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An Assessment of the Link Between Greenhouse Gas Emissions Inventories and Climate Action Plans

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Problem: Basing local climate action plans on greenhouse gas (GHG) emissions inventories has become standard practice for communities that want to address the problem of climate change. Communities use GHG emissions inventories to develop policy despite the fact that there has been little theoretical work on the implications of the assumptions embedded within them.

Purpose: We identify elements and assumptions in emissions inventories that have important policy implications for climate action plan formulation, aiming to help planners make informed, defensible choices, and to refine future GHG emissions inventory protocols and climate action planning methods.

Methods: We conducted a content analysis of 30 city climate action plans selected as a stratified random sample. We collected data on 70 different factors and used summary and trend statements, typologies, and descriptive statistics to link our findings to our research questions.

Results and conclusions: Climate action plans obviously vary in many details, but most contain all of the core GHG emissions elements suggested in common protocols. We found GHG emissions inventories to be technically accurate but found their reduction targets to fall short of international targets. We also found exogenous change and uncertainty to be unaccounted for in emissions forecasts and reduction targets. The plans generally do a poor job of linking mitigation actions to reduction targets.

Takeaway for practice: GHG emissions inventories supporting climate action planning are reasonably standardized, but documentation of data and assumptions should be improved and GHG reduction targets should be justified. The effect of future changes that are beyond the direct control of the community plan should be accounted for in GHG emissions forecasts and reduction targets. Rapid anticipated population growth should be acknowledged and taken into account, both in GHG emissions forecasts and in setting reduction targets. Effects of mitigation may be difficult to predict reliably, yet can be partly offset by effective monitoring that evaluates progress and changes course when necessary.

In this article, we review local climate action plans and their associated greenhouse gas (GHG) emissions inventories from 30 U.S cities in order to assess the degree to which climate action plans are informed by such inventories and to identify choices and assumptions the inventories require that may influence climate action plan policies and proposed actions. We hope this will help planners preparing climate action plans make informed, clear, and defensible choices, as well as optimize policy development and implementation in their communities. In addition, we hope that this research will contribute to refining future GHG emissions inventory protocols and climate action planning methods.

Keywords: climate action plans, greenhouse gas, policy, mitigation, climate change

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Communities wanting to address the problem of climate change increasingly do so by preparing local climate action plans. Such plans contain policies and propose actions designed to reduce the community's GHG emissions and are usually based on GHG emissions inventories (APA, 2008; International Council for Local Environmental Initiatives [ICLEI], n.d., 2010; National Wildlife Federation, 2008; Natural Capital Solutions, 2007; United Nations, 1998). A GHG emissions inventory aims to identify and calculate a community's current and projected emissions, which requires making some choices and assumptions. The advantage of using such an inventory as the basis for climate action planning is that it provides a quantitative baseline from which to measure progress on plan implementation, something that is uncommon in other types of planning. This approach requires simplifying and narrowing some elements being measured and, as a consequence, may have pernicious effects on plan development. For example, GHG emissions sources and mitigation actions that are hard to quantify may be left out, the technical challenge of getting the inventories perfect may be met at the expense of developing good policy, or vice versa, or essential technical accuracy and precision may be sacrificed for the sake of expediency or politics.

Communities are moving ahead with climate action planning based on GHG emissions inventories despite the fact that there has been little theoretical work on the implications for subsequent policy development of the choices and assumptions such inventories require (Linstroth & Bell, 2007; Wheeler, 2008). Although there is clearly a need for quick action to address climate change, we are concerned that climate action plans strike the right balance between simplified technical information that is accessible and useful to decision makers and the public, and accuracy, precision, and rigor in technical data and methods. Our analysis builds on the work of Wheeler (2008), who described how climate action plans are developing nationwide and made suggestions for their improvement.

Overview of Climate Action Planning

In this section, we discuss the history and purpose of climate action planning and review the professional guidance that establishes best practices for developing climate action plans and GHG emissions inventories. In addition, we review scholarly literature that addresses issues and problems with GHG emissions inventories that may affect subsequent policy development. We use this information to establish a method for analyzing climate action plans.

