UNIVERSITY OF CALIFORNIA

SANTA CRUZ

Local Government Adoption of Effective Climate Change Policies

A dissertation submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

ENVIRONMENTAL STUDIES

by

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June 2020

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Abstract

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John H. Armstrong

In the face of federal inaction on climate change, local governments have emerged as policy leaders. Yet evidence indicates that many of the policies enacted do not significantly reduce greenhouse gas (GHG) emissions. This dissertation investigates the adoption of effective local government climate policies, focusing on Community Choice Aggregation (CCA) in California. The policy promises climate and community benefits, but its effects have not been explored. With a mixed-methods approach, including an assessment of quantitative variables and qualitative analysis based on interviews and news media analysis, the study examines the effects of CCA and why local governments enact it.

The investigation makes significant contributions about what types of governments can adopt effective policies, the underlying policymaking processes and stakeholders, and the role of local control. The study finds that local governments that adopt CCA significantly reduce GHG emissions. Although liberal, environmental areas are the first to enact the policy, a diversity of areas can follow and adopt effective climate policies.

Contrary to prior research, the investigation finds that bottom-up policymaking is crucial and has driven CCA adoption, led by an interconnected effort of local elected officials and grassroots groups. They were concerned about climate change along with other issues, especially local control. Despite prevailing

expectations, local control helped communities overcome free-rider problems by allowing governments to shape policies to their unique priorities and benefit.

The dissertation also examines the ecosystem implications of urban renewable energy development, which is increasing in part because of local government climate policies. The study assesses how ground-mounted solar arrays in parking lots affect arthropods, which serve critical roles in urban ecosystems. The analysis finds substantial arthropod abundance under solar arrays and that integrating vegetation with the arrays significantly increases overall arthropod abundance, abundance of parasitoids and detritivores, and arthropod family richness.

The concluding chapter discusses the dissertation's contributions to the literature and future research directions. The findings underscore the need to examine more cases of effective climate policy adoption, analyze the transition from modest to effective policies, and reconsider the role and effects of local control for environmental issues.

Acknowledgments

I am deeply grateful to Sheldon Kamieniecki for his steadfast support and guidance. He not only made this possible, but also a very positive experience. I also sincerely thank the rest of my dissertation committee. Adam Millard-Ball and Stacy Philpott provided essential guidance, feedback, and encouragement. They were both exceedingly generous with their time and intellect. Elizabeth Beaumont offered tremendous insight, perspective, and comments. To each of you, thanks.

I would also like to thank the Department of Environmental Studies, including its faculty, staff, and graduate and undergraduate students, for their knowledge, support, and ideas. Additional acknowledgments are noted at the end of Chapters 2, 3, and 4.

Chapter One

1.1 Introduction

Cities, counties, and towns have emerged as climate change policy leaders in the last two decades. These local governments' policy actions have generated substantial interest in their potential to reduce greenhouse gas (GHG) emissions and further sustainability (Rosenzweig et al. 2010). Interest in local governments is enhanced by the climate policymaking void left by the U.S. federal government. Congress has failed to adopt any meaningful GHG emission mitigation legislation. Yet amidst optimism about the role local governments in climate policymaking, there is evidence that much of the policy action they have taken to date lacks depth and does not significantly reduce GHG emissions (Millard-Ball 2012, 2013; Ostrom 2009; Stone, Vargo, and Habeeb 2012; Wang 2013; Wheeler 2008). This dissertation investigates the policymaking process and adoption of effective local government climate policies.

Climate change, driven by anthropogenic GHG emissions from sources such as fossil fuels, is widely considered to be the most serious problem the world will face in the 21st century. The United Nations reports that climate change is the defining issue of this time (IPCC 2014). Evidence indicates that the world is close to (or may already have reached) critical tipping points in GHG emissions that will lead to irreversible changes in the planetary climate system (IPCC 2014). The World Health Organization, United Nations agencies, and dozens of academic institutions have determined that climate change represents the greatest global health threat of this century (Watts et al. 2018). Additionally, the United Nations finds that climate change is one of the greatest threats to human rights given risks to life, health, food, and adequate living standards of communities across the world (Burger, Wentz, and Knox 2015). For these and other reasons, the U.S. Intelligence Community has concluded that climate change poses a serious national security threat (Coats 2019), and the World Economic Forum (2020) has pointed to climate change as a top global threat.

The impacts of climate change are widespread and significant, affecting people and ecosystems everywhere. Impacts include extreme storms, sea-level rise, droughts, fires, elevated temperatures and heatwaves, ecosystem changes, and biodiversity loss (IPCC 2014; USGCRP 2017). These effects vary throughout the world, but virtually everywhere will experience some of these effects and disruptions (IPCC 2014). The Intergovernmental Panel on Climate Change (IPCC 2014) is 95 percent certain that anthropogenic emissions are the primary cause of global warming, leading them to call for urgent action to reduce GHG emissions.

Climate change poses serious environmental justice issues. Developing nations and disadvantaged communities will experience many of the most severe impacts, the same areas that generally contributed least to the problem of global GHG emissions (Althor, Watson, and Fuller 2016). Exacerbating the problem, these communities tend to have the least resources to adapt and recover from climate impacts.

Urban areas are a critical area of focus for GHG emissions reductions given the increasing percentage of the global population that lives in cities: 54.5 percent of all people in 2016, projected to be 60 percent by 2030 (UN 2016). Globally, cities consume approximately 78 percent of the world's energy production and contribute more than 60 percent of GHG emissions (Kehew, Reid, and Johm 2016; UN 2020). In the United States, approximately 80 percent of people live in urban areas, which are responsible for up to 80 percent of the nation's anthropogenic GHG emissions (Gurney et al. 2014; Jones and Kammen 2014).[1] As a result, policies in urban areas may be able to reduce emissions substantially.

1.1a Background and context

Local governments have enacted a variety of climate policies, from voluntary initiatives and changing the lightbulbs at city hall to comprehensive plans that set strict standards for most or all sources of emissions (Corfee-Morlot et al. 2009; Sharp, Daley, and Lynch 2011). Among the local governments that have acted on climate change, some devote significant financial and capacity resources to the issue, others almost none. The types of policies they enact and the resources they devote to the issue are paramount to local governments' role in addressing climate change.

Most studies about local government climate policies, however, have not distinguished between minimally effective policies such as changing the lightbulbs and policies that are truly impactful, such as policies that set limits on total emissions (Kalafatis 2018; Millard-Ball 2012; R. Wang 2013; Wheeler 2008; Yi, Krause, and Feiock 2017). Scholars have not addressed whether and why a broad set of

[1] As noted by the U.S. Global Change Research Program (Gurney et al. 2014), precise estimates of urban area emissions are sensitive to the urban boundary definition chosen. Jones and Kammen (2014) find that suburbs, which tend to have higher levels of emission than urban centers, account for 50 percent of U.S. household carbon footprints.

governments would adopt effective policies. Additionally, few studies have examined policymaking comprehensively including stakeholders and politics.

In this dissertation, effective (or impactful) policies are those that lead to significant and measurable changes and goals. While quantifying a specific threshold of significance would be difficult, joining a climate network without implementing new policy changes that reduce substantial amounts of GHG emissions would not be an effective policy. Neither would be small improvements like recycling government paper or aspirational statements such as "improving public transit." Setting strict new standards that require changes, such as for transportation or building efficiency, would be effective policies. Substantial financial and human resource capacity investments are almost always crucial for policies to be effective (Hawkins et al. 2016; X. H. Wang et al. 2012).

Local governments' climate policies also pose a free-rider dilemma (Olson 1965) and a broad question about the role of policy decentralization and local control. Rationally, local governments would not be expected to take on the costs of reducing GHG emissions given that climate change is a global problem, and no reduction in local emissions will measurably reduce the threats they face (Trisolini 2010). Instead, local governments would be expected to leave the issue to national and international authorities.

Further adding to the dilemma of local government climate policy adoption, local control of environmental issues has traditionally been associated with negative environmental outcomes. For instance, local control of natural resources has led to increases in mining, and local control of forests has led to more logging (Fleischman et al. 2014; Ostrom 2009; Oyono 2005). The prevalence of local government climate change policies thus raises critical questions about the efficacy of policy decentralization and under what conditions local control may lead to positive outcomes on climate change and other environmental issues.

1.1b Dissertation overview

To investigate interrelated questions about effective local government climate policies and local control, this dissertation examines the adoption and spread of Community Choice Aggregation (CCA) in California. CCA is an energy and climate policy that is transforming key parts of the state's energy system. The policy allows counties, cities, and towns to determine the energy supply by pooling residents' electricity purchasing, taking over that role from private investor-owned utilities (IOUs) like Pacific Gas & Electric (PG&E). Local governments then get to determine the makeup of the electricity supply for residents in their jurisdictions, choosing how much comes from different sources such as fossil fuels, hydropower, and renewable energy like wind and solar. Local governments have pointed to CCA as one of their most important climate policies, utilizing it to procure substantially higher amounts of renewable energy than required by California's state climate program (Armstrong 2019; O'Shaughnessy et al. 2019).

CCA is an excellent climate policy to study for several reasons. The policy stands out among climate actions for requiring considerable financial and capacity investment and for affecting significantly GHG emissions. Since 2010, the policy has been implemented throughout many parts of California. The local governments that have considered and adopted this approach are very diverse geographically, socially, politically, and economically, making findings applicable to other states and countries. Additionally, there is practical policy applicability both within the state and across the country as seven other states have enacted CCA, and several others are considering it (O'Shaughnessy et al. 2019), many of which are looking to California for direction and guidance.

This dissertation examines several aspects of CCA policymaking to address questions about policy adoption, the policymaking process, and local control. Chapter 2 analyzes the renewable energy and GHG emission implications of CCA as part of an assessment of the policy's prior and future effects on California's climate goals. To understand what governments are most likely to innovate and participate with impactful policies, the study analyzes the characteristics of local governments that have adopted the policy over time. This serves as a foundation to assess policy diffusion and consider the opportunity for strategic, targeted policymaking approaches.

Chapter 3 explores five areas of the state where local governments adopted CCA, as well as two that voted not to adopt it, to examine in depth the political and policymaking process and public participation. Through interviews and media coverage analysis, the study examines the human side of the policy process, including the stakeholders responsible for the adoption of effective climate policies and their concerns. In doing so, it addresses the role, effects, and potential of local control in climate change mitigation.

This research is situated in three overarching theoretical areas to which it contributes. First, the focus on effective policies, distinguished from minimally effective policies, marks a crucial shift in the literature about local government climate policies, including what approaches governments pursue, the reasons why, and the effects of the policies. The investigation considers strategy in policymaking and the possibility of increasing local government participation with meaningful policies. Second, the research examines stakeholders and their motivations to understand the human factors responsible for effective climate policy adoption, addressing bottom-up policymaking and the role of public participation. It assesses why and how local governments overcome the free-rider problem to enact these policies. Third, the study examines the importance and characteristics of local control in the developing landscape of ambitious climate policies. It assesses how the changing nature of urban areas, their demographics, their politics, and the issue of climate change relate to local control, which is traditionally associated with negative environmental outcomes. These theoretical issues and contributions are discussed in detail in Chapters 2 and 3 and are expanded upon in the conclusion in Chapter 5.

While Chapters 2 and 3 examine CCA policy adoption and outcomes, Chapter 4 examines the ecosystem implications of urban solar energy development, which is increasing in part because of climate policies like CCA. Many cities are seeking to develop renewable energy within their jurisdictional boundaries in urban areas. Along with rooftop solar panels, ground-mounted solar arrays are increasingly being built in urban parking lots, fields, parks, and other spaces (Gagnon et al. 2016). While urban solar energy development is likely beneficial in terms of GHG emission reductions and local economic development, researchers have not explored the ecosystem implications.

Chapter 4 links climate mitigation policies and biodiversity conservation in urban areas by investigating how ground-mounted solar arrays in parking lots affect arthropod biodiversity. Arthropods provide ecosystem services, and they are fundamental organisms in several trophic levels and interactions that support biodiversity and ecosystem functioning (Bolger et al. 2000; Sanford, Manley, and Murphy 2009). At eight study sites around San Jose and Santa Cruz, California, the study assesses how ground-mounted solar arrays in parking lots affect arthropod communities. It analyzes how integrating vegetation under the solar arrays affects arthropod abundance, abundance of different functional groups, and arthropod family richness. The study is the first to address the ecosystem effects of urban ground-mounted solar arrays, with implications for urban ecosystem management and biodiversity conservation.

The rest of this chapter situates the research within broader policymaking and political context. It begins by summarizing trends in climate change policymaking and politics at international, national, and state levels. Then it discusses local government climate actions and why they enact such policies. Lastly, it considers these issues amidst and as part of sustainability challenges and how governments may be able to address them.

1.1c Climate policy trends

Climate change is an intensely complicated and challenging policy problem. For decades, most national governments have recognized it as an increasingly urgent issue. While there is considerable certainty about the overarching causes, impacts, and solutions to climate change,[2] policymaking has been slow and insufficient to prevent unprecedented global impacts. This is not universally the case, as some governments have enacted substantial policy changes. Still, most have not enacted policies to reduce emissions at the levels necessary to reduce warming that the IPCC has identified as critical to avoid the worst impacts (1.5° Celsius or at most 2.0° Celsius). Most importantly, the countries which bear the greatest responsibility for the problem – those most essential to addressing it – have not enacted policies to curtail emissions to keep warming below 2.0° Celsius.

International policy efforts to address climate change have taken many forms and have evolved since the 1992 "Earth Summit" that produced the United Nations Framework Convention on Climate Change. The two most significant international achievements, the 1997 Kyoto Protocol and the 2015 Paris Agreement, illustrate the primary focus of that policy work: global governance and agreements paired with national actions. An international focus is rational given the intractable nature of the problem, the inherent need for a global response, and to overcome collective action and free-rider dilemmas (Olson 1965), given that GHG emissions are a global issue and require concerted international intervention and controls.

