SCALING UP

Local to Global Climate Action

Yale School of Forestry & Environmental Studies

The Stanley Foundation

R20 REGIONS OF CLIMATE ACTION

USC Schwarzenegger Institute for State and Global Policy

USC Price

Scaling Up:
Local to Global Climate Action

By Yale University, in collaboration with R20 Regions of Climate Action, The Stanley Foundation, USC Schwarzenegger Institute for State and Global Policy.

Angel Hsu

Director of the Yale Data-Driven Environmental Solutions Group

Assistant Professor of Environmental Studies at Yale-NUS College

Adjunct of the Yale School of Forestry & Environmental Studies

Kaiyang Xu

Researcher, Yale Data-Driven Environmental Solutions Group

Amy Weinfurter

Research Fellow, Yale Data-Driven Environmental Solutions Group

Stefanie Wnuck

Researcher, Yale Data-Driven Environmental Solutions Group

December 2015

Acknowledgements

We wish to thank the following individuals for their contributions to this report. Their feedback and guidance was invaluable, and their contributions and participation greatly improved this paper. Any remaining mistakes are our own.

- David Albertani, Program Director, R20 Regions of Climate Action
- Dr. Felipe Bittencourt, Director, WayCarbon
- Ana Caetano, Executive Secretary, Municipal Committee on Climate Change and Eco-efficiency, City of Belo Horizonte, Brazil
- William Dean, Office of the Secretary, Climate Change Unit, CalEPA
- Dr. Todd Edwards, Program Officer, Climate Change, Stanley Foundation
- Kristina Haddad, Director for USA, R20 Regions of Climate Action
- Bing Han, Senior Manager, China Emission Exchange
- Nesamani Kalandiyur, Air Resources Board, Air Quality Planning and Science Division Transportation Analysis Section, Manager, CalEPA
- Qiuping Li, Director for Asia, R20 Regions of Climate Action
- Yin Lin, Vice Director, China Emission Exchange
- Lavender Luo, Project manager, China Emission Exchange
- Christophe Nuttall, Executive Director, R20 Regions of Climate Action
- Aromar Revi, Director, Indian Institute for Human Settlements
- Sarang Shidore, Visiting Scholar, Lyndon B. Johnson School of Public Affairs The University of Texas at Austin
- Kartikeya Singh, Asian Affairs, Department of Energy - International Affairs
- Terry Tamminen, Strategic Advisor to the Founding Chair, R20 Regions of Climate Action
- Denise Welch, Director of Research & Technical Initiatives, R20 Regions of Climate Action
- Mark Wenzel, Office of the Secretary, Climate Change Adviser, CalEPA

Design and Layout
- Carla O'Donnell, Communications Director, R20 Regions of Climate Action

Cover
- Michelle Lee, Graphic Design/Data Visualization Student Associate, Yale Data-Driven Environmental Solutions Group

Images
- Kate Evans for CIFOR (Flickr)
- Alex Lang (Flickr)
- Freepik
- iStockphotos
- R20 MED
- Getty Images
- Wolfgang Meinhart (Hamburg)

About us

About Yale University

Since its founding in 1701, Yale has been dedicated to expanding and sharing knowledge, inspiring innovation, and preserving cultural and scientific information for future generations.

Yale's reach is both local and international. It partners with its hometown of New Haven, Connecticut to strengthen the city's community and economy. And it engages with people and institutions across the globe in the quest to promote cultural understanding, improve the human condition, delve more deeply into the secrets of the universe, and train the next generation of world leaders.
www.yale.edu

About the Stanley Foundation

The Stanley Foundation advances multilateral action to create fair, just, and lasting solutions to critical issues of peace and security. The foundation's work is built on a belief that greater international cooperation will improve global governance and enhance global citizenship. The organization values its Midwestern roots and family heritage as well as its role as a nonpartisan, private operating foundation. The Stanley Foundation does not make grants.
www.stanleyfoundation.org

About R20

R20 Regions of Climate Action is a non-profit organization founded by Arnold Schwarzenegger and other global leaders, in cooperation with the United Nations.

Our mission is to help sub-national governments around the world to develop and communicate low-carbon and climate resilient economic development projects. We do so by working in three primary aspects of development: policy, technology, and finance.
www.regions20.org

About the USC Schwarzenegger Institute

The USC Schwarzenegger Institute for State and Global Policy is committed to advancing post-partisanship, where leaders put people over political parties and work together to find the best ideas and solutions to benefit the people they serve. The Institute seeks to influence public policy and public debate in finding solutions to the serious challenges we face. While the Institute engages on a variety of critical policy areas, a primary focus is climate change, which reflects Governor Schwarzenegger's leadership on the issue and it being one of the defining challenges of our generation.
www.schwarzeneggerinstitute.com

EXECUTIVE SUMMARY

Non-state and sub-national actors are undertaking ambitious initiatives designed to cut carbon emissions and promote clean development. These actions occur alongside official, state-centric negotiation processes, and the impressive results are garnering international attention. These programs have the potential to raise national ambition; spur additional mitigation, adaptation, and climate financing; and inject an emphasis on solutions-directed efforts into the public dialogue on climate change.

Many of these non-state efforts surpass national climate policies and actions in scope and ambition. However, data demonstrating sub-national efforts' contribution to national and global climate mitigation have, until recently, been scarce. Sub-national initiatives' integration and alignment with national climate mitigation goals is also largely unknown, particularly when these efforts go beyond existing national policies and requirements. British Columbia's carbon tax and Shenzhen's emissions trading scheme, for instance, introduce policies that are not echoed in Canada and China's respective national climate mitigation efforts. If adopted nationally, these initiatives would contribute significantly to country-level mitigation goals.

This paper compiles nine in-depth case studies of sub-national climate mitigation programs that exceed or lead national policy directives. From California to Rajasthan, India, these case studies reveal a range of local partnerships that exhibit strong climate leadership. In addition to examining the policy frameworks that make these accomplishments possible, we calculate each featured initiatives' potential mitigation impact if it were scaled to the national level. Our findings demonstrate these sub-national climate actions' capacity to contribute to national 2020 mitigation goals. Each sub-national action may seem insignificant in isolation, but our analysis demonstrates how these local and regional climate initiatives could expand to greater scale and raise ambition for national efforts.

We find that these efforts, in total, could reduce 2020 emissions from the eight countries featured in this report by 1 gigaton, compared to a business-as-usual scenario. A projected 8 to 10 gigaton gap stands between existing national climate pledges and the additional actions needed to maintain a least-cost 2 degrees Celsius trajectory of global temperature rise. The sub-national climate actions described in this report could narrow the difference by approximately 10 percent, if adopted by their respective countries.

Sub-national actors are reducing emissions through a range of initiatives, including:

- **Adopting ambitious renewable energy targets**: Rajasthan's installed solar capacity is the largest among all the states in India, accounting for more than one-quarter of the country's total. If Rajasthan's rate of solar energy expansion were scaled to the national level, India's carbon dioxide emissions would decrease by 0.398 gigatons, an amount equal to approximately 19 percent of the nation's total carbon dioxide emissions in 2012.

- **Reducing deforestation rates faster than the national pace**: More than three-quarters of emissions from Acre, the third-smallest of Brazil's 27 states, come from the land-use, land-use change and forestry sector. With a target to reduce deforestation 80 percent by 2020, Acre has already achieved 63 percent of its goal, which translates to 62 million tons CO2e. When scaled nationally these efforts could contribute 31 percent to Brazil's 2020 greenhouse gas reduction ambition.

- **Setting prices on carbon, through the use of taxes and emissions trading**. The Canadian province of British Columbia has had a carbon tax, covering all fossil fuel combustion, in place since 2008. The tax targets a key source of British Columbia's contributions to climate change; fossil fuel combustion accounted for 71 percent of the province's total greenhouse gas emissions in 2012. If Canada were to adopt a nationwide carbon tax, it could achieve 35 percent of the country's 2020 reduction goal. And in China, the city of Shenzhen has adopted a pledge to peak emissions in 2022 and a 21 percent carbon intensity reduction goal – greater than the national 2015 carbon intensity target of 16 percent. Shenzhen's emissions trading scheme covers 40 percent of citywide emissions. If scaled nationally, it could contribute reductions of nearly one-fourth of the 1 gigaton total savings cited in this report.

CONTENTS

INTRODUCTION

Over the last two decades, non-state (businesses and civil society groups, for instance) and sub-national (cities, states, and regions) actors have undertaken ambitious initiatives designed to cut carbon emissions and promote clean development. These actions fall outside of official, state-centric negotiation processes, and the impressive results are garnering international attention. The programs have the potential to raise national ambition; spur additional mitigation, adaptation, and funding; and inject an emphasis on solutions-directed efforts into the public dialogue on climate change. Non-state and sub-national actors are able to innovate and experiment where states are unwilling to take necessary risks (Hoffmann, 2011).

New non-state and sub-national climate actions are proliferating in number, and these initiatives' scope and scale are expanding to encompass greater areas and longer time-horizons than earlier policies. The Non-State Actor Zone for Climate Action (NAZCA), launched at the Lima COP-20 Climate Conference in December 2014, has recorded 4,404 "commitments to action" to date.[1] The commitments include a wide range of collaborative projects in various geographies, spanning more than a dozen sectors – energy efficiency and carbon pricing, to name two – and incorporating cities and regions that account for 12 percent of the global population. The aggregate 2014 market value of companies included in NAZCA totaled $8.57 trillion USD, equal to the combined GDPs of Australia, Brazil, Canada, France and Turkey (Cheng et al., 2015). NAZCA also tracks transnational networks, including the Compact of Mayors and the related Compact of States and Regions, which link together city mayors and governors to share climate mitigation strategies and galvanize collective action.

Non-state and sub-national climate actions' growing momentum could contribute significantly to narrowing the emissions gap – the difference between the reductions countries have pledged and the cuts needed to maintain a global temperature rise of less than 2 degrees Celsius (UNEP, 2014). Early analysis of nationally determined contributions (INDCs) indicates that these climate action pledges will fall short of the efforts needed to maintain a least-cost scenario for containing global temperature rise within a "safe" zone. A further 12 to 15 gigatons of carbon dioxide equivalent (CO2e) mitigation is needed by 2025, and the reductions pledged by the 125 INDCs submitted so far[2] are insufficient for the task (Climate Action Tracker, 2015). Given this discrepancy, non-state and sub-national action could contribute a critical piece to the playing field.

The total contribution from non-state and sub-national actors is open to interpretation, and the latest research suggests a range of potential mitigation impacts from these groups. A study published in Nature Climate Change evaluated commitments made by non-state, sub-national, and national actors at the New York Climate Summit, and found that the Summit's 29 commitments could bridge the 2020 emissions gap by one-fifth, or 2.5 Gt CO2e (Hsu et al., 2015). The UN Environment Programme (UNEP) assessed 15 of the "most ambitious and specific" international cooperative initiatives (ICIs) recorded in the Climate Initiatives Platform and determined they could cut the 2020 emissions gap by nearly a third, or 2.9 Gt CO2e (UNEP, 2015).

1 As of November 1 2015.

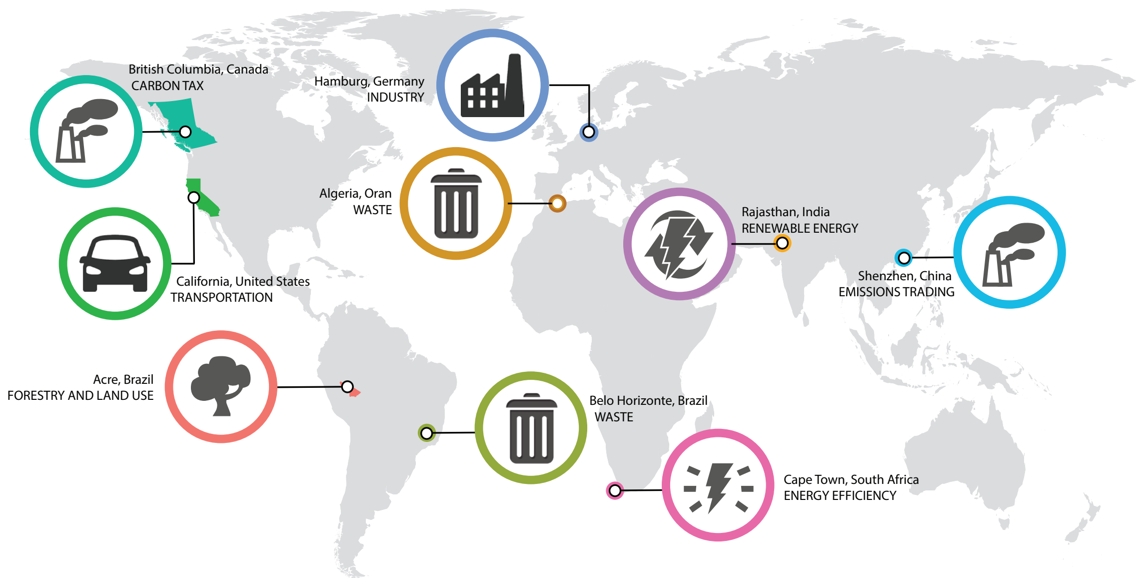
2 According to Climate Action Tracker's analysis, the INDCs submitted as of October 1, 2015, still leave a significant gap (of 11- 13 gigatons of carbon dioxide equivalent) between projected emissions and a 2-degree pathway in 2025.

Ecofys and the Cambridge Institute for Sustainability Leadership evaluated five private sector initiatives – the Cement Sustainability Initiative, en.lighten, Tropical Forest Alliance 2020, Refrigerants, Naturally! and WWF Climate Savers Program – and forecast a 200 Mt reduction in 2020. If these efforts were brought rapidly to scale, the study finds that their impact could grow to 500 Mt by 2030, an amount equivalent to the annual emissions of 131 coal-fired power plants (US EPA, 2015).

These analyses provide a perspective for understanding the impact of select initiatives, yet each shows only one piece of the global picture. Assessment methodologies, criteria, and scope vary from study to study, meaning the gigatons cannot be combined, nor the mitigation impacts compared. This shortcoming is in part due to non-state and sub-national actions' voluntary nature. A lack of consistent reporting methods and platforms results in piecemeal information, which analysts must use to make sense of who is doing what, and where. Recent efforts, such as the Global Protocol for Community-Scale Greenhouse Gas Emissions, attempt to better harmonize data collecting and reporting. While these programs are an important first step towards more robust data, we need additional initiatives, focused specifically on encouraging and incentivizing sub-national and non-state actors to voluntarily release climate data. These efforts are crucial to preventing greenwashing and the discrediting of future non-state efforts (Hsu and Weinfurter, 2015). Chan et al. (2015) propose a promising solution: a collaborative framework that would compile consistent information on non-state and sub-national climate actions to allow for transparency, benchmarking, and data harmonization.

This paper compiles nine in-depth case studies that showcase the ways sub-national governments are undertaking climate mitigation programs independent of or ahead of national policy directives. From California to Rajasthan, India, these case studies describe a range of local partnerships exhibiting climate leadership. In addition to examining the policy frameworks that make these accomplishments possible, we calculate the featured initiatives' potential impact if scaled to the national level, demonstrating these sub-national climate actions' great capacity to contribute to countries' 2020 mitigation goals. Each sub-national action may not seem significant in isolation, but the goal of our analysis is to demonstrate how these local and regional climate initiatives can expand to larger scales and raise the ambition of national efforts. We selected the nine case studies by identifying priority countries, both developed and developing, where sub-national and non-state actions are underway. We also narrowed our focus in response to the availability of data that would enable us to assess sub-national programs' mitigation contributions and their future potential to be scaled up to address national 2020 goals. We interviewed in-country experts directly involved with the climate actions and programs and collected both primary and secondary data to estimate future mitigation impact. Where countries have pledged absolute 2020 mitigation targets (e.g., the United States, Canada, and Germany), we made reference to how the sub-national case study contributes directly towards the national goal. For countries in which 2020 targets are articulated on an intensity basis (carbon emissions per unit GDP), we calculated sub-national mitigation impact using business-as-usual 2020 emission projections (see Appendix: Supplementary Information).

Figure 1. Map of the nine city and regional climate action case studies considered in this report.




ما شا ء الله
CMC ST 300
00032 614 31

A MODEL FOR INTEGRATED SOLID WASTE MANAGEMENT IN ORAN, ALGERIA

Overview

- Expanding Oran's waste sorting program could reduce the nation's annual emissions by 11 million tons of carbon dioxide, or roughly 4.3 percent, from 254 million tons to 243 million tons, in 2020.
- Expanding Oran's waste management program to the national level between 2015 and 2020 would reduce the country's carbon dioxide emissions by as much as 52 million tons, enough to power 4,744,526 million American homes for one year.
- Oran's expanded waste management efforts have the potential to create a vast number of domestic jobs.

Jumpstarting Algeria's Waste Management Strategy

Solid waste is a mounting global environmental and human health hazard. The World Bank predicts that municipal solid waste generation will nearly double by 2025, rising from the current rate of 1.3 billion tons per year, to 2.2 billion tons per year (World Bank, 2012). We see this trend in Algeria, a North African nation of 40 million, where waste management is a rapidly growing challenge. The country's population is concentrated in the north, where there are approximately 300 people per sq. km – compared to a national average of 13. The desert nation is rapidly urbanizing, at a rate of 65 percent , creating a convergence of environmental problems, waste management chief among them (SWEEP-Net, 2010).

Population pressures have led to the formation of thousands of uncontrolled landfills and dumps with which local communities struggle to cope. A Ministry of Land Planning and the Environment (MATE) survey found more than 3,000 dumps, occupying more than 150,000 hectares, spread across the country. These sites are commonly situated on or near agricultural land and dry rivers, where they pose significant health and environmental risks (SWEEP-Net, 2010).

Algeria has, despite its troubles, made great strides in managing its solid waste problem. Its implementation of the National Program of Municipal Waste Management (PROGDEM) in 2002 marked an important turning point. PROGDEM supports a range of projects, including landfills, sorting centers, and master plans for cities, all designed to tackle waste management challenges, mostly at the municipal level. Between 2002 and 2014, PROGDEM helped build 32 landfills and 29 sorting centers; rehabilitate 101 unauthorized dumps; and establish waste management plans for 1,223 of Algeria's 1,541 cities (SWEEP-Net, 2014).

From 2010 to 2014, solid waste service coverage increased by about 5 percent in both rural and urban areas (SWEEP-Net, 2013 & SWEEP-Net, 2014). Municipal solid waste services currently reach 85 to 90 percent of Algeria's urban population, and between 65 and 70 percent of citizens living in rural areas. Sixty to 70 percent of the collected waste ends up in dumps, while 30 to 40 percent reaches a landfill. These statistics put Algeria ahead of the curve for developing countries; on average, 30 to 60 percent of the urban solid waste in developing nations remains uncollected, and less than 50 percent of the population in these countries are served (World Bank, 2011). Collection rates range, globally, from a low of 41 percent in low-income countries, to a high of 98 percent in high-income countries (World Bank, 2012).

Algeria has made steady progress expanding its waste collection services, and the nation now needs to develop holistic waste management strategies that incorporate sorting, recycling, composting, and energy generation. Approximately one percent of collected waste is composted, and only seven percent is recycled (SWEEP-Net, 2014). Without significant recycling and composting programs the nation's landfills swell, exacerbating environmental and public health hazards. The government also misses opportunities to generate income through recycling, re-use, and waste conversion to energy. Establishing robust and reliable waste streams is a key first step to attracting private sector investment to a waste management industry.

Building a Foundation for Waste Management in Oran

In Oran, Algeria's third largest wilaya (province), an effort to build a holistic waste management structure is underway. Eighty percent of Oran's municipal solid waste is collected, but very little of it is recycled (Bouhadiba et al, 2014). The Algerian government, local authorities, and the non-governmental organization R20 Regions of Climate Action (R20) are collaborating to expand waste sorting and recycling, which will form the foundation for additional composting, incineration, and waste valorization programs. David Albertani, R20's Program Director, explains that while past projects have attempted to support waste management efforts in Oran, few took on the whole supply chain. Waste was sorted only to be re-mixed by trucks; sorting bins were installed without building community support and awareness of the value of sorting. Albertani attributes the new project's success, in part, to a broad and intensive outreach effort conducted before collection got underway (D. Albertani, personal communication, July 2015).

