What's Driving Changes in Local GHG Emissions? Results from Contribution Analysis

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ICLEI Local Governments for Sustainability USA

GLOBAL CLIMATE ACTION SUMMIT

Forward

This publication is part of a collaborative series from over 30 organizations released in support of the Global Climate Action Summit, which showcase the extraordinary action of states, regions, cities, businesses, investors and citizens – and assess the opportunity for even greater impact.

Collectively, working independently and in coalitions with national governments, these actors have the potential to reduce global greenhouse gas emissions in line with the Paris Agreement. For example, global emissions in 2030 could be cut by a third if all international cooperative initiatives—such as Under2 Coalition, RE100, C40, the Global Covenant of Mayors, and those defined independently by scores of communities—meet their goals.

In this specific publication, we focus on local communities, including cities and counties from the United States to understand the interplay between local, state, and national action as well as their contributions to national and global efforts to reduce emissions and prevent the most damaging impacts of climate change.

Executive Summary

This report presents results from applying a new technique called Contribution Analysis to local community greenhouse gas (GHG) inventory data. Contribution Analysis separates out the impact of different drivers of change between multiple inventory years. The drivers looked at include population/commercial growth, energy usage per person, and the carbon intensity of energy sources. Contribution Analysis is applied to three sets of GHG inventory data:

1. Data from fifteen pilot communities where a detailed Contribution Analysis was completed, including the impact of weather on energy use.
2. A broader data set of GHG inventories from 138 local governments.
3. Sixteen years of annual data for one city, Portland, Oregon.

For each data set, emissions from residential and commercial electricity and from on-road gasoline use were analyzed. In addition, for the fifteen pilot communities, results are shown for residential and commercial heating fuels.

The key findings from this analysis are:

1. **Both a cleaner electric grid and energy efficiency have important roles to play to offset growth and reduce emissions from commercial and residential electricity.** State-level policies advancing renewable energy, combined with local, utility, business and individual action for energy efficiency can overcome growth and drive significant emissions reductions.

2. **State energy efficiency policies have a noticeable effect on changes in commercial energy usage.** Local governments in states with a high energy efficiency policy score[1] show per-employee energy use decreasing more rapidly than those in lower-scoring states. This relationship was not found for residential energy use; more research is needed to determine why not.

3. **Both more efficient vehicles and reduced vehicle miles per person have important roles to play to offset growth and reduce emissions from on-road transportation.** In a majority of communities analyzed, improvements in vehicle fuel efficiency and reductions in vehicle miles per person are sufficient together to reduce emissions despite population growth.

4. **Transportation emissions are more challenging than electricity emissions and more work is needed.** While the overall trend is in the right direction, transportation emissions are not decreasing as rapidly as those from electricity, and emissions are still increasing for 37% of communities. More work is needed to address both vehicle miles per person and vehicle fuel efficiency or fuel switching.

Overall, the analysis shows that progress is being made to reduce local GHG emissions. However, each city has a unique set of factors and challenges related to GHG reduction that should be considered to identify the right mix of mitigation strategies to address the specific local context.

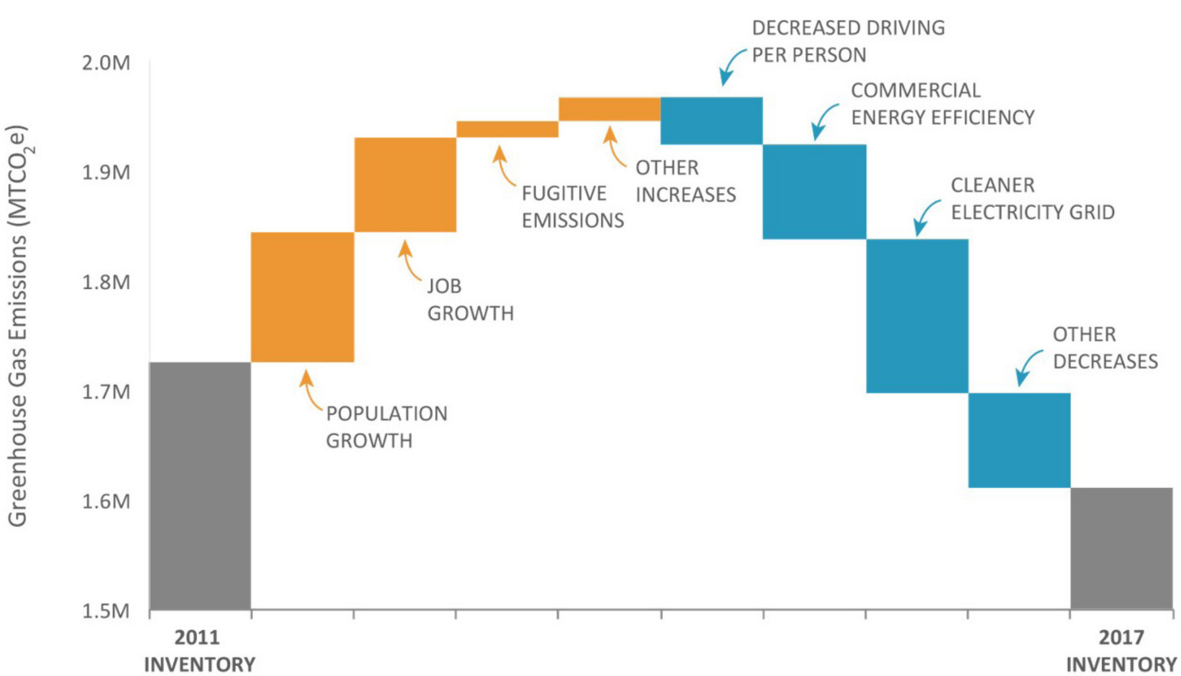
[1] American Council for an Energy-Efficient Economy (ACEEE) state energy efficiency scorecard.

Contribution Analysis

Through initiatives like the Global Covenant of Mayors, thousands of cities worldwide have stepped forward committing to address climate change and take steps to quantify baselines and progress towards their reduction targets by performing periodic greenhouse gas inventories. The practice of community scale inventories has evolved rapidly. As a large amount of performance data is beginning to emerge, it is becoming clear how important data choices are to maximizing the benefit of the effort in support of long term performance management and data driven focus on mitigation actions. A new technique called Contribution Analysis allows separating the contributions of different drivers to changes in local community emissions between multiple years' inventories.

Contribution Analysis for local GHG emissions was developed through a two-year project supported by the US Department of Energy's **Cities Leading Through Energy Analysis and Planning** (Cities-LEAP) program, and led by the City of Bellevue, WA and ICLEI-Local Governments for Sustainability, USA (ICLEI). The project conducted pilot analysis for 15 communities, and also produced a free downloadable toolkit to allow any city with two or more inventories to perform an analysis for themselves. The toolkit is available at **icleiusa.org/ghg-contribution-analysis/**.

This report presents results from applying Contribution Analysis to the nationwide set of emissions inventory data from ICLEI USA's ClearPath emissions management tool.



Pilot Community Findings

In the development of the Contribution Analysis Toolkit, ICLEI worked with several pilot communities to both advise the development of the toolkit and provide more in-depth data to test the methodologies against. Following is a summary of those results. It is important to note that this sample size is small and the communities are dissimilar in almost every aspect, including size, climate, and economic profile. Thus it is difficult to draw universal conclusions from these results, though some important trends stand out.

The charts in the following sections illustrate the percent change of emissions within the sector and energy type as a result of changes in each of the factors listed. Displaying the results in percentage terms helps to normalize for the significant size disparities between communities. Each line in the chart represents a single pilot community connecting the impact made by each of the major factors analyzed. A key aspect of the Contribution Analysis methodology is the way that each factor is accounted for in sequence such that value ascribed to it is "taking account of other factors".