The Kyoto Protocol largely failed to reduce global emissions as a result of differing goals, insufficient participation, and weak enforcement, among other issues (Rosen 2015). The efficacy of the Paris Agreement is still to be determined, but there are serious questions about its effectiveness due to its voluntary nature and varied

[2] There is certainly a great deal of uncertainty about the specifics and details of the causes, impacts, and solutions, but at a broad level there is widespread agreement.

commitments (Clemencon 2016). The United States failed to ratify the Kyoto Protocol and, upon Donald Trump's presidency and his denial of anthropogenic climate change, announced its intention to pull out of the Paris Agreement less than two years after it was enacted.

In the United States, Congress' inability to pass a climate change policy program is a significant part of why global climate governance has struggled to make progress. As the most significant GHG emission contributor until 2007 (when China surpassed it), and as a global economic leader, the United States' participation and leadership in international agreements is necessary. Indeed, the United States played an instrumental role in reaching the Paris Agreement under President Barack Obama's Administration. Yet the Paris Agreement was designed as a voluntary agreement in part because that was the only way that the United States could participate – with President Obama's executive signature – given that a binding agreement would require U.S. Senate ratification. It was clear at the time of the Paris Agreement, and in the years leading up to it, that the U.S. Senate would not vote to ratify any climate change agreement (Clémençon 2016).

At the national level in the United States, the issue of climate change, and whether or how to address it through governmental policies, has long been politically controversial. There are many reasons why this is the case. Money and special interests carry enormous political influence through lobbying, campaign contributions, and political spending. The fossil fuel industry, one of if not the most powerful special interests in the country, has invested substantially in opposing climate policies (Brulle 2018). Political polarization and sorting on environmental issues has led to growing partisan divides on the issue since the 1990s, with Republican party leaders mostly signaling opposition to climate change policies and questioning or denying the existence of anthropogenic climate change (Dunlap, Xiao, and McCright 2001; McCright, Xiao, and Dunlap 2014).

Gerrymandering has exacerbated partisan divides as primary voters increasingly influence political parties. Those voters are furthest apart ideologically, making bipartisanship and compromise harder and rarer. While a majority of Americans care about the problem of climate change, the issue lacks salience and has not been a high priority for the public (Bromley-Trujillo, Leising, and Poe 2018; Miniard, Kantenbacher, and Attari 2020). The global framing of climate change has led people to see it as a distant problem, rather than one that directly affects their lives (Pralle 2009). Additionally, addressing climate change entails making fundamental alterations to the economic system, upending powerful interests. As a result, the policymaking process faces many competing concerns and stakeholders. All these factors have contributed to gridlock and inaction at the federal level of government.

While the United States Congress has not passed climate legislation, President Obama attempted to enact policies through the executive branch and agency rulemaking procedures. Significant actions included car average fuel economy (CAFE) standards, curtailing truck emissions, methane emission regulations, the Clean Power Plan (which sought to limit carbon emissions from power plants), and signing the Paris Agreement. Yet many of the executive-based actions President Obama took are vulnerable to court challenges and reversal, as they have been under President Trump’s Administration.

Amidst the focus on global and national climate change policymaking, and in the face of their relative inaction, lower levels of government have increasingly sought to enact climate policies. Policymakers, advocates, and scholars have increasingly turned their attention to state governments, and more recently, to local governments, seeing them as more receptive and realizing that they may be able to reduce significant amounts of GHG emissions. In turn, state governments have enacted a variety of climate change and renewable energy policies such as climate action plans and renewable portfolio standards, which mandate that a certain minimum percentage of electricity comes from renewable energy (Rabe 2004, 2007). These policies, and how aggressive their goals are, vary considerably by state. Some state climate action plans, like California's, involve nearly every aspect of the economy (Armstrong and Kamieniecki 2017), whereas others are limited and vague.

While climate policies are not unique to liberal states, they tend to set the most ambitious policies. California has set a goal of a 40% reduction in GHG emissions from 1990 levels by 2030 and 60% renewable energy by 2030. New York, similarly, has a goal of a 40% reduction in GHG emissions by 2030 and 70% renewable energy by 2030. By contrast, Indiana's goal is 10% renewable energy by 2025, and states such as Alabama and Wyoming have no renewable energy targets.[3]

After the federal level, state governments are the logical place to pursue climate policy. States have the constitutional authority to control and regulate significant sources of GHG emissions, such as electricity regulation and transportation. In its

[3] As of December 31, 2019, according to data compiled by the National Conference of State Legislatures (NCSL), available from: https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx (last accessed March 9, 2020).

efforts to advance climate mitigation internationally, California often touts that its economy is one of the largest in the world (fifth as of 2018). Some states have sought to work together and to leverage their collective influence both nationally and internationally. On the east coast, nine states joined together in a market-based program, the Regional Greenhouse Gas Initiative (RGGI), to cap and reduce carbon dioxide emissions. After the Trump Administration moved to pull out of the Paris Agreement, several states formed the U.S. Climate Alliance as an interstate commitment to reduce GHG emissions consistent with the Paris Agreement, share policies, and take coordinated actions. As of July 2019, the U.S. Climate Alliance includes 24 states and Puerto Rico (usclimatealliance.org). Looking back at climate policymaking this century, it would be fair to say that states have been the primary source of progress in the United States, with varied but significant breadth and depth of policies.

1.1d Local government climate policies

Local governments have a lengthy history of climate policy adoption, but attention to them as major actors is more recent (Fuhr, Hickmann, and Kern 2018; Hughes 2017). This is partly because they are lower levels of government without the same reach as state governments and because they do not have the authority in the federal system that states have. Yet as hundreds of cities and many other local governments in the United States have adopted climate policies, advocates, policymakers, and researchers have increasingly recognized that they can have an essential role in climate mitigation (Hughes 2017; Krause 2010; Sharp, Daley, and

Lynch 2011). Many local governments are significant in size, with several cities like Los Angeles and New York City that have larger populations than many states.

While local governments do not have authority under the U.S. federal constitution, they do under state constitutions. Although constrained in some ways, local governments have authority over substantial sources of emissions, including land-use, transportation, building standards, and, in some instances, various energy and electricity matters (McCabe and Feiock 2005). In many cases, there is less partisanship and gridlock at local government levels than at the federal and state levels, with the potential to move faster and undertake innovative approaches (Castán Broto and Bulkeley 2013).

Researchers have studied the types of policies local governments enact, which governments adopt them, and why. Like state policies, local governments have adopted a broad range of measures. By 2010, more than 900 United States cities had taken some formal action on climate change (Krause 2010). Most commonly, cities have joined networks such as Cities for Climate Protection, the International Council for Local Environmental Initiatives (ICLEI), and the Mayors' Climate Protection Agreement. These networks share policy ideas, formalize a commitment to acting on climate change, provide recognition to the participating governments, and seek to leverage their collective influence (Gordon 2016).

Many local governments have enacted some form of a climate action plan, which typically includes an assessment of GHG emissions, reduction goals, and a variety of measures to reduce emissions. Common policies include efficient lighting measures, building efficiency standards, renewable energy incentives, and incentivizing public transportation (Betsill and Rabe 2009; Lutsey and Sperling 2008; Wheeler 2008). The widespread adoption of climate policies has been surprising, given rational expectations that local governments would free-ride off others and decline to assume the costs of reducing GHG emissions since the causes and effects are global.

Local government adoption of climate policies may partially be explained by the fact that many of the policies enacted, such as joining networks, are low-burden actions and require minimal financial or capacity investment. As scholars have moved from examining the adoption of these policies to evaluating their effectiveness, a crucial finding is that many of the policies have modest effects in reducing GHG emissions (Millard-Ball, 2012, 2013; Wang 2013; Stone et al., 2012; Ostrom 2009; Wheeler, 2008). In many cases, joining a network or codifying existing actions into a climate action plan provides little regulatory teeth to cut GHG emissions. Politicians may be incentivized to give the appearance of doing something residents care about while avoiding costly initiatives and contentious issues that may arise with stringent policies. Yet, the realization that many policies are not meaningfully effective points to the need to study the specific effects of policies and to investigate instances of impactful policy adoption.

Although relatively uncommon, some local governments have adopted effective policies to reduce GHG emissions, investing substantial financial and capacity resources in designing and implementing policies that target significant emission reductions, including clear goals, monitoring, and enforcement mechanisms. For example, Boston, Massachusetts, has a goal to reduce emissions substantially and become carbon-neutral by 2050. Boulder, Colorado has a goal of 100% renewable energy by 2030 and an 80% reduction in community emissions by 2050. Washington, D.C. has a policy requiring that utilities provide 100 percent renewable energy by 2032 (Ribeiro et al. 2019).

A significant body of research has examined which governments are likely to adopt climate policies and some of the reasons why (summarized in Chapter 2), but the literature has not distinguished between the adoption of low-burden, minimally effective policies and truly impactful ones. Making that distinction, and studying which governments are likely to enact meaningful climate policies, and why, is a central focus of this dissertation and a critical shift forward in the field.

For local governments to have a significant role in addressing climate change, the next generation of climate policymaking will need to develop policy programs with ambitious and measurable goals and changes. They may need to seek and assert greater authority over sources of emissions such as energy production and electricity consumption. If more local governments move to enact effective climate policies, they have the potential to reduce substantial amounts of GHG emissions and, perhaps as importantly, serve as bottom-up policy leaders that can help generate support for climate policies. In doing so, they may also help spur others and higher levels of government to enact effective climate policies.

1.1e Climate policies and sustainability

Climate policies are one part of an array of broader sustainability objectives. Achieving sustainability – which encompasses environmental, economic, social, cultural, and other issues – is a pressing and difficult challenge. Climate change is not only one of the most problematic sustainability issues, but one which tends to exacerbate other challenges in other areas, such as in agriculture and urban development (Armstrong and Kamieniecki 2019). Reflecting this, there is a growing recognition among scholars that climate change policies need to factor in other sustainability factors (Armstrong and Kamieniecki 2019; Hatfield-Dodds et al. 2015; Mbow et al. 2014; von Stechow et al. 2015). Governments need to create win-win solutions that mitigate emissions and yield social and economic benefits.

Fortunately, research indicates that there is the potential for significant sustainability co-benefits of climate mitigation efforts in a range of areas, including human health, economics, and energy security (von Stechow et al. 2015). Of course, addressing multiple sustainability issues along with GHG emission reductions makes those policies more complicated. Yet there is momentum in this direction as many governments already seek to develop climate policies that have co-benefits such as air quality improvements and job creation. Political leaders tend to frame climate mitigation policies around these local benefits (Bulkeley 2010).

As with climate change mitigation, one of the questions about sustainability is the appropriate level of government to address it (Mazmanian and Kraft 2009; Zaninetti 2009). Many sustainability issues are significant in scale, calling for national and international responses, but they are also local. Given the direct effects of policies for people and the environment, however, local governments are likely to have an important role even if higher levels of government take on the issue (Portney 2013).

Local governments may be a beneficial laboratory to develop and test comprehensive policy frameworks, providing the opportunity to innovate, experiment, and improve policies (Armstrong & Kamieniecki 2019). They are numerous and encompass many sizes, allowing greater flexibility to try out new policy approaches. Additionally, local governments may be well suited to incorporate various stakeholders and public participation, which can be essential to furthering sustainability and doing so in an equitable manner (Dahl 1967; Dempsey et al. 2011; Hess 2009).

1.1f Conclusion

This chapter discussed the difficult and complicated problem of climate change, trends in climate politics and policymaking, and the role of urban areas both in contributing to the problem and in their potential to reduce GHG emissions. Nations have struggled to address climate change at the international level, stymied by the challenging nature of the issue, difficult governance, and inadequate participation by some countries, including the United States.

While gridlock has ensued at the federal level in the United States, a significant number of local governments have adopted climate policies. Many of the local government climate policies, however, are minimally effective actions that do not reduce substantial amounts of GHG emissions. Given the high percentage of GHG emissions for which urban areas are responsible, local governments may be able to have a significant effect in mitigating climate change. To do so, they will need to enact effective policies. Local governments may also be important areas to make progress on sustainability objectives, which climate change typically make more challenging.

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Chapter Two

Modeling Effective Local Government Climate Policies that Exceed State Targets

*Note: This study is published in *Energy Policy*:

https://doi.org/10.1016/j.enpol.2019.05.018

Abstract

This study investigates how local governments can be effective and strategic in reducing greenhouse gas emissions. It examines Community Choice Aggregation in California, a policy through which counties and cities are affecting significant changes to the state's electricity system. The study finds that by 2025, counties and cities that adopt the policy are forecasted to exceed the state's ambitious renewable energy goals by 4,748 to 7,625 GWh, reducing emissions equivalent to 1.14 to 2.04 million metric tons of carbon dioxide, in addition to other energy and community effects. The policy diffuses along political and social grounds, particularly in communities with higher levels of support for the environment, Democratic and Green party voters, and more education. These findings underscore the opportunity presented by targeted policymaking approaches, showing the capacity of local governments to affect statewide changes. Local government policymakers should seek to move beyond "low-hanging fruit" policies and enact difficult, effective policies. Strategy in policy adoption and diffusion is discussed related to the potential to enhance local government participation with high-impact policies.

