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PLEDGES AND PROGRESS

Steps toward greenhouse gas emissions reductions in the 100 largest cities across the United States

Samuel A. Markolf, Inês M. L. Azevedo, Mark Muro, and David G. Victor

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EXECUTIVE SUMMARY

The COVID-19 crisis has precipitated the largest decline of global greenhouse gas (GHG) emissions on record.[1] Those massive current declines are likely temporary, but they raise important questions about the trajectory of emissions as the economic crisis abates and economic activity resumes.

Plausibly, the places that were highly-committed to action on climate before the pandemic will remain committed, while places that were reluctant to put much priority in climate earlier will be even more reluctant in the midst of economic uncertainty and uncertain priorities.

Given that, it seems important to take the pulse of what the country has been actually saying and doing on climate change, especially through its local commitments to reduce emissions. That requires looking far beyond the gridlock of Washington to the nation's interior — especially to the local level.

One place to start such an assessment is to look at the nation's many Climate Action Plans (CAPs). Since 1991, over 600 local governments in the United States have developed CAPs that include GHG inventories and reduction targets.[2]

These local plans — which entail a GHG emission inventory and the establishment of reduction targets, reduction strategies, and monitoring efforts — have been celebrated as an important counterpoint to federal drift.

At their best, the plans have exemplified the hope that "bottom-up" actions could add up to a powerful approach to climate mitigation, especially given rollbacks in federal policy under the Trump administration including the government's withdrawal from the Paris Agreement. Yet, at the same time, questions persist about the efficacy of city pledges. Are they working in the absence of binding national regulations? What kind of results are emerging? How far can city action go without bigger efforts at other levels, including federal? Are city goals or pledges meaningful given the share of emissions from goods and services used by the city occur outside the city boundary and that the city does not have control of?

Hence this report: Given the increasing importance of "bottom-up" action on climate, this analysis inventories the various GHG reduction pledges and commitments of the 100 largest U.S. cities; estimates the emissions savings that could result from those pledges; and then evaluates whether U.S. cities appear to be on track to meet their pledges. In this fashion, the information addresses the current array of results on the ground in order to inform ongoing discussions of the potential and limits of "bottom-up" climate strategies in the COVID era. For the sake of completeness we focus on 2017, the last year of complete records when this research began, though we are mindful that city-based action continues.[3]

The report draws five major conclusions about an emissions-pledge system that is generating genuine but partial climate actions:

1. Slightly less than half of large U.S. cities have established GHG reduction targets. Where the goals exist, they tend to align with the 80%-decrease-by-2050 mitigation pathway consistent with the Paris Climate Accord, but tend to fall short of the mitigation pathways that limit warming to 1.5° Celsius (C) modeled by the Intergovernmental Panel on Climate Change (IPCC) (i.e., net zero anthropogenic CO_2 emissions around year 2050).[4]

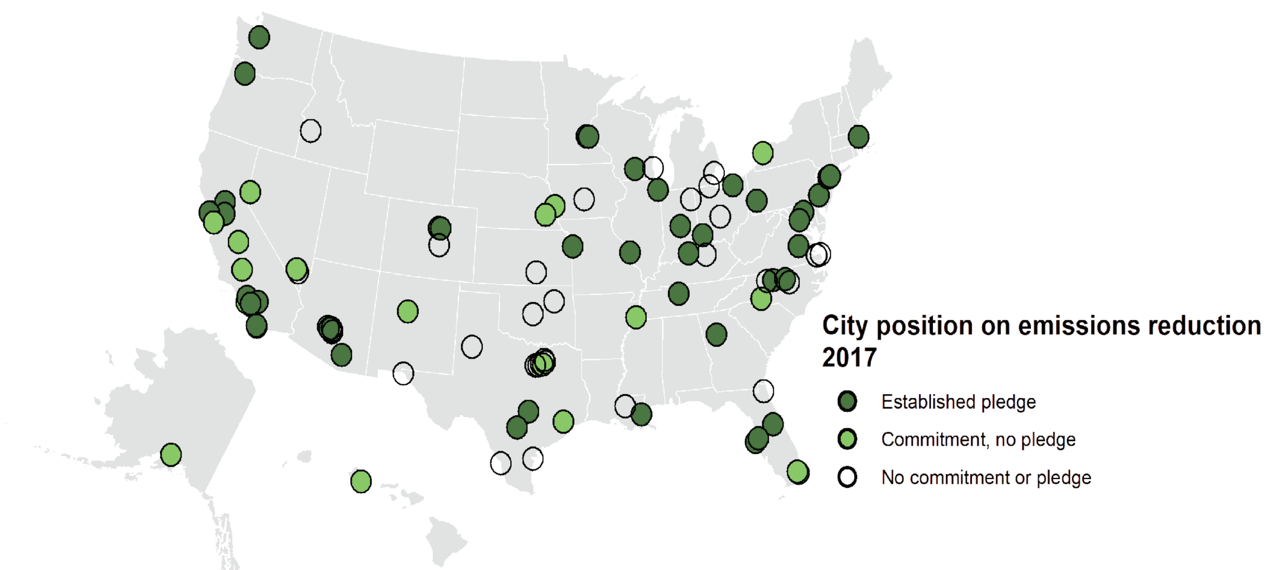
Of the 100 most populous cities in the United States, only 45 have established greenhouse gas reduction targets and corresponding baseline GHG inventories. An additional 22 cities have committed to reducing GHG emissions but have not yet established specific emission reduction targets or completed a baseline GHG emission inventory upon which to base a reduction plan. In that sense, U.S. cities' pledge-setting is sub-optimal in its coverage and design, with less than half of large cities setting targets, and most targets remaining non-binding.

With that said, the GHG reduction targets established by cities frequently comport with good practice in that they often target 80% GHG emissions decreases by the year 2050 — in line with the mitigation pathways modeled by the IPCC that limit warming to 2°C but slightly behind the mitigation pathways that, if scaled globally, would limit warming to 1.5°C. City-based climate commitments appear to be on the upswing. Seventeen of the 45 cities with plans have implemented new or updated plans since the Trump administration took office in January 2017.

2. Overall, roughly 40 million people (about 12% of the total U.S. population and 60% of the total population of the 100 largest U.S. cities) live in bigger cities with active and fully-formed climate action plans.

The 45 cities with fully-established greenhouse gas reduction targets and corresponding baseline GHG inventories encompass a total population of roughly 40 million people. The smallest city is Richmond, Virginia (with a 2017 population of about 227,000) and the largest is New York, New York (with 8.6 million residents). Larger cities are more likely to maintain climate plans than smaller ones. And while California is a hot spot of activity, with plans in place in 11 cities, the plans are relatively evenly-distributed across the nation.

America's 100 largest cities by stated commitment on emissions reduction, 2017



3. Collectively, the total annual reduction in emissions achieved by the 45 cities with both targets and completed inventories (in their respective target years) would equate to approximately 365 million metric tons carbon dioxide equivalent (CO_2e).

The savings contributions from city CAPs vary widely but are adding up. In aggregate, the prospective total annual reduction in emissions achieved by all 45 cities (in their respective target years and compared to the emissions in the city's chosen baseline year) would equate to approximately 365 million metric tons CO_2e — the equivalent of removing about 79 million passenger vehicles from the road. Alternatively, the total annual emissions reduction pledged by the 45 cities with climate action plans, if achieved, would be comparable to the 300 to 450 million metric tons of emissions reductions scored in 2018 where natural gas has replaced coal for generating electricity. There are many uncertainties and assumptions that go into an analysis like this, and those can have a big impact on the calculations of long-term emission reductions. In addition to all the usual caveats, the pandemic has added another one by affecting, among other things, travel behavior—not just right now but possibly in durable ways into the future.

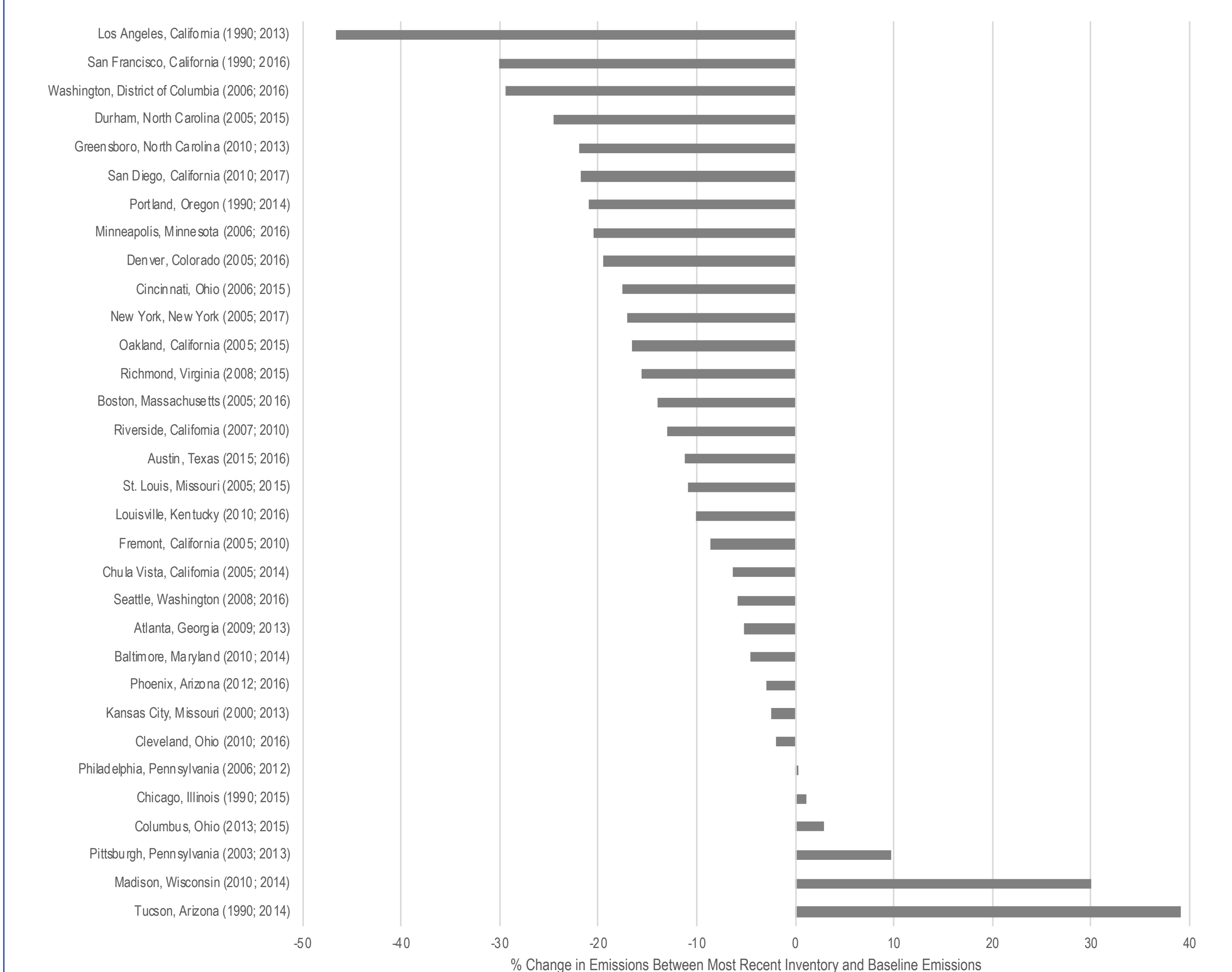
With that said, the collective prospective reduced emissions from the 45 cities equate to roughly 7% of the emission reductions to which the U.S. originally committed to achieve by year 2050 in relation to the Paris Agreement. What's more, the 45 cities would need to achieve an additional emissions reduction of 124 million metric tons CO_2e per year in order to meet the IPCC's modeled mitigation pathway for limiting warming to 1.5° C (i.e., net-zero anthropogenic CO_2 emissions by around 2050). One additional note: The 365 million metric tons that would be reduced on an annual basis by year 2050 if all 45 cities reached their GHG reduction targets translates to roughly 6% of total U.S. GHG emissions in 2017 assuming emissions without the plans would remain the same from the baseline year to the target year. Six percent is not an insignificant number, but it is a far cry from the level of emission reductions that the IPCC suggests needs to occur in order to avoid many of the more significant impacts of climate change.