R20's program operates in conjunction with Oran's local government, trash collection agency, and sorting center, implementing a door-to-door outreach campaign to engage with and inform 8,000 households on the economic benefits that waste sorting and recycling brings to the larger community (R20 Regions of Climate Action, 2015). R20 also held two workshops that taught 125 local professionals, including teachers, imams, association members, and housekeepers, about the profitable aspects of waste management, helping these professionals become stewards of the program. This engagement led to an 80 percent waste sorting compliance rate in the AADL Pepiniere and Akid Lotfi neighborhoods where the program was implemented. The project currently involves some 54,000 residents and diverts approximately 605 kilograms of recyclable materials from the waste stream each day (R20 Regions of Climate Action, 2015).

The program coordinated with waste collectors to establish new routes and pick-up times and created two new sorting lines to better separate glass, plastic, paper, cardboard, and metals. These changes created 16 new jobs: four new roles for truck drivers and 12 positions on the sorting line. The potential for additional job creation, though the participation of additional neighborhoods, is vast, and the establishment of a reliable stream of recyclable materials has begun to attract investors from the recycling industry. Based on the success of the program, R20 has approved funds to scale the project from 136 bins and 54,000 residents, to over 1,000 bins and 500,000 residents (R20 Regions of Climate Action, 2015).

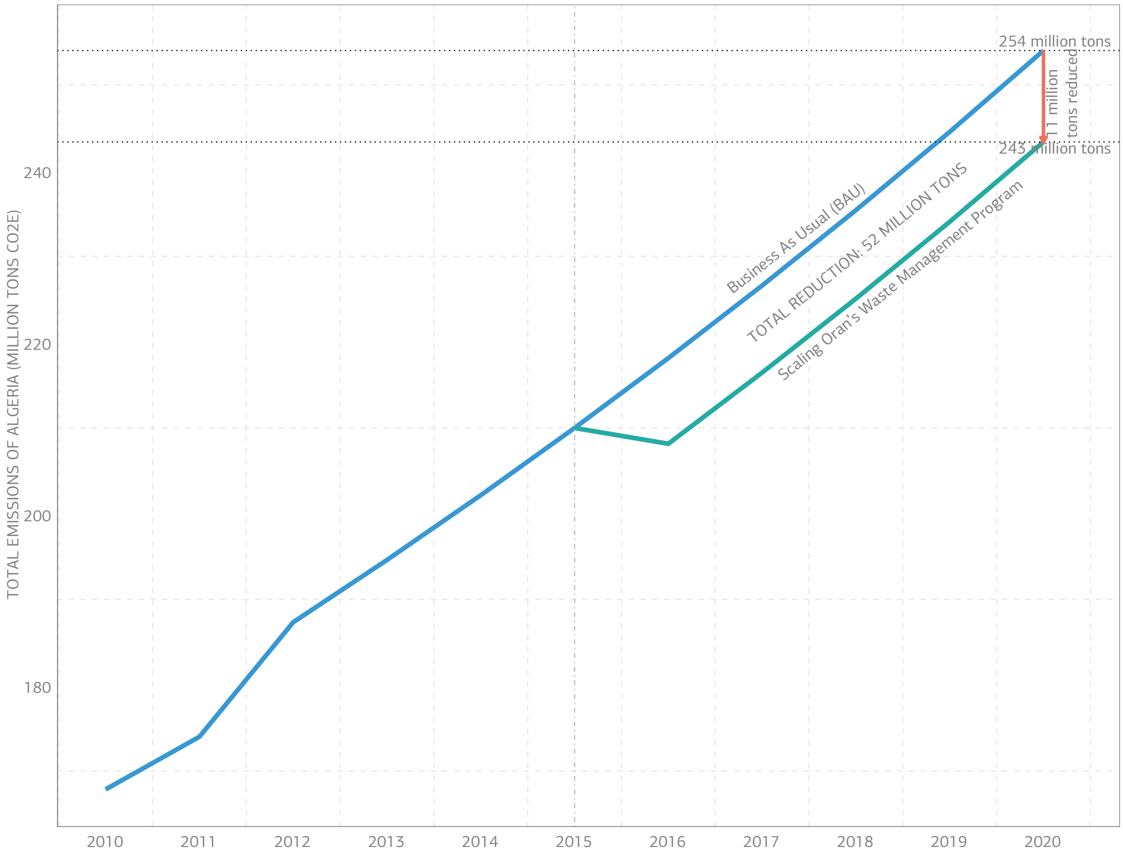
The Potential Emissions Impact of Oran's Waste Sorting Strategy

To estimate this project's potential impact on a national scale, we multiplied the per capita greenhouse gas emissions reduction from Oran's waste sorting program by the total population of the country. Compared to Algeria's business-as-usual emissions pathway (a linear projection of past emissions), expanding Oran's waste sorting program could reduce the nation's annual emissions by 11 million tons of carbon dioxide, or roughly 4.3 percent, from 254 million tons to 243 million tons, in 2020. The policy could lower the country's carbon dioxide emissions by 52 million tons from 2015 to 2020, enough to offset a year's worth of carbon pollution emitted by nearly five million American homes (EPA, 2015).

Broadening Algeria's Waste Management Strategy

Oran's contribution to Algeria's climate goals is only beginning to be felt. Its maturing sorting and recycling program holds great mitigation potential. If the city commits to leveraging its waste programs to pioneer a comprehensive approach to turning trash into treasure it would set a game changing example for the nation. In September 2015, the Wilaya of Oran and R20 will take the first steps towards doing so, by implement two new plastic recycling and composting programs. They also plan to construct a new 35.6 MW waste-to-energy facility by 2017. These proposals rely on the knowledge and materials gained from the city's ongoing sorting and recycling programs. The new waste management plan also has strong pollution mitigation potential, implementing projects that reducing toxins from the environment and forming the building blocks of an ambitious, comprehensive waste management strategy.

Figure 2. The potential emissions impact of scaling up Oran's waste management strategy throughout Algeria.



FOREST CONSERVATION IN ACRE, BRAZIL

Overview

- Land use change is the largest source of greenhouse gas emissions in Brazil, accounting for approximately 44 percent of the country's total emissions.
- As of 2013, Acre had achieved 63 percent of its goal to reduce deforestation 80 percent by 2020, compared to the state's average deforestation rate from 1996 to 2005. This reduction in deforestation has resulted in a 62 million ton CO2e reduction.
- Expanding Acre's forest conservation policies nationwide could help close the gap between Brazil's 2020 reduction goals and its emissions trajectory by about 31 percent, lowering 2020 emissions by 0.204 gigatons of carbon dioxide equivalent, compared to the deforestation reductions Brazil has maintained over the last four years.

Land Use Change at the Center of Brazil's Climate Action

Land use change and forestry (LUCF) represents the largest source of greenhouse gas emissions for Brazil, accounting for approximately 44 percent of the country's total emissions (WRI-CAIT, 2014). In Amazonian states, such as Acre, LUCF emissions comprise an even higher proportion of the region's total. In 2012, LUCF accounted for 78 percent of the state's emissions.

Brazil's climate action strategy focuses heavily on preserving forests as critical carbon sinks. In 2004, the nation adopted the Action Plan for the Prevention and Control of Deforestation in the Land Amazon, which emphasizes monitoring, enforcement, and coordination across all levels of government to curb deforestation. This policy sets an 80 percent deforestation reduction target for the Amazon, compared to the 1996-2005 historical average of 19,625 square kilometers of forest loss each year.

The country's National Climate Change Policy, passed in 2009, established a national target to reduce GHG emissions 36.1 - 38.9 percent below business as usual levels (including emissions from land use, land use change and forestry) by 2020. This target is framed as voluntary at the international level, yet Brazil's National Policy for Climate Change mandates the creation of sector-specific plans to translate the proposal into reality (World Resources Institute, 2013). Brazil released its INDC in September, pledging to reduce its GHG emissions – including LUCF emissions – 37% below 2005 levels by 2025. The country has also pledged to eliminate illegal deforestation and to restore 12 million hectares of forests by 2030 (World Resources Institute, 2015). The nation is a recent signatory to the New York Declaration on Forests, a compact that pledges to halve the loss of natural forests globally by 2020 and to end forest loss by 2030 (NY Declaration of Forests, 2014).

Climate Action and Commitments in Acre, Brazil

The Amazonian state of Acre, Brazil, has adopted Brazil's national deforestation target at the state level. As the third smallest of Brazil's 27 states, Acre contains a relatively small proportion of the Amazon forest, yet the state is a national and international leader in applying innovative policy mechanisms, such as payments for ecosystem services models, to slow deforestation. The state has maintained over 86 percent of its original forest cover (World Wildlife Fund, 2013). By adopting Brazil's national deforestation target, Acre is committing to reduce deforestation rates 80 percent by 2020, compared to the state's average deforestation rate between 1996 and 2005. Meeting this target means limiting deforestation to an annual loss of 120 square kilometers by 2020 (compared to a baseline loss of approximately 602 square kilometers per year). In 2013, Acre had achieved 63 percent of this deforestation reduction goal.

This progress is due in large part to Acre's State System of Incentives for Environmental Services (or SISA), a groundbreaking law passed in 2010 to combat deforestation and promote sustainable forest management. Cited as "one of the most advanced subnational forest carbon programs in the world" (World Wildlife Fund, 2013), SISA links local communities with international markets, garnering payments for ecosystem services for forest conservation activities.

This initiative incorporates a set of Environmental Service Incentives for Carbon, which focus on increasing agricultural and livestock yields to reduce ranching's expansion into forests, while also enhancing the economic value of standing forests, improving the livelihoods of forest-defending communities, and providing forest protection (IPAM, 2012). The primary driver of deforestation in the Amazon is the conversion of lands for cattle ranching; beef and milk production occurs on 83 percent of deforested lands (IPAM, 2012). SISA programs seek to reduce the economic incentive for deforestation and protect intact forest through zoning laws that dictate development. Notably, the Acre government's extensive consulting with local communities and civil society organizations has played a large role in SISA's success (CIFOR, 2013).

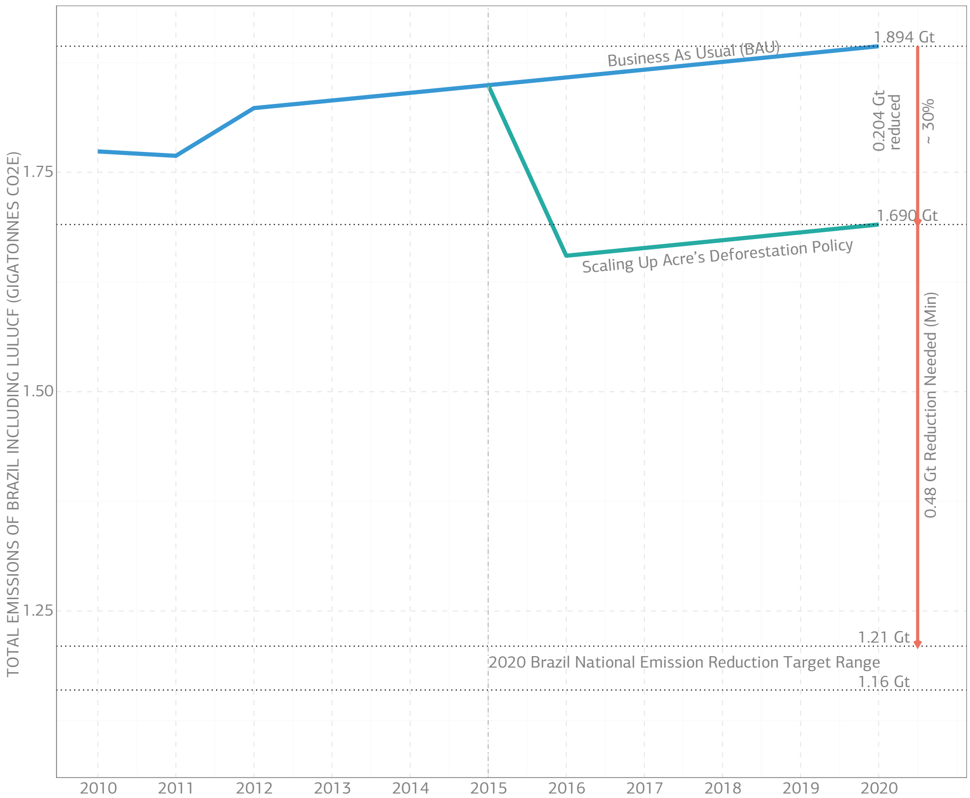
SISA's incentives include direct assistance, such as fire control, improved monitoring, technical extension programs, and community organization (Governor's Climate & Forests Task Force). The State of Acre is also working to create a comprehensive carbon offset program that allows developed countries to meet their greenhouse gas reduction targets by purchasing offsets gained from the protection of intact forests and associated carbon sequestration. The German development bank KfW plans to provide performance-based payments totaling 19 million Euros over four years through the REDD Early Movers (REM) program (Verified Carbon Standard). Acre and California have also signed a Memorandum of Understanding to use carbon offsets from Acre to help achieve compliance with California's cap-and-trade program. The Brazilian state is "widely expected to become the first jurisdiction-wide program to deliver REDD offsets" (Ecosystem Marketplace, 2014).

Expanding Acre's Deforestation Reduction to Brazil's Forests

Land conversion is the single largest driver of Brazil's greenhouse gas emissions, so expanding comprehensive forest conservation policies, such as Acre's payments for ecosystem services model, would dramatically reduce national emissions.

Applying Acre's demonstrated deforestation reductions across all of Brazil's forested areas would lower the country's 2020 emissions by 368 million tons of carbon dioxide equivalent. Acre's enhanced protection, if extended to the rest of Brazil's forests, would lower emissions by an additional 204 million tons of carbon dioxide equivalent compared to the deforestation reductions Brazil has maintained over the last four years, from 2010 to 2014. This enhanced scenario would save a total of 1,016 million tons of carbon dioxide equivalent through 2020. Expanding Acre's forest conservation policies nationally would help close the gap between Brazil's 2020 reduction goals and its emissions trajectory by about 31 percent.

Figure 3. The potential emissions impact of scaling up Acre's deforestation reduction policy throughout Brazil.



Nationalizing Acre's Policies

SISA helps Acre and Brazil reduce greenhouse gas emissions, and the program also produces an array of co-benefits. In Acre, the program will benefit up to 30,000 rural property owners, indigenous peoples, and other traditional populations. Acre contains 29,488 rural properties, and SISA will reach nearly all of the rural landowners (World Wildlife Fund, 2013). Forest protection and renewal is crucial for carbon mitigation and is also an important strategy for climate adaptation, as forests offer "the best way to buffer against the climate shocks that are affecting the Southwestern Amazon, by maintaining year-round transpiration to the atmosphere that can reduce the severity of droughts" (Nepstad et al. 2008) (IPAM, 2012). The forests also provide firebreaks, medicine, wild game, and resins, in addition to international commodities like timber, Brazil nut, and rubber (IPAM, 2012).

The lack of a global demand for carbon offsets from forestry projects in Acre, and in the rest of Brazil, is a challenge that must be addressed for SISA to be wholly successful. Expanding Acre's forest protection programs will require compatibility of REDD+ mechanisms at various scales (World Wildlife Fund, 2013), and collaboration and coordination among communities and regional and national governments. The benefits of such an expansion would be extraordinary, and make the case for setting more aggressive forest protection targets.

WASTE TO ENERGY
IN BELO HORIZONTE, BRAZIL

Overview

- Belo Horizonte's installation of a biogas plant on a former landfill – a cornerstone of its waste management strategy – reduced solid waste's contribution to Belo Horizonte's emissions by 8 to10 percent when it was installed in 2010.
- Expanding Belo Horizonte's waste management program to the national level could mitigate 9 million metric tons of carbon dioxide in 2020, cutting the gap between Brazil's 2020 reduction goals and its emissions trajectory by one percent.
- From 2015 to 2020, the national expansion of Belo Horizonte's waste management program would save a total of 42 million tons, equivalent to the emissions 11 coal plants produce in a year.

The Challenges of Solid Waste Management in Brazil

Solid waste is a pressing problem in Brazil. In 2001, solid waste production grew twice as fast as population, swelling by 1.8 percent compared to the nation's population growth rate of 0.9 percent, and weighing in at 62 million tons (Beecheno, 2013). Opportunities to reduce, recycle and reuse waste are uneven across the country, and only 32 percent of Brazil's municipalities have a waste management plan (Beecheno, 2013). Without this infrastructure, reducing, reusing, and capturing energy from waste is impossible in most areas. In 2005, greenhouse gas emissions from waste comprised 4.76 percent of the nation's total (United Nations Climate Change Secretariat, 2005). Brazil is the world's seventh highest emitting nation meaning that a few percentage points of its total make a significant difference in the global carbon budget (World Resources Institute, 2014a).

Brazil lacked a clearly defined policy for recycling and solid waste management until 2010, when the National Policy for Solid Waste filled this void, creating a 20-year National Plan for Solid Waste, and establishing guidelines, goals, and action programs, along with a mandatory review every four years. The policy requires states and municipalities to develop waste management plans and aims to close the nation's 2,906 open-air dumps and decrease the overall volume of waste. The plan also established a reverse logistics policy, which holds producers accountable for addressing and recovering waste from their industries.

While the National Policy for Solid Waste is innovative and comprehensive on paper, implementing its goals has proven difficult. The national government required cities and states to submit their waste management plans by August 2012 in order to qualify for credit, financial support and tax relief, yet less than half of all municipalities met this deadline.

Belo Horizonte’s Waste Management Leadership

As the country works to implement local and regional waste management solutions, Belo Horizonte, the nation’s sixth largest city, has developed an effective approach – a proven template to emulate. “A pioneer on waste management at the local level since the 1990s,” reports Green Growth Best Practices, “[Belo Horizonte] took innovative actions towards more efficient waste management, years before a national policy was approved ”(Green Growth Best Practices, 2014).

The city’s 1993 Integrated Solid Waste Management Model inspired national-level policy that legitimized waste pickers, who had long been an informal but integral part of the waste sector. The model also enhanced energy efficiency and conversion targets and elevated collection and recycling rates (Green Growth Best Practices, 2014). Belo Horizonte’s Municipal Urban Cleansing Law, which came into effect in September 2012, codified these new targets, with aims to increase efficiency in waste collection and recycling, promote social inclusion, create jobs and generate income for city workers (Green Growth Best Practices, 2014).

Biogas Development at the Municipal Waste Treatment Centre (Centro de Tratamento de Resíduos Sólidos (CTRS))

Belo Horizonte installed a biogas plant at its Municipal Waste Treatment Centre (or Centro de Tratamento de Resíduos Sólidos – CTRS) in 2010, contributing the bulk of greenhouse gas reductions resulting from the city’s waste management strategies. From 1972 to 2007, CTRS served as the city’s primary landfill and was the municipality’s largest single source of greenhouse gas emissions (IRENA, 2012). Towards the end of its operation, in 2006, CTRS held over 17.4 million cubic meters of waste, and stood 64 meters tall at its maximum height (IRENA, 2012). After three years of planning, the city completed its biogas plant on the site in 2010, and in 2011 the former landfill supplied 28,000 megawatts of electricity to the city’s grid, enough to power 35,000 people’s lives for a year (IRENA, 2012). The plant complements the city’s initiatives in waste sorting, recycling, composting, and community awareness and education.

The plant’s impact has been dramatic – following its implementation in 2010, waste’s contribution to Belo Horizonte’s emissions fell by 10 percent (Prefeitura de Belo Horizonte, 2012). The city estimates that building a biogas facility at another landfill, the Macaubas treatment plant, would have a similarly large impact, reducing approximately 250 million tons of CO_2e per year, equal to 6.5 percent of the city’s total 2010 emissions (Prefeitura de Belo Horizonte, 2012). The carbon savings from the biogas plant, combined with the city’s complementary waste management strategies, substantially contribute to Belo Horizonte’s progress towards reaching its goal of reducing emissions 20 percent below 2007 levels by 2030.