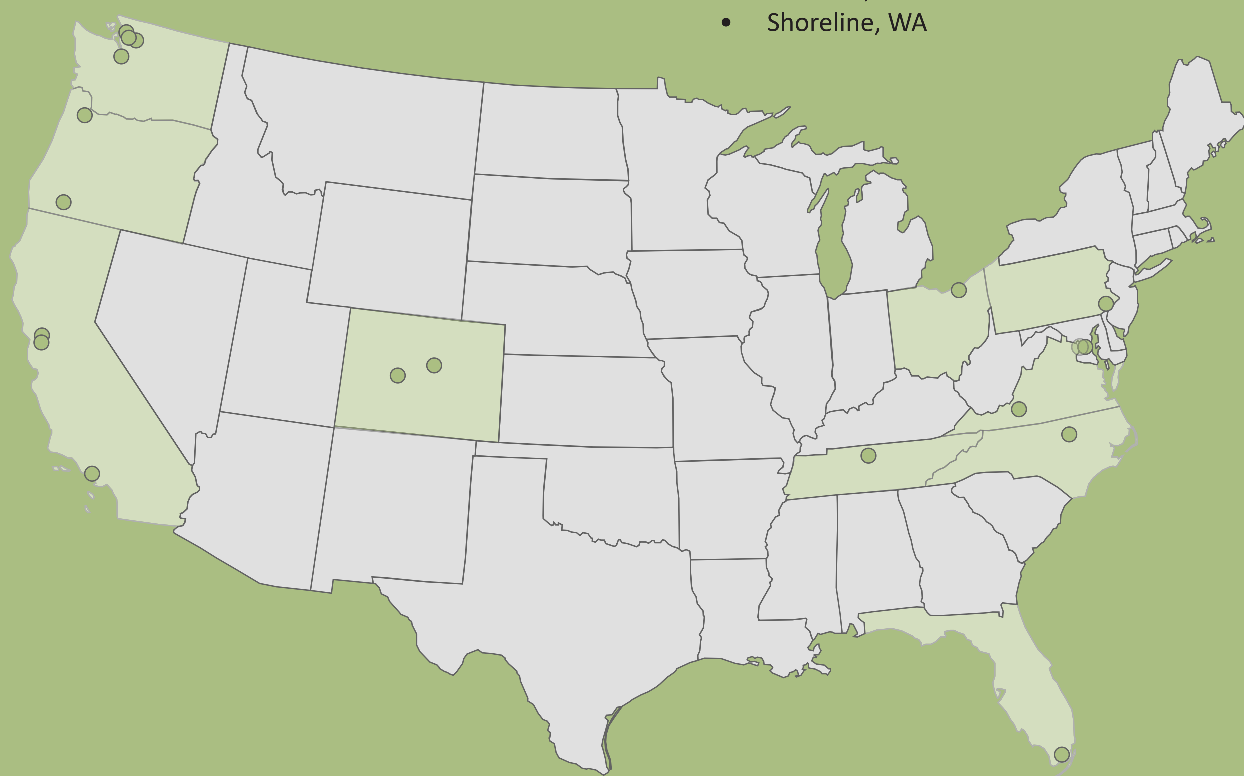
Pilot Communities

Participating Steering Committee Cities

- Aspen, CO
- Bellevue, WA
- Delaware Valley Regional Planning Commission
- King County, WA
- Metro Washington Council of Governments
- Santa Monica, CA

Second Round Participating Cities

- Ashland, OR
- Benicia, CA
- Blacksburg, VA
- Cleveland, OH
- City and County of Denver, CO
- Durham City and Durham County, NC
- Hayward, CA
- Miami-Dade County, FL
- Metro Government of Nashville & Davidson County, TN
- Olympia, WA
- Portland, OR
- Shoreline, WA



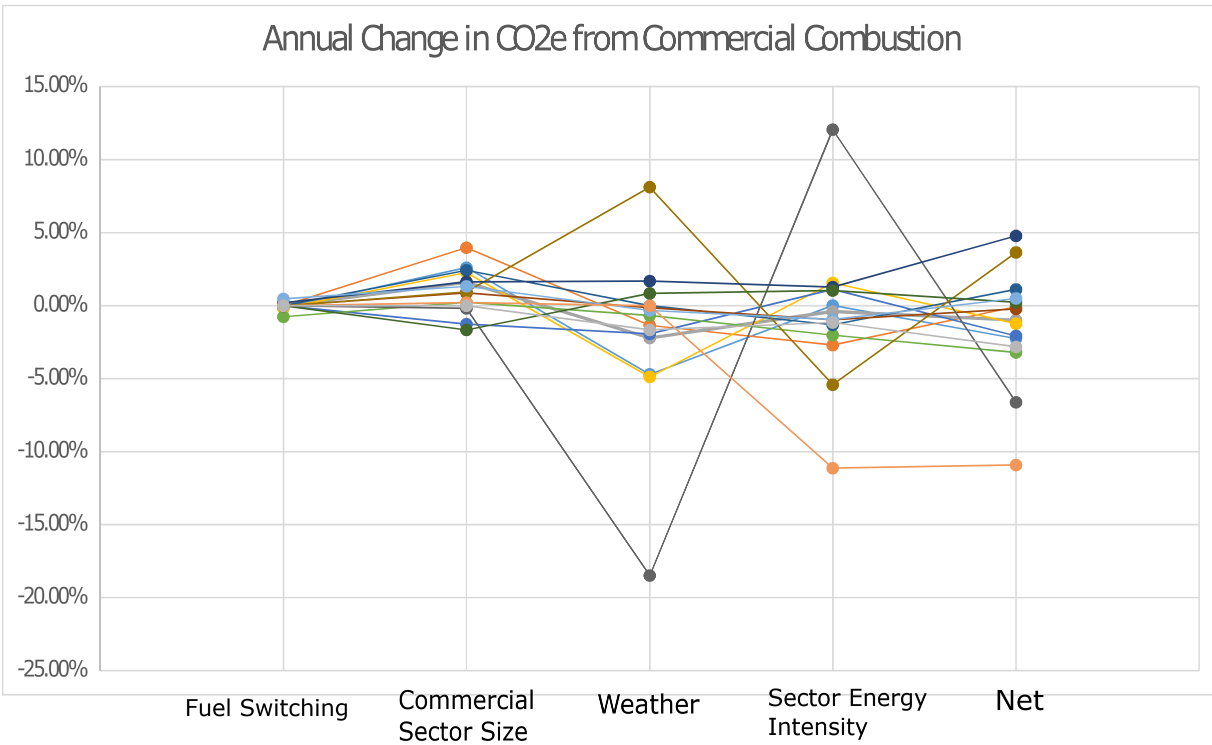
Pilot Community Findings

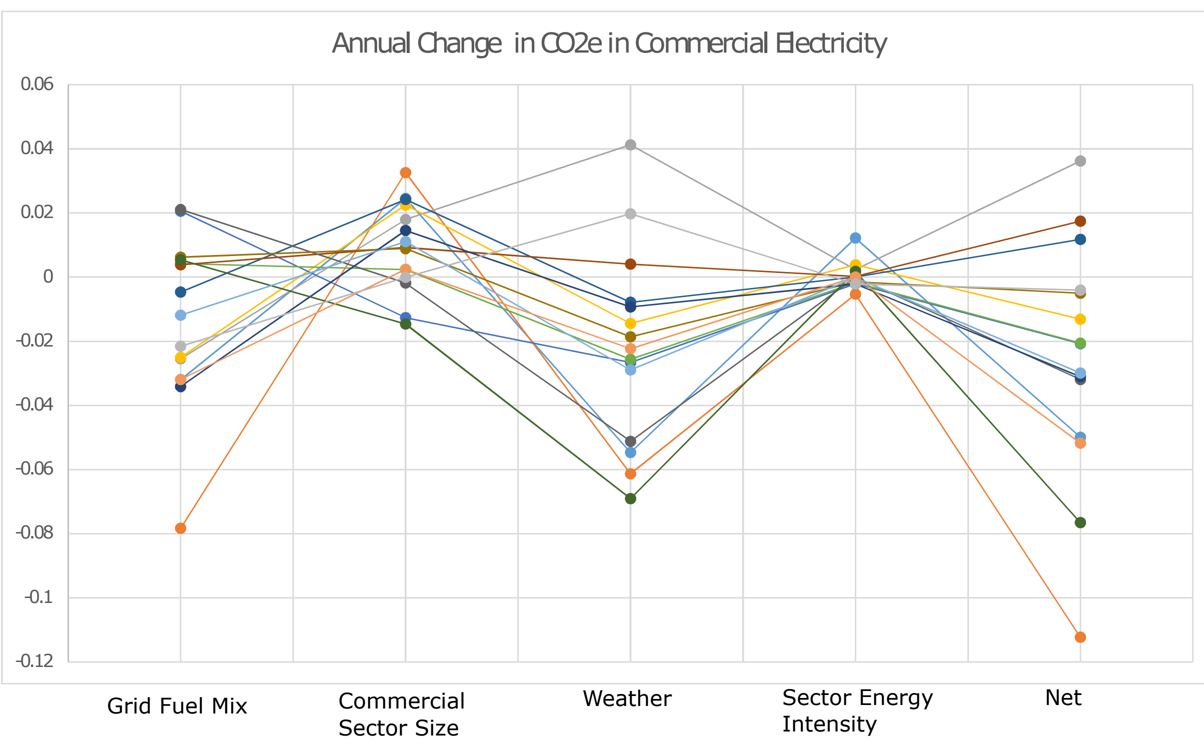
Commercial Sector

In the commercial sector it is clear that on a percentage basis, weather is a much stronger factor for heating fuels than for electricity. This is unsurprising. However, electricity use is generally a much larger portion of an overall inventory. On balance in absolute terms of the change in total MTCO2e from one inventory to the next, the high percentage change in stationary combustion equates to overall larger differences in emissions than the impact of weather on electricity usage. While individual years may be hotter or cooler, the overall trend of warmer winters is at the moment driving reductions in energy use, though several of the pilot communities are located in relatively cool areas and this trend may not hold across other regions of the country.

Also unsurprising is the size of the impact of changes to the electric grid mix. This is the dominant factor for many of the communities in the pilot for determining the change in emissions from the sector, however it is not always in a downward trajectory.

Growth in the commercial sector is positive in most cases, which drives some amount of increases. However, the majority of the time, growth is more than offset by improvements to the overall efficiency of the sector. This is a good signal of increasing efficiency of the commercial sectors of these communities.