4. Despite genuine achievements in many cities, roughly two-thirds of cities are currently lagging their targeted emission levels.

Of the 45 cities with GHG reduction targets and corresponding baseline GHG inventories, 32 have conducted at least one additional GHG inventory since 2010. The remaining 13 cities do not appear to have any publicly-available GHG inventories for the years subsequent to the establishment of their climate action plan. However, of the 13 cities without GHG inventories subsequent to setting their GHG reduction target(s), six had a baseline year of 2014 or later for their climate action plan. Therefore, GHG inventories for these locations are likely to be conducted and/or published in the near-term.

Based on their most recent GHG inventory data, 26 of the 32 cities that had at least one additional inventory since 2010 experienced a decrease in emissions compared to their baseline emission levels, while six cities experienced an increase. Los Angeles, California has experienced the largest decrease in emissions (about 47% below 1990 baseline levels), while Tucson, Arizona has experienced the largest increase in emissions amid sprawling growth (39% above 1990 baseline levels), followed by fast-growing Madison, Wisconsin. The nearby figure summarizes the difference between the most recent GHG inventory and baseline emission levels for each city.

Percent change between most recent GHG inventory and baseline emissions



Note: The first number in parentheses next to the city name represents the baseline year. The second number represents the year of the most recent GHG inventory.

Overall, about two-thirds of cities are currently lagging their targeted emission levels. Greensboro, North Carolina performed the best relative to its targeted emissions level (with emissions 20% below its target) and Chicago, Illinois, performed the worst (with inventoried emissions 50% higher than target levels). On average, the cities analyzed in this study will still need to reduce their annual emissions by 64% by 2050 in order to reach their ultimate GHG reduction targets.

5. Overall, the development and implementation of city GHG plans and pledges — while important and encouraging — leaves room for improvement in terms of reach, rigor, and ambition.

Notwithstanding the early achievements of the best city GHG reduction plans and pledges, most cities' activities suffer from shortcomings. Of the 45 cities analyzed in this report, none have GHG inventories for years 2018 or 2019, and only two have GHG inventories for 2017 (an additional 10 have inventories for 2016). Similarly, the lower rate of activity among the smaller cities (only six of the climate action plans came from among the group of cities with the 76th- to 100th-largest populations) suggests the challenges that resource constraints can pose for developing GHG reduction targets and related emissions inventories. Another hindrance to the overall success of city-led climate action plans may be rooted in the fact that the GHG reduction targets set by cities are mostly non-binding, with the exception of those in California cities. That ensures that most communities have no real incentive to meet tough GHG reduction targets.

Finally, scope and boundary issues are surely hindering progress. Factors like population growth, economic development, and changes in the local industry mix are not always explicitly discussed in climate plans. Likewise, cities' boundaries usually mean their emissions plans cannot reach and influence emissions that take place at the regional scale, whether it be commuting, suburban sprawl, or regional electricity generation.

In sum, this assessment highlights the great potential of "bottom-up" climate action to reduce one nation's emissions in meaningful ways through city action.[5] Overall, the leadership of about half of America's larger cities stands as an important counter to federal drift. With that said, more ambitious and rigorous efforts are needed in order to make the nation's "bottom-up" climate commitments more effective. Along these lines, municipalities, states, the federal government, non-governmental organizations (NGOs), philanthropies, and companies should work to:

- **Improve the quality of pledges.** Activists, policy entrepreneurs and politicians have focused a lot on bold announcements, which have a role to play, but the pledges need to include more useful plans for how emissions will be reduced, including how those efforts will be politically sustainable. More of the political activism that is driving pledging should focus in this area. Philanthropy may have a role by helping cities get organized with mitigation planning.

- **Emphasize implementation.** Activists should put more attention here, especially if they think action by cities will help fill in the gaps and push decarbonization across the economy when Washington is failing to act. Pioneer cities should put more focus on how they are turning pledges into reality and also reveal information that makes it possible to check those claims. Several NGOs are doing detailed plan comparisons for nations, inspired by the Paris Agreement, and that laser focus on implementation reality should come to cities too.

- **Develop better models to estimate actual emissions changes.** In the end, people want to know whether city-level action really reduces emissions — below the levels that might have otherwise occurred. This kind of counterfactual analysis is always hard, but it is possible to do better than current approaches (e.g., assuming emissions trajectories will be flat) with models the disentangle the factors under control of city planners and policy makers and those that vary largely beyond local control.

- **Encourage learning.** To help convert aspiration to reality, stronger mechanisms for peer review of city plans are badly needed — so that the community of activists and planners can learn, faster, what works.

And, more importantly, the lessons from the leaders can catalyze more "followership" — so that the actions that are still concentrated in a subset of the American population become more pervasive here and abroad.

In short, many cities have distinguished themselves through their efforts to reduce their GHG emissions. Now much more stringent action has become urgent.

I. INTRODUCTION

The COVID-19 crisis has precipitated the largest decline of global greenhouse gas (GHG) emissions on record. Those massive current declines are likely temporary, but they raise important questions about the trajectory of emissions as the economic crisis abates and economic activity resumes.

Over many decades, it is that trajectory that will matter much more for the climate than just the steep and possibly temporary drop of today. Some even argue that the implementation of massive COVID economic recovery measures will make it possible to alter that trajectory, perhaps along paths with cuts deep enough to stabilize the climate.[6]

In the United States, perhaps more than any other large industrial economy, much of the action to cut emissions has occurred at the subnational level. That was true before the global pandemic; it may become even more true in the aftermath, depending on how stimulus policies evolve and on the fiscal and political priorities of states and cities. Plausibly, the places that were highly committed to action on climate before the pandemic will remain committed, while places that were reluctant to put much priority in climate earlier will be even more reluctant in the midst of economic free-fall and a big shift in priorities.

Given that, it seems important to take the pulse of what the country has been actually saying and doing on climate change as the economy reopens, and to do that requires looking far beyond the gridlock of Washington to the nation's interior — especially to the local level.

One place to start such an assessment is to look at the nation's many Climate Action Plans (CAPs). Since 1991, over 600 local governments in the United States have developed CAPs that include GHG inventories and reduction targets.[7]

These local plans — which entail a GHG emission inventory and the establishment of reduction targets, reduction strategies, and monitoring efforts — have been celebrated as an important counterpoint to national drift. For a decade, the best of plans have exemplified the hope that "bottom-up" action could add up to a powerful approach to climate action.

What's more, cities across the U.S. have taken on an even larger role in GHG mitigation efforts in the wake of changes in federal policy under the Trump administration and the government's withdrawal from the Paris Agreement.[8] Since June 2017, for example, over 250 U.S. mayors have signed the "We Are Still In" pledge to uphold America's commitment to the Paris Agreement[9] — all this as the landmark 2018 special report of the Intergovernmental Panel on Climate Change (IPCC) and subsequent analyses have detailed an increasingly disturbing picture of the near-term consequences of climate change on health, ecosystems, and the economy.[10]

Considering all of this, then, along with the fact that over 80% of Americans live in urban areas[11] and almost 70% of the global population will by 2050,[12] cities will likely continue to play a growing role in national and global efforts to address climate change including in the midst and aftermath of the pandemic. Therefore, it is important to take stock of the current status of cities' GHG reduction efforts and assess the progress they are making towards those efforts.

Hence this report: Given the increasing importance of expanded "bottom-up" action on climate, the goal of the analysis here is to inventory the various GHG reduction pledges and commitments of the 100 largest U.S. cities and estimate the potential emissions savings that could result from those pledges, as well as evaluate whether cities appear to be on track to meet their pledges.[13]

This inquiry is important because for all the opportunity associated with "bottom-up" approaches to climate response, there are also numerous questions. What standards or formats exist for presenting goals and results? What kind of results are emerging? Which involve real changes in behavior? Is all of this "bottom-up" action leading to real collective learning, or disorganization and evasion? How can policymakers learn which efforts are working? Getting a handle on these kinds of questions is essential since so much of the global effort around climate is now decentralized.[14]

In this fashion, then, the information that follows is intended to assess the current array of results on the ground and so further inform the growing discussion — now intensified amid the global pandemic — of the potential and limits of "bottom up" climate strategies in national and global processes. Specifically, the report assesses data up to 2017, recognizing that city-based action has continued beyond that year. On that front, the results are at once encouraging and concerning. At present the nation's "bottom-up" emissions-pledge system is generating genuine but partial climate actions, given that both its data-gathering and review-enforcement mechanisms remain in most cases disjointed and fractional.

The remainder of this report, in any event, is organized as follows: Section II discusses the primary methods used in the analysis; Section III summarizes the key findings of the analysis; and Section IV elaborates on the conclusions and suggests broader implications.

II. METHODS

The goals of this analysis are to: (i) inventory GHG reduction pledges and commitments for the 100 largest U.S. cities; (ii) estimate the potential emissions savings that could result from those pledges; and (iii) assess whether cities are on track to meet their pledges.

In order to tackle these issues, we identify the 100 most populous cities in the United States based on 2017 estimates from the U.S. Census Bureau.[15] We then parse the literature and cities' webpages to identify the GHG reduction pledges and targets for each of the 100 cities. We produce cursory estimates of the reduced emissions that would be achieved as a result of the established GHG reduction targets. We report cumulative emission savings that would occur between the baseline year used for the pledge and the final target year of the climate action plan for each city if the pledge were to be met. We also synthesize and evaluate the current emission levels within each city, and finally estimate the current state of each city's progress toward meeting their GHG reduction targets. Each of these steps is described in more detail below.