History and Purpose

The rise of climate action planning at the community level can be traced to the emergence of the idea of "sustainable development" established in 1983 by the Brundtland Commission, also called the United Nations World Commission on Environment and Development. The Brundtland Commission report (World Commission on Environment and Development, 1987) embraced the concept of thinking globally but acting locally, which is key to the climate action planning movement. However, climate change was only one of many issues raised by the sustainability movement; it only garnered brief mention in the Brundtland Commission report. Not until the United Nations Conference on Environment and Development, (also called the Earth Summit) in Rio de Janeiro in 1992, and the signing of the United Nations Framework Convention on Climate Change (UNFCCC; United Nations, 1992b) did climate change become distinct from the larger issue of sustainability. The UNFCCC led to the ICLEI Cities for Climate Protection campaign and its Local Agenda 21 Model Communities Programme (ICLEI, 2008a, 2008b; United Nations, 1992a), President Clinton's *Climate Change Action Plan* (Clinton & Gore, 1993), and the Kyoto Protocol (United Nations, 1998). These events inspired an initial round of climate action plans, some of which were incorporated into existing sustainability planning efforts and Local Agenda 21 plans, and others that were stand-alone climate action plans (also known as local action plans, GHG reduction plans, and CO_2 reduction plans). During this period, the Intergovernmental Panel on Climate Change (IPCC) had been establishing consensus on climate change science, bringing attention to the effects of climate change and the options for mitigation and adaptation (IPCC, n.d.).

Over the last decade, other developments made community-level climate action planning a common endeavor. The New England governors collaborated with premiers of eastern Canadian provinces on a plan released in 2001 that set in motion a round of climate action planning in the northeastern United States (Committee on the Environment and the Northeast International Committee on Energy of the Conference of New England Governors and Eastern Canadian Premiers, 2001). The U.S. Conference of Mayors adopted their own Climate Protection Agreement (U.S. Conference of Mayors, 2005) to support the Kyoto Protocol standards and commit cities to reducing CO_2 emissions to 7% below 1990 levels by 2012. This agreement continues to prompt mayors to initiate planning efforts in their communities. In 2007, the IPCC produced its fourth assessment report (IPCC, 2007) which concluded that "warming of the climate system is unequivocal" (p. 5), most of it due to human-caused GHG emissions, and that this has the potential to impact social, physical, and biological systems. Many local governments have joined the ICLEI Local Governments for Sustainability Cities for Climate Protection (CCP) campaign in the last decade and committed to ICLEI's Five Milestones for Climate Mitigation methodology (ICLEI, 2010). Joining ICLEI not only commits cities to an established GHG inventory protocol, but provides access to GHG accounting software.

Despite this history, as of April 2010, only about 80 cities in the United States had adopted climate action plans based on GHG emissions inventories, although many more are in development.[1] Researchers have found that communities are more likely to adopt climate mitigation policies and actions if they have higher proportions of their registered voters in the Democratic Party, higher risks of climate-related natural hazards (Hanak, Bedsworth, Swanbeck, & Malaczynski, 2008; Zahran, Brody, Vedlitz, Grover, & Miller, 2008; Zahran, Brody, Vedlitz, Lacy, & Schelly, 2008), more staff assigned to energy or climate planning, higher levels of local government environmental awareness, and higher levels of community environmental activism (Pitt, 2009).

The Greenhouse Gass Emissions Inventory Process

In a national review of the first generation of adopted climate action plans, Wheeler (2008) observed that while communities with such plans have been largely successful at bringing stakeholders together, conducting emissions inventories, and establishing reduction targets, most have not adopted effective, enforceable implementation strategies. We aim to expand on Wheeler's work by looking more closely at the series of choices embedded in the process of developing a GHG inventory. Cities must make these choices based on technical requirements, local context, and political climate. In this section, we summarize the GHG emissions inventory process (which includes forecasting and setting GHG reduction targets) based on widely adopted best practices, and identify critical choices that may influence selection of climate action plan policies and actions.

The process of preparing a GHG emissions inventory entails decisions and procedural steps that have been codified through a variety of GHG emissions inventory protocols and related software developed by national and international organizations (see California Air Resources Board [CARB], 2008, and ICLEI, 2009). Because choices made during inventory development influence climate action plan content, the best practice is for all assumptions to be documented and justified (Institute for Local Self Reliance, 2007) and for inventories to be relevant, complete, consistent with protocols, transparent, accurate, and reproducible (CARB, 2008; U.S. Environmental Protection Agency State and Local Client Energy Program [EPA], 2009a, 2009b). These characteristics allow for third-party review and certification (if desired), comparability with other community's inventories (EPA 2009a), and enable local governments to "track their progress and create a strategy to reduce emissions in a quantifiable and transparent way" (CARB, 2008, p. 3).

Assumptions and plan components may be affected by technical concerns or data limitations, but also by local political and policy considerations (e.g., not counting pass-through trips due to reluctance to address multijurisdictional transportation policy issues). Manipulating policy indirectly through the choice of assumptions and plan components would compromise the ability of decision makers or the public to make fully informed decisions.