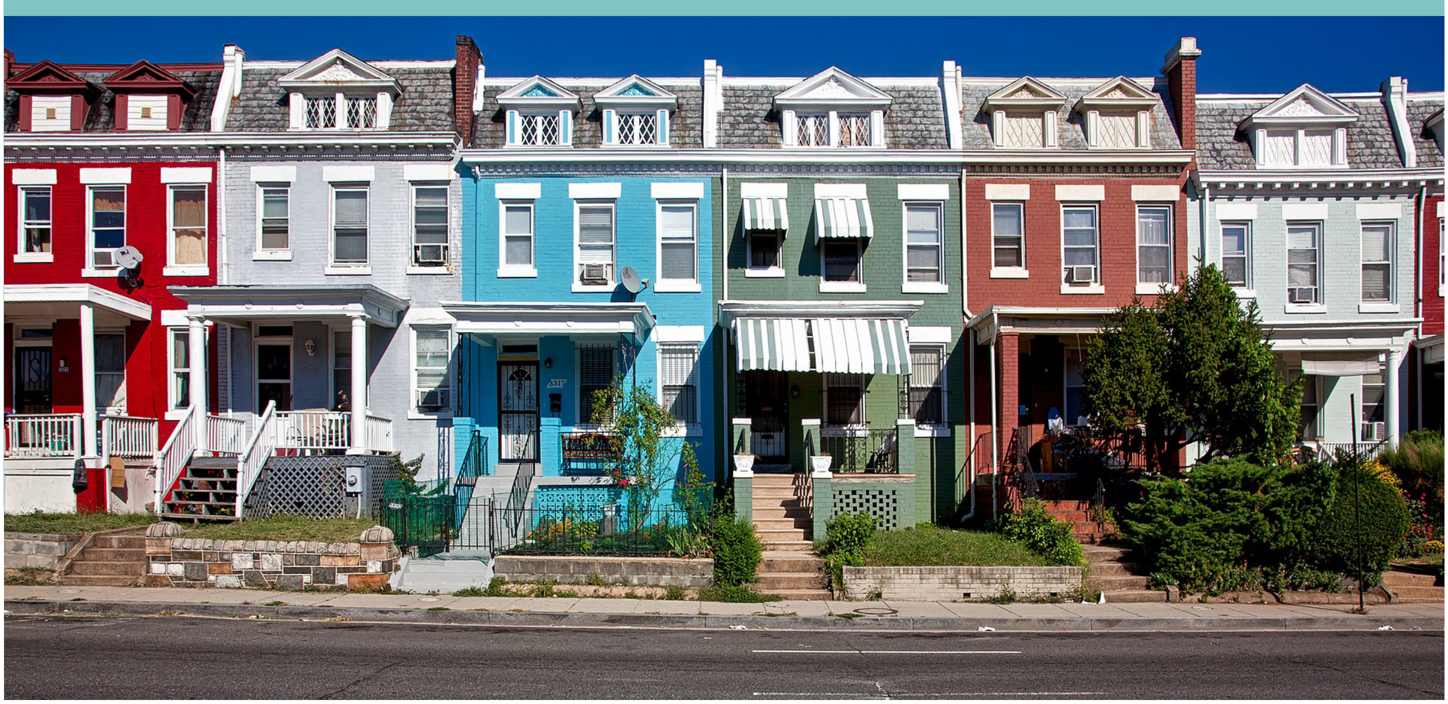

Annual Change in CO2e from Commercial Combustion
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
-25.00%
Fuel Switching
Commercial Sector Size
Weather
Sector Energy Intensity
Net

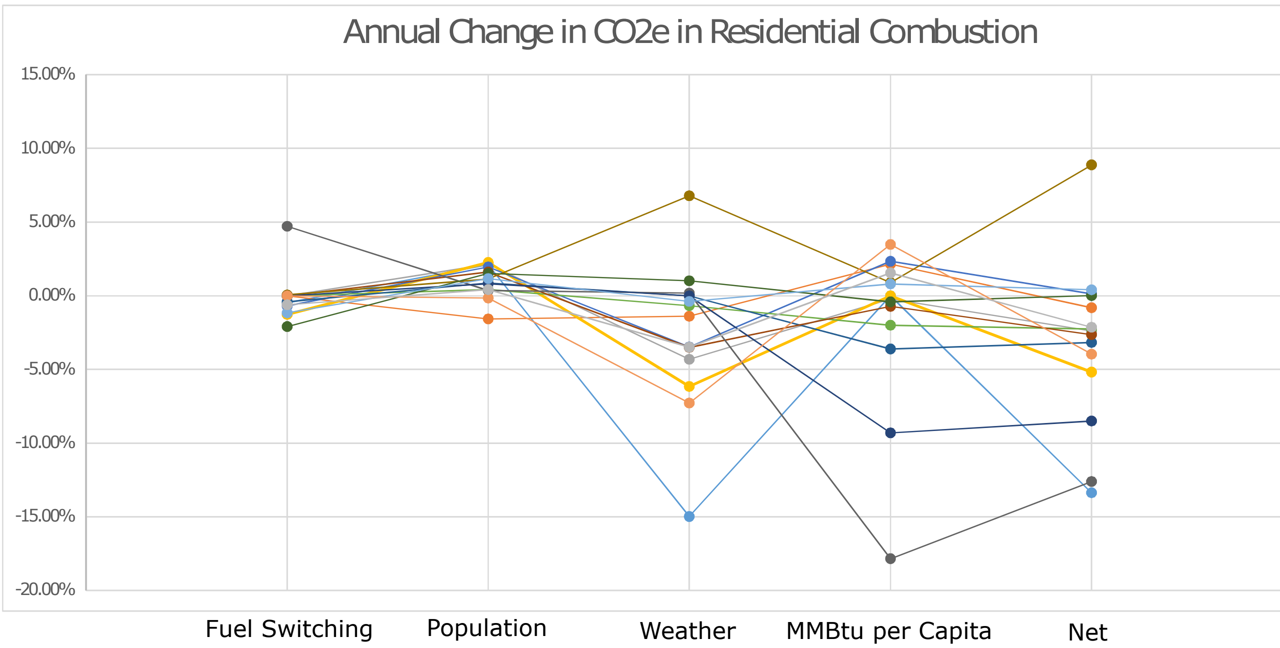

Annual Change in CO2e in Commercial Electricity
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
Grid Fuel Mix
Commercial Sector Size
Weather
Sector Energy Intensity
Net

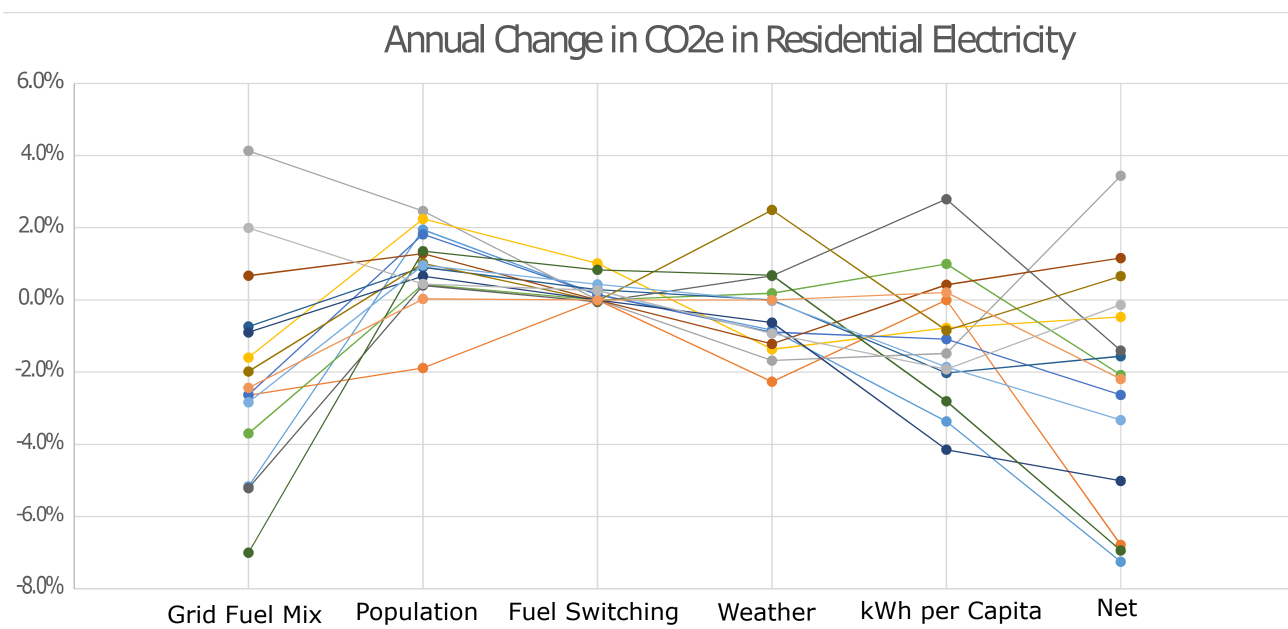
Pilot Community Findings

Residential Sector

Within the residential sector, very similar trends are visible across weather, growth, and improvements in energy efficiency of the sector. It does appear that per capita energy use is increasing in some communities which needs to be addressed if net trends in emissions are to decrease at the pace necessary to meet global reduction targets.