Bringing Belo Horizonte's Waste Management Policy to a National Scale

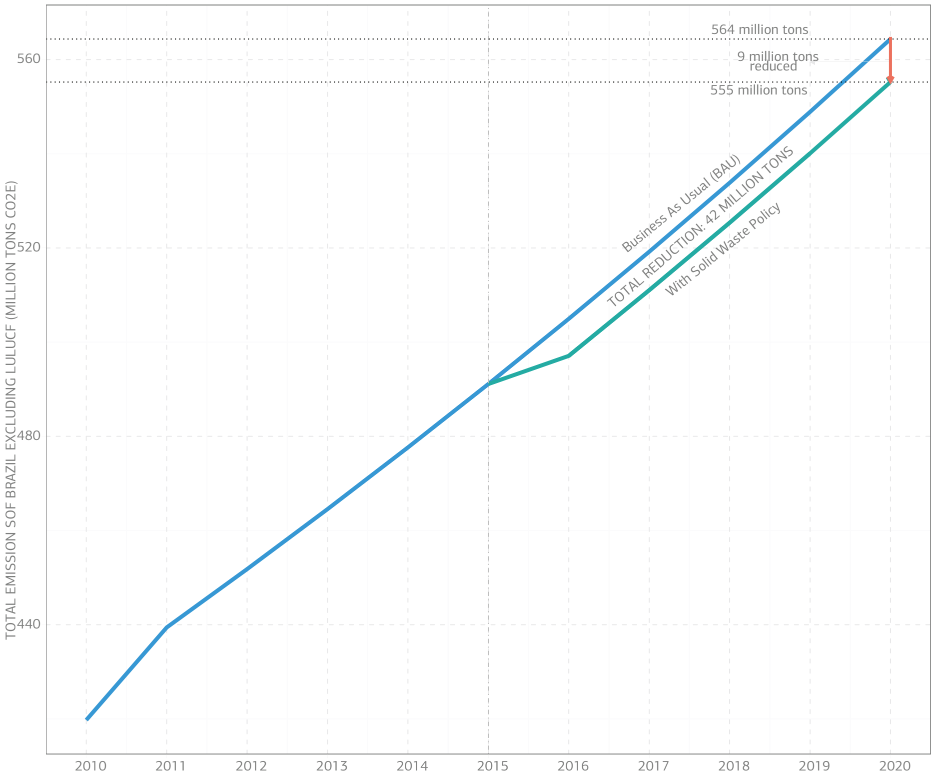


Figure 4. The potential emissions impact of scaling up Belo Horizonte's waste management strategy throughout Brazil.

If scaled nationally, Belo Horizonte's biogas program would lower Brazil's emissions by 9 million tons in 2020 – from 564 million to 555 million tons – reducing the gap between Brazil's 2020 mitigation goals and its emissions trajectory by one percent. From 2015 to 2020, this expansion of biogas would save a total of 42 million tons, equivalent to the emissions 11 coal plants produce in a year.

Biogas as a Key Piece of the Waste Management Puzzle

The world's cities produce some 1.3 billion tons of solid waste each year (Green Growth Best Practices, 2014), and this quantity is projected to grow to 2.2 billion tons by 2025. Many developing nations are making strides in their waste collection efforts, yet waste's disposal and treatment remains a hazard and an often-untapped opportunity.

Belo Horizonte's success demonstrates biogas's potential to reduce carbon emissions, expand energy and electricity access, and improve urban sanitation. This plant also created a new source of revenue for the city through the United Nations Framework Convention on Climate Change's Clean Development Mechanism (CDM), a program that enables developed countries to purchase certified emission reduction credits from developing countries.

Realizing biogas's benefits throughout Brazil will require additional financing, the creation of a comprehensive waste management system, and access to technical and logistical know-how. Biogas is only one of a suite of waste management solutions – a set that includes enhanced collection, waste sorting, waste reduction, and composting and recycling initiatives. Even so, biogas's emissions reduction potential is a loud call for mobilizing resources to implement similar strategies both in Brazil and beyond, and a demonstration of the economic benefits of doing so.

BRITISH COLUMBIA'S CARBON TAX

Overview

- British Columbia's carbon tax covers nearly all emissions from fossil fuels, which account for an estimated 70 percent of the province's entire greenhouse gas emissions.
- Since the carbon tax's introduction, British Columbia's fuel consumption has decreased, even as its GDP grew faster than the national GDP.
- If Canada were to adopt a similar carbon tax at the national level, the policy would reduce the country's emissions by 265 million tons of carbon dioxide equivalent from 2015 to 2020. Expanding the carbon tax shift model throughout the country would help close the gap between Canada's 2020 reduction goals and its emissions trajectory by over a third – or about 35 percent.

Canada's Wavering Climate Action

Canada's record in combatting climate change is mixed. The nation withdrew from the Kyoto Protocol in 2012 and did not meet its target to reduce greenhouse gas emissions six percent below 1990 levels from 2008 to 2012. Climate Action Tracker, which evaluates national climate commitments, notes that Canada's 2020 target, which aims to reduce greenhouse gas emissions 17 percent below 2005 levels by 2020, and its 2030 target, which aims to lower emissions 30 percent below 2005 levels, fall short of the action needed to ensure that global temperatures do not rise above the catastrophic 2-degrees Celsius threshold (2015).

The government has in recent years instituted a range of programs and initiatives to address the nation's largest sources of GHG emissions – transportation and electricity generation – which have laid the groundwork for bolder action. The 1999 Canadian Environmental Protection Act, for instance, enables the federal government to regulate GHG emissions. From 2005 to 2013, Canada's GHG emissions decreased 3.1 percent, while the economy continued to grow by 12.9 percent (Government of Canada, May 2015). This trend towards a decarbonized economy results from Canada's clean electricity generation sector: 79 percent of the country's electricity comes from non-emitting sources, making power generation in Canada among the cleanest in the world (Government of Canada, May 2015).

Canada's energy sector is, however, a mixed bag when it comes to climate mitigation, and overall the country's actions fall short of what is needed to prevent dangerous climate change. As the national government wavers in its efforts to tackle climate change, provinces play an increasingly prominent role, piloting ambitious and innovative strategies to cut emissions. The province's public sector has achieved carbon neutrality (British Columbia Ministry of Environment, 2015) and met its 2012 interim target for reducing emissions 6 percent below 2012 levels, succeeding where the national government failed. British Columbia aims to reduce emissions 18 percent by 2016, 33 percent by 2020, and 80 percent by 2050. Its Greenhouse Gas Reduction

Targets Act requires the provincial government to release "Progress to Targets" reports every two years to measure performance in implementing BC's 2008 Climate Action Plan, helping the province track the strategies that contribute to achieving its goals.

British Columbia's Carbon Tax: Revenue to Bolster Public Support

British Columbia's carbon tax is central to helping the province meet its climate goals. The tax, which was implemented on July 1, 2008, is the most comprehensive and ambitious in North America and is a model of effective climate policy to the rest of the world (British Columbia Ministry of Environment, 2014 Progress Report). It covers nearly all emissions from fossil fuels, which account for an estimated 70 percent of the province's entire greenhouse gas emissions (Ministry of Finance, 2013). In 2013, Sustainable Prosperity assessed the tax's effects, concluding that, "While BC was doing about as well as the rest of Canada in reducing fuel use before 2008, it has done much better since the carbon tax came in - suggesting that the tax was an important contributor to BC's success in reducing fuel use from 2009-2013" (Elgie & McClay, 2013). The tax applies to the purchase and use of fuels, including gasoline, diesel, heating oil, propane, and coal, and the use of combustibles, like peat and tires, for heat or energy generation (British Columbia Ministry of Finance, 2015). In 2012 energy-related greenhouse gas emissions were responsible for 79 percent of BC's total emissions (BC Ministry of Environment, 2012). Seventy-one percent of the 79 percent of BC's greenhouse gas emissions arise from fossil fuel combustion from both stationary and transport-related sources. Fuels exported from the province, aviation fuel, and fugitive emissions of methane from fossil fuel production and transmission (Murray and Rivers, 2015 and British Columbia Ministry of Finance, 2015) are excluded from the tax.

British Columbia's carbon tax is higher than most analogous taxes, which may help explain its impact on consumer behavior. The policy is revenue-neutral, however, meaning the provincial government uses funds collected from the carbon tax to offset other taxes. From 2013 to 2014, taxing carbon in British Columbia generated 1.2 billion (CAD), which was applied to lower business taxes, provide income tax credits to low income individuals, reduce personal income tax rates, and provide a $200 benefit to northern and rural homeowners (Canada's Ecofiscal Commission, 2015). The carbon tax on fossil fuels increased incrementally, from $10/ton in 2008 to $30/ton in 2012, so that costs and revenues grew progressively each year.

Shifting the province's tax burden from individuals and businesses directly to fossil fuel consumption may account for the carob tax's popular acceptance. Although the public initially opposed the carbon tax, support has grown post-implementation (Murray and Rivers, 2015). In a recent survey, more than 50 percent of British Columbia respondents and more than half of respondents in other provinces strongly or somewhat supported the policy (Murray and Rivers, 2015).

Bringing British Columbia's Carbon Tax to a National Scale

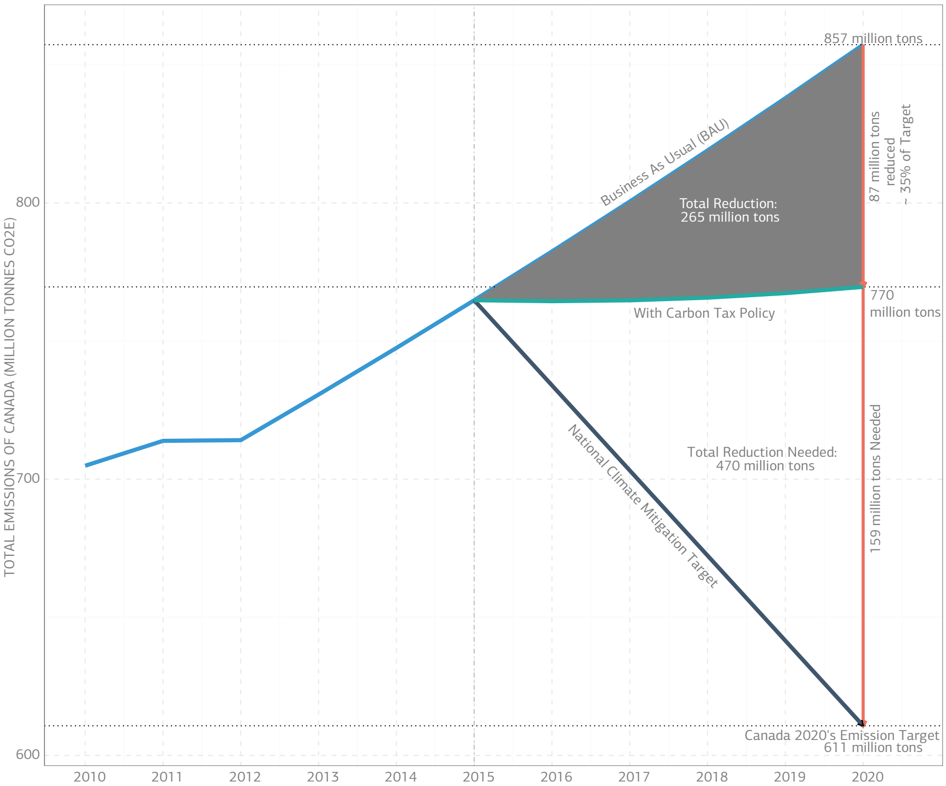


Figure 5. The potential emissions impact of scaling up British Columbia's carbon tax across Canada.

If scaled to the national level, British Columbia's carbon tax would reduce Canada's annual 2020 emissions by 87 million tons of carbon dioxide equivalent, from 857 million tons to 770 million tons. Expanding the carbon tax shift model to the rest of the country would help close the gap between Canada's 2020 reduction goals and its emissions trajectory by over a third – at about 35 percent.

Learning from the Carbon Tax's "Textbook Success"

British Columbia may be "the closest example of an economist's textbook prescription for the use of a carbon tax to reduce GHG emissions" (Murray and Rivers, 2015). The tax covers a wide base of carbon sources, scales costs up gradually, and aligns its rates with each fuel's carbon impact. The provincial government's transparent reporting of the sources and uses of the carbon tax enables policymakers and residents to understand its impacts, fostering widespread trust and facilitating the program's public acceptance.

This "textbook" carbon tax's many gains merit its expansion beyond British Columbia's borders. The tax has produced substantial cuts in carbon emissions while the province's economy has expanded, although some emissions-intensive sectors, such as basic chemical or cement manufacturing, have encountered challenges (Murray and Rivers, 2015). Since the introduction of the carbon tax, British Columbia's fuel consumption has decreased – bucking the national trend – even as its GDP growth has outpaced Canada's (Murray and Rivers, 2015). British Columbia has demonstrated that decoupling economic growth from fossil fuel consumption is not only possible but profitable, as the province's carbon tax has generated substantial revenue that offset its economic burdens. This textbook success makes a strong case for a national carbon tax.

ADVANCED CLEAN CARS PROGRAM IN CALIFORNIA, USA

Overview

- California's Advanced Clean Cars Program is expected to reduce California's greenhouse gas emissions by 289 million metrics tons of carbon dioxide equivalent in the year 2020 – equal to a nearly 65 percent reduction in the state's total passenger vehicle emissions in 2013.
- Scaling the Advanced Clean Cars Program nationwide would result in a reduction of 289 million metric tons of carbon dioxide equivalent in 2020, closing the gap between the United States' current trajectory and its 2020 goal by 28 percent.
- Scaling up all of California's climate policies could help close the gap between the U.S.'s 2020 climate goal, and its business-as-usual scenario, by about one-fifth, or 20 percent.

Ahead of the Curve: California's Climate Leadership

California is the eighth largest economy in the world, and it has the lowest per capita carbon emissions and electricity consumption of any state in the U.S (The Los Angeles Times, 2015 & The Climate Group). How has the aptly named Golden State been able to decouple economic growth from carbon emissions?

California's leadership on climate change is embedded in a decades-long history of forward-looking policies and legal frameworks. In 2006, Governor Schwarzenegger signed Assembly Bill AB 32 (also known as the Global Warming Solutions Act of 2006) into law, which committed California to restoring carbon emissions to 1990 levels (431 million metric tons of CO2e) by 2020. California has also committed to lowering emissions 80 percent below 1990 levels by 2050, although this pledge is not currently mandated by law. California's 2020 climate goal would reduce emissions by approximately 15 percent below emissions levels under a business as usual scenario (CalEPA, 2014). California was the first state to establish a comprehensive and legally binding carbon emission trading system, which today covers 85 percent of its greenhouse gas (GHG) emissions. The Cap and Trade Program is one of a host of strategies California employs to meet its ambitious climate goals.

This year, California's state government extended its climate leadership further, enacting North America's most aggressive benchmark to reduce carbon emissions in the next 15 years (California Office of the Governor, 2014). Through executive order B-30-15, Governor Edmund G. Brown established an interim target of cutting emissions 40 percent below 1990 levels by 2030 (California Office of the Governor, 2014). The order's 2030 goals surpass the ambition of U.S. national targets, and would achieve lower carbon intensity than the European Union's 2030 goals, which are generally viewed as having set the bar for global reduction targets.

California's latest Greenhouse Gas Inventory shows that the state is on track to meet its goals. In 2013, the state's emissions fell by 1.5 million metric tons compared with

2012, even as the economy expanded faster than the United State's average growth (The Climate Group, 2015). The state's decoupling of economic growth and carbon emissions makes the case for other states, and for the nation, to follow in California's footsteps.

One Prong of California's Climate Program: The Advanced Clean Cars Program

The Advanced Clean Cars Program forms one prong of California's ambitious mitigation agenda. The package of regulations is bolstered by a unique partnership between the United States Environmental Protection Agency (EPA), National Highway Transportation Safety Administration (NHTSA), State of California, and major auto manufacturers. This collaboration allowed the program to set ambitious greenhouse gas emission reduction standards for cars and light trucks in the United States.

California has long been a leader in promoting cleaner passenger vehicles, and it is the only state the federal Clean Air Act allows to request an EPA waiver for state-level vehicle emission standards that go beyond national requirements. In 2002, California passed the Clean Cars Law, commonly known as the Pavley standard, which set GHG emission limits that surpassed national requirements on new passenger vehicle models 2009-2016. The California Air Resource Board approved these regulations in 2004, and fourteen states followed suit between 2004 and 2007, adopting the stricter standards set by California (Maryland Department of the Environment).

In response to legal challenges brought against California's Pavley standard by automakers, the Obama Administration brokered a compromise in 2009, creating national vehicle emission standards for cars made between 2012 and 2016. The federal standards were developed to achieve equivalent or greater greenhouse gas reduction benefits than the Pavley Standard would achieve if applied on a national scale. California officials worked with EPA to harmonize its state standards with the newly created federal vehicle emissions standards. The regulations were also aligned with the federal Corporate Average Fuel Economy, or CAFE, standards.

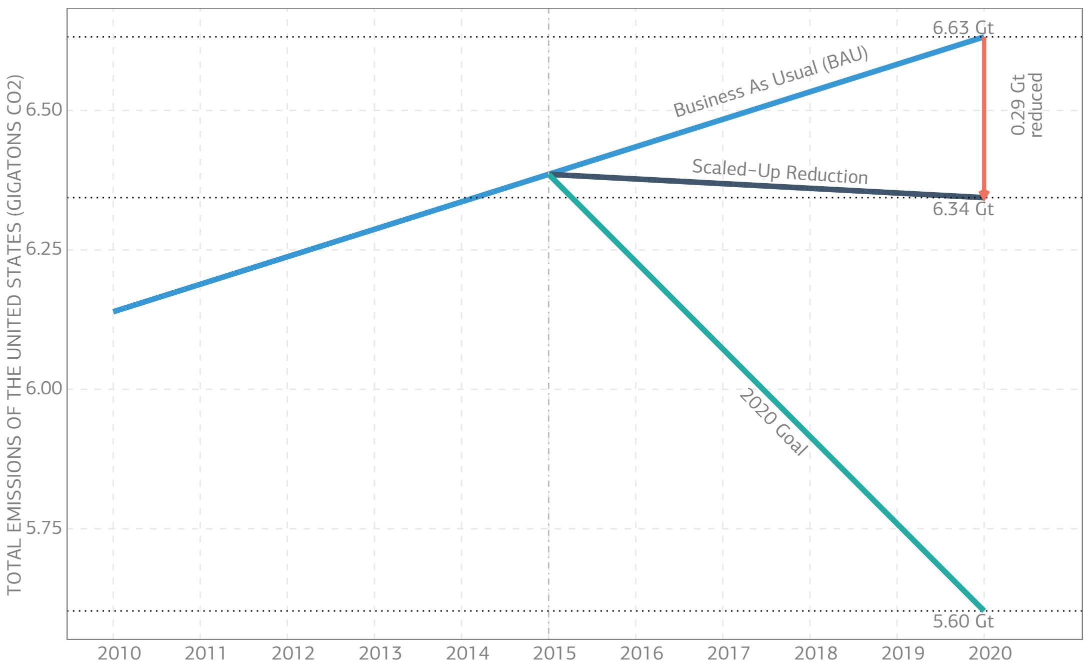
The federal standards have been expanded to new passenger vehicles for model years 2017 through 2025 – a significant augmentation. The impact of limiting passenger vehicle emissions equates to auto manufacturers achieving an average 54.5 miles per gallon fuel economy in 2025 for new cars and trucks across their vehicle fleet (The White House Office of the Press Secretary, 2012). This equates to a more than threefold increase in the average fuel efficiency for passenger vehicles, up from 17.6 miles per gallon in 2012 (FHWA, 2012).

The California Advanced Clean Cars Program builds on national standards, combining regulations for smog, soot-causing pollutants, and greenhouse gas emissions in a balanced set of requirements, known as Low Emission Vehicles (LEV) III (CalEPA, Air Resources Board) for model years 2017-2025. This policy also encompasses the Zero-Emission Vehicle Program, which aims to support and accelerate the numbers of plug-in hybrids and zero-emission vehicles in California. The Program's goal is to usher in 1.5 million plug-in hybrids, electric vehicles, and hydrogen-powered fuel cell vehicles, equal to 1 in 7 cars sold in the state, by 2025 (California Office of the Governor, 2012).

The Advanced Clean Cars Program is projected to cut California's emissions by approximately 3 million metric tons of carbon dioxide equivalent in 2020, and reduce more than 850 million metric tons of carbon dioxide equivalent from 2017 – 2050, nearly double California's total annual greenhouse gas emissions in 1990 (CalEPA). The Program will also reduce smog-forming pollutants. In 2025, California cars will emit 75% less smog-forming pollution compared to 2014 levels (California Environmental Protection Agency (CalEPA), Air Resources Board, 2012).