An inventory should encompass all the GHG emissions associated with activities in the community (CARB, 2008; ICLEI, 2009), including indirect emissions associated with sources such as electricity generation. Clear articulation of the sources included in the inventory is critical, as only these will be subject to the reduction measures in the climate action plan. By identifying the GHG emissions sources and quantifying the total, an emissions inventory provides a foundation for projecting future emissions and setting a reduction target (EPA, 2009b). These data are the benchmarks against which the success of proposed GHG emissions reduction measures can be assessed.

A key aspect of identifying emissions sources is the spatial location of the emissions. VandeWeghe and Kennedy (2007, p. 136) state: "Emissions can be attributed either to the spatial location of actual release or to the spatial location that generated the activity that led to the actual release." Kennedy et al. (2010) evaluated the consequences of which approach is taken, finding that a city's energy-related emissions increased when the inventory was consumption based, including, for example, the emissions it causes indirectly by consuming power generated outside the city limits. An even more comprehensive approach determines lifecycle GHG emissions, which include all embodied energy of a product or activity (Kennedy et al., 2010). Decisions about boundaries and associated responsibility may affect a city's policy development, such as whether it aims to influence supply or demand for electricity produced by burning fossil fuels (Hughes, Bohan, Good, & Jafapur, 2005).

The success of a climate action plan is measured against a GHG emissions forecast from a baseline year.

State and federal governments have commonly used 1990 as a baseline year to remain consistent with the Kyoto Protocol (CARB, 2008). However, local GHG inventories are increasingly using 2000 or 2005 as baseline years because both the CARB and ICLEI advise using the most recent calendar year for which data can be collected consistently, comprehensively, and reliably. They also suggest that the baseline be a typical year for emissions and not one in which they were influenced by unusual conditions such as extremely high or low economic growth, abnormal weather, or other unusual events (CARB, 2008; ICLEI, 2009).

The plan also requires a *business-as-usual forecast* of future emissions that assumes no new action to mitigate GHG emissions, prepared using local forecasts for population, jobs, and housing. The choice of the inventory forecast year establishes the planning horizon of the climate action plan (CARB, 2008; ICLEI, 2009). After the business-as-usual forecast is complete, the GHG emissions reduction target for the forecast year is chosen and the difference between these establishes the GHG reduction that must be achieved by the associated climate action plan. Such a target is most often expressed as the percentage by which emissions will be reduced relative to the baseline year (e.g., 15% reduction from baseline year by 2020; CARB, 2008; ICLEI, 2009). Reduction targets may be short-, mid-, or long-term, and the period will influence the range of actions and policy options used to achieve the targets.

There are several types of exogenous change that may affect future levels of GHG emissions in a community and, thus, should be accounted for in the GHG emissions forecast and setting of the reduction target: technological, social/behavioral, legislative and regulatory, demographic, and economic. Technological innovation and change may influence automotive technology and fuels, electricity generation and fuels, and building technology. Social and behavioral changes may include commuting habits, household energy use, or purchasing habits. Potential legislative and regulatory change may include cap-and-trade legislation, renewable energy portfolio standards, and fuel efficiency standards (e.g., the federal Corporate Average Fuel Economy [CAFE] standard). Demographic changes that have the potential to influence GHG emissions include population growth, poverty level, and housing tenure and occupancy. Long-term GHG emissions may also be influenced by economic changes in gross domestic product, industrial and manufacturing mix, and balance of trade. This sampling of issues shows that considerable uncertainty exists in forecasting future levels of GHG emissions, particularly at the community level.

It is common to address uncertainty in forecasting either by ignoring it and assuming a continuation of current trends, or by varying the assumptions and developing multiple forecasts or scenarios. The problem with the former is that change seems almost certain at this point. For example, public transit ridership is at its highest level in 52 years (Sun, 2009), bicycle commuting has jumped 43% since 2000 (League of American Bicyclists, 2009), and solar and wind power had their highest growth years to date in 2008 (American Wind Energy Association, 2009; "U.S. installed solar capacity up 17 percent in 2008," 2009). Emissions forecasts that assume long-term trends will persist, and do not take into account the potential for the kind of dramatic short-term changes these examples illustrate, are likely to overestimate future emissions. The policy implications could include the setting of overly conservative reduction targets, sticker-shock reactions to how much effort would be required to meet aggressive reduction targets, or despondency created from a sense that the future is inevitable.