An assessment of the current GHG reduction pledges and targets for the 100 largest U.S. cities was conducted by a systematic review of reports, documents, and information produced by the cities. More specifically, details about the GHG reduction targets (or lack thereof) for each city were gathered via a combination of internet searching, review and search of the official websites of cities, and a review and search of websites and reports from organizations like ICLEI-USA and the Global Covenant of Mayors for Climate and Energy. Links to the sites and documents containing information about the GHG reduction targets for each city can be found in the supplemental material. In order for a city (and its GHG reduction target) to be fully analyzed, two key pieces of information are needed: (i) a specific reduction target (e.g., 80% reduction by year 2050) and (ii) a baseline emission level (e.g., 5 million metric tons of carbon dioxide equivalent [CO_2e] emissions in year 2005). Of the 100 cities reviewed, only 45 met these two criteria. It is worth noting that information about the specific reduction target and the baseline emission level were not always presented in the same report or webpage. An additional 22 cities have made some type of commitment to reducing GHG emissions but either did not establish a specific reduction target or have not yet completed a baseline GHG emissions inventory. These 22 cities were noted, but not incorporated into the remainder of the analysis. It is also important to note that in order to be included in the full analysis, all emission information needed to be directly reported by the cities (i.e., estimates from academic articles, national agencies, or other reports were not included) and that estimates should be limited to the city-limits (i.e., GHG reduction targets and estimates for Erie County, New York were not applied to Buffalo, New York).

The final emissions levels (assuming the GHG reduction target is fully met) were estimated by applying the targeted percent reduction (established by a given city) to the reported baseline emissions. For example, Chicago has 1990 as a baseline (32.3 million metric tons CO_2e) and has established a reduction target of 80% (compared to 1990) by year 2050. Therefore, the final emissions level for Chicago in year 2050 is roughly 6.5 million metric tons CO_2e (i.e., 32.3 million metric tons CO_2e * (1-0.8)). Note, cities that have established "net-zero" emissions as their target (e.g., Austin, Texas; Indianapolis, Indiana; Los Angeles, California; St. Paul, Minnesota; San Antonio, Texas; and Seattle, Washington) were assumed to achieve a 100% reduction in their baseline emissions by their target date. The overall reduced emissions on a per-year basis was then found by subtracting the targeted emissions level from the baseline emissions level. Returning to the Chicago example, the overall reduced emissions is roughly 25.8 million metric tons CO_2e per year in 2050 (i.e., 32.3 million metric tons CO_2e in 1990 - 6.5 million metric tons CO_2e in 2050).

Estimation of cumulative reduced emissions over the lifetime of the climate action plan for each city is based on subtracting the cumulative emissions *with* the climate action plan from the cumulative emissions *without* the climate action plan. The cumulative emissions *with* the climate action plan are calculated as the sum of the yearly emissions over the lifetime of the plan, assuming a linear decrease in annual emissions between the baseline year (the year for which the target is measured against, e.g., 2005) and the final target year (e.g., 2050). The cumulative emissions *without* the climate action plan are the sum of yearly emissions over the lifetime of the climate action plan under the assumption that emissions do not change, but instead remain constant at baseline emissions levels. (Note that these vary by starting date.)[16] Overall, this analysis relies on two key assumptions: (i) yearly emissions under a climate action plan are assumed to follow a linear reduction (i.e., constant decrease in annual emissions from year to year) from the baseline year to the final target year; and (ii) baseline emission levels are assumed to remain constant from year to year when estimating cumulative emissions without a climate action plan. (See the appendix for additional details.)

Three notes are needed here. First, while the linear reduction assumption is reasonable, it is not often the case that such pathways proceed in such an orderly manner. Second, it is worth stressing that while our analysis assesses the achievement of the goals of the pledges, it does not claim causality: that the goals are being met *because* of the climate action plans. Accordingly, the changes in emissions traced here may have occurred since the baseline year more as a result of changes in demographic, market, or economic conditions (for example, changes in the electricity generation mix due to the shale gas boom and/or changes in consumption patterns as a result of the 2008 recession), rather than because of climate action plans and policies. Other drivers could lead to emission increases, such as population growth between the baseline year and the target year. Related to this point, baseline emission levels in the absence of a climate action plan are unlikely to remain constant from year to year. As previously discussed, emissions may "naturally" decrease due to broader economic conditions and changes in the energy sector. In that case, our analysis will overstate the reduced emissions that actually result from the climate action plans. Similarly, emissions may "naturally" increase due to population growth and other demographic trends. In that case, our analysis will underestimate the reduced emissions that actually result from the climate action plans. All of these types of effects are excluded from the current analysis. Ultimately, the implementation of the above assumptions highlights some of the challenges that can emerge when trying to compare total reduced emissions across cities with different baseline years and target years — especially when there is often a dearth of consistent emission estimates for interim years and/or a significant gap between the baseline year and the establishment of the reduction targets. Third, there are many uncertainties and assumptions that go into an analysis like this, and those can have a big impact on the calculations of long-term emission reductions. In addition to all the usual caveats, the pandemic has added another one by affecting, among other things, travel behavior—not just right now but possibly in durable ways into the future.

Information about the progress and status of the GHG reduction targets (or lack thereof) for each city was gathered from the most recently available greenhouse gas inventory for each city as found via a combination of internet search, review and search of the official website for a given city, and a review and search of websites and reports from organizations like the Carbon Disclosure Project (CDP).[17] Note that the most recent GHG inventory for each city is often found on different sites and/or reports from the information outlining the overall climate action plan. Links to the inventory information for each city are provided in the supplemental material. Based on the most recent GHG inventory data from each city, progress was evaluated in two ways: (i) overall change in emissions compared to baseline emissions; and (ii) difference in actual emissions compared to targeted emissions in the year of the inventory. The change in recent emissions compared to baseline emissions was calculated as a percent difference between the inventory emissions and the baseline emissions (i.e., (Inventory Emissions - Baseline Emissions)/Baseline Emissions). The comparison between actual emissions and targeted emissions was calculated as a percent difference between the inventory emissions and the targeted emissions for the year in which the inventory was conducted (i.e., (Inventory Emissions - Targeted Emissions)/Targeted Emissions). Similar to above, the targeted emissions were calculated under the assumption that there is a constant linear decrease in annual emissions between the baseline year emissions (e.g., 2005) and the emissions in the year corresponding to when the inventory was conducted. See the appendix for additional details on the methods used and analysis conducted in this study.

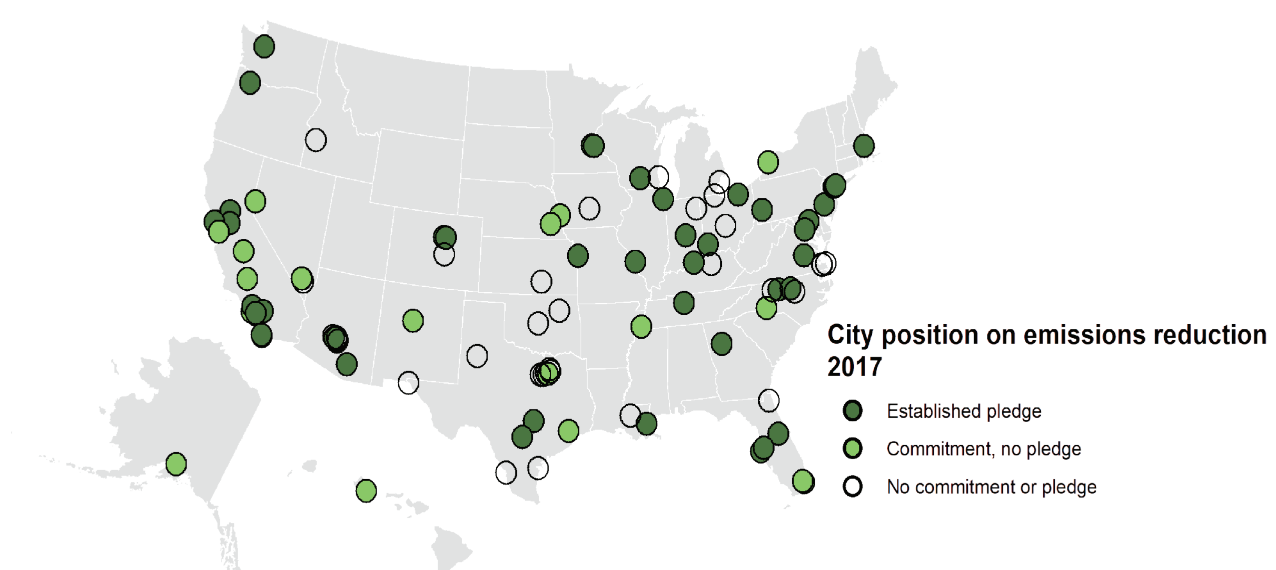
III. FINDINGS

FINDING 1

Slightly less than half of large cities have established GHG reduction targets. Where the goals exist, they tend to align with the 80%-decrease-by-2050 mitigation pathway consistent with the Paris Climate Accord, but tend to fall short of the mitigation pathways that limit warming to 1.5°C as modeled by the IPCC (i.e., net-zero anthropogenic CO_2 emissions around year 2050).

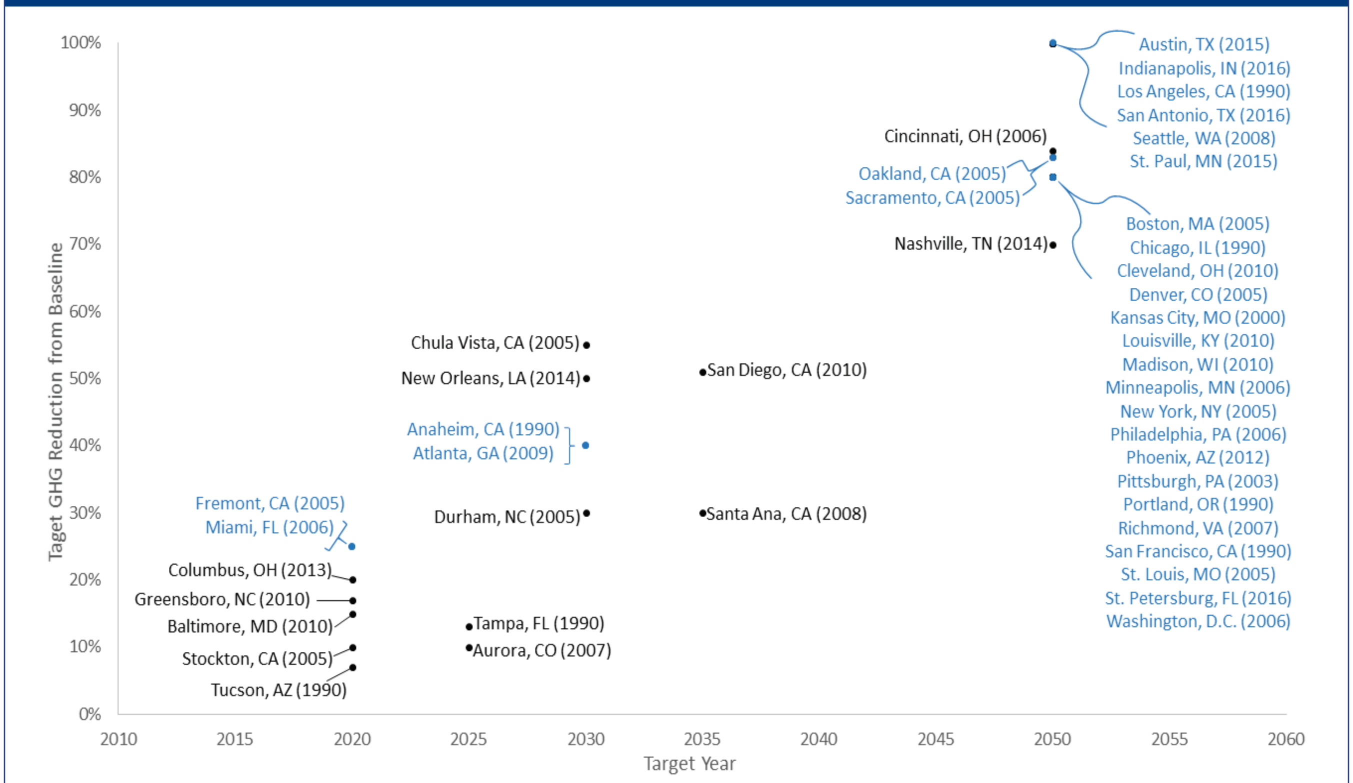
Of the 100 most populated cities in the United States, only 45 have established greenhouse gas reduction targets and corresponding baseline GHG inventories. An additional 22 cities as of 2017 had committed to reducing GHG emissions but had not established specific emission reduction targets or had not yet completed a baseline GHG emission inventory upon which to base their reduction plan. See Map 1. Where targets and baseline inventories do exist, the two sorts of information are not always presented in the same report or webpage, undercutting its utility for public benchmarking. So, in several ways U.S. cities' pledge-setting is sub-optimal in its coverage and design, with less than half of large cities setting targets.

