming a cap trajectory, are extremely difficult to get right. There is greater political risk in lowballing this prediction — a tight cap risks producing excessive costs for constituents, while a loose cap leaves more room for error. When overallocation is combined with unrestricted banking, polluters are implicitly encouraged to bank cheap allowances, use them in later years, and avoid the real reductions necessary to hit annual emissions targets.

One solution is to adjust the cap downward according to banked allowances. In 2014, RGGI adjusted its cap trajectory to account for banked allowances and an updated emissions projection, cutting nearly 140 million cumulative allowances from their 2014-2020 supply. This speaks to the value of frequent review periods — when BAU cases prove to be wrong, officials need a means to adjust the program.

However, due to delays in data analysis and the political process, manual adjustments are likely to take place years after the problem first arises. If the cap trajectory is already calibrated with mandated climate goals, there also might be political resistance to further reduce the cap over time. A more durable solution would be to either build automatic cap adjustments into program design or introduce moderate limitations to banking.

Were all unused allowances to expire at the end of each three-year compliance period, firms could retain a moderate amount of flexibility without threatening the long-term viability of the program. Alternatively, banked allowances could depreciate in value with time. For example, cutting the compliance value of a banked allowance in half at the end of each compliance period would strongly disincentivize hoarding practices to continue without rendering all banked allowances completely useless.

⁶⁴ | Ross Brown, December 2017. "Cap-and-Trade Extension: Issues for Legislative Oversight."

⁶⁵ | Inman, Mastrandrea, and Cullenward, September 2018. "Tracking Banking in the Western Climate Initiative Cap-and-Trade Program"; Chris Busch, December 2017. "Oversupply Grows in the Western Climate Initiative Carbon Market".

Use price collars and rebates to contain price impacts

Adjusting the cap and restricting banking practices would likely lead to allowance prices that are higher and more volatile, particularly if easy forms of emissions reductions run out in the next decade.

Both RGGI and WCI have implemented price collars, which can contain costs effectively even if restrictions on banking were imposed. Allowance price reserves act as a controlled form of “administrative banking,” such that a pool of allowances are introduced into auctions at certain price points in order to relieve strain between allowance demand and supply. RGGI’s current reserve trigger price is \$10.25, while WCI has three tiers of trigger prices between \$54 and \$68. Neither system has come close to hitting these prices thus far.

This is a hybrid form of carbon pricing that balances price stability with emissions targets. However, this still has a weakness — WCI is required to sell an unlimited number of allowances at a hard price ceiling. This is equivalent to “printing money” and can destroy the environmental integrity of the program. If set too low, this ceiling could prevent allowance prices from reaching the level necessary to spur GHG abatement.

It is likely that tackling emissions in sectors outside of electricity will require a far higher allowance price. RGGI currently has a reserve trigger price of \$13 planned for 2021, while WCI’s trigger prices for 2021–2030 are still under consideration.

Setting the price ceilings too low puts the program at risk. Should a price ceiling be hit, more allowances will automatically be issued, which means that the emissions cap for that year is being exceeded. If the allowance price is not allowed to rise high enough to keep emissions below the cap, then the program risks missing its environmental targets.

Policy designers must balance the goal of cutting emissions with the concern that high allowance prices could impose an excessive burden on residents and businesses. Under RGGI, prices have been too low to significantly impact consumers, so it has been feasible to use almost all funds for clean energy purposes. In California, with higher prices, the judgement was

made to return most of the allowance revenues from electricity and natural gas consumption to residential consumers, with a small share going to businesses and vulnerable industries.

By adding rebates or other return mechanisms at certain price points, WCI and RGGI can allow the price to rise according to what will keep emissions under the cap without overburdening the economy. Currently, WCI has strict requirements to spend revenue raised from allowances sold at the hard price ceiling on measurable GHG reduction projects. Instead, an increasing portion of revenue could be rebated to residents and businesses depending on which trigger price is achieved.