Additionally, assuming no exogenous changes may cause communities to misjudge the amount of local mitigation needed. With too little mitigation the community will miss its reduction target, but too much mitigation may cause it to incur high costs (an economically inefficient outcome), upset community members, or bear an unfairly large share of the state and national effort. Three recent studies show that changes in technology and legislation that are exogenous from the community's perspective do affect its decisions about which mitigation policies to choose. Frank, Kavage, and Appleyard (2007) show that even assuming a 287% increase in fleetwide fuel economy by 2050, which is very optimistic, localities in the Puget Sound region would still need to reduce vehicle miles traveled (VMT) by 20% to achieve their GHG reduction target. Anders, DeHann, Silva-Send, Tanaka, and Tyner (2009) estimate that even if half of San Diego's GHG emissions reduction target were met through state-required renewable energy portfolio standards for utilities and low-carbon fuel standards, local measures would still be required. Willson and Brown (2008) call carbon neutrality for their university campus a "fantasy unless there are supportive energy, transportation, and carbon sequestration initiatives at the state, national, and international level" (p. 497).

The problem with addressing uncertainty by developing multiple forecasts or scenarios is that making assumptions about critical future changes would exceed the capabilities of most local governments. Moreover, no standardized approach for addressing this has been developed for community-level emissions inventories. Wing and Eckhaus (2007) observe:

> Perhaps the thorniest problem is the issue of how to model the effect of technological progress, which, some have argued, has been the major influence on the intensity of fossil fuel use. But the projection of technological change is, in turn, one of the most difficult tasks that economists have undertaken, and the literature is strewn with efforts that are at best only partially successful. (p. 5267)

Once the GHG emissions forecast is complete and the reduction target is established, mitigation actions to reduce the community's GHG emissions must be developed and adopted. For the plan to be effective, adopted mitigation actions must cumulatively reach the GHG emissions reduction target identified in the inventory. To assess whether or not mitigations will be adequate to reach the target, they must be quantified. Estimating the emissions reduction associated with each mitigation action requires that assumptions be made about implementation, phasing, and emissions conversion factors (CARB, 2008; ICLEI, n.d., 2010; National Wildlife Federation, 2008). For example, estimating the emissions reduction that will result from improved bicycle infrastructure requires assumptions, such as the percentage of the population that will change behavior, the VMT reduction associated with the behavior change, and the emissions resulting from the reduced VMT. Such assumptions should be transparent, to make it easier to recognize when they are violated, to recognize the changes that would needed to meet reduction targets if this were the case, and to facilitate development of monitoring programs to track progress.

Research Method

We conducted a content analysis of 30 city climate action plans selected as a stratified random sample (see Table 1). We chose to examine adopted, stand-alone, climate action plans that were not chapters or sections of other plans. All were based on GHG emissions inventories. We identified plans through internet research, news databases, lists maintained by various government agencies and nonprofits, popular and academic literature, and from references to them in other plans. Our investigation identified 62 city plans from across the United States that met our selection criteria as of October 2009.

We categorized each of the 62 plans as belonging to one of four U.S. regions (Northeast, Midwest, South, or West) and one of three population size categories using the U.S. Census data for 2000 (under 100,000; 100,000 to 500,000; or greater than 500,000). We used these classifications to ensure regional representation (39% of the plans were from California) and diversity of city capacities as represented by population size. We considered additional stratification criteria, but the population of plans was too small to stratify further. We then drew a random sample of 30 plans for review.[2]

Consistent with Pitt (2009), the cities covered by the sampled plans varied significantly on key demographic characteristics such as population, median household income, and racial and ethnic composition, suggesting that climate action planning is not limited to metropolitan areas, wealthy communities, or progressive college towns, as is often assumed. Among the sampled plans, we found that 93% of cities were members of ICLEI and 83% were signatories to the U.S. Conference of Mayors' Climate Protection Agreement.

Table 1. Study sample of 30 local governments' climate action plans.

Jurisdiction	State	Region	Population (2000)
Los Angeles	CA	West	3,833,995
San Diego	CA	West	1,279,329
San Francisco	CA	West	808,976
Seattle	WA	West	598,541
Denver	CO	West	554,636
Chula Vista	CA	West	219,318
Tacoma	WA	West	197,181
Hayward	CA	West	142,061
Martinez	CA	West	35,866
Albany	CA	West	16,444
Aspen	CO	West	5,914
Homer	AK	West	3,946
Miami	FL	South	413,201
Winston-Salem	NC	South	217,600
Chattanooga	TN	South	170,880
Key West	FL	South	25,478
New York	NY	Northeast	8,363,710
Boston	MA	Northeast	609,203
Pittsburgh	PA	Northeast	310,037
Stamford	CT	Northeast	119,303
Cambridge	MA	Northeast	105,596
Keene	NH	Northeast	22,563
Brattleboro	VT	Northeast	12,005
Bath	ME	Northeast	9,266
Chicago	IL	Midwest	2,853,114
Kansas City	MO	Midwest	451,572
Cincinnati	OH	Midwest	333,336
Madison	WI	Midwest	231,916
Lawrence	KS	Midwest	80,098
Evanston	IL	Midwest	74,239