Annual Change in CO2e in Residential Combustion
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
-20.00%
Fuel Switching
Population
Weather
MMBtu per Capita
Net


Annual Change in CO2e in Residential Electricity
6.0%
4.0%
2.0%
0.0%
-2.0%
-4.0%
-6.0%
-8.0%
Grid Fuel Mix
Population
Fuel Switching
Weather
kWh per Capita
Net

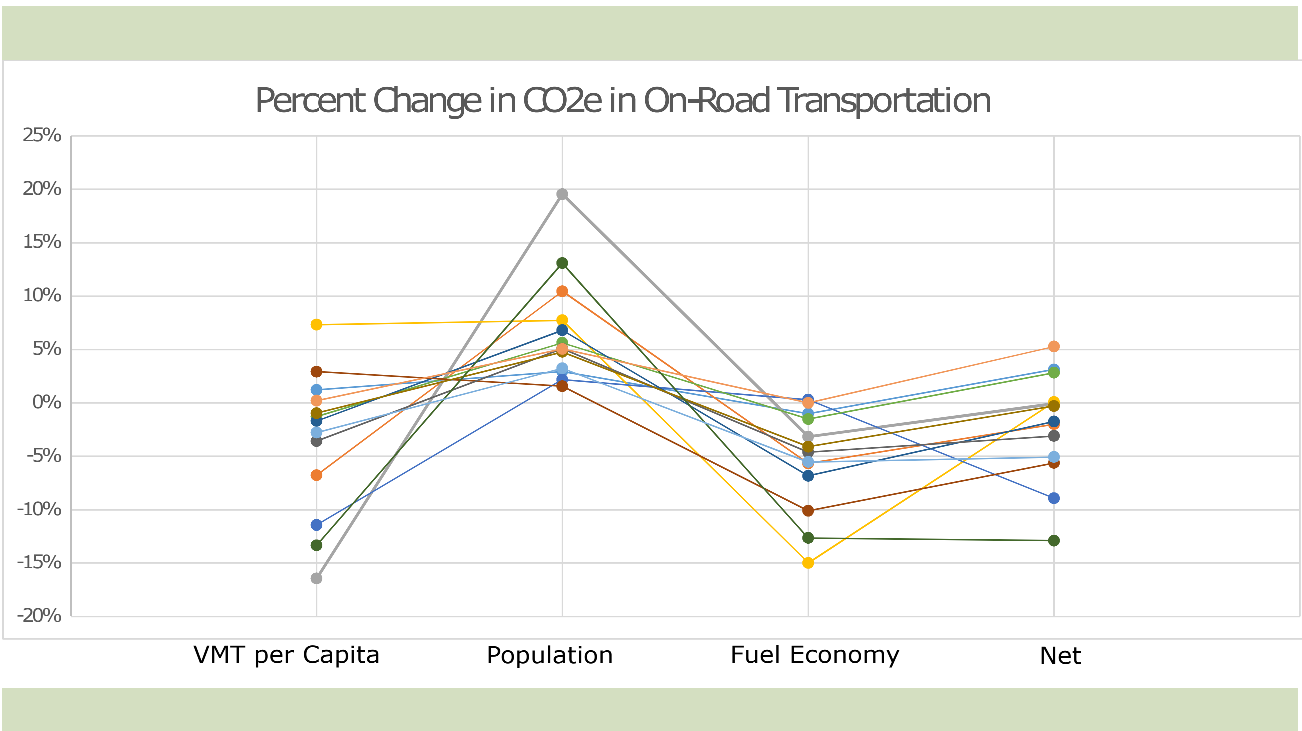
Pilot Community Findings

Transportation

Fewer factors are able to be analyzed in the transportation sector. Changes to on-road gasoline use was attributed to changes in fuel economy used in each inventory, population growth and the key indicator of vehicle miles traveled (VMT) per Capita.

Generally good trends are visible among the set of communities where reduced VMT per Capita is outweighing the influence of population growth. However, it is important to consider that the true impact of population growth on transportation emissions occurs at the regional scale and may not be fully captured among these pilot communities.

The indications in this analysis is that overall progress is made when external drivers of change have been accounted for. What is also clear from this analysis is that each city faces a unique set of factors working to determine outcomes related to GHG reduction which should be considered when prescribing the right mix of mitigation strategies to address those factors specifically.



Percent Change in CO2e in On-Road Transportation
25%
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
VMT per Capita
Population
Fuel Economy
Net

ClearPath Data

The data used in this analysis is drawn from ICLEI-USA's ClearPath emissions management software suite. ClearPath has been used since 2013 to create many community scale and government operations emissions inventories. There are now significant numbers of communities that have created multiple inventories in the tool, establishing a performance record. With this data, ICLEI-USA applied new techniques developed as part of the Contribution Analysis toolkit to dig deeper into that performance record and reveal some underlying trends among U.S. communities that have been working to address emissions for a number of years and have invested in the process to begin collecting data regularly.

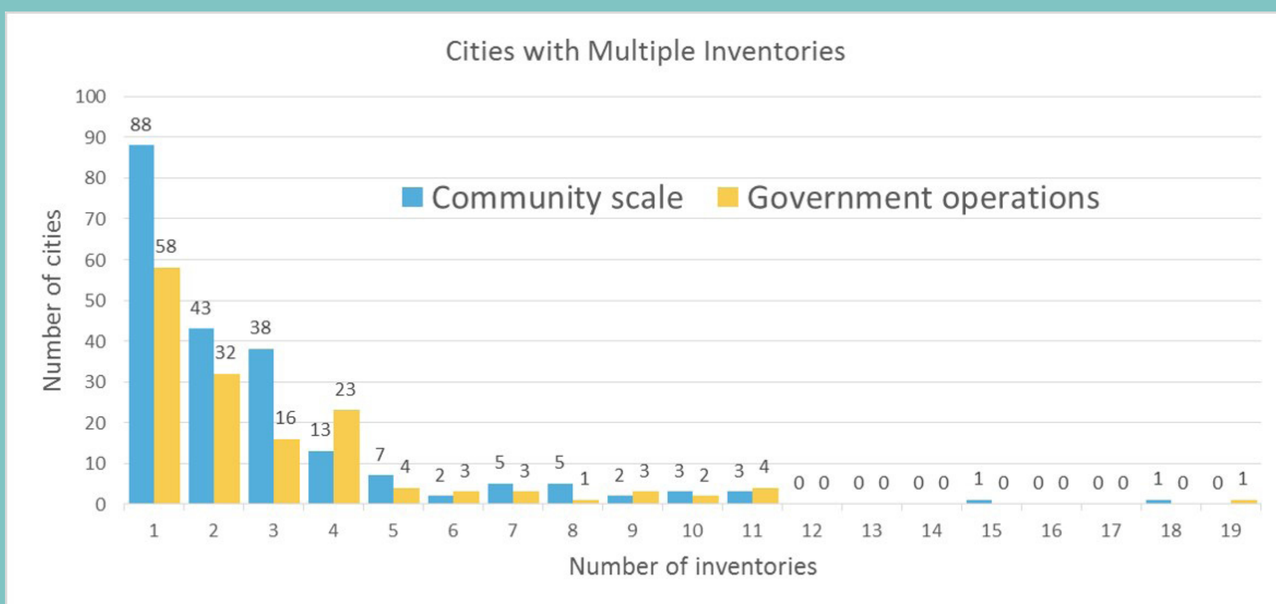
The initial dataset analyzed consisted of 312 pairs of inventories from 138 local governments. However a significant number of those inventories came from a small handful of cities that perform regular, even annual inventories. To reduce the amount of influence those cities have on the overall results, only a single pair of inventories were analyzed from each city, using the earliest and most recent inventories for that city. In addition, not all inventories included data for all three analyzed sectors, and some records were excluded because of obvious errors in the data. As a result, the number of local governments in the results for each sector is less than 138.

The data used here is self-reported and should be considered in light of the typical data challenges that many communities face when conducting an inventory, such as inconsistencies in utility data and the fact that most transportation data is modeled, not measured. Despite these limitations, the size of the dataset allows for some useful observations.

In order to account for overall growth, population data was obtained from the U.S. Census and employment data from the Bureau of Economic Analysis. While these are imperfect proxies for looking at changes to the size of the energy consuming built environment, they are the most consistently available data to capture those dynamics.

In keeping with the ClearPath End User License Agreement, the performance of individual cities and their raw data is not provided in this report. The purpose of this analysis is to look at factors that impact GHG performance on a wide scale. This report is the first attempt at analyzing this dataset at a large scale and has provided an opportunity to think about other ways of considering the data.

In addition to the wide dataset, a few cities have multiple years of data in ClearPath, allowing a view of the drivers of change over a long time period. Since Portland is one of these cities and also a pilot community of the Contribution Analysis project, we are able to view and draw conclusions from Portland's data alongside the results of many cities.