When combined with the Pavley vehicle emissions standards, this suite of regulations is the state's single largest carbon mitigation strategy. According to estimates from the California Air Resources Board (ARB), together the Pavley and Advanced Clean Car Program standards are expected to reduce California's greenhouse gas emissions by 30 million metric tons of carbon dioxide equivalent in the year 2020 – equivalent to nearly a 25 percent reduction in California's total passenger vehicle emissions in 2013 (CalEPA, 2015).

Figure 6. The potential emissions impact of adopting California's Advanced Clean Car Program at the national level in the United States of America.



Bringing California’s Advanced Clean Cars Program to a National Scale

If the United States continues its precedent of adopting California’s transportation policy, the resulting emissions savings could significantly lift the country towards its 2020 target. Scaling the Advanced Clean Cars Program to the national level would reduce emissions by 289 million metric tons of carbon dioxide in 2020, closing the gap between the country’s 2020 goal and its business-as-usual pathway by 28 percent.

California’s Climate Policies’ Total Impact

The Advanced Clean Cars Program is a part of California’s comprehensive approach to reduce greenhouse gas emissions from the transport sector, yet it represents only one piece of the state’s ambitious strategy to tackle global climate change. ARB estimates that all of California’s climate policies combined will achieve a 144.3 million metric ton reduction of carbon dioxide equivalent in 2020 alone (CalEPA, 2015).

California’s impact on the national emissions target has the potential to be even greater. The state’s climate policies will reduce per capita emissions by 3.7 metric tons of carbon dioxide equivalent in 2020. If the United States were to adopt California’s suite of climate policies, then, assuming the 3.7 metric ton per capita reduction, the U.S. could lower its greenhouse gas emissions by 1,186 million metric tons of carbon dioxide equivalent in the year 2020. In other words, scaling up all of California’s climate policies could help close the gap between the U.S.’s 2020 climate goal, and its business-as-usual scenario, by about one-fifth, or 20 percent.

Spurring Emissions Reductions Across the Transportation Sector

California is the national leader on climate action, continually raising the bar and encouraging the U.S. government and other states to increase ambition on measures that tackle climate change. The transport sector represents California’s largest source of greenhouse gas emissions (38 percent), and transport is also responsible for nearly a third of all U.S. emissions (US EPA, 2013). California’s Advanced Clean Cars Program and preceding Pavley vehicle emission standards significantly reduce the emissions created by this key sector, by implementing stringent emissions standards. The Advanced Clean Cars Program raises the already-high bar set by the Pavley standards, and helps to lay the groundwork for a transition to a cleaner transportation system, through its support of Zero Emissions Vehicles. The federal government has adopted the Pavley Standards California pioneered; following suite with California’s Advanced Clean Cars Program could help the nation decouple mobility and emissions.

EMISSIONS TRADING IN SHENZHEN, CHINA

Overview

- Shenzhen has the lowest carbon intensity of all major cities in China, and is one of seven cities piloting an emissions trading scheme.
- Assuming that all seven pilot cities' emissions trading schemes cover the same proportion of total emissions as Shenzhen's trading system, their annual emissions impact would mitigate 0.17 gigatons by 2020, enough to power 15.5 million homes for a year.
- If all of China's 45 cities with populations greater than one million adopted an ETS like Shenzhen's, the annual emissions reduction would be 0.25 gigatons by 2020, an amount greater than the United Arab Emirates' emissions in 2012.

Decarbonizing the Dragon: China's National Policies to Address Climate Change

The world's largest energy consumer and carbon emitter, China dramatically and sometimes single-handedly shapes the global climate change agenda. In the past decade, China's national policies that address energy consumption and climate change mitigation have grown in ambition. China pledged in 2009 to reduce its carbon intensity by 40 to 45 percent by 2020, compared to 2005 levels (Green & Stern, 2015). On June 30, 2015, the government released its "Intended Nationally Determined Contribution" (INDC), which pledged to reduce the nation's carbon intensity by 60 to 65 percent by 2030 (Government of the People's Republic of China, 2015). These reduction targets are intensity-based goals, yet China also submitted to the Paris Climate Conference a goal to peak emissions by 2030 – the first time an emerging economy has committed to a restriction of absolute emissions.

China has adopted a multi-pronged approach, utilizing various policy mechanisms to achieve carbon intensity reductions. The 12th Five-Year Plan (2011-2015) – China's primary national, social and economic development roadmap – required the establishment of an Emission Trading Scheme (ETS) to reduce greenhouse gases in a cost-effective way. On October 29, 2011, the National Development and Reform Commission (NRDC), China's main policy implementing body, selected five cities and two provinces – Shenzhen, Beijing, Shanghai, Chongqing, Hubei, Tianjin and Guangdong – as initial pilots to test emissions trading in China, with a goal to establish a national scheme by 2015.

Among these cities, Shenzhen stands out as a pioneer of greenhouse gas emission reduction, with the lowest emissions intensity (carbon dioxide emissions per unit GDP) of all of China's most populous cities – in this case, cities containing a population greater than 1 million people (China Emissions Exchange, 2014). Shenzhen's GDP ranks fourth among all Chinese cities, and grew by an average of 9.83% during the years between 2005 to 2010 – a rate 3 times greater than global average GDP growth in 2014 (IMF, 2014). In the same period, Shenzhen's carbon emissions increased by a total of 26.3 percent, from 60 million tons in 2005 to 80 million tons in 2010 (an average annual rate of 4.79 percent, substantially less than China's national carbon emissions growth rate of 7.43 percent (NBS-China, 2015).

Shenzhen began its efforts to decouple economic growth and carbon emissions after China announced its first targets to reduce energy consumption per unit GDP (energy intensity). To help the nation achieve its 2009 emission reduction goal, the city enacted the "Shenzhen 12th Five-Year Plan Energy-Saving Plan" in 2012 (Shenzhen Municipal People's Government Office, 2012). In the plan, Shenzhen's municipal government pledged to reduce carbon intensity by 21 percent and to lower energy intensity by 19.5 percent in 2015 compared to 2010 levels. Both of these commitments go beyond national emission reduction targets, which only seek to reduce carbon and energy intensity 16 and 17 percent, respectively, from 2005 levels by 2015. Shenzhen became one of the first 13 low carbon pilot regions in China – another climate mitigation policy (Government of the People's Republic of China, 2010). By piloting an ETS, the city is developing low-carbon development strategies and pioneering plans for building low-carbon cities.

Local Efforts to Address Climate Change: Shenzhen's Emission Trading Scheme (ETS)

Shenzhen drew on the European Union's experience to develop its ETS, and the Chinese city tailored the framework to fit Shenzhen's development stage. The program now covers 635 industrial enterprises from 26 sectors, accounting for 30 million tons of annual carbon dioxide emissions, which are traded in this system. The trading scheme includes the transportation sector and 197 public buildings that span more than 10,000 square meters. In 2010, Shenzhen's ETS encompassed 40 percent of the city's total emissions and 26 percent of Shenzhen's GDP.

The Shenzhen ETS aims to limit the emissions of participating companies to reduce the city's 2015 carbon intensity by 25 percent compared to 2010 levels (China Emissions Exchange, 2014). Companies participating in the ETS aim for an intensity reduction target that is more ambitious than Shenzhen's citywide plan, which, in turn, goes beyond the national goal China spelled out in its 12th Five-Year Plan (Table 1).

Table 1. Relationship of Shenzhen's ETS to Shenzhen's National Carbon and Energy Targets

Baseline year	No. of enterprises covered by Shenzhen Emission Trading Scheme	% of total city emission covered by Shenzhen Emission Trading Scheme	China's energy intensity target (compared to 2010 levels)	China carbon intensity target (compared to 2010 emissions	Shenzhen's energy intensity target (compared to 2010 levels)	Shenzhen's carbon intensity target (compared to 2010 emissions)
2009-2011	832	40%	-17%	-16%	-19.5%	-21%

Bringing Shenzhen's ETS to a National Scale

In its first year of implementation, Shenzhen's pilot ETS achieved its emission reduction target of 25 percent, and 631 of the 635 participating companies fulfilled their emissions reduction obligation (China Emissions Exchange, 2014). In 2013, the program allocated allowances for 33 million tons of CO2, equal to 301,000 U.S. households' annual energy emissions (EPA, 2015), but only a fraction of these permits (covering 1.57 million tons or less than 5 percent) were actually sold.

The program's 635 participants' total carbon emissions decreased by 3.83 million tons (11.7 percent) and participating companies increased their market value by 105.1 billion Yuan (42.6 percent) from 2010 to 2013, indicating a decoupling of profits and emissions. These companies' average carbon intensity dropped 38.1 percent, even more than Shenzhen's overall carbon emission reduction rate of 33.5 percent. The ETS helped Shenzhen achieve its 21 percent carbon intensity reduction targets under the 12th Five-Year Plan ahead of schedule (Table 1).

ETS's Contribution to National Goals

China's National Development and Reform Commission (NDRC), the country's main policy implementing body, intends to expand the seven pilot emissions trading schemes to the national level at the end of 2016 or beginning of 2017. Shenzhen's results offer insight into how this mitigation strategy could influence China's emission reductions in the long term.

We consider two approaches to show how Shenzhen's achievements would impact China's 2020 national climate mitigation goals (see Figure 1).

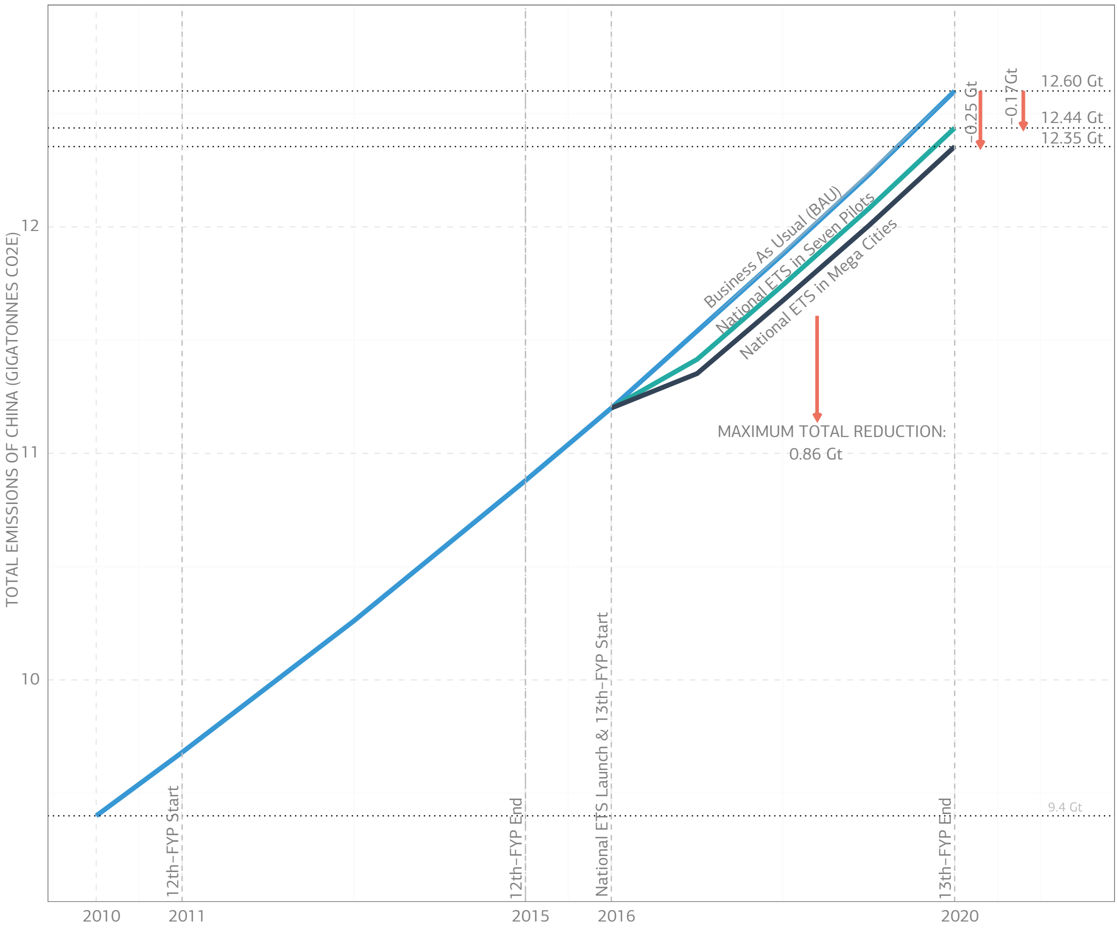
1. Assuming that all seven pilot cities' ETSs would cover the same proportion of total emissions as Shenzhen's ETS, their annual emissions impact would mitigate 0.17 gigatons by 2020.

2. If all of China's 45 cities with populations greater than one million (Nations Online, 2011) adopted an ETS like Shenzhen's, the annual emissions reduction would be 0.25 gigatons by 2020. Between 2016 and 2020, this approach would reduce a total of 0.86 gigatons of carbon dioxide.

The ETS's Role in China's 2020 Goals

With the establishment of China's next Five Year Plan in 2016, emissions trading and other market-based mechanisms to address climate change will be critical policy tools for China to reach the next phase's mitigation goals. The ETS's economic approach could make it especially attractive to other regions in China. Setting up a National ETS would help the world's largest emitter achieve – and even go beyond – its 2020 and 2030 climate mitigation goals.

Figure 7. The impact of scaling Shenzhen's ETS to the national scale by 2020.



HARNESSING INDUSTRY IN HAMBURG, GERMANY

Overview

- Between 2015 and 2020, scaling up Hamburg's partnership with industry could save a total of 94 million tons, an amount equivalent to the annual energy use of 8.5 million homes.

- Expanding Hamburg's support of voluntary industry commitments to the national level would result in an annual reduction of 23 million tons in 2020. This strategy could help close the gap between Germany's 2020 reduction goal, and the path suggested by its historical emissions, by about 16.5 percent.

- Hamburg's industry partners have extended their current commitment to 2018, pledging to expand their collective carbon reduction by an additional 130,000 tons of carbon dioxide beginning in 2018.

Hamburg's Climate Leadership

Hamburg's Climate Action Plan is comprehensive and forward-looking, covering a wide range of initiatives and mixing tried-and-true strategies with pilot projects designed to test out new ideas. In 2011, the European Commission recognized the city as a European Green Capital, designating Hamburg a role model for urban environmentalism (European Commission). Hamburg also regularly makes headlines for ambitious environmental goals, like its plans to devote 40 percent of the city's areas to green spaces (Braw, 2013). The city implemented its Climate Action Plan from 2007 to 2012, a strategy that involved more than 500 different projects, targeting adaptation and mitigation in the city's buildings, energy, mobility, and industrial sectors (City of Hamburg, 2013). The Climate Action Plan and its annual monitoring and reporting paved the way for Climate Action Master Plan, which outlines a framework for 2020 and 2050 climate targets and policy. The city plans to cut emissions 30 percent below 1990 levels by 2020, and 80 percent below 1990 levels by 2050, in support of Germany's target of lowering national emissions 40 percent below 1990 levels by 2020.

Hamburg is ideally positioned to engage industry in its efforts to combat and respond to climate change. The city sits on the Elbe River between the North Sea and the Baltic Sea and is home Europe's second largest port, which is among the 20-largest sites of container traffic in the world (City of Hamburg, 2013). The city's main industries include civil aviation, food processing and steel- and metalworking (City of Hamburg, 2015). Over the past two decades, Hamburg has also attracted companies focused on logistics, technology, aviation, services, media, and tourism, and the head offices of a range of international companies, agencies and enterprises (City of Hamburg, 2015).

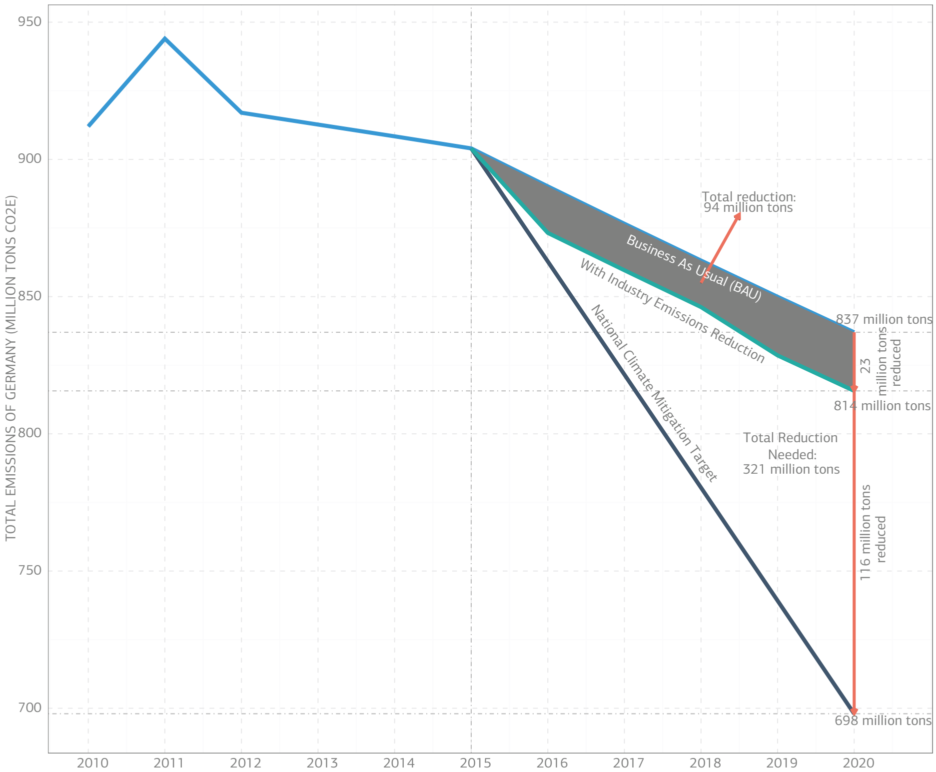
Framework for Voluntary Industry Commitments

Hamburg's climate change strategy takes advantage of its strong ties with industry and the business community. The Senate and the business community have coordinated on the rapid implementation of a range of voluntary measures for resource efficiency that go beyond legal requirements (City of Hamburg, 2013). The Hamburg Climate Action Plan includes a number of initiatives designed to engage businesses including the Companies for Resource Conservation, which provides incentives for the implementation of "voluntary, rapid-result investments in resource-efficiency measures" (City of Hamburg, 2012).

The program's cost savings – an estimated 20.5 million euro per year – motivate companies to participate. From 2001 to 2012, companies carried out over 1,750 projects enhancing efficiency in lighting, heating, and cooling. These programs have saved an estimated 146,000 tons of carbon dioxide and 432,500 megawatts of energy per year, and they have helped to conserve 687,500 cubic meters of water and avoid over 26,400 tons of waste (City of Hamburg, 2012).

Hamburg's engagement with the business community also helped convince 11 industrial companies to commit to reducing their carbon emissions by 500,000 tons of carbon dioxide per year, in the 2008 to 2012 period. This carbon savings is equal to 25 percent of Climate Action Plan's total goal, demonstrating why it is crucial to engage high-emitting stakeholders. In 2012, the participating companies exceeded their target, reducing 514,924 tons of carbon dioxide. Their success built momentum to extend the group's effort to 2018 and bring four additional companies on board, aiming to increase their carbon reduction by an additional 130,000 tons beginning in 2018 (City of Hamburg, 2013).

Figure 8. The potential emissions impact of scaling up Hamburg's engagement with industry throughout Germany.



Bringing Hamburg's Partnership with Industry to a National Scale

Expanding Hamburg's support of voluntary industry commitments to the national level would result in an annual reduction of 23 million tons in 2020. This strategy could help close the gap between Germany's 2020 reduction goal, and the path suggested by its historical emissions, by about 16.5 percent. Between 2015 and 2020, scaling up Hamburg's partnership with industry could save a total of 94 million tons, an amount equivalent to the annual energy use of 8.5 million homes (EPA, 2015).