Price containment points	% of revenue rebated to consumers
Standard auction	0%
Tier 1 Trigger Price	25%
Tier 2 Trigger Price	50%
Tier 3 Trigger Price	75%
"Hard Ceiling"	100%

Figure 31: Hypothetical rebate structure tied to trigger prices

Figure 31 is an example of how an auction price containment reserve could be integrated with a rebate system. This would allow officials to set far higher trigger prices in the future without fear of overly burdening their constituents. Once the “hard ceiling” is hit, 100% of revenue is returned in a manner that fully protects vulnerable residents and businesses. Thus, it would not be necessary to sell unlimited allowances to contain costs, threatening the environmental integrity of the program.

Rebates may be a vital part of achieving higher allowance prices. Across the world, cap-and-trade systems tend to earmark revenue for green investment, while carbon fee systems tend to earmark revenue for rebates or general funds.⁶⁶ In practice, this has allowed direct carbon fee systems to achieve higher carbon prices.⁶⁷ WCI effectively returns half of their revenue by exempting vulnerable industries and providing rebates on utility bills, which may have allowed

⁶⁶ | Schmalensee & Stavins, March 2017. “Lessons Learned from Three Decades of Experience with Cap-and-trade.”

⁶⁷ | World Bank Group, May 2018. “State and Trends of Carbon Pricing 2018.”

the program to achieve moderately higher prices than RGGI. Further rebates may be required in order to make an even higher carbon price politically feasible.

RGGI can adopt a similar approach as WCI, such that a portion of revenue is returned directly on utility bills. Providing a visible and clearly labeled climate dividend would not only protect ratepayers from costs associated with higher allowance prices, but would also spread awareness for the program and build political support for future climate policy ambition.

Higher allowance prices will be necessary for future programs to have a substantial impact. But achieving these prices is politically challenging. Revenue return mechanisms can help policy designers achieve more substantive programs with reduced risk for political fallout. However, it is also necessary to make several adjustments to the cost containment mechanisms of cap-and-trade in order to avoid compromising environmental ambition in 2020-2030.

Allowance prices need to be higher

The effectiveness of a carbon price can be evaluated from two perspectives – what is the true social cost of carbon (SCC), and what is the price necessary to spur adequate GHG abatement? These numbers are very difficult to exactly predict, but either perspective would suggest that WCI and RGGI allowance prices need to be higher in the coming decade.

Compared to social cost estimates of carbon dioxide emissions, virtually every carbon pricing regime across the globe is underpriced.⁶⁸ The allowance prices are a culmination of various design decisions such as cap ambition, cost containment, exemptions, and rebates. Thus, while cap-and-trade is not as prescriptive with its carbon costs as a more direct fee approach, it is valid to critique cap-and-trade prices on the grounds of whether the true social cost of carbon (SCC) is captured within the program.

The Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) describes the social cost of carbon for a given year as “the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide emissions into the atmosphere in that year.”⁶⁹ From an economic perspective,

⁶⁸ | OECD, September 2018. “Effective Carbon Rates 2018: Pricing Carbon Emissions through Taxes and Emissions Trading.”

⁶⁹ | California Air Resources Board, September 2018. “Staff Report: Initial Statement of Reasons.” <https://www.arb.ca.gov/regact/2018/capandtrade18/ct18isor.pdf>

PROVIDING A
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BUT WOULD ALSO
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FOR THE PROGRAM
AND BUILD
POLITICAL SUPPORT
FOR FUTURE
CLIMATE POLICY
AMBITION.

this is the basis for adequate carbon pricing — the price of a commodity should include the damages caused by its use, even if those damages occur decades later.

Calculating an exact SCC is perhaps never achievable. The complexity and dynamic nature of climate science, variety of necessary assumptions, and geographic disparity of climate impact makes it unlikely that an exact amount will ever be agreed upon. There is, however, strong evidence to suggest that this value is far higher than what current carbon pricing systems assess.

The US Interagency Working Group has been updating an academically rigorous, peer-reviewed social cost of carbon since 2009. This is currently the most reputable and best available SCC and has informed hundreds of federal policy designs.