The sampled plan titles were mostly variants of "climate action plan," "climate protection plan," "local action plan," or "CO_2 reduction plan," and city-specific variants such as *Green LA* (Los Angeles), *MiPlan* (Miami), and *Climate: Change* (Boston). The authors of the plans were mostly city staff (73%) and appointed community task forces or committees (33%).[3] In addition, many plans had other contributors such as consultants (13%), universities (10%), and nonprofits (10%). The median year the plans were prepared (or updated) was 2008, with the oldest being from November 2000. Plans averaged 62 pages (plus appendices) and ranged from 24 to 158 pages. The contents of climate action plans varied (see Table 2) but most contained the essential core elements: a GHG emissions inventory, GHG emissions forecast, GHG emissions reduction target, and mitigation policies, programs, and actions. Notably, few plans addressed climate change adaptation or provided plans for financing mitigation actions.

Table 2. Variables analyzed in climate action plans.

Category	Variables
Municipal and demographic information	Population, household size, income, race, Hispanic origin
Planning process and public participation	Plan format, the funding mechanism for plan development, plan authors, inclusion and roles of stakeholder taskforces or committees, plan adoption mechanism, intended purpose of the plan, current status, monitoring and evaluation program
GHG emissions inventory structure and content	Basic inventory content and format, author and funding mechanism if different from that of the climate plan, protocol used for inventory development, baseline year, emission forecast year, forecast method, degree of deviation from chosen protocol, consideration of external change
Climate action plan structure and content	Overall content, links to other city or regional policy (such as comprehensive plans or state climate plans), existence of selection criteria for mitigation measures
Mitigation action factors	Categories of emissions addressed, hierarchy of policy statements, relationship to emissions reduction targets, policy type (i.e., education, incentive, mandate), inclusion of an emissions reduction estimate for each policy, funding mechanism for implementation, policy phasing, clearly communicated assumptions
Adaptation actions	Identification of a risk assessment in the plan, adaptation strategy content and structure

We recorded data for approximately 70 quantitative and qualitative variables in reviewing these plans, grouping them into the following categories: municipal and demographic information, planning process and public participation, GHG emissions inventory, plan structure and content, mitigation actions, and adaptation actions (see Table 3). For each variable category, we developed several questions that we used to interrogate the climate action plan documents. To assure data quality, we each regularly examined all of the other authors' reviews to check for potential inconsistencies.

We organized our results into an analysis matrix to allow us to summarize and develop typologies and descriptive statistics to link our findings to our research questions. We identified whether certain plan elements were present, listed values such as emissions reduction targets, and wrote narrative discussions of plan content such as the degree of linkage between the emissions inventory and identified mitigation strategies. In cases where qualitative data could be quantified, we did so and developed basic descriptive statistics. In other cases, where the collected data were qualitative, we used Charmaz's (2006) method of coding data into typologies or categories for further analysis. For example, we coded data on emissions reduction targets into three categories: greater than, less than, or equal to the Kyoto standard.

As discussed earlier, we reviewed the 30 plans to assess the degree to which climate action plans are informed by the GHG emissions inventories and to identify GHG emissions inventory choices and assumptions that may influence climate action plan policies and actions. To accomplish these goals, we organized and analyzed the

Table 3. Percentage of sample of climate action plans containing specific content.

	% of plans
Climate science basics/primer	73
Local/regional climate change impacts	77
Planning process description	60
Public participation description	47
GHG emissions inventory (summary or entire report)	97
GHG emissions reduction target	100
GHG emissions forecast	70
Mitigation policies/programs/actions	100
Adaptation policies/programs/actions	27
Financing	27
Monitoring and evaluation	47

data gathered from our review of these plans to answer the following questions derived from the climate action planning overview above:

- Was the protocol for the GHG emissions inventory specified and justified?
- Did the GHG emissions inventories deviate from the established protocol? If so, was that deviation explained and justified?
- Was a GHG emissions reduction target adopted and justified?
- Was a GHG emissions forecast conducted and documented?
- Did the GHG emissions forecast account for exogenous change that is not under local government control but that would affect the community's GHG emissions, such as evolving vehicle and fuel technologies and increasing renewable energy development by electricity providers?
- Did the GHG emissions forecast account for uncertainty?
- Were the types of mitigation actions consistent with GHG emissions sources identified in the inventory and were the mitigation actions quantified as to potential GHG emissions reductions?
- Would the mitigation actions, once implemented, reduce the community's GHG emissions to the adopted reduction target?