Keywords: energy policy; local government policymaking; climate policy; policy diffusion; strategic policymaking; policy effectiveness

2.1 Introduction

2.1a Overview

Local governments (cities, counties, towns, and joint powers authorities they create) can play an important role in addressing climate change. They have considerable authority over sources of greenhouse gas (GHG) emissions within their own jurisdictions, such as land-use, transportation, building standards, and, in some cases, local energy development and power purchasing (Dodman 2009; Lefèvre 2012). The importance of these governments is heightened given federal inaction and partisan gridlock (Armstrong and Kamieniecki 2017). Despite significant policy attention and optimistic promises about what they can accomplish, however, evidence indicates that local government climate policies have had less effect in reducing GHG emissions than many had hoped (Millard-Ball 2012, 2013; R. Wang 2013; Wheeler 2008). Most policies, such as climate action plans, have made only incremental progress or served to codify existing actions (Millard-Ball 2012; Stone, Vargo, and Habeeb 2012; Wheeler 2008). While a variety of these policies such as buildings standards are worthwhile, they can be characterized as low-burden, low-impact actions requiring limited or modest financial and capacity investments (X. H. Wang et al. 2012).

For local governments to develop successfully a new generation of climate policymaking that yields greater GHG emission reductions, they will need new approaches that entail more effective policies characterized by significant and measurable changes and goals. Beyond setting stricter standards on traditional sources of GHG emissions (e.g., energy efficiency measures) over which they have authority, local governments may need to develop policies that increase their role and control over additional sources of emissions (e.g., energy production). Such approaches will likely involve substantial financial and capacity investment. This study examines one such approach, Community Choice Aggregation (CCA) in California. The policy stands out among local government climate actions for requiring significant financial and capacity investment, and for its potentially large effect on GHG emissions (Gattaciecca, DeShazo, and Trumbull 2017; Kennedy 2017; E O'Shaughnessy et al. 2015; Ruppert-Winkel, Hussain, and Hauber 2016). Additionally, to have the greatest effect, governments, policymakers, and advocates will need to tackle adoption and diffusion of policies in a strategic fashion that lets governments overcome political constraints and the perception that higher-impact policies are "impossible." While a small number of governments may enact difficult, innovative policies, the challenge is how such policies can be adopted more broadly among a greater number and diversity of governments.

In investigating the capability and approaches for local governments to have a substantial effect in addressing climate change, this study examines two specific research questions. First, are local governments in California utilizing CCA to purposefully exceed state climate requirements? Second, what factors help explain and predict which governments are most likely to adopt CCA?

This study makes several contributions to the literature on climate policy adoption. Much of the climate policy adoption literature has not distinguished among policies that require significant investments and policies that require minimal resources, such as producing climate action plans and joining climate-protection networks. Kalafatis (2018) and Yi, Krause, and Feiock (2017), for instance, have called for greater research focus on direct and specific policy actions. This study examines a policy that requires substantial financial and capacity investment, assessing the characteristics that help explain local government adoption of a high-burden policy. Scholars have also urged examining the outcomes and effectiveness of policies intended to reduce GHG emissions (Millard-Ball 2012; R. Wang 2013; Wheeler 2008), as this study does by examining the effects of CCA in conjunction with policy adoption. Second, most literature on local government climate policy adoption focuses on policies with effects that are limited to that government, such as efficiency standards for a city's buildings. This study examines the potential for local governments to affect broader, statewide and economy-wide changes, in this case with the CCA policy tool and setting renewable energy standards in excess of state requirements. In doing so, this study considers the potential for local governments to take on an expanded role, which may be an important policy direction in addressing climate change as local governments seek increased authority and to lead on the issue. Third, this analysis focuses on counties. These jurisdictions are under-explored in climate policymaking but they may prove to be an important area for new policy efforts given that counties sometimes have farther reach and more resources (Bedsworth and Hanak 2013). Lastly, building off the trends in adoption and diffusion of CCA, strategy in policy adoption is discussed including how local government participation with policies may be increased.

This paper begins with an overview of CCA in California and how the policy fits into the larger context of local government climate change efforts. Next, it reviews the literature addressing why states and cities adopt climate policies, and trends in policy diffusion. Then, the paper reviews the study's methodology and results, followed by a discussion and conclusion concerning the policy implications of the research.

2.2 Background and reasons for climate policy adoption

2.2a CCA in California and local government climate change policies

Enabled by a 2002 state law (AB 117), CCA gives local governments the ability to pool residents' electricity purchasing to control the makeup of the power portfolio, set renewable energy standards, make decisions about costs, and enact other GHG emission-related programs. By taking over energy procurement, CCA therefore allows local governments to affect and go beyond the state's renewable portfolio standard (RPS), which mandates that a certain minimum percentage of every energy provider's electricity portfolio come from renewable energy. CCA programs include concrete, annual goals, and they invest substantial resources to create cohesive governance systems. CCA can allow governments to provide electricity at a lower rate – most offer electricity at a slight discount than the incumbent investor owned utility (IOU) – because they operate as non-profit entities and because they can take advantage of newer and cheaper energy contracts (Gattaciecca, DeShazo, and Trumbull 2017). Under CCA systems, the IOUs continue to maintain the electricity grid including power lines and delivery.

CCA marks a significant change in energy decision-making and governance in California, where three large IOUs – Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDG&E), and Southern California Edison (SCE) – have long served most residents. Under that system, residents have had little choice or say about electricity decisions (Devine-Wright 2012; Welton 2018). With the emergence of CCA, many county and city governments will help determine the state's energy future. For years, some experts believed that CCA would be too burdensome for counties and cities to undertake, and there were several failed attempts between 2002 and 2009 (Gattaciecca, DeShazo, and Trumbull 2017; Ruppert-Winkel, Hussain, and Hauber 2016). Then, the first California CCA entity was started in 2010, and as of November 2018, 17 counties and several cities have adopted CCA. Nine more counties are actively exploring the adoption of CCA out of 58 counties statewide. Five counties are effectively ineligible for CCA because they are served by public utilities, such as Sacramento. In many cases, local governments have come together to form a CCA entity as a joint powers authority (JPA).

In 2017, approximately one million Californians received their electricity through a county or city CCA entity, and the state projects that CCA entities may serve a majority of residents in the next decade (CPUC 2017, 2018). They are re-shaping governance of the electricity system in California and affecting its make-up. All consumers in the territory of a CCA entity are automatically enrolled, with the ability to "opt out" and stay with the existing IOU. Starting a CCA typically takes at least two years and requires substantial costs including a technical study, business and implementation plans, setting up a JPA, and raising the capital for initial power purchase agreements. For example, it cost Marin County over $3 million to plan, study, and create its CCA.

For the local governments that have adopted and are considering it, CCA is typically placed in the context of their climate programs and goals, which entail a variety of actions. Common local government, climate-related actions include joining climate protection networks, crafting climate action plans, and policies addressing facets of the waste, energy, and transportation sectors (Betsill and Rabe 2009; Lutsey and Sperling 2008; X. H. Wang et al. 2012; Wheeler 2008). Among these policies are recycling programs, capturing landfill methane, building efficiency and efficient lighting measures, meeting Leadership in Energy and Environmental Design (LEED) standards, incentivizing public transportation, providing electric vehicle infrastructure and rebates, and implementing bike share programs (Betsill and Rabe 2009). Many municipalities also inventory their emissions and create reduction targets (Lutsey and Sperling 2008).

Kwon et al. (2014) found that California cities tend to place a higher priority on climate-related policies than cities in other states. A large number of California cities have taken various policy actions, including installing solar panels on government facilities and passing resolutions stating goals for sustainability efforts (Bedsworth and Hanak 2013; Kwon, Jang, and Feiock 2014). Their tendency, however, is to adopt "low-hanging fruit" measures such as conducting energy audits of government buildings and purchasing fuel-efficient vehicles, as opposed to more difficult actions, such as setting GHG reduction targets for residences and businesses (Krause 2010, 2011; Kwon, Jang, and Feiock 2014; R. Wang 2013). These are among the reasons why the GHG emission effects of many local government climate plans are limited (Bedsworth and Hanak 2013; Millard-Ball 2012; R. Wang 2013), illustrating the need for new approaches.

2.2b Causes of state and city climate policy adoption

While the causes and trends in adoption and diffusion of CCA have not been examined previously, a range of studied have considered why states and cities adopt climate policies. These studies seek to explain the reasons why states and cities adopt those policies and the characteristics of governments that are most likely to do so. States have a variety of reasons for enacting renewable energy and climate policies. They may do so for economic gain such as from renewable energy development, seeking to encourage industry investment (Barry G Rabe 2007b). They may pass climate policies to leverage their position, and assert their leadership, regionally and nationally (B. G. Rabe 2008). They also may pass such policies as a response to environmental threats and in response to citizen and stakeholder interests (Barry G Rabe 2004; Yi 2014).

Studies have found that several political, social, and economic characteristics are important predictors of state renewable energy and climate policy adoption. A strong presence of Democratic politicians, especially Democratic party control of state legislatures, increases the likelihood that they adopt policies such as a RPS and net metering (Bromley-Trujillo 2012; Coley and Hess 2012; Fowler and Breen 2013; Lyon and Yin 2010; Vasseur 2014). Similarly, a more liberal ideological orientation increases the likelihood of such policy adoption (Chandler 2009; Hess, Mai, and Brown 2016; Matisoff 2008; Wiener and Koontz 2012; Yi and Feiock 2012, 2014).

Important social characteristics include higher levels of education, support for the environment, environmental movement strength, and income (Bromley-Trujillo 2012; Huang et al. 2007; Matisoff 2008; Vachon and Menz 2006; Vasi 2011; Vasseur 2014). Lobbying presence of the renewable energy industry, indicative of potential economic benefits, can be significant (Jenner, Ovaere, and Schindele 2013; Barry G Rabe 2004, 2007b; Vasseur 2014). Other important factors include the presence of policy entrepreneurs, advocacy coalitions, and policy learning through networks (Betsill and Rabe 2009; Nicholson-Crotty and Carley 2016; Stoutenborough and Beverlin 2008).

Similar factors predict which local governments, particularly cities, are likely to adopt climate change policies. Prevalence of Democratic party policymakers and liberal ideological orientation are significant positive predictors of policy adoption (Krause 2011; X. H. Wang et al. 2012; Zahran et al. 2008), as is support for the environment (Bedsworth and Hanak 2013; Millard-Ball 2012). These factors are key components of three theories that help explain why local governments enact climate mitigation policies. Interest group theory posits that local elected officials adopt climate policies as a response to advocacy groups to get their support, with important contributing variables including education and income (Krause 2012; Kwon, Jang, and Feiock 2014; Portney and Berry 2016; Sharp, Daley, and Lynch 2011; Zahran et al. 2008). Capacity theory points to the importance of government staff availability and financial means to act (Krause 2012; Zahran, Grover, and Brody 2008). Lastly, risk-based theory suggests that communities vulnerable to direct climate change impacts are more likely to act due to having experienced disasters, public perception of risk, and interest in the issue (Kalafatis 2018; Sharp, Daley, and Lynch 2011; Sippel and Jenssen 2009; R. Wang 2013). Additional motivations for local government climate policy adoption include cost savings such as from energy efficiency measures (Sippel and Jenssen 2009), co-benefits such as reducing local air pollution (Krause 2011; St-Louis and Millard-Ball 2016), and seeing action as a moral imperative (Betsill and Rabe 2009).

2.2c Policy process and diffusion

Specific causes of climate policy adoption are situated in a broader literature about policymaking and the processes that affect whether policy action occurs and what governments are likely to act, as well as issues of policy diffusion and strategy. A broad framework of the policy process is often conceptualized as encompassing six stages: agenda setting, policy formation, policy legitimation, policy implementation, policy evaluation, and policy change (Kingdon 1995; Kraft 2017). Substantial research has focused on each component of the policymaking process including issue definition, framing, and salience, public opinion, and the role of elected officials, interest groups, policy entrepreneurs, and the media (e.g., Daniels et al. 2013; Entman 1993; Lindblom 1968; Pralle 2009; Weible 2007).

A rich literature on policy diffusion shows that policy learning and the spread of innovations among governments is common (Walker 1969; Berry and Berry 1999, 2018; Shipan and Volden 2008). Many studies lend support to the internal-external diffusion model, finding that government decisions are influenced by internal characteristics such as ideology, and external factors such as what other governments do (Berry and Berry 1990; Nicholson-Crotty and Carley 2016). Policymakers can be inclined to look specifically to adopt, or mimic, policies from governments with similar political ideologies and characteristics (Grossback, Nicholson-Crotty, and Peterson 2004; Volden 2006; Nicholson-Crotty and Carley 2016). Geographic proximity is an important driver of policy adoption, especially when neighboring governments have adopted the same policy (Berry and Berry 2018; Karch 2007; Shipan and Volden 2008; Krause 2010; Nicholson-Crotty and Carley 2016). A variety of studies have demonstrated the importance of geographic proximity in the spread of climate policies, including state renewable portfolio standards, net metering, and city climate protection initiatives (Krause 2010; Nicholson-Crotty and Carley 2016; Barry G Rabe 2010; Stoutenborough and Beverlin 2008).

Studies have also addressed how governments interact with each other on environmental policy matters in light of trade and economic incentives, including the potential for a "race to the bottom" to reduce environmental regulations in order to attract industry (Barrett 1992). Yet studies have found little evidence that a race to the bottom occurs, at least not frequently, whether because of costs of pollution, because of co-benefits of environmental standards such as cleaner air and greater efficiency, or because governments seek to incentivize less-polluting technologies such as renewable energy (Lyon and Yin 2010; Oates 2001; Potoski 2001; Wilson 1996). Indeed, there is evidence that a "race to the top" has taken place among states adopting a RPS (Barry G Rabe 2007b). Furthermore, Fredriksson and Millimet (2002) find a positive association between states' environmental policies, particularly among contiguous neighboring states, indicating strategic behavior in setting stringent environmental policymaking.

Attention to strategy in the environmental policymaking literature has focused primarily on planning, environmental regulation, and policy interaction and competition among decentralized governments. Researchers have developed models of strategic regulatory planning that entail careful assessments of each component of the problem, its history, stakeholders involved, desired outcomes, feasibility of solutions, assessment of regulations, and more (Cohen 2013; Cohen, Kamieniecki, and Cahn 2005; Hofer and Schendel 1978; MacMillan and Jones 1986). Strategic regulatory planning includes understanding the behavior of entities being regulated to identify specific incentives to increase compliance, along with targeted enforcement devices (Cohen, Kamieniecki, and Cahn 2005).