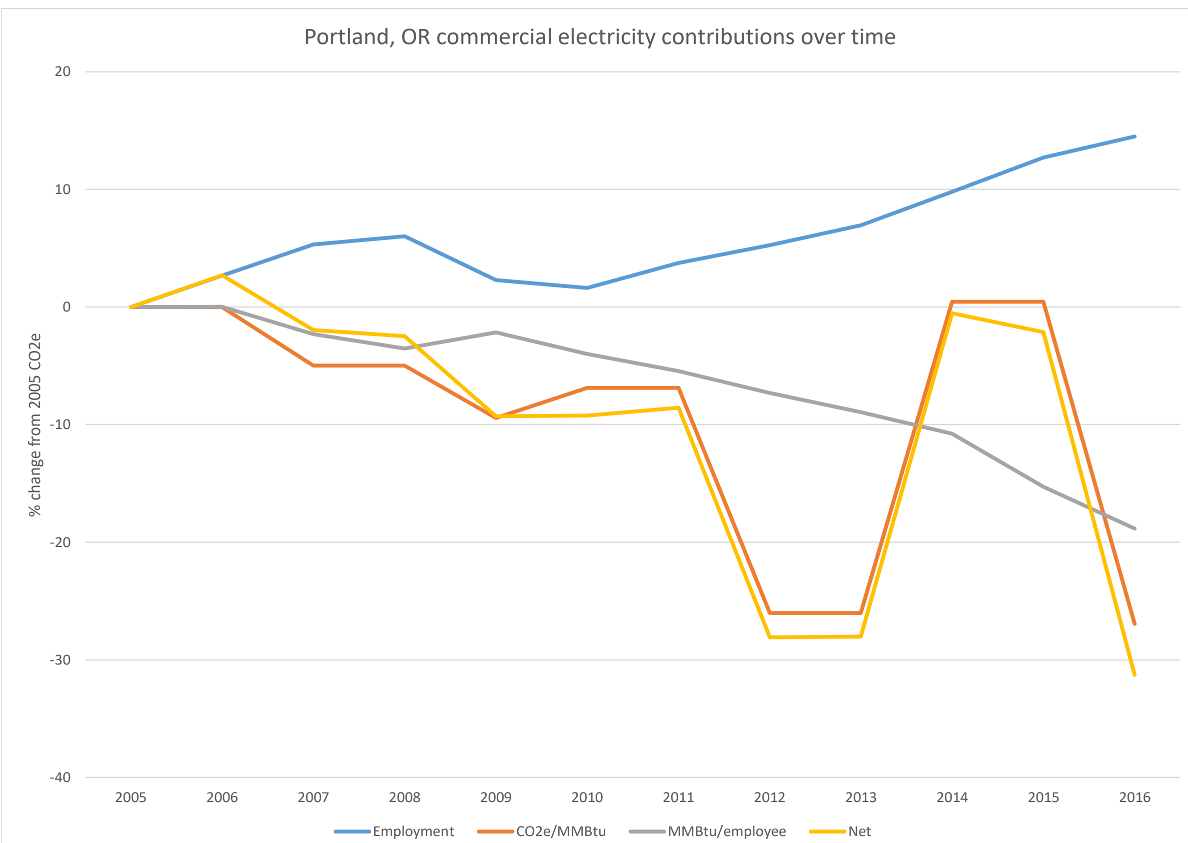


ClearPath Data

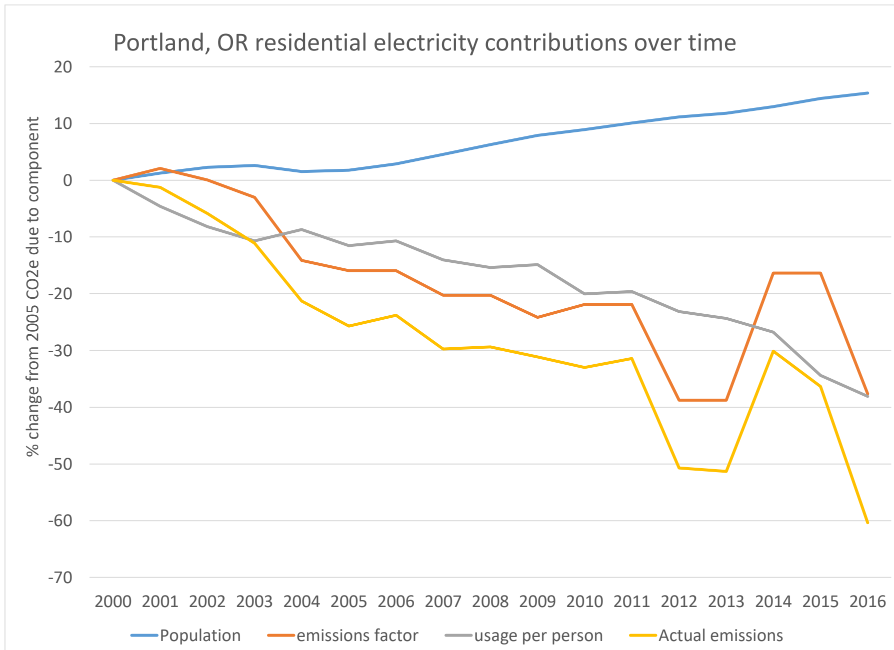
Key Findings | Residential and Commercial Electricity | 1

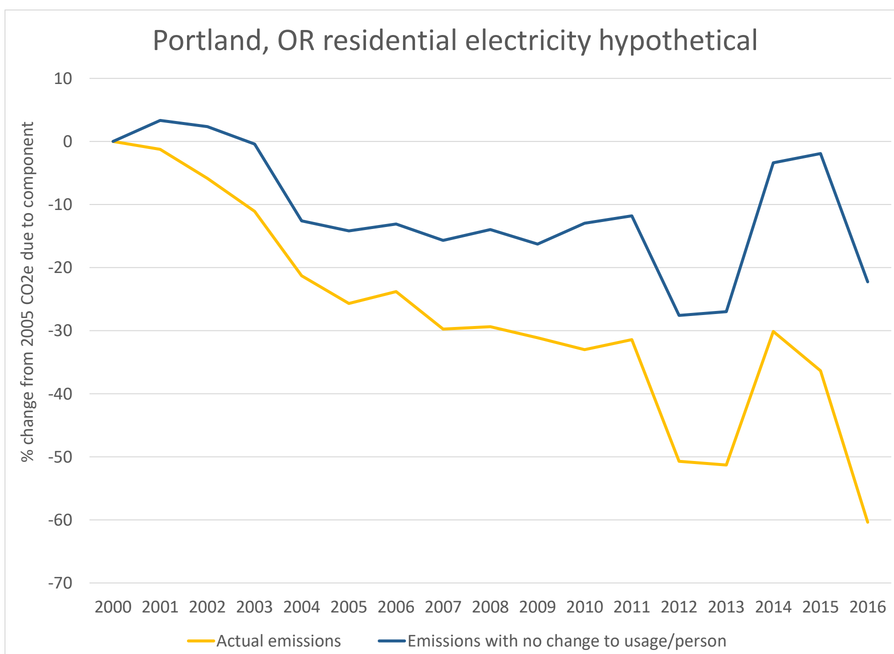
FINDING 1 | Both a cleaner electric grid and efficiency are important in offsetting growth and reducing emissions

Portland's **commercial electricity emissions** from 2005 to 2016 decreased by over 30 percent; the overall emissions trend very closely follows the emissions factor. However, employment growth of about 15 percent was slightly more than offset by a steady decrease in usage per employee. Without this decrease, the overall emissions decrease would have been much less.



With **residential electricity**, the impact of efficiency is even more noticeable, with usage per person decreasing over 30% (note the slightly longer timeframe starting in 2000). The importance of this usage reduction can be seen by looking at the hypothetical case where usage per person is constant. In this case, emissions would have decreased by less than half the actual amount.