Partnering with Industry to Capture the Low-Hanging Fruit

Germany's National Climate Action Target for 2020 is ambitious, and a significant gap remains between its current trajectory and this target. Its current path would see the country reach only 33 percent of its intended reductions by 2020 (Appunn, 2015). This wide gap makes voluntary industry commitments – a program that could close the gap an additional 26 percent – very attractive at the national scale. This strategy would help the country meet its goals, while capturing untapped mitigation potential in industry and the business world. A recent study estimated that the untapped energy savings available to business and industry from 2011-2013 is 20 to 30 percent (City of Hamburg, 2012).

Industry involvement seems to generate its own momentum, as energy savings and efficiency gains have attracted more organizations to voluntarily participate. This approach is, however, not a panacea: after the "low-hanging fruit" is collected, engaging these industries may become more difficult. Yet capturing these initial savings is a crucial first step in building the network and capacity for taking on steeper emission reductions.

SCALING UP SOLAR POWER IN RAJASTHAN, INDIA

Overview

- Reducing emissions in India's power generation sector would tackle "the largest slice of emissions" in India, around 37 percent of the country's total carbon output.
- Solar power forms the bulk of India's planned expansion of renewable energy, accounting for 100 GW of the 2022 target of 176 GW from renewables. More than half of India's four GW of installed solar capacity come from the two western states of Rajasthan and Gujarat.
- If Rajasthan's rate of solar energy expansion were scaled to the national level in India, carbon dioxide emissions would decrease by 0.398 gigatons, an amount equal to approximately 19 percent of India's total carbon dioxide emissions in 2012.

India's Bet on Solar Power

India's power sector could make or break the country's climate mitigation and development goals. Power generation constitutes "the largest slice of emissions" from the domestic economy of the world's fourth-largest emitter, accounting for 37 percent of the country's total carbon output (World Resources Institute (2011), CAIT Database, and Shidore, 2015). This sector's emissions growth rate is the second fastest in the country (Shidore, 2015). As the nation works to cap emissions from the electricity sector, it needs to simultaneously expand energy access. Nearly 400 million citizens – some 30 percent of the country's population – lack access to electricity, and many with a connection to the grid can only rely on a few hours of power each day (Shidore, 2015). Renewable energy sources are well suited to expand access to energy and electricity while reducing the country's carbon intensity.

India has made solar energy production a cornerstone of its development and climate mitigation strategies. In June 2015, the Union Cabinet approved Prime Minister Narendra Modi's goal of generating 176 gigawatts of electricity from renewable energy sources and 100 gigawatts of electricity from solar energy by 2022 (The Economic Times, 2015).[1] To put this goal into context, Germany and China, two world leaders in solar energy, had solar capacities of 38.2 gigawatts and 28.2 gigawatts, respectively, in 2014 (Bridge to India, 2015). Forty gigawatts of the target's total are slated to come from rooftop installations, and 60 gigawatts from utility-scale plants. If implemented, this expansion would increase India's solar power fivefold and account for approximately one-third of the country's total electricity capacity generation (The Economic Times, 2015).

Prime Minister Modi's pledge will accelerate India's growing solar energy industry. India's 100 gigawatt target expands the 2010 Jawaharlal Nehru National Solar Mission Initiative, which aimed to deploy 20 gigawatts of grid-connected solar energy by 2022, to establish the country as a global hub for solar manufacturing, and to support research and development to help lower the cost of solar energy (Government of India, 2012).

1 The complete breakdown of the 2022 target of 176 gigawatts of additional capacity includes: 100 gigawatts from solar capacity, 60 gigawatts from wind power, 10 gigawatts from biomass and 5 gigawatts from hydropower projects (BloombergBusiness, 2015).

Over the next three years, India is likely to enter the top five global solar markets, adding more solar capacity than Germany (Bridge to India, 2015).

Many caution that realizing this 100 gigawatt goal will be extraordinarily challenging. It is uncertain how the government and industry will finance and acquire the land for large projects, install net metering to support rooftop installations, and expand infrastructure needed to connect solar installations to the grid (for a more detailed picture of the process of scaling solar up, please see Box 1: A Closer Look at India's Solar Target). As of January 2015, 3 gigawatts of utility capacity had been installed, and 285 megawatts of rooftop capacity had been installed (Bridge to India, 2015). India will need to add an average of approximately 15 gigawatts of solar power to its current base of 4 gigawatts each year to meet its 100 gigawatt goal by 2022.

Rajasthan's Role as a Solar Leader

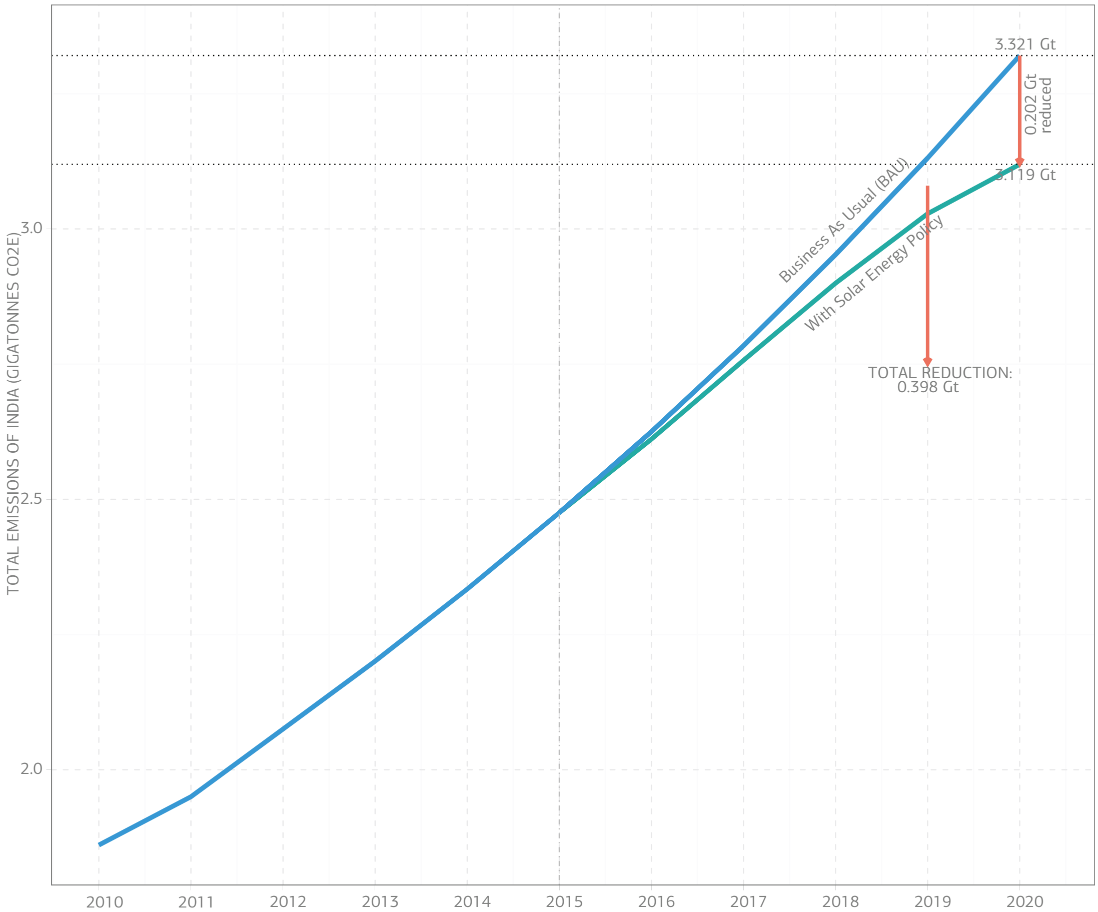
India's steep path to accelerate solar capacity along with the myriad benefits this energy transformation would deliver make successful implementation especially rewarding. Many states have taken a leadership role in turning paper pledges into reality. India is projected to add 24 gigawatts of utility-scale solar PV capacity between 2015 and 2019, the majority coming from state government schemes, which are expected to add 11 gigawatts in this period, compared to 7.6 gigawatts from central government schemes and 5.5 gigawatts from other projects (Bridge to India, 2015). Fifty gigawatts of state-level policy targets, for timelines ranging from 2015 to 2022, have already been established (Bridge to India, India Solar Handbook, 2015). These targets' creation and successful realization typically rely on renewable purchase agreements, demand for new power generation capacity, and political commitments to the renewable sector (Bridge to India, 2015).

Among the strong showing of state activity, some states stand out. Rajasthan recently edged past Gujarat to take the lead in installed solar capacity among Indian states, with 1128 megawatts compared to Gujarat's 953 megawatts (The Times of India, 2015). Together, the two states make up nearly half of India's total installed solar capacity and are well ahead of the state in third place – Madhya Pradesh, with 637 megawatts (Jaiswal, 2015).

Part of Rajasthan's success stems from its geography – it has the highest solar radiation in India, and contains large tracts of land well suited to hosting solar utilities (The Times of India, 2015). Ambitious policies have helped capitalize on these natural advantages. Before Prime Minister Modi expanded India's solar capacity target to 100 gigawatts, Rajasthan's 2011 solar power goal exceeded it, aiming to reach 25 gigawatts of new solar capacity by 2022, in comparison to the national government's goal of 22 gigawatts in the same time frame (CleanTechnica, 2014).

Rajasthan's 2014 policy builds on the momentum of both the state's 2011 energy plan and the Jawaharlal Nehru National Solar Mission's recently enhanced ambition. The Rajasthan Solar Energy Policy for 2014 targets known obstacles in financing and land acquisition: it introduces lowered net worth requirements for prospective project developers, lengthens land leases from 30 to 40 years to allow developers to plan for longer-term investments, and eases the application process for plants under 10 megawatts to facilitate faster approval (CleanTechnica, 2014).

Figure 9. The potential emissions impact of scaling up Rajasthan's rate of solar installation across India.



Bringing Rajasthan's Solar Policies to the National Level

If Rajasthan's rate of solar capacity expansion were applied across India, the country's 2020 emissions would decrease by 202 million tons of carbon dioxide, from 3.321 gigatons to 3.119 gigatons. Adopting the state's rate of solar energy expansion would reduce 0.398 gigatons of carbon dioxide emissions from 2015 to 2020, an amount equal to approximately 19 percent of India's total carbon dioxide emissions in 2012.

Matching Ambition with Implementation

Despite its rapid growth, Rajasthan, like much of India, is still gearing up for accelerating its solar power expansion. The state has signed memorandums of understanding with power developers including SunEdison, Adani Enterprises, Reliance Power and Azure Power, and has signed power purchase agreements for 223 MW of solar capacity for projects still under development (Business Standard, 2015 & Bridge to India, 2015).

The nation's 100 gigawatt target faces great challenges, yet Rajasthan's development shows that solar can help India realize the target while eliminating the challenges that hinder its expansion.

A Closer Look at India’s Solar Target

India’s goal of expanding solar capacity to 100 gigawatts by 2022 has triggered both praise and skepticism. The rising cost of conventional power, falling cost of solar power, pressure to address India’s energy deficit, and the country’s “ability to quickly bring power generation capacity online” could help propel this goal forward, and help the country tap into an estimated 749 gigawatts of solar potential (Bridge to India, 2015 & NISE, 2014).

Despite these advantages, a series of financial and logistical difficulties have already hindered the expansion of solar capacity. The difficulty of land acquisition, gaps in the availability and security of financing, and gaps in the infrastructure needed to connect utilities to the grid make up the most commonly cited obstacles to utility scale projects (Bridge to India, 2015). Net metering forms a crucial – and often un-met – prerequisite to rooftop solar development, though new policies are attempting to change this. Twenty-five out of India’s 29 states had approved or proposed net-metering policies as of May 2015 (Bridge to India, 2015).

Renewable Purchase Obligations (RPOs), one of the country’s primary tools for expanding its use of renewable energy, speak to the challenges of translating policy into practice. The agreements create quotas for the purchase of renewable energy, and require states that do not meet these thresholds to purchase Renewable Energy Certificates (RECs) (NISE, 2014). While a strong strategy in theory, in practice, “RPO compliance is currently extremely poor”(NISE, 2014). An expanded RPO target, that increases the quota from 3 percent to 10.5 percent of India’s power consumption by 2022, has yet to be ratified and remains politically contentious (Bridge to India, 2015). The government is also considering a Renewable Generation Obligation (RGO) on large power producers, in addition to states, to help ensure a reliable market for new sources of renewable energy (NISE, 2014).

The poor financial health of India’s largely state-run distribution companies (DISCOMs) represents another crucial hurdle solar power will need to overcome in order to reach a broader scale of implementation.

Collectively, DISCOMS face approximately $33 billion of debt (NISE, 2014). This financial burden leads DISCOMs to under-purchase power, and makes them skittish of the long-term power purchase agreements solar producers rely on to guarantee returns on their investments in new plants (NISE, 2014). Between 2009 and 2014, India saw an 8.8 percent rate of annual growth in additional net capacity, but only a 6.3 percent growth in electricity generation of the same time period (Government of India, 2015 & NISE, 2014). In other words, the distribution system is at risk of being unable to take advantage of viable sources of solar power.

Despite these challenges, solar energy seems poised for a bright future in India. Its costs are edging closer to the cost of imported coal in some states, and, if these trends continue, utility-scale solar power could compete with power plants run on domestic coal within two to three years (NISE, 2014). The rate of solar energy's expansion continues to grow. The question is not whether solar will play an important role in India's energy portfolio, but whether the 100 gigawatt target will constitutes a realistic target, or acts as more of a symbolic signal to investors and the markets.

ENERGY EFFICIENCY IN CAPE TOWN, SOUTH AFRICA

Overview

- Bringing Cape Town's energy efficiency program to low-income households throughout South Africa could reduce the nation's carbon dioxide emissions by 148 million tons from 2015 to 2020 – equal to the total emissions produced by 40 coal-fired power plants in one year.

- The national adoption of Cape Town's energy efficiency program could reduce emissions in 2020 by 35 million tons, closing the gap between South Africa's 2020 reduction goals and its emissions trajectory by about 22 percent.

- The Kuyasa Program reduced local residents' reliance on paraffin fuel for heating, saving each household an average of US $7 per month and lowering incidences of respiratory illnesses.

South Africa is the most carbon-emitting nation in Africa and one of the most energy-intensive economies in the world (Government of South Africa, 2009), an unflattering status that stems in large part from its energy sector. High-emitting industries play a crucial role in the nation's economy, and coal combustion is the base of energy and electricity generation, making up 71 percent of the primary energy consumed and 93 percent of the electricity generated (ADF, 2010).

Disruptions in electricity reliability, however, have pushed South Africa to embrace energy efficiency measures. The nation's energy and electricity prices had been among the world's cheapest, providing little incentive for the country to invest in energy efficiency measures (ADF, 2010). An electricity scarcity crisis began in late 2007 – an energy crunch attributed to coal supply problems and increasing demand for electricity – and this predicament motivated the government to employ measures to save energy and diversify electricity sources (van der nest, 2015 & Government of South Africa, 2009). Electricity costs are projected to rise by as much as 400 percent from 2006 to 2016 (City of Cape Town, 2013), making energy conservation an urgent economic, developmental, and environmental concern.

South Africa's cabinet approved in March 2005 the National Energy Efficiency Strategy, which aimed to improve the country's energy efficiency 12 percent by 2015. The plan notes that 50 percent of the energy efficiency measures identified in its pages could pay for themselves within three years (Government of South Africa, 2009). The strategy also calls for efficiency initiatives that create jobs, reduce air pollutants and carbon dioxide emissions, enhance energy security, increase citizens' access to energy and electricity, and reduce the need for additional power generation capacity (Government of South Africa, 2009).

The City of Cape Town has led the charge towards developing a comprehensive energy efficiency strategy. The municipality stands out for its ability to use climate adaptation and mitigation strategies to meet development goals. Its efforts to create a green economy (City of Cape Town, 2011), an approach under implementation across the entire Western Cape region, focus on finding new opportunities for investment and job creation (GreenCape & City of Cape Town, 2013). Part of this plan is made possible by the fact that, unlike the rest of South Africa, Cape Town's economy primarily relies on service professions instead of industry. Though Cape Town's economy remains less carbon intensive than South Africa's, its use of coal-fired electricity keeps emissions high (City of Cape Town, 2013).

In 2006, Cape Town became the first African city to release an Energy and Climate Strategy. This document rests on the foundation built by the city's Integrated Metropolitan Environmental Policy, which outlined a municipal commitment to reducing energy waste, promoting energy efficiency, and supporting renewable and cleaner fuel sources (City of Cape Town, 2003). A flurry of energy-related legislation followed in the wake of these two policies, and the new laws helped translate policy goals into a long list of programs and initiatives. The city's Environmental Resource Management Departments runs more than 50 programs, which encompass over 115 renewable energy and energy efficiency projects (City of Cape Town, 2015).

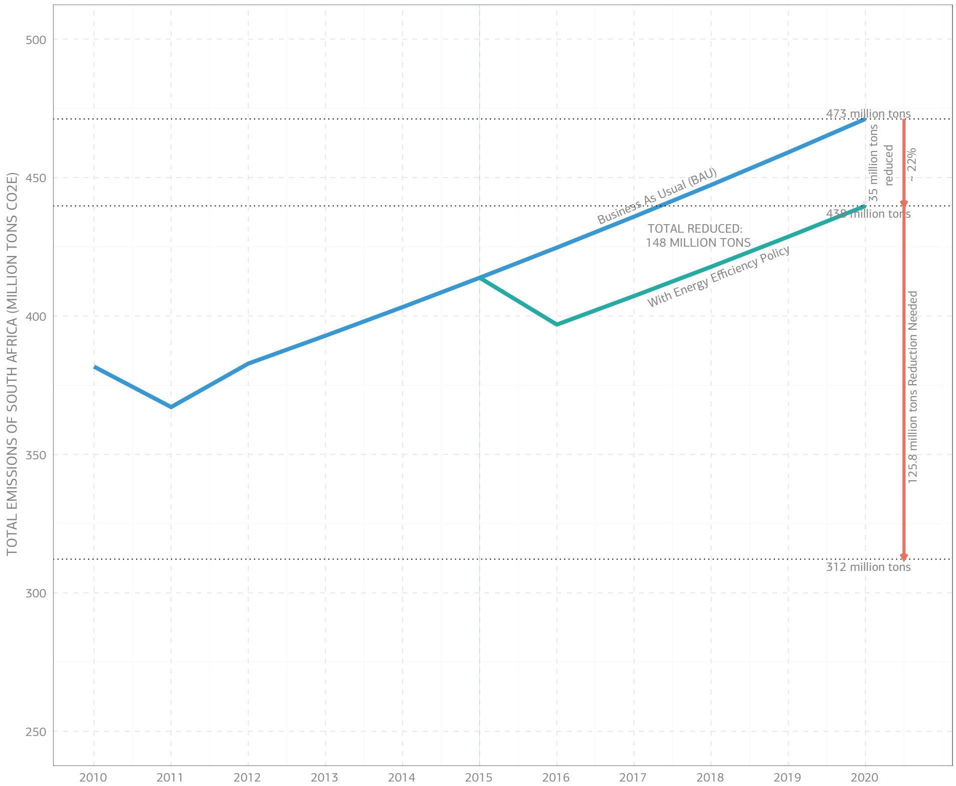
Leap-frogging Carbon-intensive Pathways: The Kuyasa Project

Among Cape Town's renewable energy and energy efficiency programs, the pioneering Kuyasa Project stands out for its rigorous monitoring, engagement of stakeholders, and melding of energy access and climate mitigation needs. This project enabled an impoverished community in the Cape Town township of Khayelitsha to "leap-frog" beyond carbon-intensive strategies for meeting their heating and lighting needs in favor of solutions that lessen the community's dependence on an overloaded and polluting grid. From 1999 to 2010, the project retrofitted 2,309 low-income homes with solar water heaters, insulated ceilings, and energy efficient lighting, saving energy and electricity while reducing carbon emissions (ESMAP, 2012).

The project also created 87 local jobs and trained Kuyasa residents as plumbers, electricians, and builders. Others learned about the installation and maintenance of renewable and energy efficiency technologies through the program (ESMAP, 2012). By the project's end, almost half of the residents who received training had found full-time jobs or business opportunities outside of the community (ESMAP, 2012). Local residents also reduced their reliance on paraffin fuel for heating, saving each household an average of US $7 per month, and lowering incidences of respiratory illnesses. A survey found that 76 percent of residents reported an easing of respiratory illness due to reduced exposure to the fuel's fumes (ESMAP, 2012).