Based on the findings of prior studies about policy diffusion and about factors driving climate policy adoption, it is expected that certain California counties and cities are most likely to adopt CCA. The likely-to-adopt governments are those with select political, social, and economic characteristics, particularly high levels of support for environmental protection and high percentages of Democratic and Green party voters. These factors should be most important among the early-adopting governments that have to overcome the burdens of innovation, which are greatest for the earliest adopters. From there, it is expected that CCA diffuses in part along political and social grounds, with a trend in adoption among governments from higher-to-lower levels of support for environmental protection and prevalence of Democratic and Green party voters.

2.3 Methods

The methodology begins with a description of the unit of analysis. Section 2.3b describes the methods used to answer the first research question, analyzing energy procurement data for all CCA entities to determine if local governments are using the policy to exceed state climate goals. Then, section 2.3c reviews the descriptive analysis conducted to address the second research question about what factors predict which governments adopt CCA, and to assess the policy's diffusion.

2.3a Unit of analysis

Counties and cities that have adopted CCA are included in the analysis of renewable energy effects, an overview of CCA characteristics, and the diffusion of CCA. Counties are the focus for assessment of policy adoption because they are the governments that have started most CCA entities to date. Additionally, counties share similar institutional governance structures and practices to compare across the state. All California counties are governed by elected, nonpartisan five-member Boards of Supervisors (except San Francisco which is a consolidated city-county). Although California is unique in many ways politically and economically, the counties themselves are numerous and diverse, allowing for broader generalizations to other parts of the United States. Seven other states have enacted CCA in a different form, and several other states are considering CCA (O'Shaughnessy et al. 2019).

2.3b Renewable energy effects of CCA

CCA energy procurement data and forecasts are drawn upon to evaluate whether local governments are using the policy to exceed the state RPS and the policy's effects in terms of renewable energy. Each year, all CCA entities are required by the California Public Utilities Commission (CPUC) to submit RPS procurement plan compliance filings, detailing quantitatively their past energy procurement and forecasting their future energy procurement. Data from each CCA entity's 2018 RPS compliance filing were compiled to determine total energy procured by CCA entities since 2011, the first full year of an operational CCA entity, through 2025.[4] Data show the total energy procurement, which is the total energy needed to supply all of their customers' electricity demand each year, and the amount of that which is renewable energy. From those data, the total renewable energy procurement for all CCA entities combined was calculated for each year. To date, most CCA energy procurement has come from non-utility generation sources, contracting directly with wholesale generators (CPUC 2018; Gattaciecca, DeShazo, and Trumbell 2018; Kennedy 2017). As they penetrate a greater portion of IOU energy demand, it is possible that CCA entities will purchase existing renewable energy contracts from the IOUs, as they have begun to do (discussed further in section 2.4b relating to complications and changes in the energy landscape).

The CCA RPS is the percent renewable energy of total energy procurement. The percentage renewable energy procurement for all CCA entities each year was then compared to the annual state RPS. California's RPS was 33% by 2020 and 50% by 2030 until September 2018 when Governor Brown signed legislation (SB100)

[4] Individual RPS compliance filings for each CCA, with prior procurement and future procurement forecasts, are available through the CPUC E-file documents search (http://docs.cpuc.ca.gov/EFileSearchForm.aspx, accessed 03.01.19) under proceeding R1502020. CleanPowerSF data for 2018-2021 in the 2018 RPS compliance filing are confidential. They were not confidential in their 2017 RPS compliance filing, however, so those data were used.

increasing it to 60% by 2030. Because the 2018 RPS compliance filing data submitted by the CCA entities reflects planning for the lower RPS threshold, both the old and new state RPS are presented and compared.

The CCA RPS compliance filings used to evaluate past and future energy procurement forecasts are official data submitted to the state. In addition, some of the CCA entities, particularly the newer ones that are still partially in the process of power procurement planning, submitted energy procurement forecasts to meet the minimum state RPS despite other stated goals and plans to exceed it. To account for this discrepancy, all CCA websites, implementation plans, and integrated resource planning compliance filings were reviewed. An alternative CCA RPS was calculated using planned procurement data and RPS percentages listed in the implementation plans and integrated resource planning filings for six of the CCA entities that listed different procurement targets in those documents (Clean Power Alliance, CleanPowerSF, Desert Community Energy, East Bay Community Energy, Redwood Coast Energy Authority, and Valley Clean Energy).

To provide a range estimate of the GHG emission effects of CCA entities exceeding the state's RPS, the CO_2e reduction of that renewable energy was calculated based on the U.S. Environmental Protection Agency's Emissions & Generation Resource Integrated Database's 2016 electricity emission data for California. The low end of the estimate utilizes the total output emission rate (529.9 lbs/MWh CO_2e); the high end of the estimate utilizes the non-baseload output emission rate (945.6 lbs/MWh CO_2e). The U.S. EPA suggests using the non-baseload output emission rate to estimate emissions avoided by renewable energy displacing marginal fossil fuel generation, which would mean the higher CO_2e reduction end of the range as a result of the renewable energy implications of CCA. The range estimate is used, however, because of uncertainty about what electricity generation the renewable energy displaces and changes in emission rates.

Electricity providers in California, including CCA entities, are required to meet the state's mandated RPS, which is one of the primary regulatory decarbonization tools. The state RPS acts as a floor; state regulators require that each electricity provider individually procure the mandated threshold of renewable energy in their power portfolios. Each CCA entity calculates total energy procurement – as reported and forecasted in their RPS compliance filings – to meet the entirety of consumer electricity demand for the residential and commercial accounts covered by each CCA. Under California's energy system, consumers get all their electricity from one provider. As such, any electricity provider that procures a greater amount of renewable energy than the minimum requirement serves to increase the overall statewide percentage. Thus, as CCA entities meet a rapidly-growing share of electricity demand in the state, they have a greater opportunity to affect the overall percentage of renewable energy procured in the state.

While energy procurement is the primary measure of the GHG emission implications of CCA, many of the CCA entities are also prioritizing other climate and emissions-related characteristics and programs. Various CCA entities have prioritized low or zero-carbon energy and have or are in the process of developing other programs such as electric vehicle incentives. Given that many of the CCA entities are just starting, it is too soon for a full quantitative assessment of the effects of these characteristics. However, they are important to consider in evaluating CCA. The carbon free percentage of each CCA entity's base level electricity service for the most recent year available, as well as other program characteristics, were compiled from a comprehensive review of California Energy Commission power content labels, CCA implementation plans, CCA websites, and the California Community Choice Association website.

2.3c CCA policy adoption

To examine what factors help predict which governments are most likely to adopt CCA, a broad range of social, political, and economic data were compiled to assess the characteristics of the counties that have adopted CCA, the counties exploring CCA, and the counties without CCA. Because of the relatively small sample size and associated challenges in causal inference, a descriptive analysis of predictive variables is utilized to assess cross-sectional results and time trends in adoption and diffusion of CCA. Mean values of the social, political, and economic variables were graphed for the three categories of counties to compare with each other and the statewide averages. Then, Cohen's *d* values were calculated to assess the effect of each variable, calculated for the standardized difference of means between counties that have adopted CCA (n=17) and all other eligible counties (n=36). Until such time that a larger data pool is available, a descriptive assessment of the variables is most useful to identify the factors that are associated with adoption.

County CCA status was identified from state and county government, consulting business, and advocacy sources (CPUC 2018b; Gattaciecca et al. 2018). Variable data were gathered from government, academic, and independent sources.

The variables were selected based on prior studies about environmental policy adoption and characteristics that the research literature demonstrates are important, as reviewed in Section 2.2b Democratic party voter registration numbers were combined with Green party voter registration numbers given their similar voting patterns on environmental matters. Most of the voters recorded in the variable are Democratic party voters; the mean county Green party voter registration percentage is .9 ($s = \pm$ .007%). Beyond the variables displayed in the Results section, data were also compiled for age, Republican party voter registration, and African American, Asian, and Hispanic population numbers, but the results of these analyses are not shown due to space limitations.

A descriptive, time-series comparison of the counties and cities that launched CCA entities is used to examine the key characteristics of the counties and cities that were the first, early, and more recent adopters of CCA, and the counties that are exploring CCA. Based on their theoretical importance and the variable Cohen's *d* values, select characteristics were chosen for these counties and cities. They were then graphically analyzed by launch year for comparison with each other and the statewide mean for each variable. This assessment helps to evaluate the CCA policy diffusion process.

2.4 Results

2.4a CCA renewable energy and GHG emission implications

As evident in Fig. 2.1, CCA entities are gaining an increasing share of California's statewide energy procurement – which totaled 284,060 GWh in 2016

(CEC 2018a) – and are selecting to procure substantial amounts of renewable energy. Between 2011 and 2018, as a group they exceeded significantly the state RPS every year. CCA entities are forecasted to continue exceeding the state's RPS every year through 2025, enough to surpass the state's old RPS (42% by 2025 and 50% by 2030). This was the regulatory mandate they were working off when they planned their procurement as reflected in Fig. 2.1. Nevertheless, CCA entities are also forecasted to exceed the state's new RPS (~46% by 2025 and 60% by 2030). While each CCA entity's individual RPS procurement varies, collectively they are forecasted in 2025 to exceed the state's old RPS by 13% and the state's new RPS by 9%. This equates to an excess amount of renewable energy in 2025 of 6,782 GWh and 4,748 GWh, respectively. If the CCA entities procure the alternative RPS based on their higher targets (in other plans than their RPS compliance filings), in 2025 they will exceed the state's old RPS by 19% (9,658 GWh renewable energy) and the state's new RPS by 15% (7,625 GWh renewable energy). Because the state RPS acts as a floor for each electricity provider individually, this additional renewable energy procurement increases the total statewide. Note that non-renewable energy (as shown in Fig. 2.1) includes hydropower, from which many CCA entities procure significant energy but which California does not classify as renewable energy.

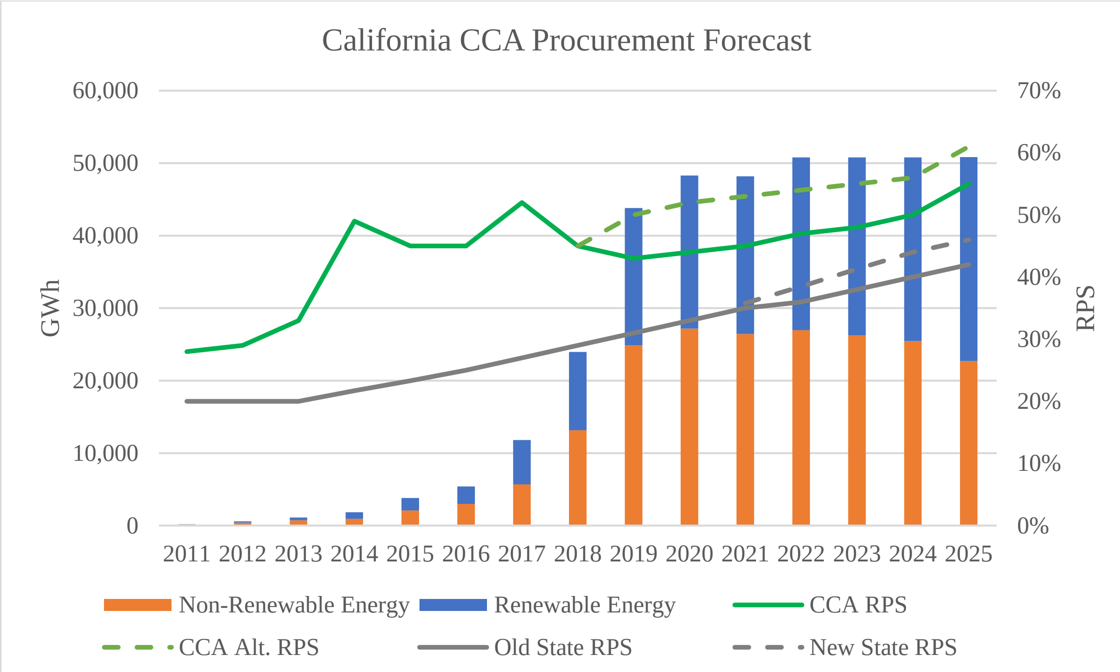

Fig. 2.1: Total and renewable energy procurement by year for all CCA entities (as of November 2018), with the old and new state RPS. Source: The CCA RPS reflects the procurement projection data from their 2018 RPS compliance filings to the CPUC. The alternative CCA RPS reflects procurement projections from their 2018 RPS compliance filings to the CPUC with the higher targets listed in the implementation plans and integrated resource planning documents for six of the CCA entities (Clean Power Alliance, CleanPowerSF, Desert Community Energy, East Bay Community Energy, Redwood Coast Energy Authority, and Valley Clean Energy) for which there was a discrepancy.

The procurement forecast data for all CCA entities are projections, and the CCA entities will have to solicit and attain the renewable energy procurement to meet their goals. The precise amounts of total procurement and renewable energy could change due to various market and regulatory conditions. The total projected energy procurement of CCA entities presented in this study is likely an underestimate given that additional counties and cities are expected to start or join CCA entities (CPUC 2018). In October 2018, for instance, the City of San Diego decided to adopt CCA. The CPUC has estimated that CCA entities could take over as much as 85% of the electricity share served by IOUs by the mid-2020s, a majority of the state's energy demand (CPUC 2017). Additionally, there are many complexities in operation of the energy and regulatory system, discussed in Section 2.4b, that affect how these renewable energy targets translate into the exact renewable energy effects statewide.