Map 1: America's 100 largest cities by stated commitment on emissions reduction, 2017



Yet with that said, the targeting appears to comport with best practices in many instances. In the 45 cities, the GHG reduction targets now in place reflect the existence of a baseline emission inventory and the establishment of a target level of emission reductions by a target date. For example, the city of Richmond, Virginia has established year 2008 emissions as the baseline and has pledged to reduce overall GHG emissions by 80% by the year 2050. Across the cities, the targeted reduction ranges from 7% (in Tucson, Arizona) to 100% (i.e., "carbon neutral" in Austin, Texas; Indianapolis, Indiana; Los Angeles, California; St. Paul, Minnesota; San Antonio, Texas; and Seattle, Washington). Generally speaking, cities with lower reduction targets tend to have more condensed timelines. For example, Tucson's target year for its 7% reduction is 2020, while Austin's target year for its 100% reduction is 2050. Figure 1 summarizes the GHG reduction targets for each of the 45 target-setting cities. In particular, the figure depicts the final targeted percent reduction in emissions and the final year by which the reduction should be fully achieved. The values in parentheses next to the city names correspond to the baseline year of their climate action plan. Values in blue represent cities with the same reduction target and year.

Figure 1: Summary of greenhouse gas reduction targets (including targeted percent reduction and target year) for each city



Notes: The numbers in parentheses represent the baseline year of their climate action plans. Values in blue indicate multiple cities with the same reduction target and target year. The figure solely depicts the final targets for each city — not any interim targets.

In looking at the figure, it is worth noting that the most common reduction target among cities entails an 80% decrease in GHG emissions by the year 2050. This is significant because the 80% decrease by 2050 target is in line with the mitigation pathways modeled by the IPCC that limit warming to 2°C (but slightly behind the mitigation pathways that limit warming to 1.5°C), and so represents a well-informed and serious promise of effort.[18]

With that said, GHG reduction targets established by cities are generally non-binding commitments. To be sure, the cities in California are subject to the Sustainable Communities and Climate Protection Act of 2008 (SB 375) and California's Global Warming Solutions Act of 2006 (CA AB 32), which require state-wide GHG emissions to return to 1990 levels by year 2020 and an overall reduction of 80% below 1990 levels by year 2050.[19] Subsequently, Executive Order B-30-15 and SB 32 extended the goals to a 40% reduction below 2020 levels by the year 2030.[20] Subsequent legislation and executive action require the electric grid gets to zero emissions by 2045, and the whole economy to net-zero emissions by the same year. But even so, cities in California are not required to prepare a CAP or to make it binding although all the big cities are doing that. Additionally, a source of variation among cities and their respective GHG reduction targets across the country is the choice to establish interim GHG reduction targets. Ultimately, 16 cities established one target, 16 cities established two targets (one final target with one interim target), and 13 cities established three targets (one final target with two interim targets).

One other observation: Climate activity appears to be on the upswing. The results described above are based on the establishment of a new CAP or the most recent update to an existing plan. Overall, the oldest plans or updates are from 2010 and the newest are from 2019 (the median year for the plans is 2015). The years 2015 and 2018 turn out to have seen the most "activity" in terms of the establishment of a new climate action plan or an update to an existing climate action plan. In each year, seven new plans or updates were put into place. What's more, there are indications of an increase in city efforts since the Trump administration took office in January 2017. Seventeen of the 45 cities have implemented new or updated plans since 2017. See the supplemental material for full details of the year associated with each city's plan.

FINDING 2

Overall, roughly 40 million people (about 12% of the total U.S. population) live in bigger cities with active and fully-formed climate action plans.

The 45 cities with fully-established greenhouse gas reduction targets and corresponding baseline GHG inventories encompass a total population of roughly 40 million people. The smallest city is Richmond, Virginia (2017 population of about 870,000) and the largest is New York, New York (8.6 million residents). The 25 largest cities of the 100 included in our analysis contain 16 of the 45 climate plans. On the other hand, the 25 smallest cities of the 100 included in our analysis contain just six of the 45 climate plans. Overall, this distribution of plans appears to indicate that the limited time, money, and/or resources available to smaller cities may be hindering their ability to craft and maintain climate action plans.

Regarding the geography of the climate action plans, the inventory here finds that 24 states have at least one city with a climate action plan. California contains the most activity with plans in 11 cities, and no other state contains more than 4 cities with climate action plans. With the exception of the Northeast Census Region, the cities with climate action plans are relatively evenly-distributed across the country: The West Census Region contains 17 cities with plans, the South region contains 14, the Midwest contains 10, and the Northeast contains 4. One likely explanation for the relatively low representation in the Northeast is the fact that only seven of the 100 largest cities in the U.S. are located in the Northeast. In that context, the four cities with plans may in fact be quite good representation.

FINDING 3

Collectively, the total annual reduction in emissions that would be achieved by the 45 cities with both targets and completed inventories (in their respective target years) equate to approximately 365 million metric tons CO_2e assuming emissions without the

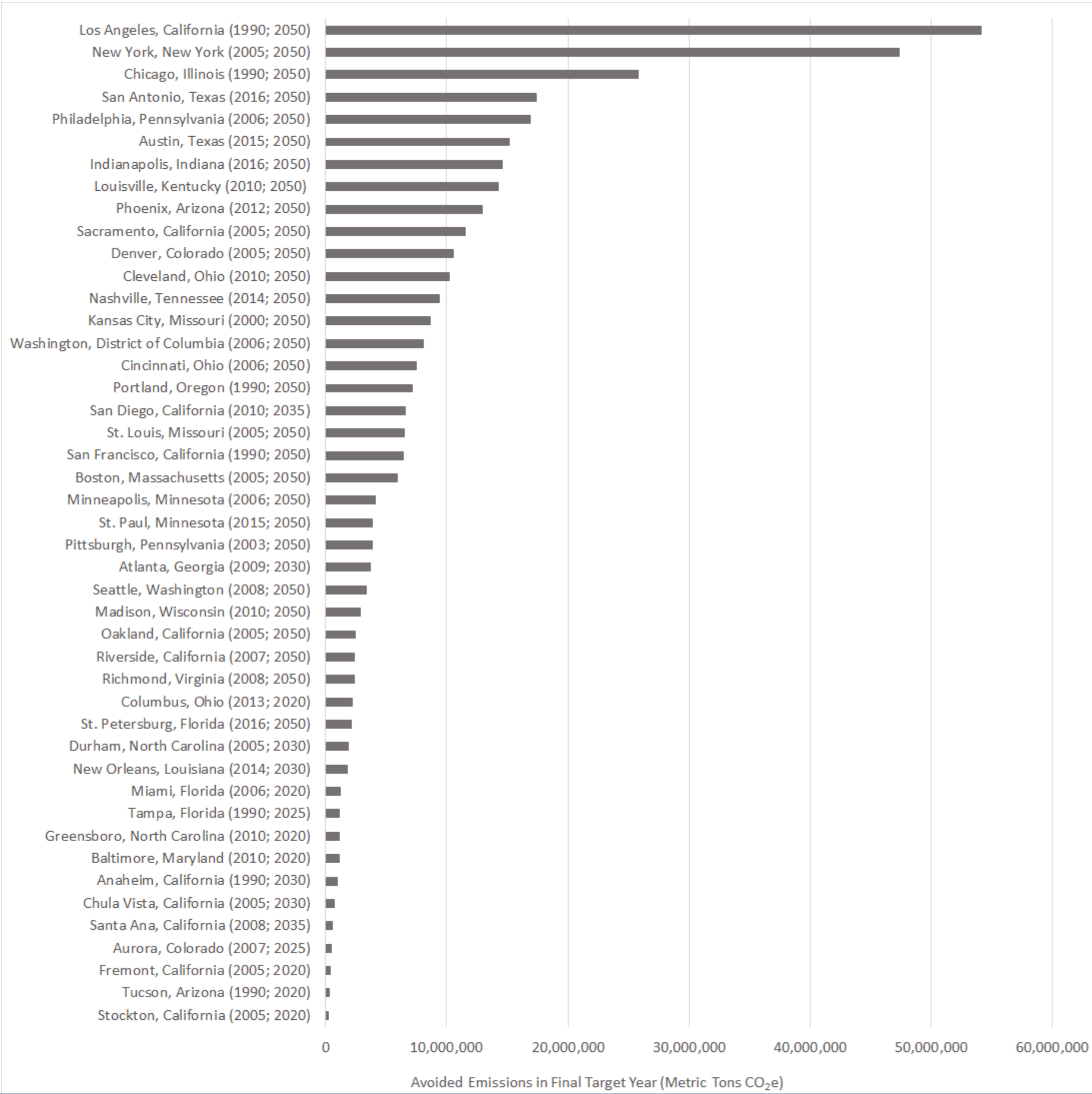
plans would remain the same from the baseline year to the target year. That's equivalent to removing about 79 million passenger vehicles from the road and comparable to the emissions reductions associated with natural gas switchovers in 2018.

The savings contributions from city CAPs vary widely but are adding up. Stockton, California is expected to achieve the smallest overall reduction (roughly 236,000 metric tons CO_2e per year), given its small size and narrower time-scale (its target year is 2020), and Los Angeles, California is expected to achieve the largest reduction (roughly 54.1 million metric tons CO_2e per year), given its large size and longer time-scale (its target year is 2050).