Year	3 Percent Discount Rate	2.5 Percent Discount Rate
2015	\$ 43.41	\$ 67.53
2020	\$ 50.65	\$ 74.76
2025	\$ 55.47	\$ 82.00
2030	\$ 60.29	\$ 88.03

Figure 32: Social cost of carbon (real 2018 US dollars)

There is considerable expert consensus that the federal SCC is low.⁷⁰ The federal methodology uses a static discount rate (which determines what value future climate change damages are relative to today) and omits several climate impacts from its models. To what extent the SCC is higher is not yet agreed upon, however the federal SCC serves as a useful estimate of what the minimum true social cost of carbon could be.⁷¹ Both RGGI and WCI have been far below this value thus far.

RGGI has set a price ceiling of \$13 in 2021, while the minimum social cost of carbon will be \$50 in 2020. Under its currently planned trajectory, RGGI will

continue to do very little to correct for the future damages of pollution. We recommend that at the very least, the price ceiling is maintained above the SCC values put forward by the Interagency Working Group.

WCI’s allowance prices are higher than RGGI. But there are over a dozen carbon pricing systems worldwide with higher prices, reaching as high as \$140/tCO₂ in Sweden.⁷² In addition, California provides free allowances to what it views as vulnerable industries (EITE), particularly manufacturing and petroleum extraction and refining. As a result, a substantial portion of the social cost of carbon is not yet captured within the WCI carbon market.

As under RGGI, we recommend that the WCI’s price collars are high enough in 2021–2030 to include the SCC. Current CARB proposals suggest that the price is barely high enough. We suggest that WCI further raise these price ceilings to best enable their program to capture the true SCC.

The other perspective by which a carbon price can be critiqued is the price necessary to spur GHG abatement. This number varies widely based on industry, location, complementary policies, and technological innovation. As such, we do not make a case as to what the specific carbon prices need to be within RGGI and WCI in order to hit their mandated goals. Current literature suggests, however, that they will likely have to be higher.

California designed cap-and-trade as a “backstop” policy through 2020, such that other policies achieve far more GHG abatement than the cap-and-trade program.⁷³ In the event that other policies fail, the cap-and-trade program is prepared to pick up that slack. As California’s complementary policies have remained active and successful, it has not been necessary for California to capture the full cost of GHG abatement within their cap-and-trade program.

California plans to rely more heavily on cap-and-trade from 2021–2030 and will likely require higher allowance prices that more closely resemble actual

70 | Howard & Sylvan, May 2015. “The Economic Climate: Establishing Consensus on the Economics of Climate Change.” <http://ageconsearch.umn.edu/record/205761>

71 | NYU Institute for Policy Integrity, February 2017. “Social Costs of Greenhouse Gases.” https://www.edf.org/sites/default/files/social_cost_of_greenhouse_gases_factsheet.pdf

72 | Most of these initiatives are direct carbon fee approaches. Some of these systems have a narrower scope than WCI. As of May 2018, WCI has the third highest cap-and-trade allowance prices in the world behind EU ETS and Korea’s ETS. Source: World Bank Group, May 2018. “State and Trends of Carbon Pricing 2018.” <https://openknowledge.worldbank.org/bitstream/handle/10986/29687/9781464812927.pdf?sequence=5&isAllowed=y>

73 | California Air Resources Board, December 2008. “Climate Change Scoping Plan: a framework for change”.

GHG abatement costs. But this depends on the durability and success of other policies, which will hide some of the apparent cost from the allowance price. The Stern-Stiglitz High-Level Commission on Carbon Prices concludes that the carbon price necessary to achieving the Paris temperature target is at least \$40-80/tCO₂ by 2020 and \$50-100/tCO₂ by 2030, assuming complementary policy is in place. This serves as the best available prediction of what WCI may need in order to tackle stubborn emissions from the transportation, industry, and building sectors.

Require local offsets and gradually reduce exemptions in order to produce more equitable outcomes

Offsets are currently available as a form of cost containment in both RGGI and WCI. Should an emitting entity wish to reduce its cost of compliance with cap-and-trade it can instead choose to purchase “offset credits,” which fund one of several available carbon sequestration projects.

This is an effective form of cost containment for sectors with high GHG abatement costs. While prices in RGGI have been too low for offset projects to be a sensible choice, WCI firms have used offsets fairly extensively, covering up to 8% of each firm’s compliance obligation. In 2021, this limit reduces to 4%, moving up to 6% in 2025.