Analysis and Findings

GHG Emissions Inventories Follow Protocols, but Aim Only for Modest Reductions

We examined whether plans deviated from established emissions inventory protocols and whether any explanation was evident or provided for such deviations. We were specifically interested in whether political or policy considerations affected the inventory methods and assumptions. This is difficult to assess directly, as most plans did not explicitly address political issues, so instead we focused on whether local planners had provided reasonable technical or practical justifications for any deviations.

We found that only 27% of plans deviated from the methods or assumptions in the locally chosen protocol for emissions inventories. Most of the cases either explicitly explained technical reasons for these deviations or the reasons were clearly evident. In only one case (3% of plans) did we find evidence of a deviation from standard practice that suggested local political considerations were controlling. In this case, the community decided to exclude vehicle trips on the state highway from their reported community emissions, explaining that they had no control over vehicles passing through their jurisdiction. This community is in a major metropolitan region and over three quarters of their transportation-related emissions came from these trips. The explanation is reasonable, but reflects a deviation from the standard protocol that may show an attempt to make the city's emissions profile look better or absolve the city of responsibility for regional trip reduction.

Of the plans that did not use the ICLEI protocol, two chose methods that closely resembled the ICLEI protocol and two chose to develop their own protocols that allowed their emissions inventories to more closely mirror the jurisdiction's view of global warming and their contribution to it. Aspen, CO, took the latter approach (see City of Aspen, 2007). Its inventory aimed to quantify the broader climate impacts of an economy based largely on tourism, including emissions released outside Aspen's boundaries, such as ski lift operations and visitors' travel to the area. In another case, Seattle's inventory predated the ICLEI protocol (see City of Seattle, 2006). In its absence, the city adapted for local use a UNFCCC protocol for national-level inventories.

All communities adopted specific GHG emissions reduction targets. Fifteen communities adopted targets equal to (nine communities) or greater than (six communities) the Kyoto Protocol (7% below 1990 levels by 2012) and 15 communities adopted lesser targets. Of the nine communities that adopted the Kyoto Protocol target, not surprisingly, most cited the Kyoto Protocol as their justification. Of the six communities that exceeded the target, most were not clear on why, but two cited desires to meet levels set by their peer communities. For example, the City of San Francisco cited as an inspiration the 16 international cities that had formally declared intentions to go beyond the Kyoto Protocol in the Toronto Declaration communiqué to the Conference of Parties meeting in Morocco in November, 2001 (City of San Francisco, 2004).

Of the 15 communities setting targets less ambitious than the Kyoto target, six provided no clear justification, three cited limitations on implementation feasibility, two averaged targets from other sources (including similar communities), and three in California cited that state's adopted standard. In addition, one community (Denver, CO) adopted a per capita reduction target that allows for a significant increase in total GHG emissions over the baseline, the only plan to allow such an increase (see

City of Denver, 2007). The Denver plan justifies this increase by explaining that Denver expects significant population growth, but will still be able to attain the chosen goal. The Denver case highlights the challenge faced by fast-growing communities whose emissions will increase simply because they are adding people, whereas slow-growth communities will see little increase over baseline even if they do nothing.

In order to examine the potential to reach the adopted reduction targets, 70% of the plans contained GHG emissions forecasts for their reduction target year. This means that the others, about one third of communities, adopted reduction targets, but have not examined how future growth and change will affect their ability to achieve them. Such an approach seems unlikely to be effective. Of the plans that did contain GHG emissions forecasts, half used standard ICLEI protocols and the other half either developed their own protocols or did not document the protocols they used.

Overall, few cities deviated from established emissions inventory methods, and there was little evidence that assumptions had been manipulated for political or policy reasons among those that did make adjustments. Perhaps this is not surprising, since we would expect early-adopter communities to be motivated by internal progressive or innovative policy agendas, as demonstrated by their voluntary participation in the U.S. Conference of Mayors' Climate Protection Agreement. As federal and state governments move toward mandating that local governments take action to mitigate climate change, there may be more instances in which localities subvert the inventory process; there is some evidence of this in small and mid-size communities' responses to federally mandated stormwater planning (White & Boswell, 2007). Or perhaps we missed this, since only half of the sampled climate action plans disclosed enough information about assumptions and methods sufficient for detailed analysis.

Exogenous Change and Uncertainty Left Unaddressed

Only two plans addressed exogenous change directly; an additional nine plans mentioned it but did little to account for it. None of the plans directly addressed uncertainty by reporting ranges or incorporating error bars into forecasts. Two plans forecasted for multiple scenarios, but both then selected one scenario to use rather than retaining multiple scenarios to account for uncertainty and inform reduction targets or mitigation action development.