In aggregate, the prospective total annual reduction in emissions achieved by all 45 cities (in their respective target years) would equate to approximately 365 million metric tons CO_2e assuming emissions without the plans would remain the same from the baseline year to the target year. Under the assumption that if a plan target year occurs before 2050, the emissions after the target year remain constant, the results could be restated as a prospective total annual reduction of 365 million metric tons CO_2e by the year 2050. For context, the typical passenger vehicle in the United States emits approximately 4.6 metric tons CO_2 per year.[21] Therefore, the collective potential reduced annual emissions from the GHG reduction targets proposed by the 45 cities is equivalent to removing about 79 million passenger vehicles from the road. By way of a further comparison, the total annual emissions reductions pledged by the 45 cities with climate action plans, if achieved, would be comparable to the 300-450 million metric tons of emissions reductions scored in 2018 where natural gas has replaced coal for generating electricity.[22] Admittedly, the assumption of constant emissions between the target year and 2050 is unlikely to actually occur. Presumably, additional emission reduction targets and efforts would be put in place. However, this analysis takes a conservative approach to its estimates and so makes no assumptions about such follow-on reduction efforts. As a result, the present estimates are likely a lower bound of the emission reductions that will actually occur by 2050 (especially for cities that currently have final emission reduction targets in year 2030 or sooner).

In relation to the Paris Agreement, the collective prospective reduced emissions from the 45 cities equates to roughly 7% of the emission reductions to which the U.S. originally committed to achieve by year 2050.[23] Additionally, the IPCC suggests reducing global emissions to net zero CO_2 by roughly year 2050 in order to limit global warming to 1.5°C.[24] Thus, although the 45 cities would collectively achieve a 75% reduction in their annual emissions if they met their proposed reduction targets, an additional reduction of roughly 124 million metric tons CO_2e per year would be needed in order for the cities to be on pace with the IPCC's recommendations. Figure 2 depicts the estimated reduced annual emissions if each city achieved its GHG reduction target.

Figure 2: Summary of reduced annual emissions for each city upon achieving their GHG reduction targets (when compared to the annual baseline emissions) in the final target year

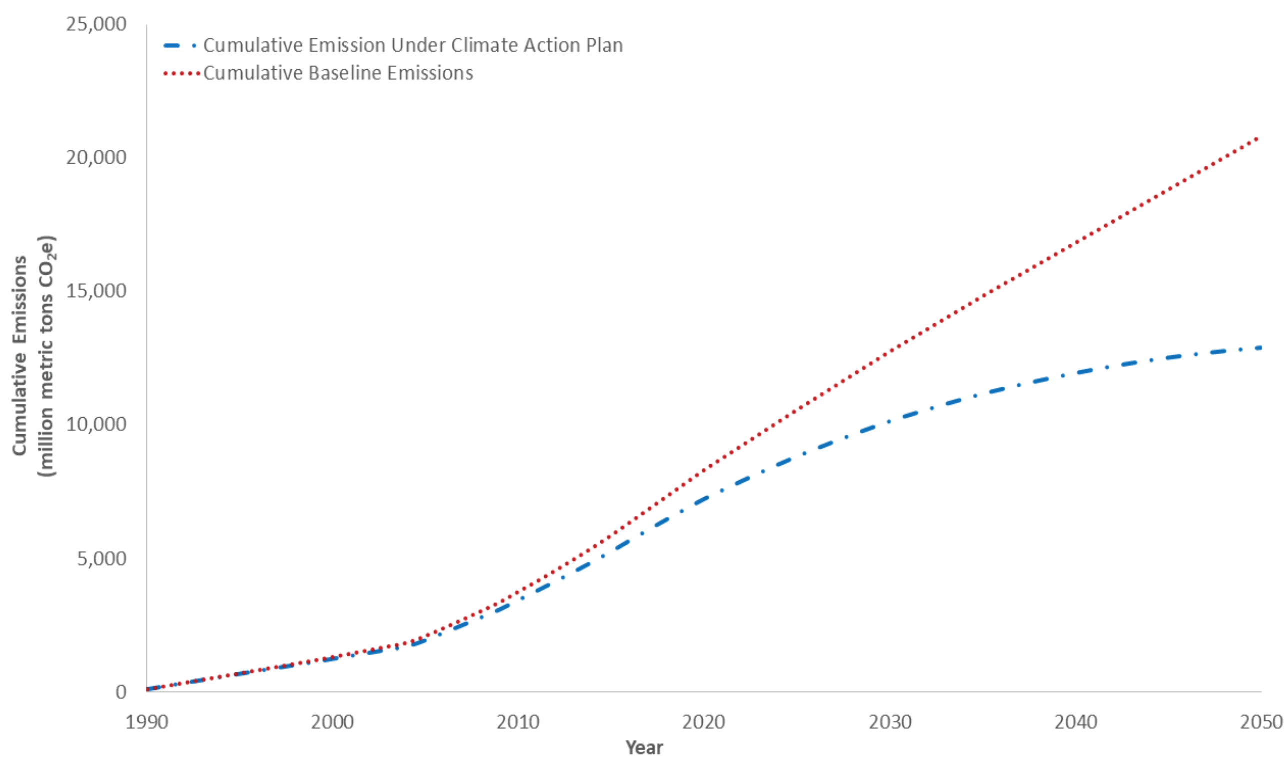


Notes: The final target year varies from city to city. The baseline year for each city is the first number included in parentheses. The second number represents the final target year for each city's reduction target.

Regarding the cumulative emissions savings achieved between the baseline year and the target year, we find that Stockton, California, is expected to achieve the lowest cumulative reduced emissions (roughly 1.9 million metric tons CO_2e). Stockton's relatively low cumulative reduced emissions is likely due to its relatively modest reduction target and its relatively short-term scope (i.e., a 10% reduction from 2005 emission levels by year 2020). Los Angeles, California is expected to achieve the highest cumulative reduced emissions (approximately 1.5 billion metric tons CO_2e). Los Angeles' relatively large cumulative reduced emissions are due to a combination of large reduction targets over a relatively long timeframe (i.e., 100% reduction from 1990 emission levels by year 2050) and relatively aggressive interim targets in the near term (i.e., 50% reduction in 1990 emission levels by year 2025) and the large size of the city.

In order to more easily compare cities, we have also computed the cumulative emissions savings for all cities between 1990 and 2050. Figure 3 compares estimates of cumulative GHG emissions for all cities from 1990 to 2050 with and without the proposed emission reductions. The cumulative baseline emissions are based on the sum of baseline emission levels for each city and are assumed to remain constant from year to year. In reality, cities may have seen increases or decreases in their emissions since the baseline year for reasons both related and unrelated to the climate action plan. However, due to a lack of widely available and reliable emission inventory data, these interim fluctuations in emissions between baseline year and present are not included in the analysis. Emission estimates under the GHG reduction plans are assumed to decrease in a linear fashion throughout the course of the plan. (See the appendix for additional details.) Furthermore, if a climate action plan's target year occurs prior to 2050, we assume the emissions will remain constant after the target year (at the targeted level). The figure highlights the fact that a large proportion of targeted emission reductions is not expected to occur until year 2030 or later — a timeframe that does not necessarily align with the urgency and haste recommended by entities like the IPCC.[25] Additionally, the concentration of emission reductions in the timeframe between 2030 and 2050 likely places additional pressure on cities to ensure that they have all of the correct technologies and policies in place to facilitate such a rapid emissions decrease over a relatively condensed time period (10 to 20 years).

Figure 3: Comparison of cumulative emissions from all cities between years 1990 and 2050 under two scenarios: (i) no climate action plans; and (ii) climate action plans/GHG reduction targets are fully implemented and met with emissions remaining constant after the target year



Notes: These cumulative emissions numbers should be interpreted with caution, as a city is only represented in the plot after its baseline year/ baseline inventory. For example, we show that Fremont, California has a baseline year in 2005 (see Figure 1), so Fremont will only be represented in this figure after 2005.

FINDING 4

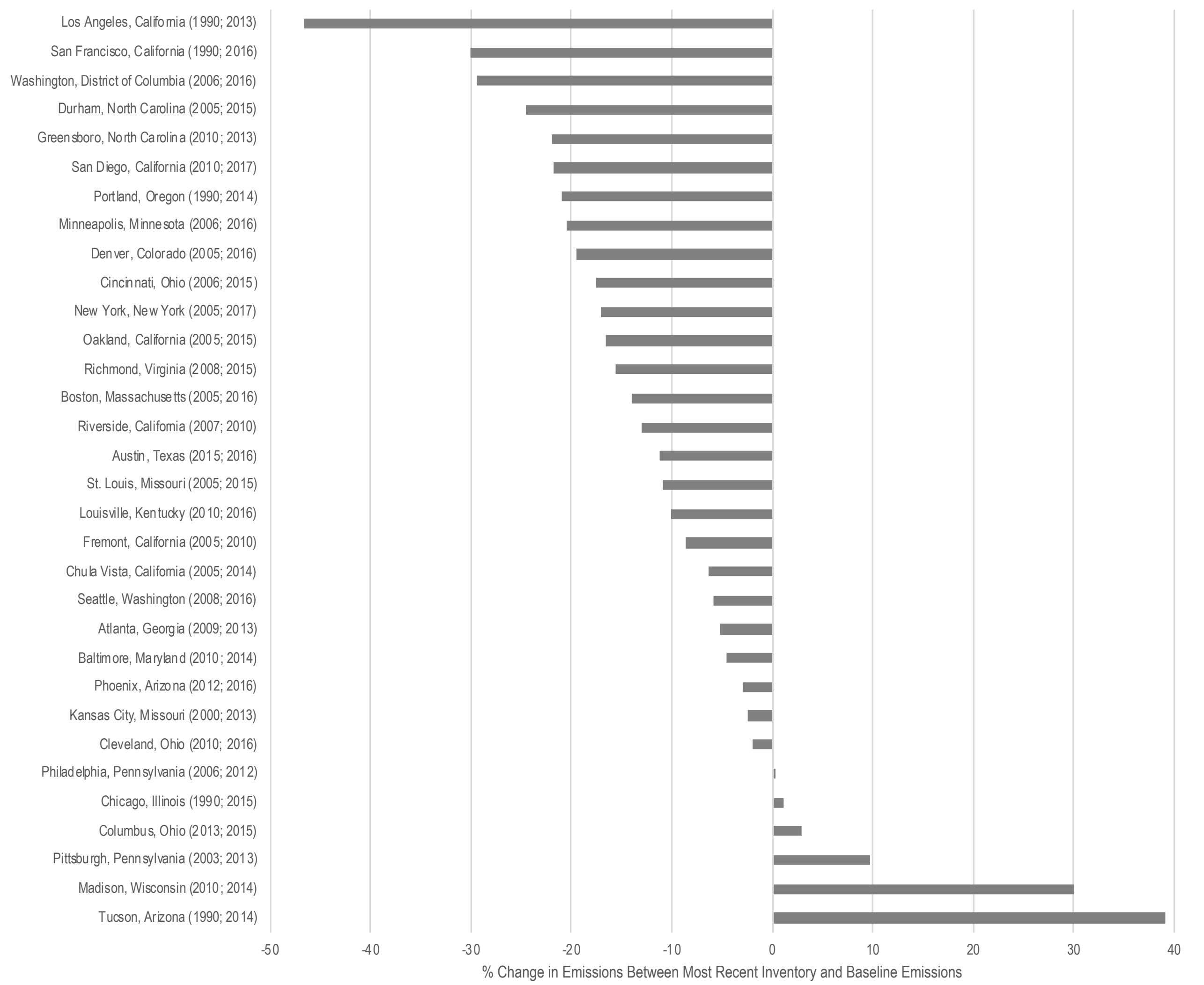
Despite genuine achievements in many cities, roughly two-thirds of cities are currently lagging their targeted emission levels.