Based on the U.S. EPA's electricity emission rates for California and using the range of 529.9 to 945.6 lbs/MWh CO_2e to account for uncertainty about effects and energy displacement, the 6,782 GWh renewable energy procurement by CCA entities in excess of the old state RPS in 2025 equates to a reduction of GHG emissions in the electricity sector of 1.63 to 2.91 MMT CO_2e. The 4,748 GWh renewable energy procurement above the new state RPS equates to a reduction of GHG emissions in the electricity sector of 1.14 to 2.04 MMT CO_2e. If the CCA entities meet the alternative RPS forecast, that would equate to 2.32 to 4.14 MMT CO_2e reduction over the old state RPS, and 1.83 to 3.27 MMT CO_2e reduction over the new state RPS. The lower forecast is used based only on the RPS compliance filings, however, to be conservative.

A comprehensive review of all CCA entities finds significant variation in their characteristics beyond simply renewable energy procurement (Table 2.1). Many CCA entities have prioritized a high level of carbon-free energy, typically hydropower, in their base level electricity product. The base product is what consumers are automatically enrolled in, while most CCA entities also offer the option to opt up to a higher threshold of renewable energy at an additional cost. CCA entities have created and are further developing programs to develop local renewable energy, electric vehicle infrastructure and rebates, energy efficiency programs, electrification, wildfire recovery with high-efficiency homes, and other initiatives.

Many CCA entities have sought to maximize renewable energy procurement and these types of community co-benefit programs, while others have prioritized maximizing cost savings for consumers. The older CCA entities in particular – such as MCE (launched in 2010) and Sonoma Clean Power (launched in 2014) – are expanding their programmatic areas beyond energy procurement. Review of all CCA implementation plans indicates that most CCA entities are interested in pursuing similar forms of local community-oriented programs once they are established. This reflects one of the core arguments that governments and advocates make in favor of CCA: they are best suited to address local issues and to innovate (Gattaciecca, DeShazo, and Trumbull 2017). The GHG emissions and other effects of these programs may be consequential beyond the effects of renewable energy procurement alone.

*Table 2.1: CCA entities, as of September 2018, included in this paper's analysis and their key characteristics. Data sources: California Energy Commission power content labels, CCA implementation plans, CCA websites, and the California Community Choice Association website. *Desert Community Energy delayed its planned 2018 launch date and it is uncertain if it will launch in 2019.*

CCA Entity	**Launch Year**	**Base Service Carbon-Free Energy**	**Select Program Characteristics**
Apple Valley Choice Energy	2017	38% (2017)	• Extra incentives for consumer-generated renewable energy • Energy efficiency program
Clean Power Alliance	2018	87% (2018)	• Local renewable energy development • Energy efficiency program
CleanPowerSF	2016	100% (2017)	• Local renewable energy development • Energy efficiency and conservation program

Desert Community Energy	2019*	N/A	• Local renewable energy development • Energy efficiency program
East Bay Community Energy	2018	62% (2016)	• Local renewable energy development • Energy efficiency program
King City Community Power	2018	N/A	• Installation of solar powered street lights • Installation of solar panels on limited-income housing
Lancaster Choice Energy	2015	50% (2018)	• Residential and small commercial energy efficiency program • Supporting local renewable energy • Supporting electric bus fleet
MCE	2010	87% (2017)	• Local renewable energy development • Local solar workforce development • Energy efficiency program • Electric vehicle charging station program • Electric vehicle rebate program • Renewable energy and efficiency wildfire home rebuilding program
Monterey Bay Community Power	2018	100% (2018)	• Electric vehicle charging stations and rebates • Rooftop solar incentives • Energy efficiency program
Peninsula Clean Energy	2016	85% (2017)	• Local renewable energy development • Electric vehicle charging stations and rebates • Building and transportation electrification programs • Energy efficiency program
Pico Rivera Innovative Municipal Energy	2018	N/A	• Local renewable energy development
Pioneer Community Energy	2018	N/A	• Expanding energy saving programs

Rancho Mirage Energy Authority	2018	50% (2018)	• Solar energy incentives
Redwood Coast Energy Authority	2017	82% (2018)	• Local renewable energy development including exploration of offshore wind energy • Electric vehicle infrastructure and rebates • Energy efficiency program
San Jacinto Power	2018	N/A	• Energy efficiency program
San Jose Clean Energy	2018	80% (2018)	• Local renewable energy development • Energy efficiency program
Silicon Valley Clean Energy	2017	100% (2018)	• Building and transportation electrification programs • Electric vehicle charging stations • Local renewable energy development • Energy efficiency program
Solana Energy Alliance	2018	75% (2018)	
Sonoma Clean Power	2014	87% (2018)	• Wildfire recovery energy efficient homes program • Local renewable energy development • Electric vehicle charging stations • Building efficiency program
Valley Clean Energy	2018	75% (2018)	• Local renewable energy development • Energy efficiency program

2.4b Energy system complications and regulatory changes

Most CCA entities have set goals to exceed the California's renewable energy requirements and to offer a higher threshold of renewable and carbon-free energy than their incumbent utility. The precise effects of growing CCA market penetration on total renewable energy procurement in the state are difficult to isolate, however, given several factors that complicate the situation and leave the energy landscape uncertain. This section discusses the complications, including customer migration to

CCA entities and how that affects the renewable energy position of IOUs, short-term and long-term energy contracts, resource adequacy issues, questions about the future role of IOUs, and California's eventual move to 100% renewable and low-carbon energy.

The three major IOUs (PG&E, SCE, and SDG&E) had a combined renewable energy procurement of 36% in 2017 and report being on track to have 50% by 2020 (CPUC 2018a). This increase comes despite issuing no new renewable energy procurement solicitations between 2016 and 2018 and no anticipated solicitations in the next several years (CPUC 2018a). The renewable energy percentage increase is forecasted primarily for three reasons. First, electricity providers that had more renewable energy certificates (RECs) than necessary to fulfill RPS obligations in one compliance period may use them in subsequent compliance periods, as is the case for the IOUs (CPUC 2017b). Second, the IOUs have contracts for renewable energy projects that are under development but are not yet delivering electricity, which add to their renewable energy forecast (other contracts are also expiring) (CPUC 2018a). Lastly and most significantly, migration of customers from IOUs to CCA entities equates to significant departing load, meaning that existing RECs and long-term renewable energy contracts (defined as ten or more years) make up a higher percentage of the IOU total electricity demand (Gattaciecca, DeShazo, and Trumbell 2018). Although much of the IOU RPS procurement compliance filing data are confidential, the CPUC (2018a) reports that further CCA growth and load migration will mean that a higher portion of IOU portfolios will be renewable energy, with the IOUs forecasted to average 53% in 2021 and 51% between 2022 and 2024.

The future renewable energy percentage of the IOUs is complicated, however, by the fact that in 2018 they each began selling it from their portfolios, citing the growing migration of load to CCA entities (CPUC 2017c, 2018a). PG&E, for instance, stated that it plans to sell excess RPS volumes to rebalance its RPS portfolio to align with RPS requirements (CPUC 2017c). CCA entities, many of which have a procurement need, may end up purchasing much of this renewable energy from the IOUs (CPUC 2018a). The combined effects of regulatory and market forces remain to be seen. There is also an increasing focus among CCA entities in soliciting contracts with new renewable energy projects, which totaled 1,239 MW by August 2018 (CPUC 2018a). As of November 2018, California also had approximately 8,400 MW of permitted but not-yet-operational renewable energy projects, which will help to meet increased renewable energy demand, along with other renewable energy from out of state (CEC 2018b). Additionally, California has an increasing amount of distributed renewable energy generation (CEC 2018b).

Departing load from the IOUs may affect their need for existing natural gas and nuclear power, adding potential complications with baseload power availability. In 2017, PG&E's power portfolio included 20% natural gas and 27% nuclear; SCE's power portfolio included 20% natural gas and 6% nuclear; and SDG&E's power portfolio included 39% natural gas.[5] PG&E cited the departing customer load to CCA entities among the reasons for deciding to close its Diablo Canyon Nuclear Plant (CPUC 2018c). In their accompanying 2018 decision, the CPUC (2018c) noted that it

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[5] Based on 2017 annual power content labels from the California Energy Commission, available online (https://www.energy.ca.gov/pcl/labels/2017_index.html, accessed 03.21.19).

was their intent to avoid any increase in GHG emissions resulting from Diablo Canyon's closure, stating that it was unclear what, if any, level of GHG-free procurement would be needed to offset it given the rapid changes in the electricity market and the growth of renewable energy generation. Reduced costs, legislative action, and regulatory action on large-scale energy storage may also be factors in reducing the need for natural gas generation and in alleviating curtailment issues.[6]

The energy landscape and the interactions between the IOUs and CCA entities is further affected by the declining price of renewable energy and the length of energy procurement contracts with generators. The IOUs have substantial long-term renewable energy procurement contracts that are more expensive than recent market prices. State statutes required the IOUs to invest millions of dollars every year in such renewable energy from 2002 to 2012, in part to stimulate growth in renewable energy (Gattaciecca et al. 2017). CCA entities can benefit from lower-cost renewable energy power purchase agreements given the decline in energy prices for solar and wind energy. To ensure the investment costs are shared by all consumers, the CPUC developed the Power Charge Indifference Adjustment (PCIA) to account for the difference between the current electricity value and the IOUs' average electricity

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[6] Analysis of possible grid reliability outcomes, effects of changing natural gas and nuclear power generation, storage, and curtailment are beyond the scope of this paper. The CPUC (2018a) discusses curtailment issues in its 2018 RPS Annual Report to the Legislature and notes that initial modeling indicates that selective renewable energy curtailment can displace natural gas generation and allow for higher renewable energy penetration. Separately, the CPUC has an energy storage proceeding (R.15-03-011) that is instituting greater amounts of energy storage. In 2018, the CPUC approved a PG&E plan to replace three natural gas-fired power plants with large-scale battery storage (http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M238/K048/238048767.PDF accessed 03.21.19). Additionally, an analysis by the Union of Concerned Scientists found that significant natural gas generation could be taken offline under present conditions and with additional renewable energy penetration, but that as natural gas generation declines, grid changes, including storage, will be necessary to avoid natural gas power plants cycling on and off (Specht and Wisland 2018).

portfolio cost (Gattaciecca et al. 2017). The PCIA, including its methodology, estimates, and rates, has been controversial between IOUs and CCA entities because of the significant effect it has on electricity rates, and it is the focus of ongoing CPUC proceedings (O'Shaughnessy et al. 2019).

PCIA changes may lead to a market-based redistribution system that lets CCA entities purchase long-term energy contracts from the IOUs (O'Shaughnessy et al. 2019). This could help address future resource adequacy requirements to ensure that load-serving entities can exceed peak demand and that there is sufficient local capacity and flexibility (O'Shaughnessy et al. 2019; Gattaciecca et al. 2018). Beginning in 2021, California will require that 65% of renewable energy that counts toward an electricity provider's RPS requirements comes from long-term contracts. To date, CCA entities have procured primarily short-term contracts for renewable energy, in part because they are new entities without credit scores and track records, although the older CCA entities are accumulating more long-term contracts (Gattaciecca et al. 2018).

These ongoing shifts in California's energy system and the interactions between the IOUs and CCA entities leave the situation in considerable flux, with the potential for greater changes. The IOUs estimate that they could lose 60-80% of their demand in the next 8-10 years as CCA spreads to more places (CPUC 2018a). SDG&E has proposed getting out of energy procurement altogether and having a state-level procurement entity take it over (Gerdes 2019). PG&E filed for bankruptcy in January 2019 after facing billions of dollars of liabilities related to wildfires. Several CCA entities proposed to the CPUC that PG&E should get out of energy procurement and focus entirely on electricity transmission and distribution, and PG&E said it supports consideration of such a transition (Roth 2019). These issues will be among potentially significant regulatory changes the state undertakes as it accounts for CCA and other energy system transformations, and as it moves toward the goal that SB100 set of 100% zero-carbon electricity by 2045. Whether or not the IOUs retain a significant role in energy procurement, electricity providers will eventually converge at that procurement target.

In the meantime, CCA entities are driving changes to the energy system including a push beyond state renewable energy requirements. If the IOUs do in fact reach a combined 51% renewable energy in 2024 (CPUC 2018a), and the CCA entities attain their combined renewable energy targets, the total renewable energy in excess of state requirements would be most significant. If the IOUs instead sell a substantial amount of their excess renewable energy, with the effect of transferring it to the CCA entities, the total effect statewide would be diminished somewhat. Yet the effect of CCA entities meeting their goals to exceed substantially state requirements would still be significant, given that the state RPS acts as a floor for each individual electricity provider.

2.4c CCA policy adoption and diffusion

Fig. 2.2 shows the social, political, and economic characteristics of counties that have adopted CCA, are exploring CCA, and are without CCA. While the small sample size prohibits the establishment of a causal model, descriptive results and Cohen's *d* effect size values (Table 2.2) suggest clear trends across the three groups of counties. The counties that have adopted CCA tend to be more environmentally oriented, have more registered Democratic and Green party voters, be more supportive of local choice, have populations that are more educated, and have higher income levels and have more residents. The mean of the counties that have adopted CCA surpass the statewide average for all these variables. These results align with the literature's findings about characteristics predicting climate policy adoption, reflecting that communities with higher levels of these characteristics are more inclined to enact climate-related policies (Kwon, Jang, and Feiock 2014; Lyon and Yin 2010; Sharp, Daley, and Lynch 2011; Vachon and Menz 2006; Zahran et al. 2008).