Despite the fact that exogenous change and uncertainty will affect climate change and how localities respond to it, it appears that most communities found this too challenging to address in their forecasts. Of the plans that did address exogenous change, some incorporated assumptions into the forecasts, while others showed exogenous change as a mitigation action with quantifiable results. This raises the issue of whether exogenous change should be taken as given by the community preparing a plan or whether the community has a role to play in helping to lobby for, or support, efforts of others to promote such change.

The plans only addressed three of the forms of exogenous change mentioned previously: technological innovation, legislative and regulatory initiatives, and economic change. Social and behavioral change and demographic change (other than population growth) were ignored. Three plans addressed future CAFE standards, two plans used U.S. Energy Information Administration (EIA) forecasts to adjust for future technology (fuel mix) changes, and three plans incorporated changes in the anticipated fuel mix of their regional energy providers. Only one plan mentioned the potential impact of federal cap-and-trade legislation, and it did not adjust its emissions inventory or forecast.

In California, Hayward's climate action plan was notable for its detailed consideration of issues of exogenous change (see City of Hayward, 2009). The forecasts in the Hayward plan showed two scenarios. Scenario 2 assumed increases in fleet average fuel economy and in the percentage of electricity generated using renewable sources, while Scenario 1 did not make these assumptions. The Hayward plan showed in detail that even if the proposed mitigation actions were fully implemented, the exogenous changes assumed in Scenario 2 would have to occur to reach the 2020 emissions reduction target. Although the plan contemplated the potential for new technology to help reach targets, it acknowledged the uncertainty in trying to forecast these changes. The Hayward plan suggested regularly monitoring progress not only on plan implementation, but also on exogenous technological change. Moreover, the plan suggested that the city advocate for, and itself take advantage of, technological change:

> Developing technology is not the biggest challenge to achieving the 2050 goal. The biggest challenge is creating the conditions for the existing technologies to sufficiently penetrate the market and the culture. Hayward faces the challenge of using its resources to help direct its residents and businesses to embrace new technologies and new ways of thinking about our collective impact on the climate. (City of Hayward, 2009, p. 34)

Hayward's proactive effort shows one way communities can address the issue of exogenous technological change.

Mitigation Actions Were Poorly Linked to Reduction Targets

Existing protocols direct that GHG emissions sources identified in the inventory be reflected in the mitigation actions. In 83% of plans, the emissions identified in the inventory were generally addressed by the mitigation actions, although two plans focused on municipal actions to the exclusion of actions in the wider community.

Once mitigation actions are identified, their potential GHG reduction should be quantified and any key assumptions identified. For example, the City of Cincinnati identified collaborating with "regional bicycling advocates in order to increase bicycle use as a mode of transportation" (City of Cincinnati, 2008, p. 64). They then assumed that through this collaboration they could increase the percentage of workers over the age of 16 that bike to work from 0.15% to 0.67%, a conservative number well below the national average. Based on existing and forecasted transportation mode share, average bicycle trip length, and vehicle emissions factors, they estimated that this would reduce annual GHG emissions by 6,300 tons per year.

This level of quantification and documentation was not common. One third of the plans did not quantify emissions reductions from mitigation actions, meaning they did not assess whether or not targets could truly be reached. Of the plans with quantified emissions, 57% of these were not backed with a clear discussion of assumptions. Without clearly communicated assumptions, a city cannot evaluate progress or make adjustments as new conditions emerge that may speed or hinder progress. Thus, 71% of plans either failed to quantify mitigation reductions or if they did quantify them, failed to make the underlying assumptions clear.

The final aspect of linking emissions to mitigation actions is to use the identified and quantified mitigations to reach the adopted GHG emissions reduction target. In the plans we reviewed, 50% expected to reach their reduction targets through the proposed mitigations, 17% fell short (two by more than 75%) and, as noted above, 33% did not quantify their mitigation actions. Several communities plan to reach their reduction targets by counting on single, large proposed actions such as offshore wind farms or significant changes in the fuel mix of local energy providers. Although these may be legitimate considerations, these communities will fall well short of their targets if these few actions are not implemented.

Implications for Practice

Climate action planning poses a set of new challenges for practicing planners, from technical emissions estimation to developing a plan that simultaneously meets the needs of a community and plays a part in solving a global problem. Based on the analysis and findings, we have identified five recommendations for improving GHG emissions inventories and climate action plans.