Of the 45 cities with GHG reduction targets and corresponding baseline GHG inventories, 32 have conducted at least one additional GHG inventory. The remaining 13 cities do not appear to have any publicly available GHG inventories for the years subsequent to the establishment of their climate action plan (and corresponding baseline emissions). However, of the 13 cities without GHG inventories subsequent to setting their GHG reduction target(s), six had a baseline year of 2014 or later for their climate action plan. Therefore, subsequent "progress" GHG inventories for these locations are likely to be conducted and/or published in short order.

Based on their most recent GHG inventory data, 26 of the 32 cities that have at least one additional inventory (subsequent to the establishment of their climate action plan and baseline emissions) experienced a decrease in emissions compared to their baseline emission levels, while six cities experienced an increase. Los Angeles, California has experienced the largest decrease in emissions (about 47% below 1990 baseline levels), while Tucson, Arizona has experienced the largest increase in emissions amid runaway, sprawling growth (39% above 1990 baseline levels), followed by fast-growing Madison, Wisconsin. Figure 4 summarizes the difference between the most recent GHG inventory and baseline emission levels for each city.

Although the majority of cities experienced an overall decrease in their emissions compared to their baseline emissions, based on linear extrapolation, only a few appear to be on track to meet their emission reduction targets. More specifically, 12 cities met their targeted level of emissions for the year of their most recent inventory, while 20 cities had higher emissions levels than what the target level should have been for their most recent inventory year (again, assuming that cities would follow a linear decrease in emissions over time). Greensboro, North Carolina performed the best relative to targeted emissions levels (about 20% below target emission levels) and Chicago, Illinois performed the worst relative to targeted emissions levels (inventoried emissions were about 50% higher than target emission levels).

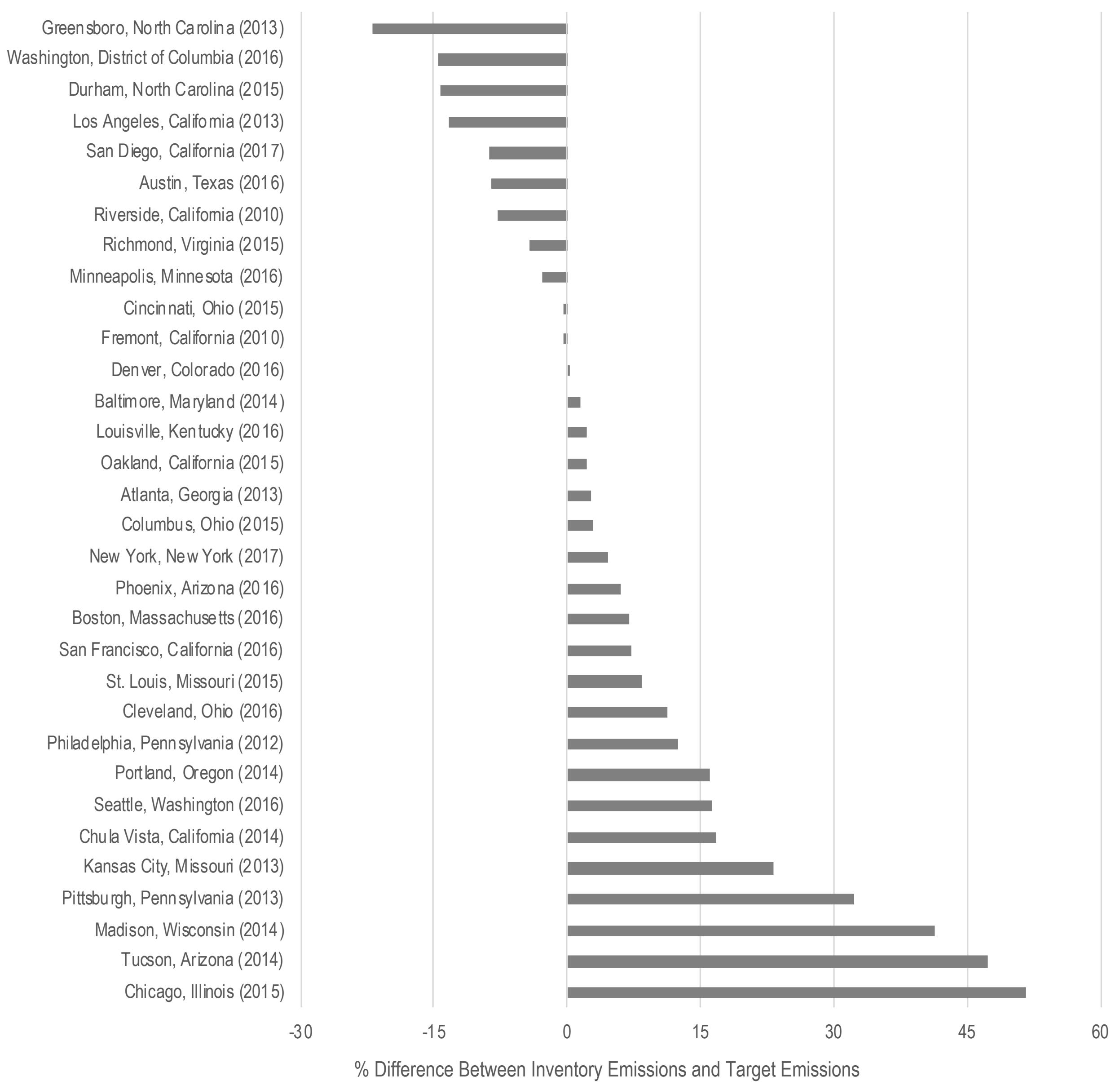
Figure 4: Percent change between most recent GHG inventory and baseline emissions



Note: The first number in parentheses next to the city name represents the baseline year. The second number in parentheses next to the city name represents the year of the most recent GHG inventory.

Figure 5 shows the difference between emission levels from the most recent GHG inventory performed by the city and the targeted emissions (under the climate action plan) for that same year. For example, Washington, DC performed its last emission inventory in 2016, and we compute the difference between emissions reported in that inventory and what they should have been under climate action plan goal in 2016 (assuming straight-line decrease in emissions between the baseline year and target year). Likewise, Chicago updated its inventory in 2015 and we report its emissions increase compared to the plan.

Figure 5: Difference between most recent GHG inventory emissions and targeted emission level in the year of the inventory



Notes: The numbers in parentheses next to the city name represent the year of the most recent GHG inventory. Positive values mean that the emissions from the city were higher than the targeted emissions for that year.

Overall, about two-thirds of cities are currently lagging their targeted emission levels, as is depicted by Figure 5. On average, in fact, the cities analyzed in this study will still need to reduce their annual emissions by roughly 64% by 2050 in order to reach their ultimate GHG reduction targets. This level of reduction corresponds to roughly a 4.7% average annual decrease in emissions per year across all cities (over the course of roughly 30 years) — a rate that only eight cities have been able to sustain over the course of their climate action plans. For additional context, the U.S. has only experienced an annual decrease in GHG emissions of at least 2% seven times since 1990, and between 1990 and 2017, the longest streak of consecutive annual decreases in emissions of at least 2% was two years.[26] Additionally, in order to achieve a reduction of 26-28% below 2005 levels by 2025 (as established by the Obama administration), the annual rate of reduction would need to be approximately 2.6% per year.[27]

FINDING 5

Overall, the development and implementation of city GHG plans and pledges — while important and encouraging — leaves room for improvement in terms of reach, rigor, and ambition.

Notwithstanding the early achievements of the best city GHG reduction plans and pledges, most cities' activities suffer from several shortcomings.

Generally speaking, forming accurate, consistent, and regularly updated GHG inventories is a relatively time-consuming and costly endeavor. In particular, data from and coordination with utility companies, departments of transportation, regional planning organizations, and other entities is often needed to develop GHG inventories that typically include emissions estimates for the building sector (i.e., electricity and natural gas used in the residential, commercial, and industrial sectors), transportation, and the production/disposal of waste generated within the city. Even though there are tools and organizations that help facilitate this process (e.g., ICLEI ClearPath,[28] CDP Reporter Services,[29] etc.), most of the burden of the inventory process still often falls on city staffers who may not have the full resources, training, or wherewithal needed to continually monitor and report community-level GHG emissions. This challenge is highlighted by the fact that of the 45 cities analyzed in this report, none have GHG inventories for years 2018 or 2019, and only two have GHG inventories for 2017 (an additional 10 have inventories for 2016). Similarly, the lower rate of activity among the smaller cities (i.e., only six of the climate action plans came from among the group of cities with the 76th- to 100th-largest populations) may be an additional indicator of the challenges that resource constraints can pose for developing GHG reduction targets and related emissions inventories.

Another possible hindrance to the overall success of city-led climate action plans is the fact that the GHG reduction targets set by cities are often non-binding. The primary exception is California, where SB 375 and AB 32 ensure that "cities and counties are involved in the development of regional plans to achieve [targets for reducing greenhouse gas emissions]." [30] Having non-binding GHG reduction targets can create a few different types of challenges. First, there is no real incentive to meet GHG reduction targets (or consequence for not meeting targets). This type of outcome is at least partly illustrated by the fact that roughly two-thirds of the cities analyzed in this report exceeded their targeted emissions levels for the year of their most recent inventory (see Finding 4). Second, without any type of legal or regulatory standing, the GHG reduction targets are subject to alteration or discard every time there is turnover within the city government. Considering that many of the climate action plans have a time frame of roughly 30 years (i.e., final reduction targets are often set for year 2050), the staff and administration changes likely to occur over this time period may be particularly disruptive to overall GHG reduction goals.

Finally, there are scope and boundary issues that can potentially hinder the progress of GHG reduction strategies.[31] Related to the GHG inventory process, factors like population growth, economic development, and changes in the energy mix are not always explicitly discussed and/or included in climate action plans. This is not to say that these factors are not considered by cities, but rather that it is often unclear whether they are included and to what effect. Ultimately, if the influence of population growth and economic development are underestimated or omitted from GHG reduction planning, then there is the potential for actual emissions in the future to far exceed expected/targeted emission levels. Related to the implementation of climate action plans, cities are often confronted with jurisdictional limitations. With the exception of places like Austin and San Antonio that have city-owned electric utilities, cities may be limited in their ability to influence or control the energy source(s) (and related emission intensities) associated with the electricity consumed by their citizens and businesses. Similarly, transportation is frequently an activity that occurs at a regional scale and may not necessarily be confined to the city limits (e.g., living in suburban areas and commuting to work). Therefore, cities may ultimately be capped in the amount of GHG reductions they can achieve without forming key partnerships with electric utilities and/or addressing transportation activity outside the city limits (but within the region).