The program's co-benefits ripple out broadly. The Kuyasa Project is South Africa's first internationally registered Clean Development Mechanism (CDM) venture, meaning that industrial firms can purchase some of the project's annual 6,580 tons of reduced carbon emissions to help them meet their Kyoto Protocol targets.

Figure 10. The potential emissions impact of scaling up Kuyasa's energy efficiency policy across South Africa.



Kuyasa's Energy Efficiency Contribution to National Goal

The Kuyasa project reduced emissions by 2.80 tons per household. Scaling this program up to all South Africa's low-income homes could reduce carbon dioxide emissions by 148 million tons from 2015 to 2020, equal to the total emissions produced by 40 coal-fired power plants in one year (EPA Energy Resources Calculator, 2015). This approach could lower South Africa's 2020 emissions by 35 million tons, from 473 million tons to 438 million tons of carbon dioxide, closing the gap between South Africa's 2020 reduction goals and its emissions trajectory by about 22 percent.

Integrating Access and Efficiency into South Africa's Energy Strategy

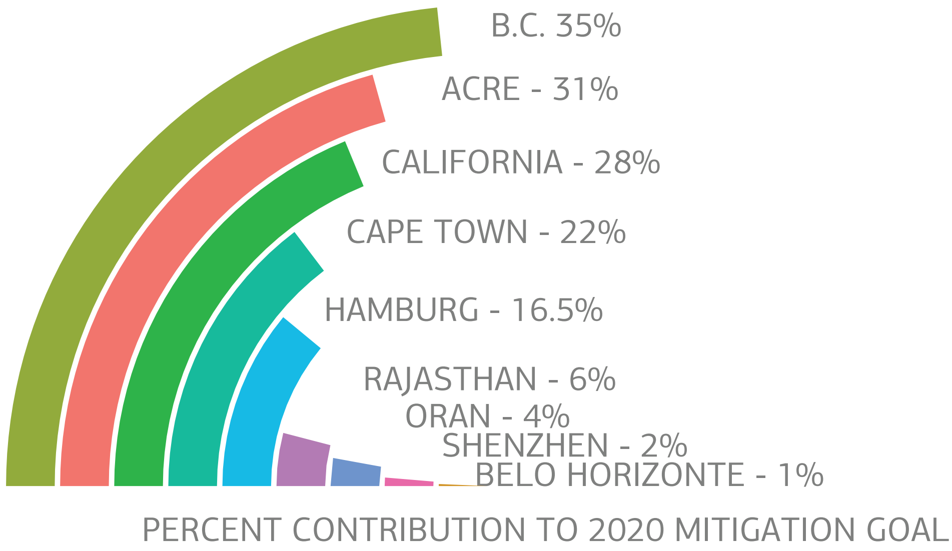
The Kuyasa Project improves the community's quality of life as it lowers greenhouse gas emissions, providing a model for sustainable development. Reducing a neighborhood's reliance on the grid makes its resident's access to energy and electricity more secure and resilient. The Kuyasa approach expands energy access without adding pressure to the existing system, modeling a feasible way for South Africa to reconcile its climate mitigation, poverty reduction, and grid protection goals.

CONCLUSION

The nine case studies selected for this study represent a range of sub-national climate actions. From efficiency and technology innovations, such as waste management and renewable energy deployment, to policy instruments, like carbon taxes and emissions trading schemes, sub-national governments are undertaking a variety of climate mitigation actions. While this study selects one just example from each sub-national government featured, these sub-national governments implement a suite of additional policies and measures to reduce their climate footprint. Their actions not only help mitigate climate change, but many generate co-benefits in tandem. For example, Rajasthan's solar parks could offset the growth of coal use in the province, leading to improved air quality and public health.

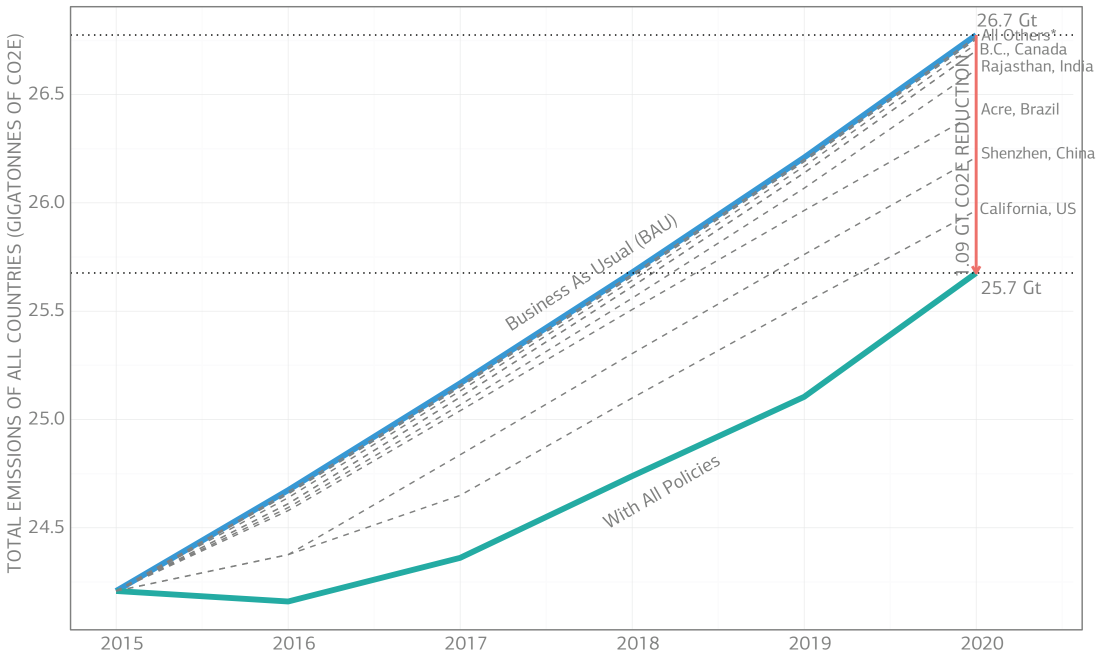
Each climate action's contribution towards both national and global mitigation goals differs when scaled up. Figures 11, 12 and 13 demonstrate the national and global contributions of the nine case studies featured in this report.Scaling up British Columbia's carbon tax could create the largest potential emissions reduction, bringing Canada 35 percent closer to its 2020 mitigation goal. As illustrated in Figure 11, British Columbia's carbon tax would lower the emission reduction cuts needed in 2020 by 35 percent. Acre is the next highest contributor to national mitigation goals; its deforestation prevention program could potentially contribute 28 percent to Brazil's 2020 mitigation goals, if expanded across the country.

Figure 11. Contributions of sub-national climate actions to national mitigation efforts.



Examining the impact of these sub-national efforts to national climate mitigation goals only tells half of the picture. From a global perspective, the respective contributions of sub-national climate efforts look dramatically different (Figures 12 and 13). If adopted nationally, Shenzhen's emissions trading scheme contributes less than 2 percent towards China's needed 2020 emission cuts, but would result in a reduction of 245 megatons of carbon dioxide equivalent globally, or 25 percent of the cumulative 0.94 gigaton reduction of carbon dioxide equivalent that all nine case studies would achieve. Similarly, although extending Rajasthan's solar deployment will only yield a 6 percent reduction in India's 2020 business-as-usual emissions, globally its contribution would be around 201 megatons of carbon dioxide equivalent, or about one-fifth of the total projected emissions reductions in 2020 from the nine case studies. Acre, Brazil, the only land-use based example, is the second largest contributor to the global emissions reductions achieved in this study. Acre's success in reducing deforestation, if scaled nationally, could avoid 203 megatons of carbon dioxide equivalent in 2020.

Figure 12. The global contribution of the subnational case studies to mitigation efforts. In total, the subnational case studies featured in this report have the potential to reduce emissions by 1 gigaton in 2020, closing the emissions gap (UNEP, 2014) by approximately 10 percent.

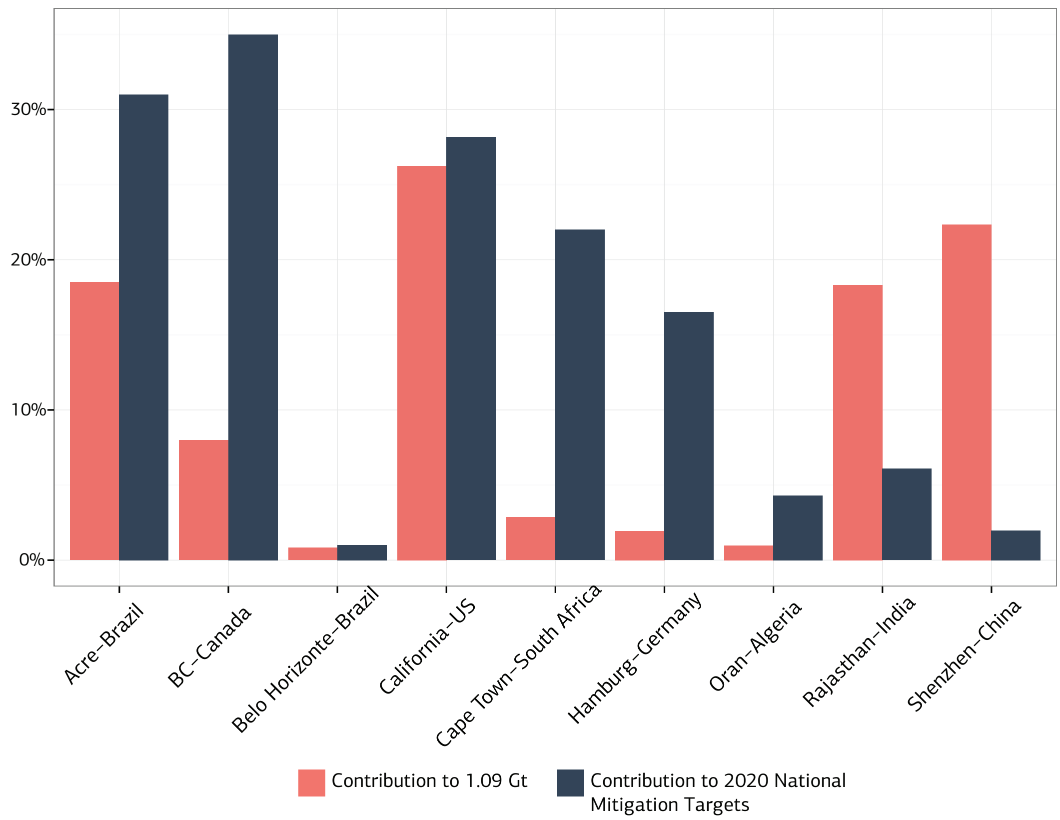


Coordination with National Actors and Pledges

The sub-national climate efforts highlighted in this paper also emphasize the importance of coordination between all levels of climate action. The success of many of the case studies featured here spring from a close alignment and vertical integration with national climate goals. For example, Acre's innovative suite of deforestation prevention programs grew out of its adoption of Brazil's national deforestation goal. Coordination between California and the federal government facilitated the national adoption of more ambitious fuel standards, which now form a core part of the United State's climate action plan.

Finally, Shenzhen's emissions trading scheme (ETS), although initiated through a mandate to establish seven regional emissions trading pilot programs, goes further than what is required by China's national government. The ETS's alignment with national policy directives facilitated the Shenzhen program's creation, but Shenzhen has set its own carbon intensity reduction target and peak emission year that exceed national equivalents.

Figure 13. Comparison of national and global contributions of sub-national climate efforts. The blue national bars show the percentage sub-national efforts contribute towards country 2020 mitigation goals, while the red global contribution bars demonstrate the percentage each sub-national case study contributes towards the 1.09 Gt savings assessed in this report.



The success of Shenzhen's ETS may be a key indication of what China's national ETS, to be launched by 2017, will achieve. These examples suggest the importance of coordination between sub-national and national efforts. Facilitating positive feedback loops, sub-national actors can ramp up the ambition of national mitigation actions by providing a vital space to experiment with new policies and demonstrate clear results.

Beyond Paris

The success of a post-2020 climate agreement rests on the ability to effectively implement the proposed "four pillars." First, a universal climate agreement that creates a mitigation framework for 2020 onward; second, national contributions to support post-2020 global mitigation goals; third, scaled-up financial support for developing countries; and last, a fourth pillar of "scaled-up cooperative action with participation of all levels of Governments and of a broad range of stakeholders" (UNFCCC, 2015a). Never before has the role of non-state and sub-national actors been featured so prominently in the UNFCCC.

This recognition of sub-national governments reflects the dramatic expansion in their engagement in climate action over the last two decades. City and regional programs directly contribute towards national 2020 mitigation goals, but, in some cases, sub-national governments go above and beyond their countries' mitigation policies and actions. These sub-national climate mitigation actions, if adopted by national governments, could contribute towards national climate goals, both in 2020 and in the years beyond. Current intended nationally-determined contributions (INDCs) pledged by countries fall short of reducing emissions to a level consistent with a least-cost 2-degree C pathway, at 19 percent higher (8.7 Gt CO_2e) in 2025 and 35 percent higher (15.1 Gt CO_2e) in 2030 (UNFCCC, 2015b). Demonstrating the sub-national contribution to national pledges, and the potential to achieve greater reductions when scaled, could facilitate increasing ambition for INDCs in the next round of submissions.

Initiatives like the Compact of States and Regions, Compact of Mayors, R-20 Regions for Climate Change and ICLEI – Local Governments for Sustainability enable sub-national governments to independently adopt mitigation actions and targets, showcasing how their initiatives factor in the context of national goals. Such networks allow sub-nationals to share best practices, harmonize data collection and reporting methodologies, and achieve outside recognition for climate mitigation efforts. Platforms like the Non-State Actor Zone for Climate Action (NAZCA) are prominently showcasing sub-national climate actions within official UNFCCC channels that traditionally feature state-level actions.

This report joins a growing effort to quantify the sub-national actors' contributions to national and global mitigation goals. From Brazil to the United States, these case studies demonstrate that sub-national climate action is not insignificant. When scaled nationally, these programs to reduce deforestation, increase renewable energy generation, improve waste management, and build public-private partnerships could have a significant impact, in many cases contributing more than a third to national climate goals. Globally, these scaled-up efforts could reduce 2020 emissions from the eight countries featured in this report by 1 gigaton, compared to current policy scenarios. The sub-national climate actions described in this report could narrow the projected 8 to 10 gigaton gap (UNEP, 2014) between existing national pledges and the additional actions needed to maintain a least-cost 2 degrees Celsius trajectory by approximately 10 percent.

REFERENCES

Agence Francaise Developpment (ADF). (2010). Promoting energy efficiency in South Africa. Retrevied from: http://carte.afd.fr/afd/fr/projet/lutte-contre-le-rechauffement-climatique.

Amazonian Environmental Research Institute (IPAM). (2012). Acre state's progress towards jurisdictional REDD+ research, analysis, and recommendations for the state carbon incentive program (ISA-Carbono). Retrieved from: http://www.gcftaskforce.org/documents/acre%27s_progress_towards_jurisdictional_redd.pdf.

Appunn, K. (2015, May 9). Germany's greenhouse gas emissions and climate targets. Clean Energy Wire. Retrieved from: https://www.cleanenergywire.org/factsheets/germanys-greenhouse-gas-emissions-and-climate-targets.

Beecheno, K. (2013). Recycling and waste management in Brazil: Overview Report. Proceedings from: Consumption Work and Societal Divisions of Labour Conference. Retrieved from: http://www.essex.ac.uk/sociology/research/divlab/Recycling_and_Waste_Management_in_Brazil_Overview_Report.pdf.

Bouhadiba, B., Hamou, A., Hadjel, M., Youssef, K. & Matejka, G. (2014). New schemes of municipal solid waste management for the wilaya of Oran, Algeria. Iranian Journal of Environmental Health Science and Engineering. Retrieved from: https://www.researchgate.net/publication/270901539_New_schemes_of_Municipal_Solid_Waste_Management_for_the_wilaya_of_Oran_Algeria.

Braw, E. (2013, October 13). Hamburg's answer to climate change. The Guardian. Retrieved from: http://www.theguardian.com/sustainable-business/hamburg-answer-to-climate-change.

Bridge to India. (2015). India solar handbook. Retrieved from: http://www.bridgetoindia.com/our-reports/india-solar-handbook/.

British Columbia Ministry of Environment. (2012). British Columbia Greenhouse Gas Inventory Report. Retrieved from: http://www2.gov.bc.ca/assets/gov/environment/climate-change/reports-and-data/provincial-ghg-inventory-report-bcs-pir/pir-2012-full-report.pdf

British Columbia Ministry of Environment. (2014). Climate action in British Columbia: 2014 progress report. Retrieved from: http://www2.gov.bc.ca/assets/gov/environment/climate-change/reports-and-data/provincial-ghg-inventory-report-bcs-pir/2014-progress-to-targets.pdf.

British Columbia Ministry of Environment. (2015). B.C. celebrates five consecutive carbon neutral years. Retrieved from: https://news.gov.bc.ca/releases/2015ENV0037-000987.

British Columbia Ministry of Finance. (2015). Tax Bulletin (Bulletin MFT-CT 005). Retrieved from: http://www.sbr.gov.bc.ca/documents_library/bulletins/mft-ct_005.pdf.

California Environmental Protection Agency (CalEPA), Air Resources Board. California Advanced Clean Cars Summary. Retrieved from: http://www.arb.ca.gov/msprog/clean_cars/acc%20summary-final.pdf.

California Environmental Protection Agency (CalEPA), Air Resources Board. (2012, January 27). California Air Resources Board approves Advanced Clean Car rules. Retrieved from: http://www.arb.ca.gov/newsrel/newsrelease.php?id=282.

California Environmental Protection Agency (CalEPA). (2014). Assembly Bill 32 overview. Retrieved from: http://www.arb.ca.gov/cc/ab32/ab32.htm.

California Environmental Protection Agency (CalEPA). (2015). State agency greenhouse gas reduction report card. Retrieved from: http://www.climatechange.ca.gov/climate_action_team/reports/2015_CalEPA_Report_Card.pdf.

California Office of the Governor. (2012, March 23). Executive order B-16-2012. Retrieved from: http://gov.ca.gov/news.php?id=17472.

California Office of the Governor. (2014, April 29). Governor Brown establishes the most ambitious greenhouse gas reduction target in North America. Retrieved from: http://gov.ca.gov/news.php?id=18938.

Canada's Ecofiscal Commission. (2015). A snapshot of carbon pricing in Canada. Retrieved from: http://ecofiscal.ca/reports/wayforward/infographic/.

Center for International Forestry Research (CIFOR). (2013, November 4). How a remote Amazonian state is leading the way in climate change policy. Bogor, Indonesia: Evans, K. Retrieved from: http://blog.cifor.org/17275/special-report-how-a-remote-amazonian-state-is-leading-the-way-in-climate-change-policy#.VdC6d0Xd4-9.

Chadha, M. (2014, October 8). Indian state of Rajasthan simplifies regulations to boost solar power capacity by 25 GW. CleanTechnica.
Retrieved from: http://cleantechnica.com/2014/10/08/indian-state-rajasthan-simplifies-regulations-boost-solar-power-capacity-25-gw/.

Chan et al. (2015, forthcoming). Reinvigorating International Climate Policy: A Comprehensive Framework for Effective Nonstate Action. Global Policy.

China Emissions Exchange. (2014). Annual report on Shenzhen emissions trading scheme first-year operation: Compliance period I (2013-2014). Retrieved from: http://www.ieta.org/assets/China-WG/shenzhen-2013etsreport.pdf.

The City of Cape Town. (2003). Integrated metropolitan environmental policy. Retrieved from: https://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Documents/IMEP_Eng%20v2.pdf.

The City of Cape Town. (2011, September 11). City to focus on positioning Cape Town as 'green economy' for COP17 conference. Retrieved from: https://www.capetown.gov.za/en/MediaReleases/Pages/CitytofocusonpositioningCapeTownasgreeneconomyforCOP17conference.aspx.

The City of Cape Town, Strategic Policy Unit Office of the Executive Mayor. (2013). Cape Town Economic Growth Strategy. Retrieved from: https://www.capetown.gov.za/en/IDP/Documents/EconomicGrowthStrategy.pdf.