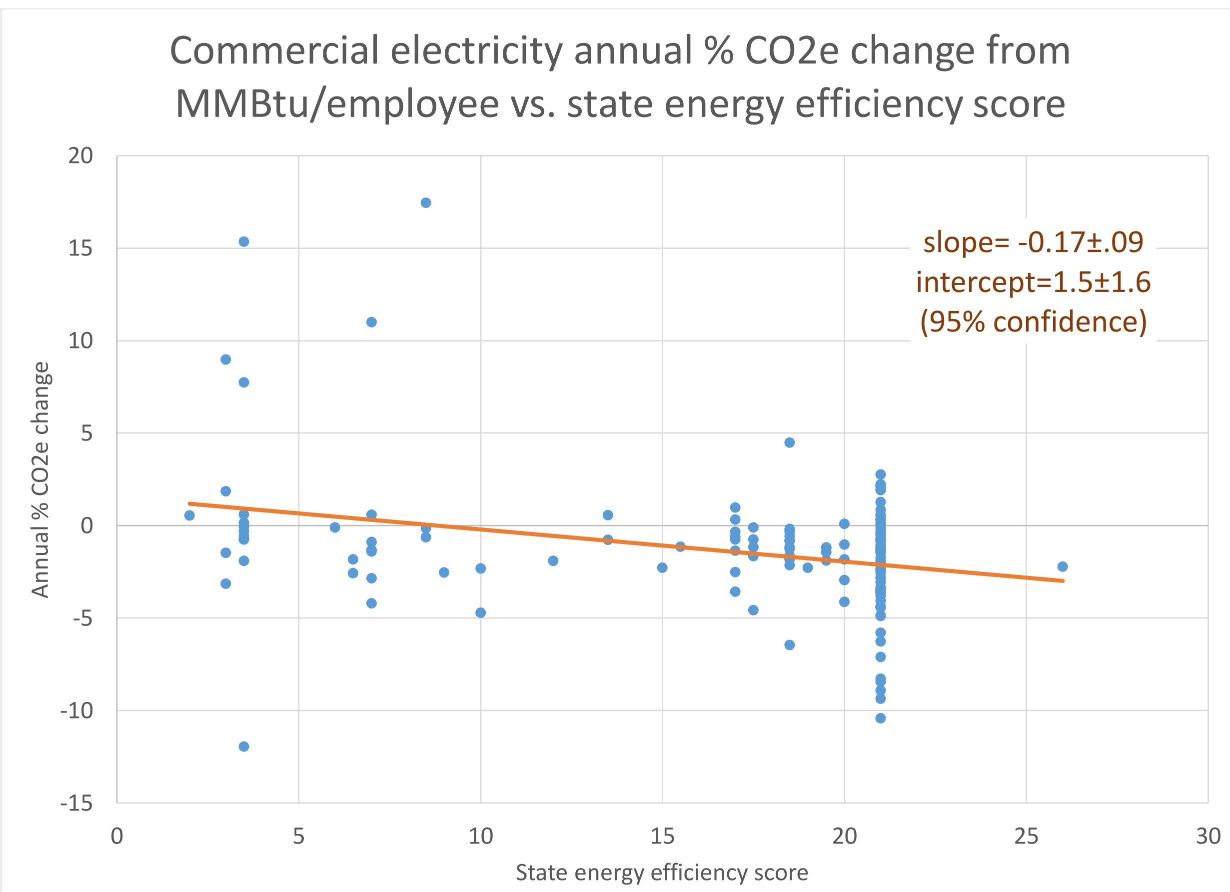


ClearPath Data

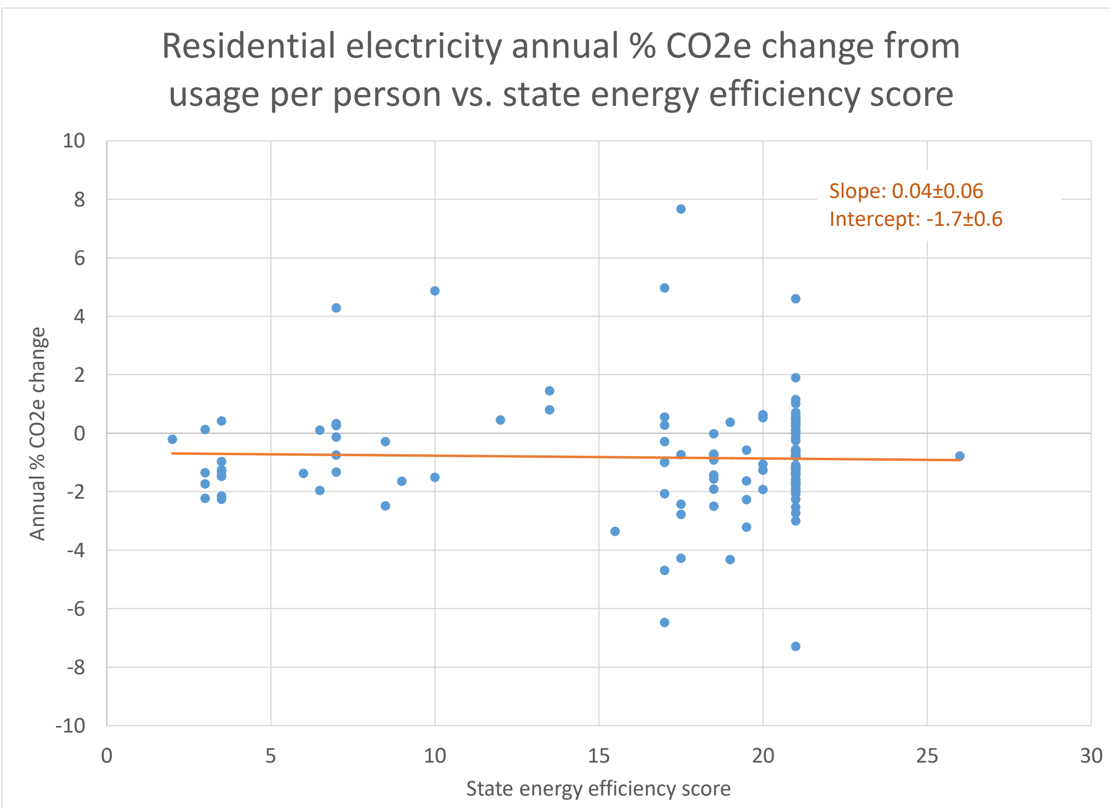
Key Findings | Residential and Commercial Electricity | 2

FINDING 2 | State efficiency policies have a noticeable effect on changes in commercial energy use per employee

By looking at the emissions change component that is driven by per-employee energy use, we can see that on average, usage is decreasing faster for cities in states that get a high energy efficiency score[2]. For cities in states with a lower energy efficiency score, usage is decreasing more slowly, or is more likely to be increasing. The usage shown is not corrected for weather. Individual cities may show increasing or decreasing usage because of changes to weather and the types of economic activity. Increases or decreases in a few particular energy-intensive building uses may strongly affect an individual city's results. **For residential energy use, the relationship between usage change and efficiency scores is not statistically significant.**



Through this analysis we can also observe how different factors combine to determine the final result. The charts below illustrate the percent change from year-1 emissions driven variously by the change in emissions factor, population growth, and the apparent change in energy per capita. Each chart is sorted left to right by the net impact of the factors combined. Population growth is an often cited factor that challenges a community's ability to meet its reduction targets. In the first chart, we can see the balance of impacts between population growth and per capita energy consumption only. It's clear that several communities are demonstrating an ability to drive down energy use per capita at a rate that exceeds the impact of population growth. In total 73 of 131 cities or 55% have residential sectors where efficiency gains outweigh population driven increases.