Meanwhile, exemptions have been used to significantly reduce the compliance obligation of many of California’s largest producers, including nearly 20 million allowances freely allocated to petroleum refiners in 2018.

From an economic and political perspective, protecting vulnerable industries is a sensible tool in passing carbon pricing. Current allowance prices could put many of these industries at a disadvantage on the competitive global market. Exempting these industries eases political resistance to carbon pricing legislation, yet does little to change the early impacts of the program, because the lowest-cost emission reductions are mainly in other sectors.

However, this has created disparate health impacts in California, and likely Québec as well. California has experienced increases in petroleum refining

emissions in local communities, largely allowed by offsets and industry assistance.⁷⁴ These facilities, like coal plants, emit SO_x and NO_x that are harmful to human health, yet they received 45% of freely allocated allowances in 2018. As a result, cap-and-trade has done little to address inequitable health outcomes in the low-income and people of color communities where these facilities are located. And with no coal plants to retire, there have been little direct health benefits for California to claim thus far.

CARB cites offsets as a vital means for both cost containment and accelerated reductions. Sectors with a GHG abatement cost higher than the allowance price are granted opportunities to reduce their net emissions cost-efficiently. As offsets will remain in the program through 2030, more research is needed into how offset requirements can be designed so that the benefits they provide are verified, local and equitable.

Leakage concerns

Electricity leakage can only be truly prevented by expanding carbon pricing regimes to surrounding jurisdictions. Until expansion is achieved, California presents the best tool available at this time. By assessing a fee on the emissions of imported electricity, some of the more direct concerns of leakage can be mitigated. However, resource shuffling restrictions and a lack of market monitoring data may have lead to additional forms of electricity leakage.

RGGI has gotten away with no coverage on imports due to their access to competitive Canadian hydro-electricity. But other states may not have such options available. Future carbon pricing systems in other states must examine what surrounding resources exist to inform how import policy is designed.

Industrial leakage has been minor in both programs thus far, but must be closely examined as the allowance price increases in the next decade. Initially allocating generous assistance to vulnerable industries at program launch does not compromise the environmental effectiveness of the program, and can be a vital means to achieving the political support necessary.⁷⁵ However, these assistance mechanisms must be reduced over time as the easy sources of GHG reductions run out.

⁷⁴ | Cushing et al., July 2018. “Carbon trading, co-pollutants, and environmental equity: Evidence from California’s cap-and-trade program (2011-2015).”

⁷⁵ | Bang, Victor, & Andresen, 2017. “California’s Cap-and-Trade System: Diffusion and Lessons.”

Future jurisdictions must carefully analyze their economic makeup in order to appropriately design their industry protections. Future initiatives should recreate California's EITE approach in order to identify vulnerable industries and create a proper phase-out plan for their protections. In order to prevent political bias, this process should remain objectively and transparently determined by the acting agency.

In certain cases, officials have needed to "promise" certain industry protections to build political support for carbon pricing legislation. While this is inherently corrupting the objective process, it can be done without significantly harming the viability of the program if legislation remains non-prescriptive to the degree and timing of assistance to these industries.

Methane leakage

The emissions reduction figures published by RGGI, Inc. are only for CO₂. They do not account for increases in fugitive leakage of un-burned methane (the main component of natural gas) that occur during drilling, interstate transmission, local distribution, and elsewhere in the gas distribution system. Such methane has many times the greenhouse gas impact of CO₂ and therefore is a serious concern.

There is great uncertainty concerning the rate at which methane is leaked, with the federal EPA, the California Air Resources Board, other state governments, and academic sources all differing substantially. It is also likely true that emissions from gas supplied to power plants has lower leakage than gas used for heating of buildings, since the many miles of distribution pipes through local streets are not present.

High leakage rates could cancel out a substantial part of the gain due to conversion from coal to gas. To the extent that RGGI, WCI and other carbon pricing systems cause increases in natural gas use for generation, the CO₂ equivalent of methane leakage should be included in the compliance obligation of natural gas-based activity. ■