The City of Cape Town. (2015). Energy and climate change. Retrieved from: https://www.capetown.gov.za/en/environmentalresourcemanagement/projects/climatechange/Pages/default.aspx.

City of Hamburg. (2012). Hamburg climate action plan 2007-2012, update 2011-2012. Communication of the Senate to the Hamburg Parliament. Retrieved from: http://www.hamburg.de/contentblob/3959638/data/download-update-2011-12-englisch.pdf.

City of Hamburg. (2013). Status quo report. Retrieved from: http://urbantransform.eu/wp-content/uploads/sites/2/2015/07/Status-Quo-Report_Hamburg.pdf.

City of Hamburg. (2015). City Transformation Agenda Hamburg. Retrieved from: http://urbantransform.eu/wp-content/uploads/sites/2/2015/07/D2.2_Transformation-Agenda-Hamburg.pdf.

City of Hamburg. (2012). Hamburg climate action plan 2007-2012, update 2011-2012. Communication of the Senate to the Hamburg Parliament. Retrieved from: http://www.hamburg.de/contentblob/3959638/data/download-update-2011-12-englisch.pdf.

Climate Action Tracker. (2015a). Emissions Gap - How close are INDCs to 2 and 1.5°C pathways?. 2 September. Available: http://climateactiontracker.org/news/222/Emissions-Gap-How-close-are-INDCs-to-2-and-1.5C-pathways.html.

Climate Action Tracker. (2015b). Assessment of China. Retrieved from: http://climateaction-tracker.org/countries/china.html.

Climate Action Tracker. (2015c). Assessment of Canada. Retrieved from: http://climateaction-tracker.org/countries/canada.html.

The Climate Group. The state of California. Retrieved from: http://www.theclimategroup.org/what-we-do/network/the-state-of-california.

The Climate Group. (2015, July 6). California cuts GDP emissions below 2000 levels while GDP grows: On track for AB32 targets. Retrieved from: http://www.theclimategroup.org/what-we-do/news-and-blogs/california-cuts-emissions-below-2000-levels-while-gdp-grows-on-track-for-ab32-targets/.

Ecofys and Cambridge Institute for Sustainability Leadership. (2015). Better Partnerships: Understanding and increasing the impact of private sector cooperative initiatives.

Ecosystem Marketplace. (2014). Acre and goliath: One Brazilian state struggles to end deforestation. Retrieved from: http://www.ecosystemmarketplace.com/articles/acre-and-goliath-one-brazilian-state-struggles-to-end-deforestation/.

Elgie, S., & McClay, J. (2013). BC's carbon tax shift after five years: Results. Sustainable Prosperity. Retrieved from: http://sustainableprosperity.ca/sites/default/files/publications/files/BC%27s%20Carbon%20Tax%20Shift%20after%205%20Years%20-%20Results.pdf.

European Commission. Policy and Background. European Green Capital. Retrieved from: http://ec.europa.eu/environment/europeangreencapital/about-the-award/policy-guidance/index.html.

Government of Canada. (2015). Canada's INDC submission to the UNFCCC. Retrieved from: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Canada/1/INDC%20-%20Canada%20-%20English.pdf.

Government of India, Ministry of Environment & Forests. (2012). National Communication to the United Nations Framework Convention on Climate Change. Retrieved from: http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/indiacphaccord_app2.pdf.

Government of India, Ministry of Power. (2015). Power Sector at a Glance - All India. Retrieved from: http://powermin.nic.in/power-sector-glance-all-india.

Government of India, National Institute of Solar Energy (NISE). (2014). State-wise estimated solar potential in the country. Retrieved from: http://mnre.gov.in/file-manager/UserFiles/Statewise-Solar-Potential-NISE.pdf.

Government of South Africa. (2009). National energy efficiency strategy of the Republic of South Africa. Retrieved from: http://www.energy.gov.za/EEE/Review%20of%20National%20Energy%20Efficiency%20Strategy%202008.pdf.

Government of the People's Republic of China, National Development and Reform Commission. (2015). China's submission of its national independent contribution to address climate change. Retrieved from: http://www.sdpc.gov.cn/xwzx/xwfb/201506/t20150630_710204.html.

Government of the People's Republic of China, National Development and Reform Commission. (2010). National Development and Reform Commission regarding the development of low-carbon inform provinces and low-carbon city pilot work. Retrieved from: http://www.gov.cn/zwgk/2010-08/10/content_1675733.htm.

Governor's Climate & Forests Task Force. (2013). Current REDD+ program progress. Retrieved from: http://www.gcftaskforce-database.org/ReddImplementation/Acre
Verified Carbon Standard (VCS). Jurisdictional and nested REDD+ pilot programs. Retrieved from: http://www.v-c-s.org/jnr-pilot-programs

GreenCape. Regional Resource Flow Model. Retrieved from: http://greencape.co.za/what-we-do/projects/regional-resource-flow-model/.

Green, F. & Stern, N. (2015). China's "new normal": structural change, better growth, and peak emissions. Retrieved from: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/06/Chinas_new_normal_green_stern_June_2015.pdf.

Green Growth Best Practices. (2014). Waste and Recycling in Belo Horizonte. Laloe, F. Seoul, Republic of Korea: Laloe, F. Retrieved from: http://www.ggbp.org/case-studies/brazil/waste-and-recycling-belo-horizonte.

Hoffmann, M.J. (2011) Climate Governance at the Crossroads. New York: Oxford University Press.

Hsu, A., Moffat, A.S., Weinfurter, A.J., and Schwartz, J.D. (2015) 'Towards a New Climate Diplomacy', Nature Climate Change, 5, pp. 501–503.

International Monetary Fund (IMF). (2014). World Economic Outlook: Legacies, Clouds, Uncertainties. Retrieved from: http://www.imf.org/external/pubs/ft/weo/2014/02/.

International Renewable Energy Agency (IRENA). (2012). Waste to energy for more effective landfill site management. Renewable Energy Policy in Cities: Selected Case Studies. Retrieved from: https://www.irena.org/Publications/RE_Policy_Cities_CaseStudies/IRENA%20cities%20case%203%20Belo%20Horizonte.pdf.

Jai, S. (2015, June 6). Solar power at 4,000 Mw, Rajasthan in the lead. Business Standard. Retrieved from: http://www.business-standard.com/article/economy-policy/solar-power-capacity-touches-4-000-mw-rajasthan-races-ahead-of-gujarat-115060500726_1.html.

Jaiswal, A. (2015, June 30). Rapid growth in India's solar energy market: Stronger policies to achieve 100 GW by 2020. Natural Resources Defense Council, Switchboard Blog. Retrieved from: http://switchboard.nrdc.org/blogs/ajaiswal/rapid_growth_in_indias_solar_e.html.

Maryland Department of the Environment. States adopting California's Clean Car standards. Retrieved from: http://www.mde.maryland.gov/programs/Air/MobileSources/CleanCars/Pages/states.aspx.

Masunaga, S. (2015, July 2). We're No. 8: California near top of world's largest economies. The Los Angeles Times.
Retrieved from: http://www.latimes.com/business/la-fi-california-world-economy-20150702-story.html.

Ministry of Finance, British Columbia. (2013). Myths and Facts about the Carbon Tax. Retrieved from: http://www.fin.gov.bc.ca/tbs/tp/climate/A6.htm.

Murray, B.C., & and Rivers, N. (2015). British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy. NI WP 15-04. Durham, NC: Duke University. Retrieved from: https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_wp_15-04_full.pdf.

Nations Online. (2011). The most populated cities in China. Retrieved from: http://www.nationsonline.org/oneworld/china_cities.htm.

Nagarajan, G. (2015, February 28). India to quadruple renewable capacity to 175 gigawatts by 2022. BloombergBusiness. Retrieved from: http://www.bloomberg.com/news/articles/2015-02-28/india-to-quadruple-renewable-capacity-to-175-gigawatts-by-2022.

National Bureau of Statistics of China (NBS-China). (2015). Retrieved from: http://data.stats.gov.cn/.

Office of the Secretary of the United Nations. Forests action statements and action plans. Proceedings from Climate Summit 2014: Catalyzing Action. Retrieved from: http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/07/New-York-Declaration-on-Forest-%E2%80%93-Action-Statement-and-Action-Plan.pdf.

Prefeitura de Belo Horizonte. (2012). 2 degree inventory of greenhouse gas emissions. Belo Horizonte, Brazil.

R20 Regions of Climate Action. (2015). Program overview: Integrated solid waste management, Oran, Algeria. Retrieved from: http://www.regions20.org/images/Oran%20Waste%20Overview.pdf.

Shenzhen Municipal People's Government Office. (2012). Shenzhen Municipal People's Government on the issuance of Shenzhen Energy Saving "Twelfth Five Year Plan." Retrieved from: http://www.sz.gov.cn/zfgb/2012_1/gb778/201203/t20120306_1823115.htm.

Shidore, S. (2015). India's power sector and the climate challenge. Proceedings from: Workshop on Key Regional Actors and Sector Opportunities for International Climate Change Cooperation, May 27-28 2015.

SWEEP-Net. (2010). Country Report on the solid waste management in Algeria. Retrieved from: http://www.sweep-net.org/ckfinder/userfiles/files/country-profiles/RA%20ALGERIE%20ANG.pdf.

SWEEP-Net. (2014). Country Report on the solid waste management in Algeria. Deusche Geselleschaft fur Internationale Zusammenarbeit (GIZ). Retrieved from: http://www.sweep-net.org/sites/default/files/ALGERIE%20RA%20ANG%20WEB_0.pdf.

The Times of India. (2015, June 23). Rajasthan pips Gujarat in solar power, becomes No. 1 in country. Retrieved from: http://timesofindia.indiatimes.com/india/Rajasthan-pips-Gujarat-in-solar-power-becomes-No-1-in-country/articleshow/47776965.cms.

van de Nest, G. (2015, February, 11). The economic consequences of load shedding in South Africa and the state of the electrical grid. tralac. Retrieved from: http://www.tralac.org/discussions/article/7000-the-economic-consequences-of-load-shedding-in-south-africa-and-the-state-of-the-electrical-grid.html.

United Nations Climate Change Secretariat. (2005). Emissions summary for Brazil. Retrieved from: https://unfccc.int/files/ghg_data/ghg_data_unfccc/ghg_profiles/application/pdf/bra_ghg_profile.pdf.

UNEP (2014) The Emissions Gap Report 2014. Nairobi: UNEP.

UNEP (2015) Climate Commitments of Subnational Actors and Business. A Quantitative Assessment of Their Emission Reduction Impact. Nairobi: UNEP.

United Nations Framework Convention on Climate Change. (2015a). UNFCCC Strategy Chief Explains Road to Paris. UNFCCC. Bonn. Retrieved from: http://newsroom.unfccc.int/lima/unfccc-strategy-director-explains-road-to-paris-agreement/.

United Nations Framework Convention on Climate Change. (2015b). Synthesis report on the aggregate effect of INDCs. UNFCCC. Bonn. Retrieved from: http://unfccc.int/focus/indc_portal/items/9240.php.

U.S. Department of Transportation, Federal Highway Administration (FHWA). (2012). Highway statistics series. Retrieved from: https://www.fhwa.dot.gov/policyinformation/statistics/2012/vm1.cfm

United States Energy Information Administration (US EIA). 2011. Emissions of Greenhouse Gases in the U.S. Retrieved from: http://www.eia.gov/environment/emissions/ghg_report/tables_ghg.cfm

United States Environmental Protection Agency (EPA). (2012). EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks. Retrieved from: http://www.epa.gov/otaq/climate/documents/420f12051.pdf
United States Environmental Protection Agency (EPA). (2013). U.S. greenhouse gas inventory report: 1990-2013. Retrieved from: http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html#data.

United States Environmental Protection Agency (EPA). (2015). Greenhouse gas equivalencies calculator. Retrieved from: http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results.

Vishnoi, A. Is Modi government's target to increase solar power capacity to five-fold in seven years achievable? (2015, August 22). The Economic Times. Retrieved from: http://articles.economictimes.indiatimes.com/2015-08-22/news/65739641_1_indian-railways-solar-power-solar-energy-corporation.

The White House, Office of the Press Secretary. (2012, August 28). Obama Administration Finalizes Historic 54.5 MPG Fuel Efficiency Standards. Retrieved from: https://www.whitehouse.gov/the-press-office/2012/08/28/obama-administration-finalizes-historic-545-mpg-fuel-efficiency-standard.

World Bank. (2012). A global review of solid waste management (Chapter 3). Urban Development Series Knowledge Papers. Retrieved from: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/Chap3.pdf.

World Bank Energy Sector Management Assistance Program (ESMAP). (2012). Good practices in City Energy Efficiency: Cape Town-Kuyasa Settlement, South Africa- LowIncome Energy Efficiency Housing Project. Retrieved from: http://www.esmap.org/sites/esmap.org/files/Kuyasa_EECI_Housing_FinalCaseStudy_Africa.pdf.

World Resources Institute. (2013). GHG mitigation in Brazil's land use sector: An introduction to the current national policy landscape. Washington, D.C.: Gebara, M.F., & Thuault, A. Retrieved from: http://www.wri.org/sites/default/files/ghg-mitigation-brazil-land-use-sector.pdf.

World Resources Institute. (2014a). 6 graphs explain the world's top 10 emitters. Washington, D.C.: Ge, M., Friedrich, J., & Damassa T. Retrieved from: http://www.wri.org/blog/2014/11/6-graphs-explain-world%E2%80%99s-top-10-emitters.

World Resources Institute, CAIT. (2014b). Climate Analysis Indicators Tool: WRI's Climate Data Explorer. Washington, DC: World Resources Institute. Retrieved from: http://cait2.wri.org.

World Resources Institute. (2015, July 3). What the U.S.-Brazil joint statement on climate change means for the world. Washington, D.C.: Romeiro, V. & Biderman, R. Retrieved from: http://www.wri.org/blog/2015/07/what-us-brazil-joint-statement-climate-change-means-world.

World Wildlife Fund. (2013). Environmental service incentives system in the state of Acre, Brazil: Lessons for policies, programmes and strategies for jurisdiction-wide REDD+. Retrieved from: http://d2ouvy59p0dg6k.cloudfront.net/downloads/acre_brazil_sisa_report___english_10_13.pdf.

APPENDIX
Supplementary Information

Scaling Local and Regional Climate Policies to the National Level

Time Frame

We assume that policies will be implemented gradually in 2015, before being fully implemented in 2016. As a result, the emissions impact of the case study policies grows gradually throughout the course of 2015, before reaching its full impact in 2016. The case study of Shenzhen is the exception to this approach: since China plans to scale this policy up in 2016, we assume that the policy will be gradually implemented during 2016 to 2017, and will reach full implementation in 2017.

Business As Usual (BAU) Calculations

Country's business as usual calculations (BAU) were determined by creating linear projections of historic data. This approach allowed us to apply a consistent methodology for determining the business as usual pathway across different countries. (Data predicting countries' 2020 business as usual emissions was not consistently available for all of the countries considered in this paper.) As a result, the predicted business as usual pathways described in this report may vary slightly from other sources or from countries' internal assessments of their predicted business as usual pathways and targets (based on differences in the methodologies used to calculate these figures).

Greenhouse Gas Emission Targets

Where countries have pledged 2020 mitigation targets (i.e., the United States, Canada, and Germany), we made reference to how the sub-national case study contributes directly towards that goal. For other countries where 2020 goals are articulated on an intensity basis (e.g., carbon emissions per unit GDP), we calculated mitigation impact of sub-national efforts from business-as-usual 2020 emission projections.

Case Study 1: Oran, Algeria

The Emissions Impact of Oran's Waste Management Strategy
To determine the greenhouse gas emissions reduction achieved by Oran's waste sorting and recycling program, we multiplied the composition of Oran's municipal solid waste to the volume of waste measured by the R20 program, to determine the total amount of recycled materials removed from the waste stream. We then multiplied the emissions factors for the removal of these materials by the previously calculated amount of recycled materials recovered by the R20 program, to determine the mitigation impact of these efforts.

Scaling Oran's Emissions Impact to the National Level

To determine the impact this project would have if scaled to the national level, we applied the per capita greenhouse gas emissions reduction from Oran's waste sorting program to the total population of the country. Compared to the nation's business as usual emissions (a linear projection of past emissions), the expansion of Oran's waste sorting program could lower national 2020 emissions by 11 million tons of carbon dioxide, or roughly 4.3 percent, from 254 million tons to 243 million tons. Between 2015 and 2020, the policy could reduce the country's carbon dioxide emissions by a cumulative total of 52 million tons.

As Algeria's population continues to expand, the emissions reduction impact of adopting a waste sorting program will also grow over time. Between 2015 and 2020, the rate of expansion is small enough that it is not visible on the graph, but the emissions reductions will grow according to the rate of population growth, rather than at a linear rate.

Case Study 2: Acre, Brazil

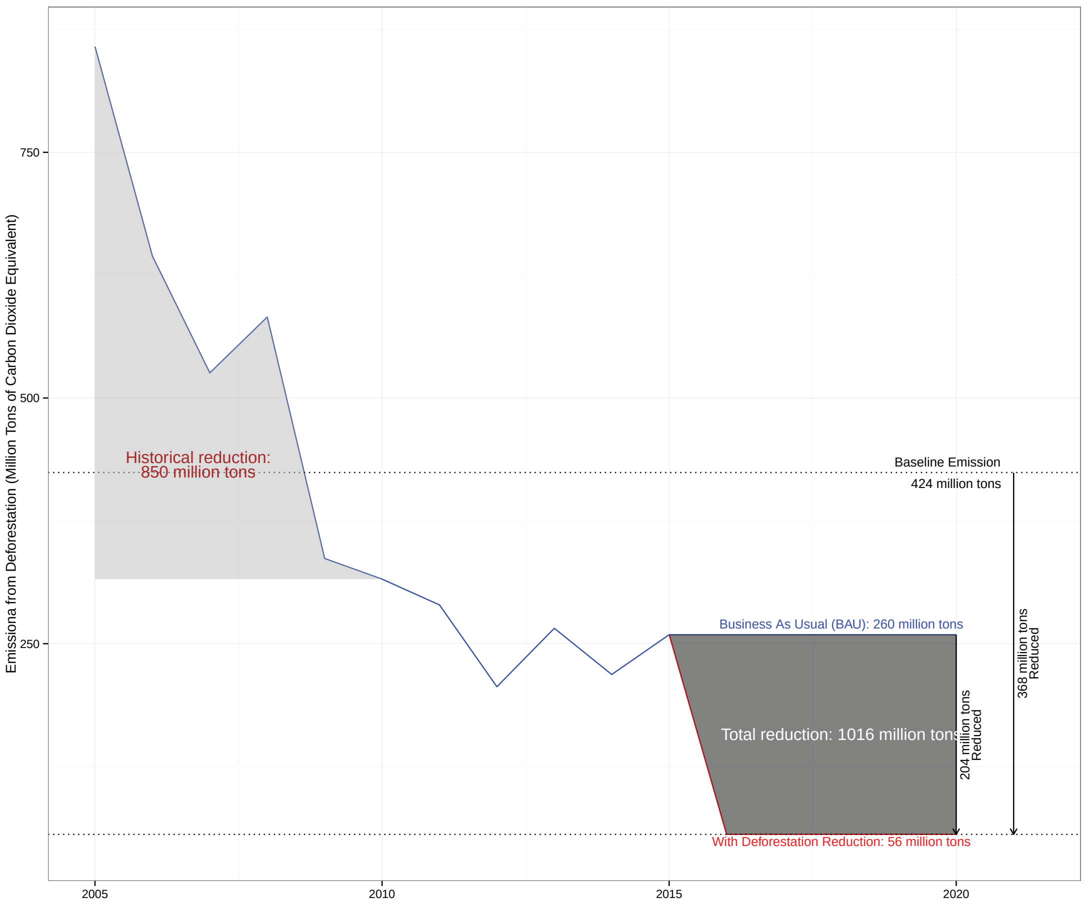
Brazil's Projected Rate of Deforestation

To determine how Acre's forest protection policy approach might translate to the national context, we applied the reduction Acre has achieved in its rate of deforestation in the Amazon to Brazil's national deforestation rates. These calculations apply Acre's progress in slowing its deforestation rate to all of Brazil's forested areas, rather than just to the Amazon specifically. It is important to note that this method assumes a consistent forest composition across the country, although the carbon storage and greenhouse gas savings realized by protecting other forests, such as the Cerrado forest, may vary.