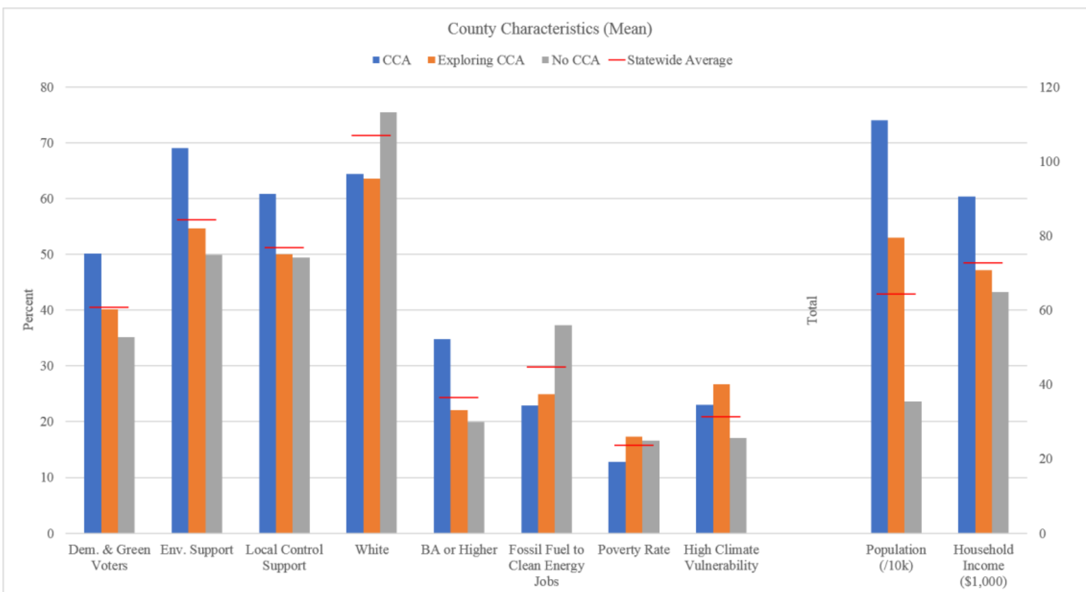

Fig. 2.2: Social, economic, and political characteristics of California counties that have adopted CCA (n=17), that are exploring CCA (n=9), and eligible counties without CCA (n=27). Variable data sources listed in Table 2.2.

Table 2.2: Data sources for county political, social, and economic variables shown in Fig. 2.2. Cohen's d values are the standardized difference of means between counties that have adopted CCA (n=17) and all other eligible counties (n=36) (Deshazo et al. 2018; leanenergyus.org).

Variable	**Cohen's *d***	**Description and Source**
Dem. & Green Voters	2.27	Total percent of registered Democratic and Green party voters in 2010, from the California Secretary of State.
Env. Support	2.72	Total "No" vote on Proposition 23 in 2010, a measure that would have effectively repealed AB 32, California's chief climate legislation, from the California Secretary of State.
Support for Local Energy Choice	1.84	Total "No" vote on Proposition 16 in 2010, a measure that would have effectively prevented CCA and local control of energy decision-making, from the California Secretary of State.
White	0.62	Listed as one race, from the 2010 U.S. Census.
BA or Higher	1.69	Total of the population (age 25+) with a bachelor's degree or higher, from the 2009-2013 American Community Survey.
Fossil Fuel/Clean Energy Jobs	.36	Proportion of oil and gas jobs (Sedgwick 2017) to clean energy jobs (Advanced Energy Economy Institute 2016), 2015 data.
Poverty	0.9	Percent of people with incomes below the then-federal poverty line (an income of $18,498 for a family of three with two children), from the California Budget & Policy Center, utilizing U.S. Census data (2008-2012).
High Climate Vulnerability	0.19	Based on 19 indicators of vulnerability to climate change (2012 data) (Cooley et al. 2012).
Population (/10k)	0.37	From the 2010 U.S. Census.
Household Income ($1,000)	1.5	Five-year household income, from the 2010 American Community Survey.

Although 19 CCA entities were launched between 2010 and the end of 2018, diffusion of the policy began slowly. It was four years before the second CCA entity started in 2014, followed by one CCA entity in 2015, two in 2016, three in 2017, and then 11 in 2018. Fig. 2.3 shows the percent environmental support, Democratic and Green party voters, and educational attainment for all the counties and cities (and the Town of Apple Valley) that have started their own CCA entities, by launch year, with the statewide average for each variable. These characteristics are likely closely interrelated. Other counties and cities have joined existing CCA entities, but they are not included in Fig. 2.3 because they do not bear the same financial, capacity, and risk burden of starting a new CCA entity.

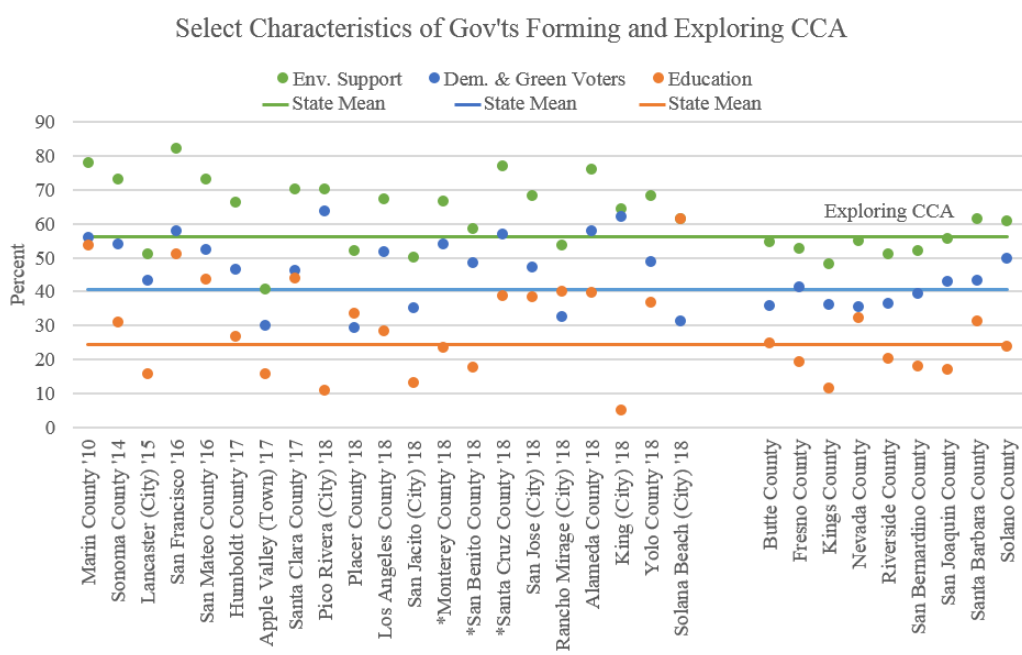

Fig. 2.3: Counties and cities that started CCA entities, ordered by launch date (Deshazo et al. 2018; leanenergyus.org). *Solid lines represent the statewide mean values. *Monterey, San Benito, and Santa Cruz counties (arranged alphabetically) joined together to launch a regional CCA. Counties exploring CCA are ordered alphabetically. Variable data sources listed in Table 2.2.*

As Fig. 2.3 illustrates, Marin and Sonoma counties have high levels of support for the environment, Democratic and Green party voters, and educational attainment. That they would be innovators follows theoretically from the climate policy adoption literature (e.g., Bedsworth and Hanak 2013; Fowler and Breen 2013; Krause 2011; Lyon and Yin 2010; Millard-Ball 2012; Wang et al. 2012; Zahran, Brody, et al. 2008). The City of Lancaster, which started the third CCA entity in the state, stands out for its lower levels of these characteristics, although its early decision to adopt CCA may be partly explained by the city's history of local renewable energy development and clean energy goals. Most of the local governments that started CCA entities between 2010 and 2018 exceed the state average of the three characteristics, but several of the other local governments that started CCA entities after 2016 are closer to or below the state average levels. The counties exploring CCA, by contrast to the early adopting counties, mostly have substantially lower levels of environmental support, Democratic and Green party voters, and educational attainment.

Based on review of all CCA entity implementation plans, each CCA entity points to the success of earlier ones. The CCA entities started by Marin County and Sonoma County, in particular, cleared the path for others to follow. Marin County faced the additional challenge of public opposition from the incumbent IOU (Ruppert-Winkel, Hussain, and Hauber 2016), which spent more than $4.1 million opposing the creation of the CCA and had spent millions opposing earlier efforts elsewhere (Halstead 2011). In 2011, the legislature enacted a law preventing IOUs from using ratepayer funds for marketing themselves against CCA, curtailing the ability of IOUs to oppose future CCA entities.

The CCA policy adoption and diffusion process demonstrates that the first and early local governments to adopt the policy are likely suspects, with high concentrations of residents who are expected to support an innovative climate policy. They proved the policy's efficacy. Then the policy diffused to different areas and geographies where there was support along political and social lines, gradually diffusing to more areas that are less likely to adopt such a climate policy.

2.5 Discussion

The spread of CCA entities shows that local governments can adopt, scale up, and diffuse high-impact policies. California counties and cities are using CCA to procure higher thresholds of renewable energy than the state's renewable energy targets. Beyond their renewable energy procurement, many CCA entities have embraced a high percentage of low and carbon-free energy. Additionally, many of the local governments are using money associated with energy procurement and sales to implement and expand a variety of energy efficiency, renewable energy development, electrification, and other emissions-related programs in their communities, the effects of which go beyond the GHG emission implications of renewable energy procurement. As the CCA entities mature over time, they may be positioned to achieve greater environmental and community gains along these lines.

Local governments are utilizing CCA to affect change across not only the public and private sector within their jurisdictional boundaries through energy procurement and other programs, but also beyond their borders by affecting the state's overall energy portfolio. This raises the potential for local governments to take on expanded roles in climate policymaking and regulation of GHG emissions. Given the growth of urban areas, and the fact that many of them have sought to take a leadership role in mitigating climate change, it is possible that they could seek additional authority over GHG emissions and to leverage their financial power in new ways.

As expected, local government adoption of CCA is associated with support for environmental protection, prevalence of Democratic and Green party voters, higher education, and similar characteristics. Starting a CCA entity is a high burden action. It requires significant financial and capacity investment, as well as elected officials and their staff tackling the complicated, technical nature of the energy system. There is also an element of risk given unknowns about energy costs, participation in the program, loans, power procurement, and regulatory conditions. These risks and uncertainties were greatest for the first and early adopters of CCA, given doubt about whether CCA was a viable policy.

Marin County, a low-population county and an environmental and Democratic party stronghold, formulated and implemented the policy and provided a track record and blueprint for other governments (Ruppert-Winkel, Hussain, and Hauber 2016). The initial, slow diffusion rate indicates that other governments were cautious, and primarily communities with similar characteristics adopted the policy at first. Then as more governments adopted CCA and there was a clearer track record of success, the pace of diffusion increased and a broader set of governments began to adopt the policy including several with substantially lower levels of those characteristics. The counties that are exploring CCA after 2018 fall primarily below the state mean for environmental support, Democratic and Green party voters, and education. In less than a decade, policymakers and advocates have garnered widespread support for a policy that was considered impossible.

These trends suggest the potential for policymakers to be strategic in policy adoption and diffusion to maximize policy participation. In many cases, it may be impossible to enact a policy statewide due to political constraints or because a majority of the population would not support it. Yet a substantial portion of a state's population may be supportive. Residents with similar views are often clustered together regionally in counties and cities. By targeting those supportive areas, high-impact policies can still be pursued. As more jurisdictions adopt a policy, support may increase among the public and elected officials, and more places may consider adopting the policy, having the effect of increasing policy impact. These effects may be even greater in states more conservative than California, where state governments are less inclined to pursue aggressive climate policies – such as not having or setting a low RPS – but where a variety of local governments may take the initiative. By proactively utilizing such a strategy in policymaking and diffusion, innovative policies may be constructed and enacted for a greater number of people. This represents a nimble and practical implementation of the laboratories of democracy concept on a local scale (Fowler and Breen 2013; Osborne 1988). Like state policies diffusing and working their way up to the federal government, such as clean air standards initiated in California that set the stage for the Clean Air Act of 1970, local adoption of effective policies may pave the way for higher levels of government to adopt similar policies as they increase recognition and support.

2.6 Conclusion and policy implications

This study investigated the potential of local governments to take a greater role in mitigating climate change. It examined the prior and forecasted renewable energy procurement effects of CCA in California. The policy stands out among local government climate actions for requiring substantial investment and having the potential to affect significantly renewable energy procurement and GHG emissions. Counties, cities, and towns that adopt CCA are forecasted to exceed California's RPS (increased in late 2018) by 9-15% in 2025, yielding an additional 4,748 to 7,625 GWh renewable energy. This equates to a reduction in GHG emissions in the electricity sector of 1.14 to 2.04 MMT CO_2e. Other emissions-related programs and characteristics – including high percentages of carbon-free energy in many of the CCA entity portfolios – have effects beyond those from renewable energy procurement. These results demonstrate the capability of local governments to have a substantial, statewide effect in reducing GHG emissions and addressing climate change. These governments can be important in achieving and advancing climate mitigation in states.

The study examined the adoption and diffusion of CCA among local governments in California, finding that communities with high levels of environmental support, Democratic and Green party voters, and higher education are most likely to innovate and adopt CCA. Pioneering local governments demonstrated the policy's efficacy, which then diffused over time along social and political lines to those less-inclined to take risks and enact burdensome climate policies. The paper discussed how policy adoption and diffusion along these lines may be able to increase local government participation with high-impact policies. By strategically building innovative policies out from jurisdictions likely to adopt them, a greater number of local governments may be able to enact policies which they would likely not otherwise be able to adopt. While the study focused on California, the findings extend well beyond the state.

Specific to CCA, future research should evaluate the GHG emission and community effects of the full scope of CCA initiatives, especially as CCA entities implement more emissions-related programs. More generally, while a good amount of research has addressed local government climate actions, investigating high-impact policies, and the effectiveness of policies in general, is a relatively under-explored area of study with several important areas for future research. Scholars should measure precisely the outcomes of climate policies, including separating the policy effects from market-based influences such as on renewable energy. Researchers should obtain or create and analyze larger datasets that allow them to examine the intercorrelations of variables driving policy adoption such as support for environmental protection and Democratic and Green party voters. Finally, future research should examine how to share and diffuse high-impact policies at wider scales including across state lines.