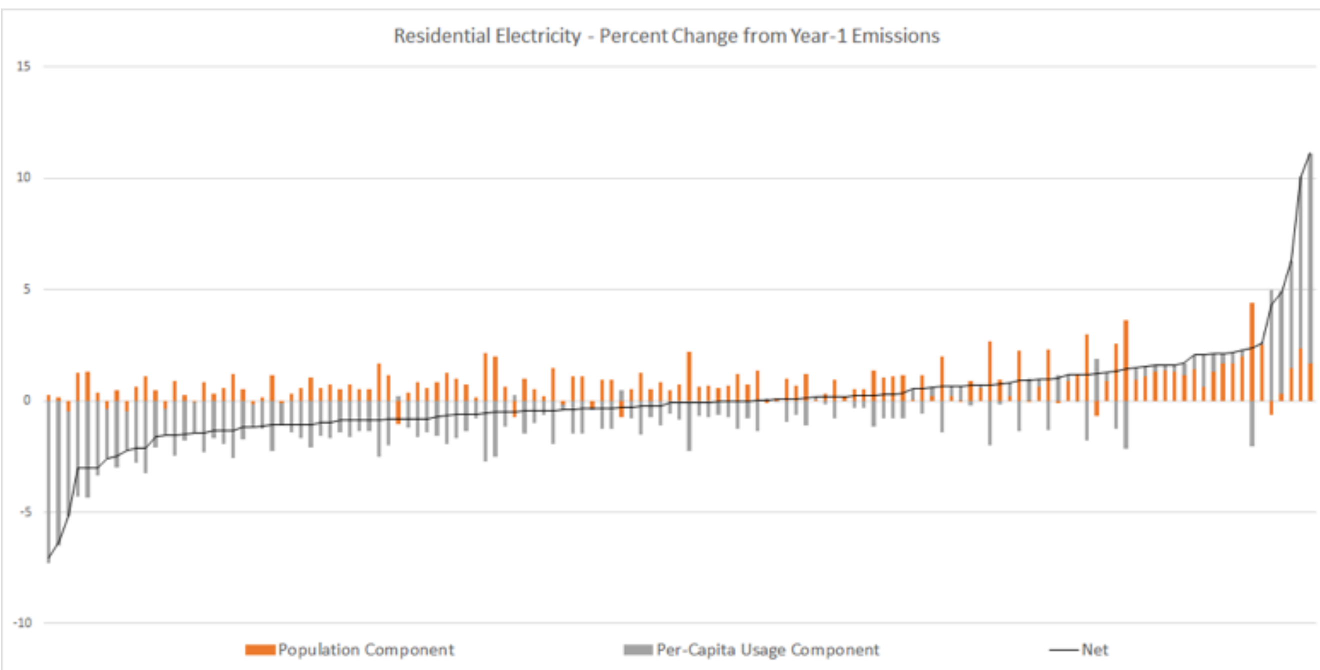


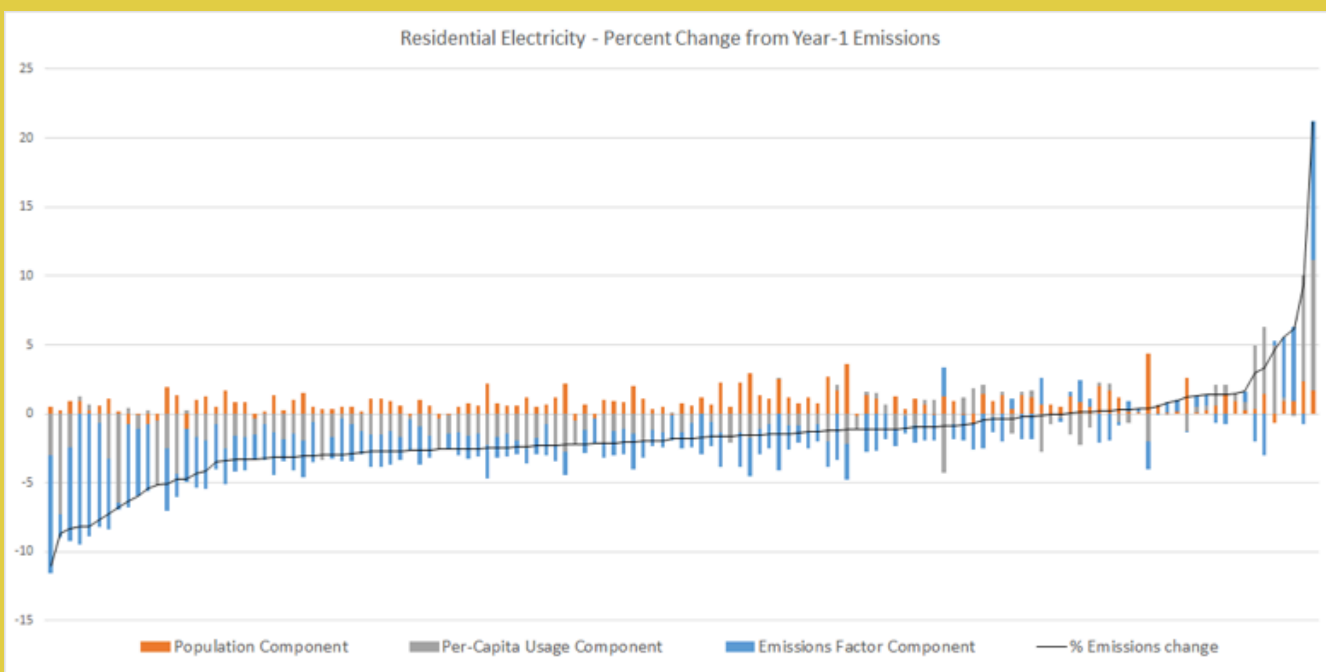
2 Energy efficiency score is based on data from the ACEEE state energy efficiency scorecard. The ACEEE scorecard is based on state policies in six areas: utility policy, transportation, building codes, combined heat and power, state government and appliance standards. Of these areas, we determined utility policy and building codes to be the most likely to affect residential and commercial energy use, so we use the sum of scores in these two areas.

ClearPath Data

Key Findings | Residential and Commercial Electricity | 2

When adding the impact of changes to the grid emissions factor, an additional 32 cities move to the side of an overall net percent decrease in emissions. While comforting to know that emissions factor changes deepened reductions for 110 cities, it is also true that for those 32 cities, the changes to emissions factors may be masking a lack of internal progress and failing to signal the necessary policy changes.



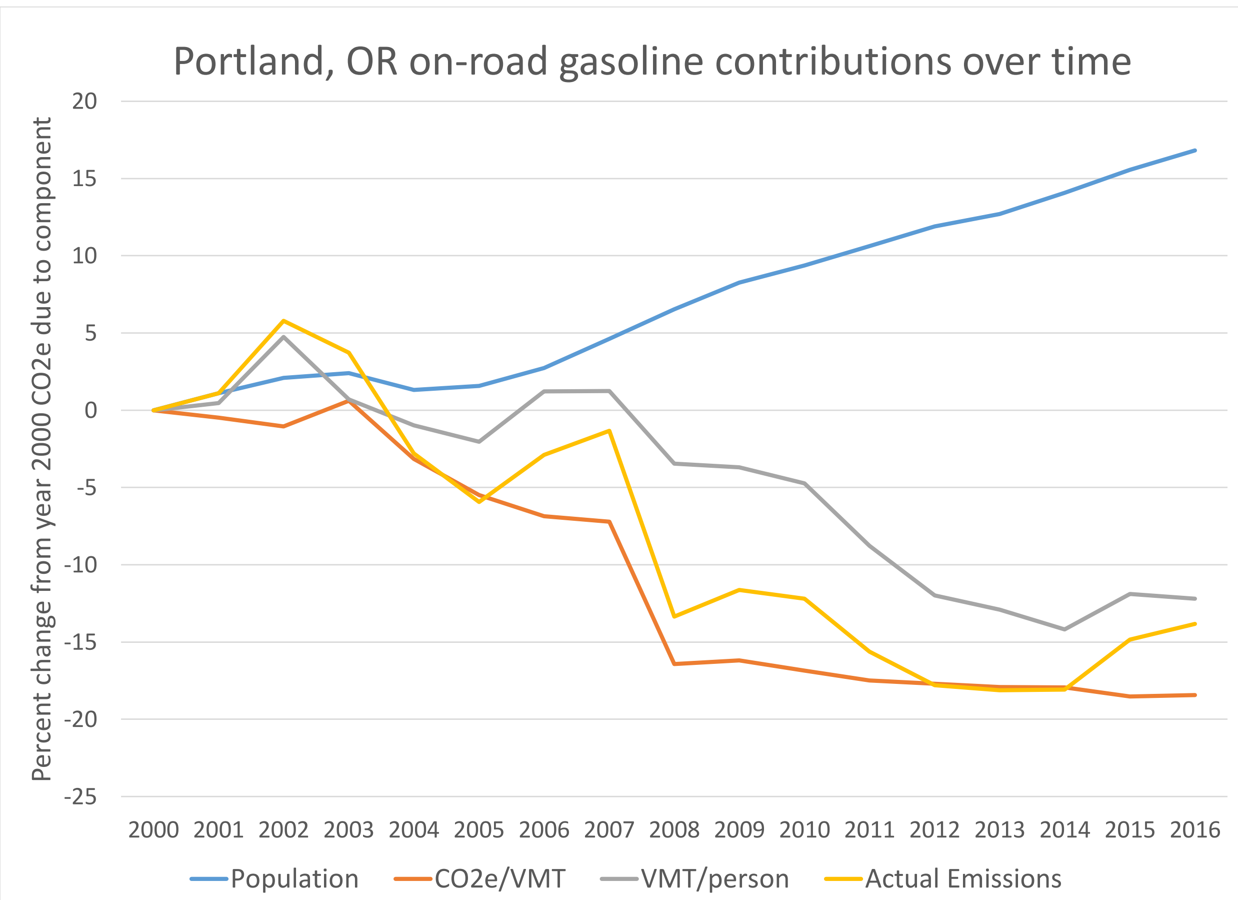

Residential Electricity - Percent Change from Year-1 Emissions
25
20
15
10
5
0
-5
-10
-15
Population Component
Per-Capita Usage Component
Emissions Factor Component
% Emissions change