1. GHG emissions inventories supporting climate action planning are somewhat standardized, but documentation of data and assumptions should be improved. We observed that the technical quality of GHG emissions inventories had not been compromised through political or policy considerations. The well-developed protocols and software that communities use have made this a mostly technical exercise, and manipulating it would be difficult to conceal. For example, electricity and natural gas use is easily assessed through utility bills, leaving little room for interpretation or manipulation. We observed that many plans still do not document their data and assumptions sufficiently in inventories, particularly when they require simplification or interpretation, such as the GHG emissions resulting from private vehicle use. We believe these data and assumptions should be made transparent to encourage review by decision makers and the public. It would also be valuable to increase discussion of the level of uncertainty in the assumptions and the implications this has for policy.
2. GHG reduction targets should be substantiated. We found greater variation in the emissions reduction targets than in the inventories themselves. Half of the communities' adopted targets were more stringent than the Kyoto Protocol target of 7% below 1990 levels by 2012. Setting a target is a community value judgment, yet we were surprised at this level of variation given the existence of the Kyoto target, which is cited in the U.S. Conference of Mayors' Climate Protection Agreement to which most of the communities are signatories. Communities should provide clear justification for their reduction targets, especially when they fall short of the Kyoto target. Clearer guidance from states, as in the case of the statewide GHG reduction targets established in the 2006 California Global Warming Solutions Act, and the federal government may help correct this deficiency in climate action plans.

3. The effect of exogenous change should be accounted for in GHG emissions forecasts and reduction targets. This is one of the most difficult technical issues in GHG emissions forecasting. Guidance is poor and often conflicting; moreover, there is no crystal ball to foresee the rate of technical, legislative and regulatory, and social change for those who would consider adjusting business-as-usual forecasts to account for it. Yet, these changes will have a significant impact on the communities aiming to develop mitigation actions that adequately account for their share of needed GHG emissions reductions. In fact, some communities are counting on such change to help them achieve their targets. If federal, state, and local governments coordinated more effectively to divide up this responsibility, it would advance the larger goal of reducing global emissions. The American Planning Association (2008) has called for this greater coordination of climate action planning at all levels of government.
4. Rapid population growth should be acknowledged and accounted for in GHG emissions forecasts and reduction targets. Fast-growing communities can expect increases in total emissions simply because they add people, regardless of any other factors. Some communities in the United States were growing faster than 10% per year in the past decade. They have little hope of achieving any near-term emissions reduction targets, which can make climate action planning seem pointless. The City of Denver addressed this problem by setting a per capita reduction target in the near term rather than adopting one for the community as a whole. In California, per capita emissions standards have been proposed for examining the environmental impact of land use changes (see Bay Area Air Quality Management District, 2009). Whether this is a good alternative is debatable, but it has not been critically examined in the context of climate action planning.
5. Lack of quantified and reliable mitigation actions should be offset with clear and effective monitoring and evaluation programs. Most climate action plans either failed to quantify mitigation reductions, or, if they did quantify them, failed to make assumptions clear. Although emissions inventory protocols clearly specify the importance of quantifying reductions and clarifying the assumptions on which they are based, many communities may still find this detailed, technical work challenging. Given that mitigation actions may not actually achieve desired reductions, plans should incorporate well-developed monitoring and evaluation programs to track implementation success and link it back to achieving emissions reductions. Only half of the community plans we reviewed had monitoring and evaluation programs, and most were inadequate.

Conclusion

Best-practice standards for GHG emissions inventories and climate action plans are changing and improving on a regular basis. Our review of 30 local climate action plans and their associated GHG emissions inventories from a variety of U.S cities shows mixed adherence to these standards. Although most communities preparing climate action plans do begin with a GHG emissions inventory, many fail to follow through on conducting adequate emissions forecasts, setting meaningful reduction targets, or linking their mitigation measures to these forecasts and targets. Since the choices and assumptions made in GHG emissions inventories, forecasts, and reduction targets influence selection and implementation of climate action plan policies and actions, these plans may not effectively address the climate change problem, as Wheeler (2008) also concluded. We hope that the city planning profession can take a more prominent role in bringing principles of good planning to the emerging field of climate action planning. We encourage the American Planning Association, college and university departments of city planning, and other professional planning organizations to take a more active role in the education of planners, allied professionals, local officials, and citizens on the possibility of meaningful local planning for solving the climate crisis.

Notes

1. The estimate is based on plans verified by the authors to be completed, approved, and inclusive of basic plan components.
2. Since populations varied highly among the strata, we were not able to sample an equal number of plans from each. For example, the Midwest only had one city with a population of over 500,000 and the South had none.
3. The percentages do not add to 100% because some plans have multiple authors.

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