The policy implications of this study include specific considerations for California policymakers and for policymakers working on local government climate policymaking throughout the United States and internationally. In California, policymakers in counties and cities throughout the state – not just likely-suspect communities – should look to how CCA may help them attain renewable energy, GHG emission, and other energy and emissions-related goals. Several states that have already enacted some form of CCA, and others that are exploring it, should examine these results in designing their policy and similar approaches to local government climate policymaking. More broadly, policymakers, advocates, and researchers should attempt to design and enact local government climate policies that may seem difficult, not just "low-hanging fruit" policies. In that vein, there may be a benefit to states giving greater authority and discretion to local governments over sources of emissions and other environmental issues, allowing them greater latitude to affect change. Finally, counties, regional governments, and conglomerations of governments deserve greater attention as targets for such policies, not just cities.

Acknowledgements

I would like to thank Dr. Sheldon Kamieniecki and Dr. Adam Millard-Ball for their insight and comments in undertaking the study and preparing this paper, and Dr. Elizabeth Beaumont and Dr. Douglas Bonett for their feedback. I appreciate the thoughtful feedback from three anonymous reviewers, which helped to improve the paper. I would also like to thank the Hammett Fellowship, awarded by the Department of Environmental Studies at UC Santa Cruz, for support.

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Chapter Three

Taking control to do more: how local governments and communities can enact effective climate mitigation policies

Abstract

While local governments have emerged as policy leaders on climate change, evidence indicates that many of the policies enacted do not significantly reduce greenhouse gas emissions. This study focuses on the adoption of effective climate policies, examining the underlying policymaking process and stakeholders, including the role of local control. The study analyzes local government adoption of Community Choice Aggregation in California, a climate policy that has been pursued throughout the state over the past decade. A qualitative-driven approach is used, including interviews with policymakers and stakeholders in five areas of the state that adopted the policy and two areas that rejected it. In contrast to prior research, a bottom-up policymaking process was behind policy adoption. An interconnected effort of grassroots groups and local elected officials led the policy process. Whether localities pursued the policy is driven by concern about climate change – indicative of an emerging climate change culture – and a desire for local control. Despite prevailing expectations about it, communities embraced local control as a means to shape and implement policies to match their priorities and achieve a variety of co-benefits. By letting governments do so, local control can help lead to effective climate policy adoption.

Keywords: climate change policy, local governments, bottom-up policymaking, stakeholders, local control

3.1 Introduction

In the last two decades, cities, counties, and towns have emerged as climate change policy leaders. In the United States, these local governments have sought to fill a void created by federal inaction on the issue. The breadth of local government policy actions (Krause 2010) has generated substantial optimism about their potential to reduce greenhouse gas (GHG) emissions and further sustainability (Rosenzweig et al. 2010). In response, an important body of literature has emerged that examines which governments have adopted climate policies and the conditions and characteristics that explain why (Yeganeh, McCoy, and Schenk 2020).

Yet evidence indicates that the climate policies enacted by many local governments are minimally effective and do not significantly reduce GHG emissions (Krause 2011; Millard-Ball 2012; Stone, Vargo, and Habeeb 2012; R. Wang 2013; Wheeler 2008). Common actions include joining climate protection networks, codifying existing actions into climate plans, and setting far-off goals. These are modest actions that entail minimal financial or capacity investment and which only marginally reduce GHG emissions. There are exceptions, however,[7] and a growing recognition of the need to examine instances of effective policies and the stakeholders and their motivations behind them (Kalafatis 2018; Yi, Krause, and Feiock 2017).

Local government adoption of climate policies also raises questions about local control and the free-rider dilemma (Olson 1965). The widespread adoption of climate policies is surprising given that local governments would not rationally be

[7] Examples include Washington, D.C.'s policy requiring utilities to provide 100% renewable energy by 2032; Boston's ambitious standards on energy, transportation, buildings, and community initiatives; and Austin, Texas' goal of 65% renewable energy by 2027 (Ribeiro et al. 2019).

expected to assume the costs of reducing GHG emissions since they are a global problem (Trisolini 2010). Local governments will see no lessening in the impacts of climate change from the GHG emissions they reduce within their jurisdictions. Additionally, prior studies have generally associated local control with adverse environmental outcomes (Oyono 2005). Nevertheless, local governments are utilizing local control over sources of GHG emissions to address climate change, a surprising occurrence for which the literature has not examined the role of local control.

This study analyzes why local governments and communities adopt effective climate policies. It addresses two research questions: 1) Who are the stakeholders and what are their concerns in the policymaking behind the adoption of effective climate policies? 2) What is the role of local control in the adoption of climate policies?

These questions are investigated through a case study of Community Choice Aggregation (CCA) in California. CCA allows local governments to take over electricity procurement from private investor-owned utilities (IOUs) by pooling residents' electricity purchasing. This lets local governments determine the makeup of the electricity supply, choosing how much electricity comes from different sources such as renewable energy, hydropower, and fossil fuels. Local governments have pointed to CCA as one of their most important climate policies, utilizing it to procure substantially higher amounts of renewable energy than required by California's state climate program (Armstrong 2019; O'Shaughnessy et al. 2019). In promoting CCA, local governments also point to local control as a central feature and benefit of the policy.

Sections 1.1 and 1.2 situate the study and its contributions within the literature. Then the policy system and study methodology are detailed, followed by a review of the results. The discussion addresses the importance of the findings and broader implications for local government climate policymaking and local control. The paper ends with recommendations for future research.

3.1a Climate policy adoption and policymaking processes

By 2010 more than 900 cities within the United States had taken some form of climate action (Krause 2010), among thousands globally (Hughes 2017). Research has assessed the conditions that help explain why so many cities have engaged in this policymaking, primarily relying on quantitative assessments of political, social, and economic characteristics (Sovacool 2014). Within the United States, studies have found positive associations between climate policy adoption and prevalence of Democratic party voters (Krause 2011; Lubell, Feiock, and Handy 2009), support for the environment (Millard-Ball 2012), environmental interest groups (Portney and Berry 2016), and vulnerability to climate impacts (R. Wang 2013). Research has also identified policy co-benefits as important, including economic savings and improving local air quality (Betsill and Bulkeley 2004; Kousky and Schneider 2003; Krause 2012), and a move among some cities to "think globally and act locally" given increasing global awareness (Clark and Gaile 1997; Rosenthal et al. 2015).

One of the literature's limitations is rarely assessing policy effects and not distinguishing between types of policies enacted (Yeganeh, McCoy, and Schenk 2020; Yi, Krause, and Feiock 2017). Joining a climate network such as the International Council for Local Environmental Initiatives (ICLEI) or the United

States Conference of Mayors Climate Protection Agreement (MCPA), participation in which is commonly used as the indicator of climate action, may not result in direct GHG emission mitigation measures (Kalafatis 2018; Krause 2012). Similarly, the adoption of climate action plans, another common indicator used in quantitative assessments, may not equate to significant GHG emission reductions (Millard-Ball 2012). This underscores the need to focus on effective policies.

In this study, effective policies are those that lead to significant and measurable changes and goals. While it would be difficult to quantify a specific threshold of significance, joining a climate network without implementing policies that create new changes and reduce substantial amounts of GHG emissions would not be an effective policy. Nor would small improvements like recycling government paper use or aspirational statements such as “improving public transit.” Setting strict new standards that require changes, such as for transportation or building efficiency, would be effective policies. Financial and human resource capacity investments are almost always important for policies to be effective (Hawkins et al. 2016; X. H. Wang et al. 2012).

For policies in general, and effective policies, in particular, there is a dearth of research about the policymaking process, the role of stakeholders, and their concerns behind policy adoption (Sovacool 2014). Most studies that have conducted policymaker and staff interviews and surveys have focused on the types of policies adopted and their implementation (e.g., Bedsworth and Hanak 2013; Wheeler 2008), not on the policy adoption process. While the literature points to the importance of interest groups and stakeholders (Portney and Berry 2016; Sovacool 2014), their role in the policymaking process has not been investigated in much depth. Additionally, the extent to which policy adoption is driven from the top-down, as some research has indicated (Kousky and Schneider 2003), or from the bottom-up is unknown.

Studies have found that public support, which scholars tend to measure as expressed support for environmental activism, is an important factor behind climate policy adoption (Yeganeh, McCoy, and Schenk 2020). Yet the role of that environmental activism in the policymaking process, including grassroots groups (primarily unfunded, volunteer organizations), remains largely unexplored. Similarly, while the literature on environmental regulation has found that public participation can be important, especially when the public understands the technical components of policies (Beierle and Cayford 2002; Coenen 2009), it has not been examined in local government climate policymaking.

3.1b Local control and climate policies

Researchers have traditionally associated local control of environmental matters with negative environmental outcomes. For instance, local control of forests has led to increases in logging (Oyono 2005), and local control of natural resources has led to increases in mining (Fleischman et al. 2014). Additional complications have arisen from local government and not-in-my-backyard (NIMBY) resistance to the siting of waste facilities and locally unwanted land uses, creating environmental justice issues (Luloff, Albrecht, and Bourke 1998; Schively 2007). Such issues can occur because low-income areas and communities of color are targeted for development of unwanted facilities, because they lack the monetary and political influence to stop them, or because they end up living nearby due to low housing costs and jobs.

Local government climate policies challenge such assumptions and may reflect a shift in the role and outcomes of local control. In a study of localism movements in the United States, Hess (2009) documented growing efforts to increase local control of retail, food, energy, transportation, and media industries. Some scholars and communities have begun looking to local control as a pathway to sustainability (Homsy 2016; Morris and Jungjohann 2016).

With climate mitigation policies, especially those that are far-reaching in their aims, local governments are asserting local control to address GHG emissions. This entails creating policies based on the authority held by local governments in areas such as land-use planning, local transportation, building codes, and waste management measures (Dodman 2009; Lefèvre 2012). Local governments have always had authority over local building standards, for example. With climate policies, some are now using that authority to set efficiency standards in the interest of reducing GHG emissions (Ribeiro et al. 2019).

In some cases, local governments have sought new authority to address climate change, either by seeking greater oversight from a higher level of government or by creating policies around issues with which they have not previously engaged. In an example of the former, New York City has sought increased control from the state government such as the ability to implement traffic congestion pricing (Betsill and Rabe 2009; Schaller 2010). As an example of the latter, since 2012 Boulder, Colorado has sought to take ownership of the electricity grid from the private utility (a process called municipalization), citing lack of control as a limitation on the city's ability to meet its climate goals (Outka 2016). Boulder is among an increasing number of local governments interested in setting electricity-related standards or taking over some part of the electricity business from private utilities (Fischer et al. 2016; Homsy 2018; Welton 2018).

Changing demographics and politics around climate change may be a factor in why local control can be associated with climate policy adoption. Many urban areas are becoming increasingly liberal (Parker et al. 2018; Scala and Johnson 2017). A high percentage of cities are led by Democrats, for whom climate change has become an increasingly important and salient issue (McCright and Dunlap 2011; McCright, Xiao, and Dunlap 2014). While earlier literature points to city governments being relatively unresponsive to citizen preferences, recent studies now show that they are (Switzer 2017; Tausanovitch and Warshaw 2014). These shifts may create conditions favorable to climate policy adoption.

Local control is inherently at the heart of what local governments can and will accomplish on climate change. With a growing percentage of the population living in cities, those governments increasingly have authority over GHG emissions and other environmental matters. Whether related to energy or other issues, the expanding pursuit of local control underscores the need to examine its role in climate policymaking.

3.2. Methodology

3.2a Policy system overview

CCA in California is an excellent case study to address effective local government climate policymaking and local control. It is a recent policy undertaking that a diverse group of governments has considered. Between 2010 and 2019, 17 out of 58 counties statewide adopted the policy along with many cities, often in multi-government collaborations set up as joint powers authorities. Among local government climate policies, CCA stands out for requiring substantial financial and capacity investments. It generally takes millions of dollars in upfront costs (including for feasibility studies and technical and business plans) and around two years for governments to adopt and begin implementing the program. Governments that enact CCA set up new staffed agencies to manage the programs, overseen by policy boards of elected officials.

Prior research demonstrates that CCA is an effective climate policy mechanism. In every year of their operation, CCA entities have procured more renewable energy than required by California's renewable portfolio standard (RPS), which mandates that a minimum percentage of every energy provider's electricity comes from renewable energy (Armstrong 2019; O'Shaughnessy et al. 2019). In 2025, CCA entities are forecasted to exceed the state's RPS by 9-15%, procuring 4,748 - 7,625 GWh renewable energy beyond state requirements, equating to 1.14-2.04 MMT CO_2e reductions (Armstrong 2019). While their primary focus is electricity procurement, most CCA entities are using associated financing to initiate or expand a variety of other energy and climate-related programs such as energy efficiency, renewable energy deployment, and electric vehicles (Armstrong 2019).

CCA is an example of local governments seeking increased local control authority, taking a role in the energy system where they previously had not. Traditionally, except for cases of public utilities, IOUs and state regulators have controlled the electricity system in California. With CCA, the private utilities maintain the grid and power delivery, but local governments take a substantial role by controlling electricity procurement. A 2002 state law (AB 117) enabled CCA following the California energy crisis of 2000 and 2001. The IOUs have opposed CCA because it takes away from their business (Hess 2019; Ruppert-Winkel, Hussain, and Hauber 2016). Seven other states have CCA in some form, and several others are considering adopting it (O'Shaughnessy et al. 2019).