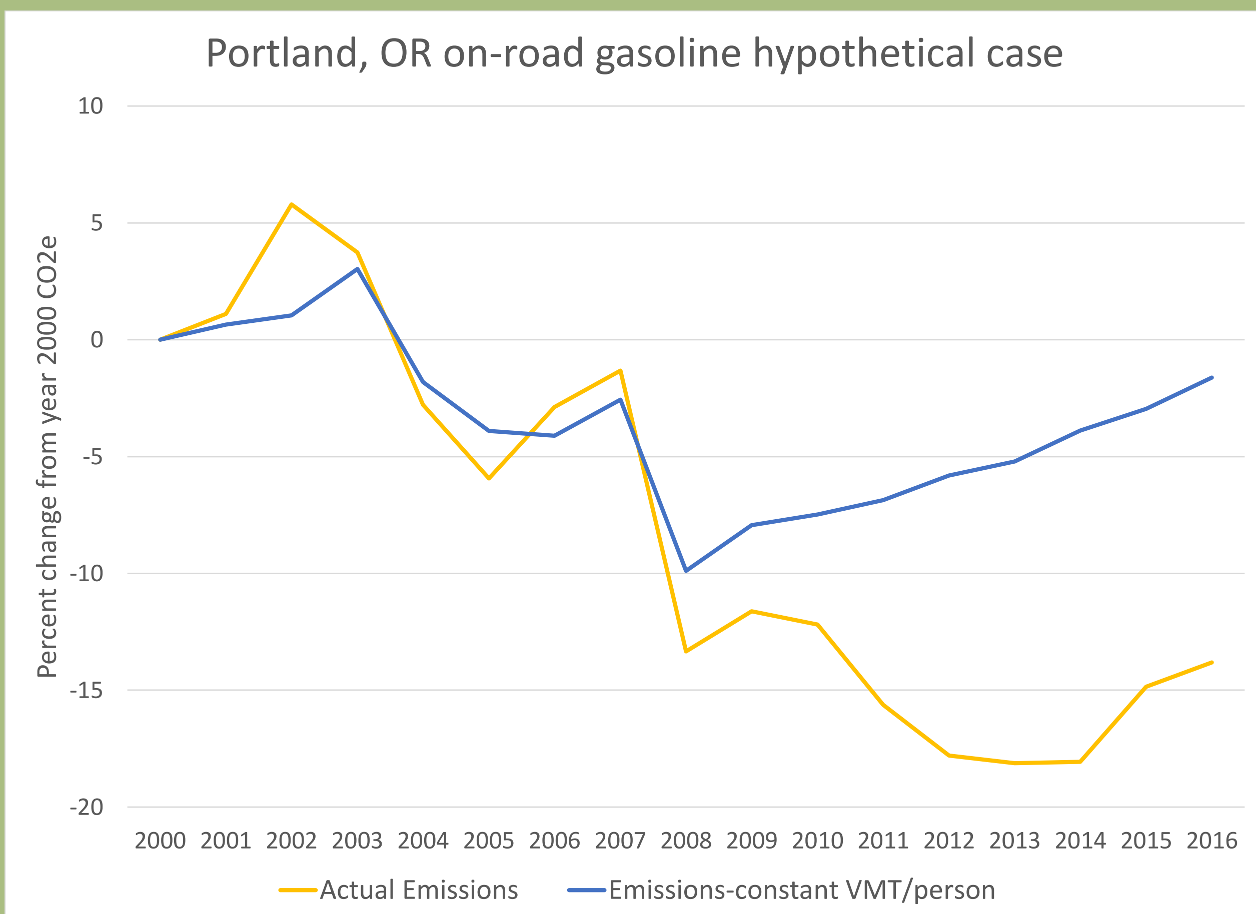
ClearPath Data

Key Findings | On-road Transportation | 1

FINDING 1 | Both more efficient vehicles and reduced vehicle miles per person have important roles in offsetting growth and reducing emissions

Looking at results for Portland over time, more efficient vehicles and cleaner fuels reduced the emissions intensity per mile almost 20 percent from 2000 to 2016. However, if VMT per person had remained constant, this reduction would have been almost entirely cancelled by population growth, as shown in the hypothetical case on the following page. In fact, decreased VMT per person when combined with reduced emissions per mile, lead to an actual net decrease of fourteen percent for emissions from on-road gasoline.




Portland, OR on-road gasoline hypothetical case
Percent change from year 2000 CO2e
10
5
0
-5
-10
-15
-20
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
Actual Emissions
Emissions-constant VMT/person

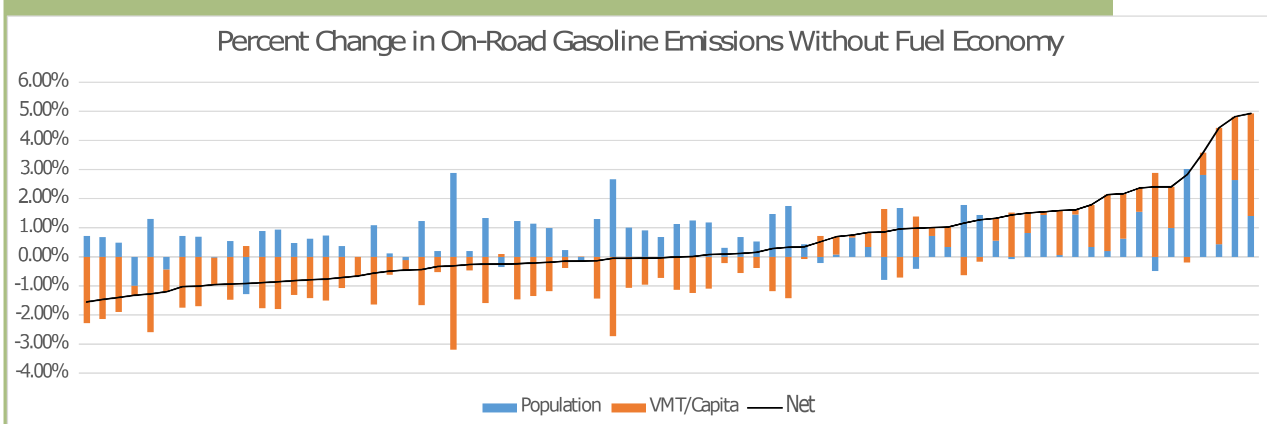
ClearPath Data

Key Findings | On-road Transportation | 2

FINDING 2 | Across communities, there is a range of changes in transportation emissions, though a majority show decreasing emissions

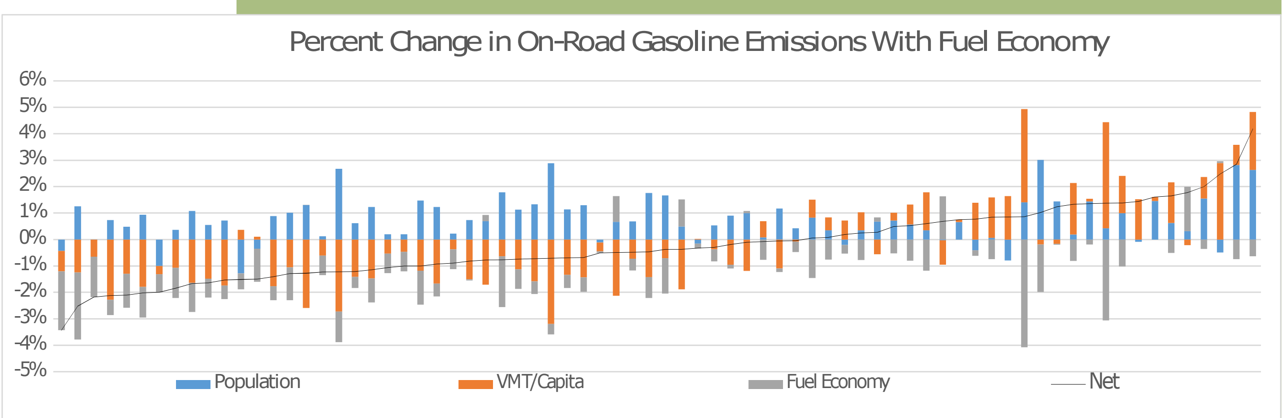
Turning again to the data collected in ClearPath, we can observe apparent trends at a much wider scale. In this analysis, overall changes in emissions from on-road gasoline consumption were broken down by primary drivers between population, VMT per capita, and changes to the rate of emissions per mile, which is largely the result of improvements in fuel economy.

Viewing the first two factors it is possible again to see how cities are handling population growth. In this case 38 of 74 inventory pairs (51%) show communities with a net decrease when the VMT per capita reduction is greater than the increase attributable to population growth.



When accounting for the impact of fuel economy there are an additional nine cities that fall into the net negative emissions trends for a total of 63% that are showing net negative emissions. Local action is clearly important here for managing transportation demand and driving performance, however reductions in carbon intensity of the transport sector are a critical component as well whether they are driven by federal or state policies, or by market forces working to reshape the sector.

Overall, reductions are not as widespread or as large in the transportation sector as those in residential and commercial electricity. Transportation proves a more challenging sector to manage across all communities from both a demand management point of view but also the speed at which the carbon intensity of on-road transportation has changed to date.



Conclusions

Overall we find that when cities engage in climate mitigation in a serious way, tangible progress is attainable. Local action combined with action from states, national policy, and climate friendly market forces in energy supply produce even larger gains.

The dynamic of growth is an underlying factor for all community performance and can be significant headwind to cities reaching their reduction targets. These results indicate that growth can be accommodated while reducing Greenhouse Gases (GHG). Many of the cities included in this analysis are in the core of urbanized regions with smaller jurisdictions around them who may not be tracking the GHG performance of their community and who may not be growing in ways that improve efficiency. As much as we can celebrate successes here, it is important to recognize that blind spot and more analysis is needed in that area.

The results presented here demonstrate a step forward in leveraging data produced in GHG inventories to better understand the dynamics at play as cities strive to make progress towards their climate goals. There is significant opportunity to extend these analyses further and answer more questions. The most important lesson drawn from this work is that the most informative analyses come from locally specific inventories and supporting data. It is apparent that the practice of inventories must evolve to place greater emphasis on documenting the context in which GHG generating activities occur, going beyond basic description of population, land area, and GDP; to include richer descriptions of the built environment and the mix of economic activity for a given place.

Signs are pointing in a positive direction as more communities become truly engaged in the effort and begin to track GHGs as a key indicator of overall community performance. At the same time many are upgrading and digitizing information related to the building mix of their community and new sources of observed transportation data are on the horizon. Those that are able to make the connections between these pieces of information as they pursue GHG inventory development with an eye towards understanding what factors drive their performance will be at an advantage when it comes to planning, evaluating, and ultimately achieving their emissions reduction targets.

The GHG inventory is more than just a tool for charting progress on emissions trends. Done well, the inventory should be an opportunity for a community to better understand how it functions with regard to building and transportation energy in order to inform policy to build cleaner and stronger communities. Every community working on a GHG inventory, whether it's the first or tenth, should be working to maximize the benefit of the effort to understand not just the current level of emissions, but why emissions are occurring at that level.

Acknowledgments

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