The nation's business as usual (BAU) rate, or recent rate of deforestation, was calculated as the average of deforestation rates between 2010 and 2014. While Brazil's national deforestation target uses data from 1996 and 2005 as its baseline, we calculated the impact of reducing deforestation against a more recent target, because deforestation in Brazil has slowed significantly since 2003. Figure 3 demonstrates the difference between the two baselines.

Applying Acre's reduction of deforestation across Brazil as a whole would lower the country's 2020 emissions by 368 million tons of carbon dioxide equivalent, compared to the reductions that would be achieved at the nation's baseline rate of deforestation reduction (between 1996 and 2005). The national application of Acre's strategy would lower emissions by 204 million tons of carbon dioxide equivalent, compared to the deforestation reductions Brazil has maintained over the last four years.

Figure S1. The national reduction in deforestation that could be achieved by applying Acre's reduction rate to Brazil's forests. The "Business as Usual" line represents Brazil's recent rate of deforestation (an average of the annual deforestation rates from 2010 to 2014), while the "Baseline Emissions" line represents Brazil's official baseline for its deforestation reduction target, which includes older data (it averages annual deforestation rates from 1996 to 2005).



Scaling Acre's Emissions Impact to the National Level

To determine the emissions impact of applying Acre's rate of deforestation reduction to Brazil's forests, we used Acre's deforestation data from 2010 to 2014 to calculate an average projected deforestation rate for 2015 through 2020. We then calculated the total area of land that avoided being degraded or deforested as a result of this policy. Comparing this amount of preserved land to the total area of forested land in Acre created a ratio of preserved forest area to total forest area. Multiplying this ratio by Brazil's total forested area provides an estimate of the impact Acre's policy could have on all of the country's forests. Assuming that the national deforestation rate is constant from 2015 to 2020, applying Acre's reduction in deforestation to the national level would save 1240 square kilometer per year. Multiplying this figure by 451 tons of carbon dioxide equivalent per hectare, the conversion factor used by the Government of Acre, yields the emissions impact of adopting Acre's policy at a national level.

Applying Acre's deforestation reduction rate across all of Brazil's forested areas would lower its 2020 emissions by 0.204 gigatons of carbon dioxide equivalent, compared to the deforestation reductions Brazil has maintained over the last four years.

Case Study 3: Belo Horizonte, Brazil

The Emissions Impact of Belo Horizonte's Waste Management Strategy

To determine the impact of implementing Belo Horizonte's waste management program at the national scale, we first determined the reduction in solid waste emissions that resulted from Belo Horizonte's policies. The average population growth for Belo Horizonte in the years between 2000 and 2010 was used to project the city's growth until 2020. Comparing the projected emissions from solid waste and population growth enabled us to calculate the per capita reductions emission resulting from Belo Horizonte's biogas program.

Scaling Belo Horizonte's Emissions Impact to the National Level

To scale the emissions impact of Belo Horizonte to a national level, we assumed that other large cities in Brazil - those with a population of 500,000 or more - would be most able and likely to implement similar programs. The emissions reductions were applied to the 39 Brazilian cities that contain at least 500,000 residents (as of 2014), based on their projected population growth to 2020.

If scaled nationally, Belo Horizonte's biogas program would result in lowering Brazil's emissions by 9 million tons in 2020, from 564 million tons to 555 million tons. Between 2015 and 2020, this expansion of biogas would save a total of 42 million tons.

Case Study 4: British Columbia, Canada

The Emissions Impact of British Columbia's Carbon Tax

To determine the emissions impact that would occur if Canada adopted British Columbia's carbon tax, we estimated the emissions reductions that a national fossil fuel tax would generate, using fuel sales data, and subtracted the emissions reductions from the nation's projected total emissions between 2015 and 2020. The first step of this process involved finding the fossil fuel emissions of British Columbia and Canada, between 2008, the year British Columbia enacted its carbon tax, and 2014. Provincial sales tax data and Canadian emissions factors for the fuels covered by the tax enabled us to calculate the reduction in fossil fuel emissions that resulted from British Columbia's carbon tax. Natural domestic sales tax data and Canadian emissions factors enabled us to calculate the growth rate of fossil fuel emissions in Canada. Notably, these calculations assume that the drop in fossil fuel sales over time can be attributed to the effect of the carbon tax; we recognize that there are other factors that affect domestic fuel sales, which may not be accounted for in this analysis.

Determining Emissions Impact of the Carbon Tax at the National Level

We projected Canada's future emissions from fossil fuel use between 2015 and 2020, based on historical data from 2008 to 2014. We also projected another 2015-2020 scenario, that applied British Columbia's rate of reduction in fossil fossil emissions to the national level. We calculated the difference in the emissions generated by these two scenarios, to determine the emissions reductions that could be realized by applying a national carbon tax.

To put this emissions reduction in the context of Canada's total emissions, the emissions reductions that would occur if Canada implemented a national carbon tax were subtracted from Canada's business as usual (BAU) emissions scenario. Canada's business as usual scenario was calculated based on historical data from 2008 to 2012 (the last year of available data for the Canada's total emissions).

If scaled to the national level, British Columbia's carbon tax would reduce Canada's annual 2020 emissions by 87 million tons of carbon dioxide equivalent, from 857 million tons to 770 million tons. Expanding the carbon tax shift model to the rest of the country would help close the gap between Canada's 2020 reduction goals (17 percent below 2005 levels by 2020) and its emissions trajectory by over a third – at about 35 percent.

Case Study 5: Shenzhen, China

China's Projected Emissions

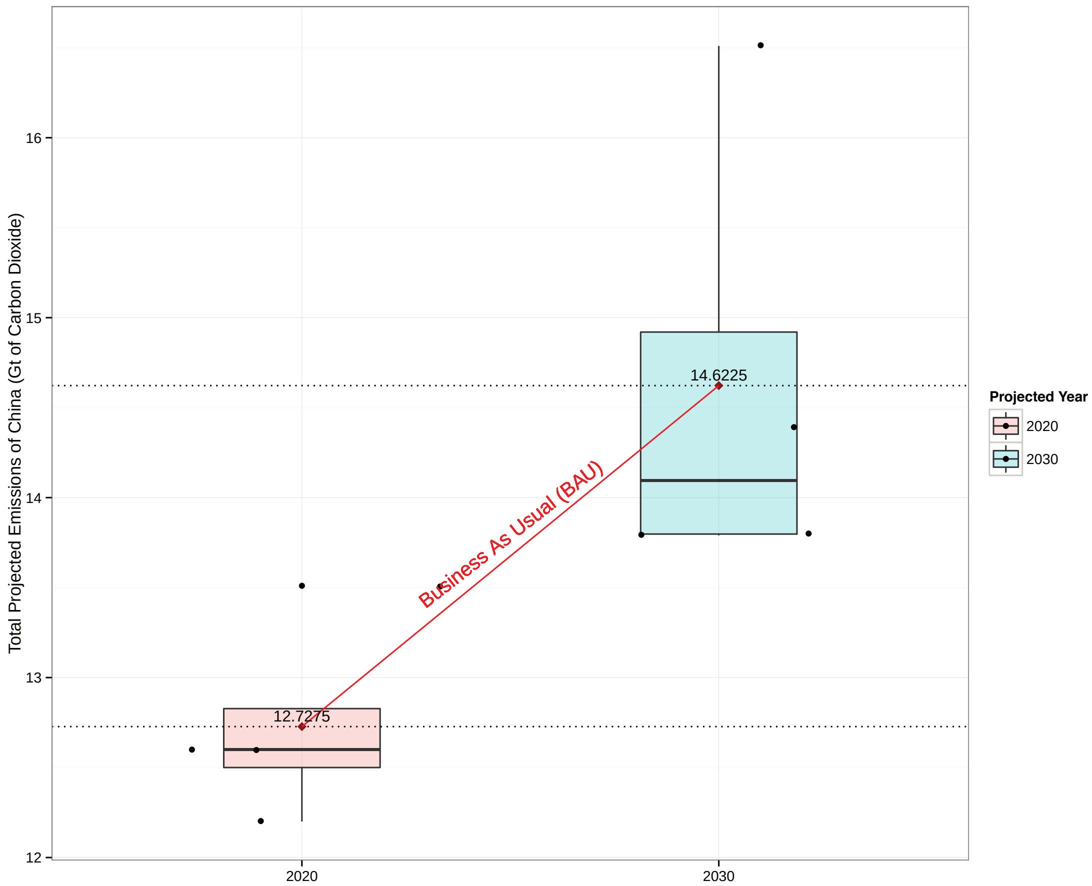
Determining the impact of the adoption of Shenzhen's emissions trading scheme (ETS) on the national level depends on the expected growth of China's carbon emissions. Table 1 and Figure S2 summarize different estimates of the ways China's emissions are expected to grow by 2020 and 2030, in terms of both the country's total carbon emissions and its average annual carbon emission growth rate. These projections are based on the country's 2010 emissions data.

Table 1. China's projected carbon emissions in 2020 and 2030

Business-As-Usual (BAU) Projected Carbon Emissions				
Year	**Projected Emissions (Green & Stern, 2015)**	**Projected Emissions (Climate Action Tracker)**	**Annual Emission Growth Rate (Green & Stern, 2015)**	**Annual Emissions Growth Rate (Climate Action Tracker)**
2020	12.6 - 13.5 Gt	12.2 - 12.6 Gt	2.97 - 3.69%	2.64 - 2.97%
2030	13.8 - 16.5 Gt	13.8 - 14.4 Gt	1.94 - 2.85%	1.94 - 2.1 %

*China's actual 2012 carbon emissions were 9.4Gt.

Figure S2. China's projected carbon emissions in 2020 and 2030. The boxes represent the range of China's projected emissions, according to averaged estimates from two sources (Green & Stern, 2015 & Climate Action Tracker, 2015). The solid black line represents the projected median level of emissions, while the red dot represents the projected mean level of emissions in 2020 and 2030.



Assumptions

Scaling the mitigation potential of Shenzhen's ETS to the national level rests on several key assumptions:

- China's ETS will cover roughly the same proportion (40 percent) of carbon emissions as Shenzhen's ETS;

- China's national ETS participants will have the same reduction rate (11.7 percent) as Shenzhen's compliant companies had in 2013.

- In 2013, Shenzhen's ETS cut the city's total carbon emissions by 4.68 percent. China will establish its national ETS in 2016 or 2017, so carbon emission reductions can only occur at the national level from 2016 onwards.

- A "Business-As-Usual" (BAU) scenario of China's total emissions was calculated by averaging two estimates of China's future emissions (these estimates came from the New Normal Report (Green & Stern, 2015), and Climate Action Tracker (2015)).

Potential Pathways for Scaling Shenzhen's Emissions Impact to the National Level

While China's government has decided to expand an ETS to the national level, how it will nationalize it remains unclear. There are two potential pathways:

- China could connect the emissions markets of the seven pilot cities first, then expand it to all cities or provinces gradually; or,

- China could build an emissions trading market in all mega-cities (i.e., cities with a population greater than 10 million), and allow the markets to trade between each other.

Both pathways anticipate that the government will apply the ETS to urban areas. The emission per capita and population growth rates will likely be similar across these areas, so the impact of adopting the ETS on the national level emission could be determined by scaling its impact up in terms of population.

Assuming that all seven pilot cities' ETS would cover the same proportion of total emissions as Shenzhen's ETS, their annual emissions impact would reach 0.17 gigatons (17 million tons) by 2020. In 2010, China contained 45 cities that had a population greater than one million. If the national ETS covered these 45 mega city areas, in addition to the seven pilot ETS cities, the annual emission reduction would be 0.25 gigatons by 2020 (Figure. 2). Between 2016 and 2020, this approach would reduce a total of 0.86 gigatons of carbon dioxide.

Case Study 6: Hamburg, Germany

The Emissions Impact of Hamburg's Voluntary Industry Agreement

The emissions impact of Hamburg's voluntary industry agreement was taken directly from the city's assessment of its 2007-2012 Climate Action Plan.

Scaling Hamburg's Emissions Impact to the National Level

To determine the mitigation impact of expanding Hamburg's engagement with industry to the national level, we relied on data specifying the different contributions of industry to the city's and the country's total emissions. These ratios allowed us to apply carbon dioxide reductions realized in Hamburg to calculate the carbon dioxide reductions possible across Germany as a whole. These reductions were then subtracted from Germany's business as usual emissions scenario, which was calculated using a linear projection of its historical data, to determine the overall effect of a national engagement with industry on Germany's 2020 emissions.

Applying Hamburg's approach at the national level could reduce Germany's business as usual emissions (calculated using a linear projection of its historical data) by 23 million tons in 2020, lowering it from 837 million tons to 814 million tons of carbon dioxide. This strategy could help close the gap between Germany's 2020 reduction goal, and the path suggested by its historical emissions, by about 16.5 percent. (Germany's goal is to lower national emissions 40 percent below 1990 levels by 2020.) Expanding Hamburg's support of voluntary industry commitments to the national level would result in an annual reduction of 23 million tons in 2020. This strategy could help close the gap between Germany's 2020 reduction goal, and the path suggested by its historical emissions, by about 16.5 percent. Between 2015 and 2020, scaling up Hamburg's partnership with industry could save a total of 94 million tons, an amount equivalent to the annual energy use of 8.5 million homes (EPA, 2015).

Case Study 7: Rajasthan, India

Scaling Rajasthan's Emissions Impact to the National Level

To calculate the impact of scaling Rajasthan's solar policies to the national level, we applied the growth rate Rajasthan has demonstrated in its expansion of solar energy to India's other states, during 2015 to 2020. This approach accounts for explicitly state-supported solar projects, as well as projects that have spearheaded by the private sector, but (we assume) have also been facilitated by Rajasthan's work to eliminate obstacles in financing and acquiring land for solar utilities. Rajasthan's high rate of solar capacity also depends on factors, such as its availability of large tracts of land and high solar potential, that other states might not share. To account for this disparity between the solar potentials of different parts of the country, we used the rate of Rajasthan's solar installation (rather than the net amount of solar capacity it has installed) to scale its policies to the national level. An emissions factor from India's Central Electricity Authority's CO2 Baseline Database (which was based on data from 2009 through 2014) translated the impact of renewable energy into the resulting reduction of carbon dioxide emissions.

As Figure 9 illustrates, if Rajasthan's solar policies were to be applied across India, the country's 2020 emissions would fall by 202 million tons of carbon dioxide, from 3.321 gigatons to 3.119 gigatons. In total, adopting this rate of solar energy expansion would reduce 0.398 gigatons of carbon dioxide between 2015 and 2020, an amount equal to approximately 19 percent of India's total carbon dioxide emissions in 2012.

Case Study 8: Kuyasa, South Africa

The Emissions Impact of the Kuyasa's Energy Efficiency Program

In total, the Kuyasa energy efficiency project reduced emissions by 2.80 tons per household, an amount calculated using a suppressed demand calculation methodology, and specifically, the Indicative Simplified Baseline and Monitoring methodologies for selected small-scale Clean Development Mechanism project activity categories. The suppressed demand calculation methodology determines the emissions impact of energy services in an area where income or infrastructure limits energy access.

This approach assumes that the baseline for a project's energy use should "reflect the technology and/or service levels that would be required if suppressed demand did not exist, rather than the technology currently in use by poor households" (Clean Development Mechanism Simplified Project Design Document for Small Scale Project Activities, 2005). In other words, suppressed demand calculations compare the emissions impact of new projects to the energy use and emissions that would occur if residents had access to traditional sources of energy. Without this assumption, projects that expand energy access could often be found to create a net increase in overall energy consumption.

Scaling Kuyasa's Emissions Impact to the National Level

To determine the impact of expanding the Kuyasa Project to the national level, we applied the household reduction in emissions to South Africa's entire low income population. Assessments of the Kuyasa Project determined that energy "demand would be suppressed similarly in other communities in South Africa with a similar socio-economic status" (Clean Development Mechanism Simplified Project Design Document for Small Scale Project Activities, 2005), making the application of the suppressed demand calculation appropriate.

The City of Cape Town defines the poverty line in terms of an income of less than 3,500 Rand per month, a number which includes about 35.7% of the city's population (City of Cape Town, 2012). This translates into a yearly income of 42,000 Rand, a total which approximately corresponds to the first three quintiles used by the South African census to classify population based on income (specifically, theses quintiles account for citizens with yearly incomes of or below 43,897.15 Rand (Quintile 3)). Based on these numbers, the GHG reductions per capita can be scaled up to the first three quintiles of South Africa's national population.

Scaling this program up to all of South Africa's low-income households could result in a net reduction of 148 million tons of carbon dioxide between 2015 and 2020. This approach could lower South Africa's 2020 emissions by 35 million tons, from 473 million tons to 438 million tons of carbon dioxide. It lowers the gap between the country's 2020 goal, of reducing its scenario 34 percent below a business as usual scenario by 2020, and its current pathway, by approximately 22 percent. This contextualization uses South Africa's historical emissions to project its business as usual scenario.

Case Study 9: California, United States of America

Scaling up California's Advanced Clean Cars Program

To determine the emissions impact that would occur if California's entire Advanced Clean Cars Program were to be scaled nationally, we first calculated the average baseline carbon dioxide emissions that passenger vehicles, light trucks, and combined light-duty vehicles would emit in the absence of the Advanced Clean Cars Program, using data from California Environmental Protection Agency (CalEPA). This yielded an average protected baseline of 341 grams of carbon dioxide emitted per mile traveled by the vehicle. We then determined the average projected 2020 emissions from these vehicle classes if the Advanced Clean Car Program were to be implemented, again using projections from CalEPA to arrive at a total of 211 grams of carbon dioxide emitted per mile traveled by the vehicle.

Both of these numbers – the projected baseline emissions, and the projected emissions if the Advanced Clean Cars program were in place – were multiplied by 0.68 (the ratio of cars covered by the Advanced Clean Cars program to the total number of cars on the road) and by the projected annual number of vehicle miles traveled in the US in 2020 (3.5332 x 1012 miles) according to projections based on United States Department of Transportation data. The emissions produced under the Advanced Clean Cars Program were subtracted from the baseline emissions, and yielded a total of 289, 110,142 metric tons of carbon dioxide.

This reduction was subtracted from the business-as-usual (BAU) carbon dioxide emissions for the United States in 2020. The BAU was calculated through a linear projection of historic carbon dioxide emissions from energy and industry, provided by the U.S. Energy Information Administration (US EIA, 2011). Since the United States BAU projection includes California's AB 32 legislation, which encompasses the Advanced Clean Cars Program, in its calculations, we projected the BAU, rather than using official estimates of this target, to avoid accounting for the impact of the Advanced Clean Car Program twice.

Since the emissions factors of the Advanced Clean Cars Program relate to carbon dioxide, and not to carbon dioxide equivalent, we limited this case study to carbon dioxide emissions, which also contributes to the difference between the BAU used in this case study and the BAU target estimates adopted by United States agencies (6.1 gigatons of carbon dioxide equivalent in 2020, according to projections based on the U.S. Environmental Protection Agency's data, and 5.9 gigatons of carbon dioxide equivalent in 2020, according to projections based on the U.S. Energy Information Administration.

Scaling up California's Comprehensive Climate Policies

We used CalEPA estimates to determine the total greenhouse gas reduction impact of all of California's climate policies; ARB estimates that all of California's climate policies combined will achieve a 144.3 million metric ton of carbon dioxide equivalent reduction in 2020. We calculated a 3.719 ton of carbon dioxide equivalent per capita reduction rate using California population data. We then applied this per capita rate of emissions reduction to the U.S. population, to determine that 1,186 million tons of carbon dioxide equivalent would be reduced in 2020, if the U.S. adopted California's comprehensive suite of climate policies. The projected emissions reduction in 2020 from all California climate policies could help close the gap between the U.S.'s 2020 climate goal, and its business-as-usual scenario, by about one-fifth, or 20 percent.

www.environment.yale.edu

www.stanleyfoundation.org

www.regions20.org

www.schwarzeneggerinstitute.com

R20 Regions of Climate Action
48 Chemin du Grand Montfleury
CH-1290, Geneva
Switzerland