IV. CONCLUSION AND IMPLICATIONS

In response to growing concerns about the likely impacts of climate change, cities have increasingly carved out leadership roles in the campaign to reduce greenhouse gas emissions. Accordingly, this report represents a significant effort to assess the current state of climate mitigation across U.S. cities, and so reviews and synthesizes the GHG reduction pledges and plans of the 100 most populated cities in the country. Overall, 45 of these cities have established GHG reduction targets and corresponding baseline GHG inventories, with the most common target representing an 80% reduction in emissions by the year 2050. So far, the cities analyzed in this study have achieved an average reduction of 10% compared to their baseline emission levels. However, our cursory estimates suggest that only about one-third of the studied cities — 15 of them — appear to be on track to reach their targeted emission reductions within the desired period. Ultimately, the results of this analysis detail a mixed story of laudable aspirations, notable GHG reductions in some cases, and less auspicious outcomes in most other cities.

With that said, there appear to be additional opportunities for leadership that cities across the country can avail themselves of in order to extend their leadership role and further their impact in global efforts to mitigate the impacts of climate change. Given that, the following discussion focuses on three broad priorities for increasing and widening the impact of the nation's important city climate pledges. These priorities focus on the need to:

- Improve the quality of pledges;
- Emphasize implementation;
- Develop better models; and
- Encourage learning.

What follows elaborates on these priorities:

Improve the quality of pledges. The middling participation and mixed performance of the city pledges assessed here point to an urgent need to inspire more cities to engage, elevate their sights, and commit.

More, and tougher, action is needed, to begin with. Even if the cities studied in this report achieve their GHG reduction targets, it would unfortunately account for a relatively small fraction of overall national (and global) emissions. For example, the 365 million metric tons that would be reduced on an annual basis by year 2050 if all 45 cities reached their GHG reduction targets translate to roughly 6% of total U.S. GHG emissions in 2017 (assuming emissions without the plans would remain the same from the baseline year to the target year). Six percent is not an insignificant number, but it is a far cry from the level of emission reductions that the IPCC suggests needs to occur in order to avoid many of the more significant impacts of climate change.

In light of that, one potential approach for facilitating the adoption and implementation of more climate action plans would be to focus on small-to-midsize cities, which could be aided through the development of aggressive new philanthropic initiatives comparable to the former Rockefeller Foundation 100 Resilient Cities initiative. However, instead of providing funding and resources to allow for the establishment of "resilience officers" and plans, major NGOS might *provide support to establish "Chief Mitigation Officers" in cities to drive the implementation of new climate action plans.*

Importantly, it will also be critical to address the fact that many of the needed emissions reductions will be achieved more cost-effectively outside of the city boundaries. For example, the electricity generation mix of the broader metropolitan or multi-state region where the city is located can have an enormous impact on the overall emissions. It would therefore be beneficial for larger cities to *form partnerships with surrounding suburban/exurban cities, metropolitan planning organizations, utility companies, and state/national government agencies.* In doing so, it is likely that knowledge and resources will be shared more effectively across regions and sectors, and GHG reduction plans will become more comprehensive and impactful. Through such partnerships, as well as through intensified peer sharing (including through intensified "leadership" and "followership"), bigger designs and impact may emerge.

In more practical terms, advancements that can help cities streamline or automate their emission inventory process have the potential to significantly influence the success of climate action plans.[32] Some potentially useful starting points include the Environmental Protection Agency's Greenhouse Gas Inventory Tool, and the Department of Energy's Cities Leading through Energy Analysis and Planning (Cities-LEAP) program.[33] Based on our analysis, it appears that maintaining consistent and up-to-date GHG inventories remains a challenge. For example, 22 cities that have established greenhouse gas reduction targets are not yet able to fully pursue their climate action plan because they have not yet conducted a baseline emissions inventory. Similarly, as mentioned for Finding 5, only two cities have GHG inventories from 2017 or later. Thus, any steps that can be taken to reduce the resources and/or effort needed by the cities to conduct GHG inventories will likely help them focus more attention on implementing GHG reduction policies and strategies (rather than continual inventorying of emissions), and have an overall positive effect on successfully reaching their GHG reduction targets.

One potential strategy for streamlining and consolidating the GHG inventory process would therefore be to *designate a centralized entity (or group of entities) to handle all data processing and inventorying activities.* For example, this type of effort aligns well with (and is complementary to) ongoing initiatives by the U.S. Environmental Protection Agency (e.g., the Inventory of U.S. Greenhouse Gas Emissions and Sinks,[34][GHGRP],[35] and the Facility Level Information on Greenhouse Gases Tool [FLIGHT],[36] for example) and/or the U.S. Energy Information Administration (e.g., the Annual Energy Outlook,[37] the Short-Term Energy Outlook [STEO][38]). If given the appropriate resources, state governments and/or NGOs such as ICLEI USA, CDP, and the Global Covenant of Mayors for Climate and Energy might also be well-suited to serve as centralized entities for conducting and reporting GHG inventories.

Such an approach could allow for new approaches to emissions pledging. Rather than devoting limited resources to continually inventory and reduce emissions from all activities and sectors, cities might be might be able to consider an unorthodox approach that would have them *focus their efforts on the activities or sectors where they are likely to have the largest impact* — at least in the near- to mid-term — including by inspiring "followership" among other cities worldwide. Climate cooperation is a followership game in which leaders should pay closer attention to which factors scale; and which green steps inspire action by others.[39]

After conducting an initial baseline emission inventory, in this regard, it might be most effective for cities to focus their reduction efforts (and subsequent inventory efforts) on one or two activities rather than all sources of emissions, with a special focus on ones with outsized impact or novelty or experimental value. For example, a given city may want to focus most of its initial efforts and resources on initiatives like minimizing emissions from waste generation and disposal, incentivizing efficiency programs within buildings, or updating building codes. The emissions from these activities may be modest compared to other sources, but at least the city is likely to have jurisdictional control and a strong ability to enact change as well as emulation. Alternatively, although it would be more difficult and require more coordination across a given region, certain cities may choose to focus a majority of their effort on reducing emissions from the transportation sector (which is the largest or second-largest source of emissions in nearly every city). For example, in the United States, city and regional governments can play a major role in reducing the amount of vehicle miles traveled by investing in public transportation systems and implementing policies that encourage high-density urban development. Additionally, cities can also make strategic investments and implement insightful policies that ensure the growing adoption of electric vehicles, ride share programs, and autonomous vehicles accelerates the decline in GHG emissions from the transportation sector. Ultimately, this approach of limiting inventory and reduction efforts to one or two key activities will likely mean that cities would forgo placing much emphasis on emissions from the electricity sector, as these often occur at geographic and temporal scales that are difficult for cities to meaningfully affect. Nonetheless, cities could still serve as powerful advocates and proponents for state/national-level policies aimed at encouraging low carbon electricity sources.

Emphasize implementation. Second, and relatedly, widening and improving the present partial, voluntary, and mostly inadequate pledge system is going to require more incentives.[40] The current decentralized process is driven by cities feeling pressure to act and, in theory, from incentives that could help pay for some of the costs of experimentation. Without much support at the federal level, there aren't very many carrots available, although some states are creating carrots for example in California. Here, again, state, NGO, and philanthropies could play a critical role if they *put in place new incentives for new, strong pledges as well as implementation*. Right now, the fear factor is large as are the rewards of symbolic politics. What would be helpful would be a new incentive system that encouraged new action, rigorous execution, and bold, well-publicized experiments, including ones that fall short.

Develop better models to estimate actual emissions changes. Thirdly, in the end, people want to know whether city-level action really reduced emissions — below the levels that might have otherwise occurred. This kind of counterfactual analysis is always hard, but it is possible to do better than current approaches (e.g., assuming emissions trajectories will be flat) with models the disentangle the factors under control of city planners and policy makers and those that vary largely beyond local control.

There are no magic bullets for fixing this problem, but there is a large community of energy systems modelers with powerful tools that, for the most part, have not focused on the city level — instead, their models tend to be designed for broader tasks such as analyzing nation-wide or global energy trends. As this community turns its attention to where the action is — at state and city levels-they could use these subnational pledges as good tests for the accuracy of their models. A tournament of modelers, for example, could give teams the information available about city pledges up to a certain year and see which models perform best. Retrospectives and model intercomparisons — as done, for example, the Energy Modeling Forum — could put more attention on this frontier in modeling, with a particular emphasis on learning which kinds of city action have big impacts on emissions and which are orthogonal because the activities that cause emissions beat to drummers that aren't in City Hall but, instead, are at the state level (e.g., state regulatory commissions) federal level (e.g., FERC) or exogenous to these policy processes (e.g., some types of profound technological change).

Encourage learning. Finally, and relatedly, the system for pledging and delivering on commitments must be improved to better assess, review, and strengthen actions. For one thing, cities and third-party actors need to *publish much more detailed and frank information about what cities are trying* in order to allow assessment and learning. Whereas top-level abstract targets are available, what is equally or even more needed is detailed information about which policies are being put into place, which initiatives are working and which are failing.

Beyond that, rigor requires mechanisms that *make transparent and review what is working and failing.* That is vital to learning. Almost everywhere such mechanisms have a substantial degree of centralization because one must be able to look across diverse experiences and make that information available. Which is why effective "bottom-up" systems are neither completely decentralized nor hierarchical. In this vein, improvement of the pledge system may in the future find city-based institutions doing a lot more to review and share information about each other's commitments.[41] Cities that want to be in the lead might nominate themselves to lead in organizing reviews and assessments of their willing and interested peers. Meanwhile, networks are needed for spreading the word about what works and fails that make it easier for other cities to pick up the lessons of today's current living laboratories. In that way, mutual review might lay out best-practices for review processes that then might begin to build up norms and procedures and expectations that might improve the quality and results of commitments. In that fashion, the leaders may be able to inspire and instigate more action by the followers.

In sum, cities across the country (and the globe, although that is outside the scope of this study) have made substantial efforts to reduce their GHG emissions. Given the commitments discussed and analyzed in this report, cities appear poised to remain leaders in global GHG mitigation efforts over the next several decades. However, given recent recommendations by the IPCC, it appears that a redoubling of efforts is needed by cities (as well as surrounding states, regions, countries, and companies) in order to avoid the worst of the potential consequences of climate change. The cities that have already pledged to reduce their emissions will need to pursue aggressive GHG reduction strategies over the next 30 years in order to ensure that their GHG reduction targets are met (and perhaps exceeded). Similarly, additional efforts are needed to ensure that climate action plans and GHG reduction targets are nearly ubiquitous across all cities — currently, only 45 of the 100 largest cities in the U.S. have such strategies in place.

For sure, cities across the country will be key catalysts in preventing catastrophic damage from the effects of climate change over the coming decades. But ultimately, a few dozen vanguard cities alone cannot be the primary mechanism by which GHG mitigation efforts are implemented. Overall, the world is facing an unprecedented challenge with climate change, that requires action at all levels. The needed emissions reductions that we face as a society is daunting and pressing. People, cities, states, and the nation need to move forward in enable these emissions reductions as soon as possible.

APPENDIX A: DETAILED METHODS

Broadly speaking, the analysis associated with this report consisted of the following elements: (i) a summary of the GHG reduction pledges and targets for the 100 largest cities in the U.S.; (ii) an estimation of the final emissions level and overall reduced emissions that would be achieved as a result of the established GHG reduction targets; (iii) an estimation of the cumulative emissions savings that would occur over the lifetime (i.e., the time between the baseline year and the final target year) of the climate action plan for each city and also up to 2050; (iv) a synthesis and evaluation of the current emission levels within each city; and (v) an estimation of the current state of each city's progress toward meeting their GHG reduction targets. The remainder of this section provides additional elaboration on specific approaches and terminology associated with each of these elements of the analysis.

Summary of GHG reduction pledges

The basic framework for climate action plans (CAPs) is to conduct a greenhouse gas (GHG) emission inventory, establish GHG emission reduction targets, develop strategies for achieving the reduction target(s), implement those strategies, monitor results and progress, and make modifications as necessary. Following is some key terminology related to the CAP process.

- *Baseline Year*: If a city has established a GHG reduction target(s), this value corresponds to the year of the baseline emission levels to which the targeted reductions are measured against.
- *Baseline Emissions Reported (metric tons CO_2e)*: The baseline emission level to which the targeted reductions are measured and assessed against. All values are reported by the cities themselves in their greenhouse gas reduction plan or supporting documents. All values are in units of metric tons CO_2e.
- *Targeted Decrease*: Desired percent reduction in emissions (from baseline levels) established in the greenhouse gas reduction plan/pledge. Some cities establish a single target, while others establish two or three targets. For example, Denver has a long-term GHG reduction target of 80% below 2005 emission levels by year 2050 and two interim targets (45% reduction by 2030 and 65% reduction by 2040).
- *Target Year*: The year in which the desired percent reduction in emissions should be achieved.

Estimation of reduced emissions

We estimate reduced annual emissions in the target year by subtracting the emissions level in the target year (assuming the established GHG reduction target is met) from the emissions level in the baseline year. The analysis is only conducted for cities that have both a firmly established GHG reduction target and an estimate of baseline emissions levels. Following are some key terms related to the estimation of reduced emissions:

- *Reduced Emissions*: The amount of emissions (in metric tons CO_2e) that would be reduced in the target year if the target reduction is fully achieved. This value is calculated by multiplying the Baseline Emissions Reported (metric tons CO_2e) by the Target Decrease (%). For our analysis, this term refers to the reduction associated with the final reduction target. However, it could also apply to interim reduction targets.
- *Emissions Level at Target*: The total emissions (in metric tons CO_2e) for a given city in the target year if the targeted reductions are achieved. This value is calculated by subtracting the Reduced Emissions from the Baseline Emissions Reported.

Estimation of cumulative reduced emissions

This analysis estimates the cumulative emissions savings that would occur over the lifetime (i.e., the time between the baseline year and the final target year) of the climate action plan for each city, and out to year 2050. Estimates are based on the final target in order to represent "fully" implemented plans. The overall calculations are based on two key assumptions: (i) For cities with greenhouse gas reduction targets, yearly emissions were assumed to follow a straight-line reduction from baseline year to final target year; and (ii) to estimate cumulative emissions without a climate action plan, baseline emission levels were assumed to remain constant from year to year. In other words, for years between the baseline and target year we assume that the emissions that would have occurred if no plan was in place would be the same as the baseline emissions, and that the emissions that would occur with a plan are decreasing linearly between the baseline and target year. Finally, when we report cumulative emissions reduced until 2050, we assume that if a plan target year occurs before 2050, the emissions after the target year remain constant. As a result of these assumptions, the values in this analysis are likely to be lower-bound estimates because the year-to-year emissions without a climate action plan would likely increase (at least for a certain amount of time) as a result of factors like population growth rather than remain constant. Additionally, for select cities where the baseline year significantly pre-dates the establishment of the climate action plan, there is the possibility that emission reductions that occur between the baseline year and the establishment of the plan are incorrectly attributed to the plan. In this case, the assumptions are likely to result in an overstatement of the emissions reductions for those interim years. However, this situation only really applies to the six cities with 1990 as a baseline (Anaheim, Chicago, Los Angeles, Portland, San Francisco, and Tucson). Despite the potential uncertainties that may result from our assumptions, we believe our approach to be the most straightforward and justifiable. Any additional approaches to estimating emissions in the interim between a baseline and the establishment of the climate action plan (and/or estimating emissions between the final target year and 2050) would have required additional assumptions that would have introduced additional uncertainty (and that we felt were harder to justify). More details about specific elements of the estimated cumulative reduced emissions follow:

- *Final Target Year*: This is the year in which the final GHG reduction target is expected to be fully achieved. For cities with two targets, this is the year at which Target 2 is expected to be reached. For cities with three targets, this is the year at which Target 3 is expected to be reached.

- *Reduced Emissions in Final Target Year*: This reflects the amount of emissions (in metric tons CO_2e) that would be reduced in the final target year if the target is achieved. For cities with two reduction targets, this is the amount of emissions (in metric tons CO_2e) that would be reduced in the second target year if the target is achieved. For cities with three reduction targets, this is the amount of emissions (in metric tons CO_2e) that would be reduced in the third target year if the third target is achieved.

- *Emission Level in Final Target Year*: This reflects the total emissions (in metric tons CO_2e) for a given city in the final target year if the targeted reductions are achieved. For cities with two reduction targets, this is the total emissions (in metric tons CO_2e) for a given city in the second target year if the Target 2 reductions are achieved. For cities with three reduction targets, this is the total emissions (in metric tons CO_2e) for a given city in the third target year if the Target 3 reductions are achieved.

- *Averaged Per Year Decrease in Emissions*: This is the estimate for the annual decrease in emissions that would occur throughout the lifetime of the greenhouse gas reduction plan. This value is based on the assumption of straight-line reduction in annual emissions between Baseline Year and Final Target Year. This value is calculated as:

  Reduced Emission in Final Target Year / (Number of years between baseline and target year)

- *Cumulative Emissions Without Climate Action Plan*: This is the sum of yearly emissions over the lifetime of the climate action plan under the assumption that emissions do not change, but instead remain constant at baseline emission levels. This value is calculated as =:

  *Baseline Emissions Reported * Number of years between baseline and target year*

- *Cumulative Emissions With Climate Action Plan*: This is the sum of yearly emissions over the lifetime of the climate action plan assuming the final target emission level is achieved in the Final Target Year. To calculate this value, emission levels are estimated for each year of the climate action plan by starting with the baseline emission level and subtracting the Averaged Per Year Decrease in Emissions for each year until the Final Target Year is reached — calculation of interim emissions targets was included in the analysis where applicable. Finally, cumulative emissions are found by taking the sum of the estimated emission levels for each year of the climate action plan.

- *Cumulative Reduced Emissions*: This is the cumulative emissions reduced over the lifetime of the climate action plan. This value is found by subtracting the Cumulative Emissions with Climate Action Plan from the Cumulative Emissions without Climate Action Plan. As mentioned above, this value is likely a lower-bound estimate, but in some cases could be an upper-bound estimate (especially in cases where the baseline year substantially predates the establishment of the climate action plan). Related to this point, baseline emission levels in the absence of a climate action plan are unlikely to remain constant from year to year. Emissions may "naturally" decrease due to broader economic conditions and changes in the energy sector. In this case, our analysis will overstate the reduced emissions that actually result from the climate action plans. Similarly, emissions may "naturally" increase due to population growth and other demographic trends. In this case, our analysis will underestimate the reduced emissions that actually result from the climate action plans.

Analysis of current emissions status and progress toward GHG reduction goals

This analysis seeks to evaluate the progress that cities are making toward their GHG reduction targets by comparing current GHG estimates (as indicated by the most recently available GHG inventory for a given city) to baseline emission levels and target emission levels (for the year in which the inventory was conducted). Following are additional details and key elements of this analysis.

- *Inventory Year*: This is the year in which the most recent GHG inventory was conducted.

- *Inventory Emissions (metric tons CO_2e)*: This is the overall GHG emissions estimated and reported by a city as a result of its GHG inventory in the given Inventory Year.

- *Percent Change from Baseline*. This reflects the percent difference between the emissions levels in the most recent GHG inventory and the baseline emissions levels for the climate action plan. This value is calculated as:

  *{(Inventory Emissions – Baseline Emissions Reported) / Baseline Emissions Reported} * 100*

- *Target Emissions for Inventory Year (metric tons CO_2e)*. This figure is an estimate of the total emissions for a given city for the year in which the most recent GHG emissions inventory was conducted. This estimate assumes that there is a constant linear decrease in annual emissions over the course of a climate action plan as cities move from their baseline emissions to their final target emissions. For example, Atlanta has an overall target of a reducing GHG emissions by 40% compared to baseline 2009 levels by the year 2030. This reduction target translates to an annual decrease in emissions of roughly 1.9% between years 2009 and 2030. Likewise, Atlanta's most recent GHG inventory was conducted in 2013. Therefore, the Target Emission Level for Inventory Year for Atlanta (roughly 8.6 million metric tons) was calculated by starting with Baseline emission levels (roughly 9.3 million metric tons) and applying the 1.9% annual decrease in emissions to each year between 2009 (the Baseline Year) and 2013 (the Inventory Year).

- *Percent Difference between Inventory and Target Emissions in Inventory Year*. This is the percent difference between the emissions levels in the most recent GHG inventory and the level of emissions expected under the climate action plan for the year in which the inventory was conducted. This value is calculated as:

  *{(Inventory Emissions – Target Emissions for Inventory Year)/ Target Emissions for Inventory Year} * 100*

- *Percent Change Needed to Reach Target Emissions*. This is the percent difference between the projected emissions in the Final Target Year (assuming targeted reductions are fully achieved) and emissions levels in the most recent GHG inventory. This value is calculated as:

  *{(Emissions in Final Target Year – Inventory Emissions)/Inventory Emissions} * 100*

- *Average Annual Percent Change Needed to Reach Target Emissions*. This estimates the average annual percent change in emissions that would need to occur throughout the remaining lifetime of the greenhouse gas reduction plan in order to move from the inventory emissions level to the final targeted emissions level. This value is based on the assumption of straight-line reduction in emissions between Inventory Year and Final Target Year. Based on this assumption of linear emissions reductions, the emission level for each year between the inventory year and the target year are estimated. Then, the percent change in emissions levels is calculated for each year between the inventory year and the target year. Finally, the mean of the annual percent change in emissions levels for each year is calculated to produce the Average Annual Percent Change Needed to Reach Target Emissions. The average of the averages for each city was also calculated (4.7% decrease per year) and discussed toward the end of Section IV.

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