Although focusing on one state can potentially be a limitation, California is a large state with very different regions, including very different people. The political, economic, and social characteristics of the governments adopting CCA vary substantially, making the study broadly applicable throughout the United States and internationally. Additionally, utilizing counties and cities within one state, operating under the same state institutional system, is a strength. Analyzing local governments in one state means that most of the legal structures and higher-level government politics are the same, allowing for a more robust comparison of characteristics and causes.

3.2b Study site selection

Five case studies of the state were selected where local governments adopted CCA, as well as two county governments that voted against adopting the policy (Fig. 3.1). The areas of the state were selected for demographic, political, economic, and geographic variation (George and Bennett 2005; Palinkas et al. 2015). In selecting the study areas, a variety of these characteristics of all local governments that adopted CCA in the state were evaluated, including the percentage of Democratic party voters, support for the environment, educational attainment, poverty rates, household income, and population.

The areas selected that adopted CCA are: 1) the Monterey Bay region, where Monterey, Santa Cruz, and San Benito counties joined together to adopt the policy; 2) San Mateo County; 3) the City of San Diego; 4) the City of San Luis Obispo, where the city voted to adopt CCA but then opted to join Monterey Bay's CCA entity following regulatory changes; and 5) Yolo County, where the unincorporated county joined with its cities of Davis and Woodland to adopt CCA.

The two county governments selected that voted down CCA are San Diego County and San Luis Obispo County. They were selected because they were the only two that had officially considered and then voted against adopting the policy. Including these cases where the policy was voted down provides a critical contrast in policy considerations and outcomes (Mahoney and Goertz 2004). This is also notable given how unusual the inclusion of negative cases is in qualitative research on climate planning.

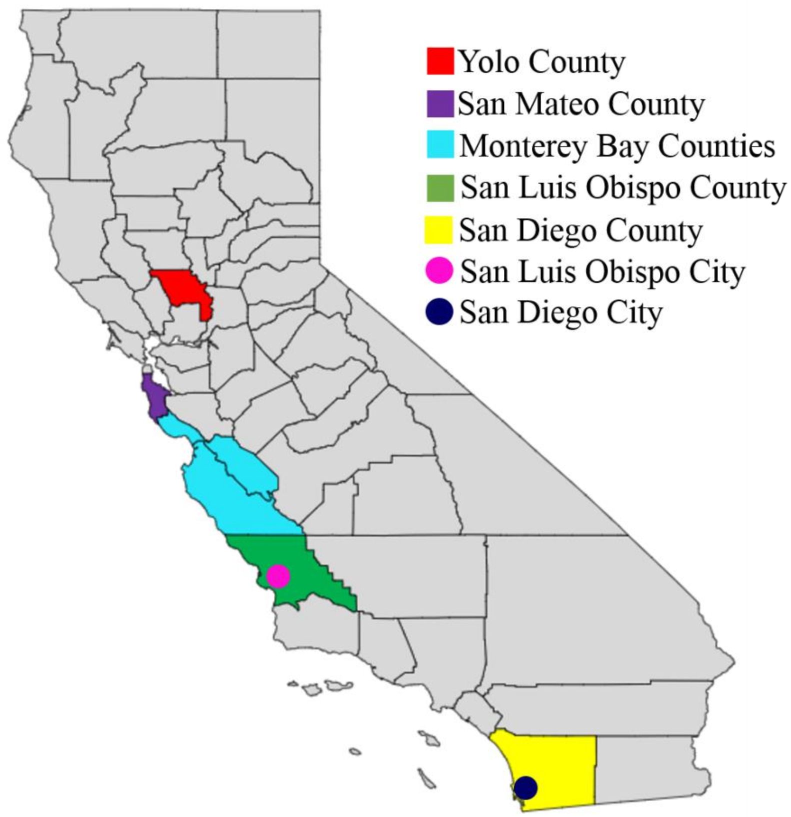

Fig. 3.1: Map of areas included in this study.

3.2c Interviews, respondents, and questions

A total of 42 formal, semi-structured interviews were conducted with policymakers and stakeholders. Respondents were first selected from a review of all media coverage related to CCA consideration in the study areas, which was searched and accessed using *Access World News: Research Collection*, a database of news sources. Media coverage was used to identify policymakers and stakeholders involved in the policymaking process. They were contacted by email with an interview request. Snowball sampling was then used to identify additional respondents (Thompson 2002). At the end of each interview, respondents were asked to recommend 3-5 people who have been involved in CCA policymaking. A total of

56% of people agreed to be interviewed, 31% did not respond, and 13% declined. Table 3.1 shows the type of respondents in each area.

Table 3.1: Interview respondents overview.

Area	**Elected official**	**Government staff**	**Local NGO staff**	**Grassroots leader**	**Business leader**
Monterey Bay	2	2	1	3	2
San Diego	0	1	3	3	2
San Luis Obispo	3	1	1	2	0
San Mateo County	3	1	1	2	0
Yolo County	3	2	2	2	0
Total	**11**	**7**	**8**	**12**	**4**
Percent	**26%**	**17%**	**19%**	**29%**	**9%**

A series of 17 interview questions were developed for respondents in the three-county areas that adopted CCA. Respondents in San Diego and San Luis Obispo were asked the same core questions about why their cities adopted CCA, as well as questions about why their counties did not. The interviews included open-ended questions, numerical and percentage estimates, and several questions using a seven-point semantic differential scale where 1 was “not at all important” and 7 was “extremely important.” The variables included in the differential scale questions were based on factors shown to be important in the literature, as covered in Section 1, and from a review of issues commonly cited in the news coverage and policy formation documents.

Most interviews lasted between 35 minutes and one hour. In terms of communicating with respondents, 26 were conducted in person and 16 were conducted over the telephone or Zoom. Interviews were conducted between October 2018 and May 2019. Interviews were recorded and then transcribed. To encourage candid responses, interviews were confidential, and hence quotes are not attributed by name or location.

3.2d Analysis

The responses to the seven-point semantic differential scale questions provide the foundation of the analysis to answer the two central research questions. Responses from all areas were combined to test the difference of means with a one-way Welch's ANOVA with Tamhane's T2 multiple comparison post-hoc tests (unequal variances) in SPSS v. 25.[8] The significance level was set at 0.05 and higher. Given the small sample sizes, a difference of means tests of variables within each study area was not conducted, but the 95% confidence intervals are reported.

The quantitative assessment is paired with respondent quotes and summation of themes from interviews and reviews of media coverage. Such a paired quantitative-qualitative approach enhances the comprehensive understanding of the policy process and provides a fuller picture of CCA adoption and rejection (George and Bennett 2005; Lester and Lombard 1990).

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[8] In addition to Welch's ANOVA and Tamhane's T2 post-hoc tests, Kruskal-Wallis tests were performed with Dunn's Multiple Comparisons tests, adjusted using the Bonferroni correction, because some scholars have raised questions about whether 1-7 semantic differential scales are appropriate to treat as interval data (Darbyshire and McDonald 2004). In all cases, the results of the Kruskal-Wallis tests and Dunn's tests agreed with the results of the Welch's ANOVA and Tamhane's T2 post-hoc tests. Research evaluating the effectiveness of 7-point scales versus continuous (generally 0-100) scales, including in American National Election Surveys and "feeling thermometers," indicates that 1-7 scales can be as or more effective (Alwin 1997; Thomas and Bremer 2012).

Media coverage is used to supplement interview responses. Media coverage provides additional context and serves as an independent source about the policymaking process. While interview response rates are always a cause for some concern about the omission of perspectives and information, sustained media coverage of the policymaking processes helps to ensure a full and accurate accounting. As such, select context and quotes from news coverage are also reported.

3.3. Results

3.3a Stakeholders and their concerns driving policy adoption

Respondents reported, and local media coverage indicated, that CCA adoption was driven primarily by one or more elected official champion(s) and local grassroots groups, with minimal differences among the regions. Fig. 3.2 shows respondents' mean ratings about which stakeholder groups were important in supporting and driving CCA adoption forward. For all areas combined, there is a significant difference ($F(4,200) = 63.773$, $p < 0.001$) between stakeholder types. Post-hoc comparisons found statistically significant differences ($p < 0.001$) between elected officials and members of the public, state/national groups, and industry groups. Elected officials and local grassroots groups are statistically indistinguishable.

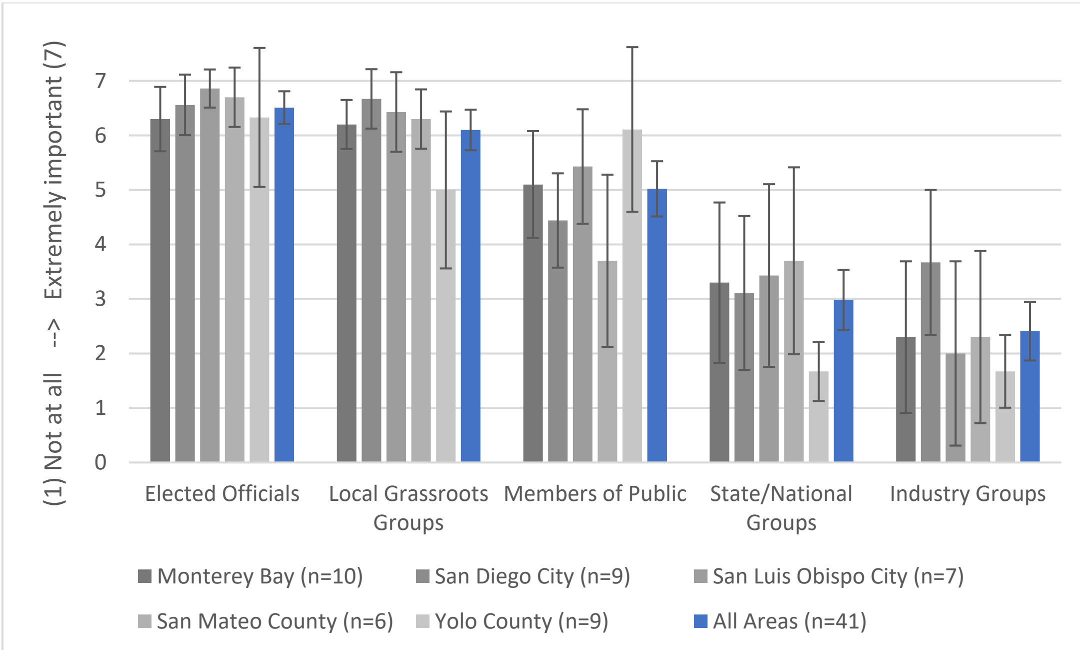

Fig. 3.2: Interview respondents' mean rating for the importance of elected officials and stakeholders in supporting and driving forward the adoption of CCA, with 95% confidence intervals.

Respondents reported that individual elected officials were crucial to policy adoption, soliciting responses such as "it would not have been possible without them." In their responses, respondents pointed specifically to one or two individual elected officials who led the effort. Elected official leaders drove policy adoption forward in close partnership with grassroots groups, which served to educate the public, mobilize public support, and pressure other decision-makers to support the policy. Respondents described grassroots groups as very important. One government official said, "The elected officials would not have done it without them." Another government official remarked, "Elected officials were important... but local grassroots organizations were the other half."

Elected officials and grassroots groups undertook significant outreach to build broad-based coalitions in support of the policy. While environmental grassroots groups were the leaders, they targeted outreach and garnered support from other community groups, businesses, farmers, unions, and others. One government official said, “The community outreach, really gathering the support, was just fundamental to this.”

Those interviewed noted that most members of the public participated through or because of grassroots groups, which actively sought to involve residents. This differed somewhat in Yolo County, where respondents reported that several resident experts, mostly unaffiliated with grassroots groups, were instrumental in driving forward CCA. Respondents reported that state and national groups, as well as industry groups like solar power companies, provided limited support. A trade association, California Community Choice Association, was formed in 2016 to support CCA interests. However, it was not very active in the policymaking processes examined in this study.

3.3b Public participation in the policymaking process

Table 3.2 reveals interview respondents’ mean estimates about the number of people who participated in each CCA policymaking process and their level of technical understanding about the policy. In each of the five case studies, many educational events and meetings were held as part of the policymaking processes. Some respondents indicated that many meetings, both official government and grassroots-organized meetings, likely helped to build issue salience, create an ongoing sense of inclusiveness, and educate the people who participated to be well informed about the issue.

Table 3.2: Interview respondents' mean estimates of CCA-related meeting attendance, total participation, and level of understanding about the basic technical nature of CCA and the changes it would have on the energy system.

	Avg. Meeting Attendance	**Total Participation**	**Technical understanding: Very little**	**Technical understanding: Some basic**	**Technical understanding: High level**
Monterey Bay	49	1750	50%	39%	11%
San Diego City	47	1000	29%	56%	15%
San Luis Obispo City	24	646	56%	29%	15%
San Mateo County	35	775	16%	43%	41%
Yolo County	28	253	22%	55%	23%

Respondents estimated that a substantial portion of the people who participated in the process had a basic or high level of technical understanding about CCA. This suggests that they would be able to weigh in meaningfully about the direction of the policy and assert their values. Indeed, 92% of respondents said that specific policy components or decisions about CCA changed because of the public's involvement.

3.3c Issue concerns behind policy adoption

Fig. 3.3 shows respondents' mean rating of the importance of issue concerns behind CCA adoption. As readers can see, there is a significant difference between concerns ($F(6,287) = 39.879$, $p < 0.001$). Post-hoc comparisons found significant differences ($p < 0.001$) between climate change and job creation, environmental protection, dissatisfaction with the utility, dissatisfaction with state regulators, and cost savings ($p < 0.01$). There is no statistically significant difference between climate change and local control. Local control is also significantly different ($p < 0.01$) from job creation, environmental protection, dissatisfaction with the utility, and dissatisfaction with regulators. Asked if there were other important factors, six respondents noted community co-benefits broadly, two noted resiliency, one noted transparency, and one noted environmental justice.

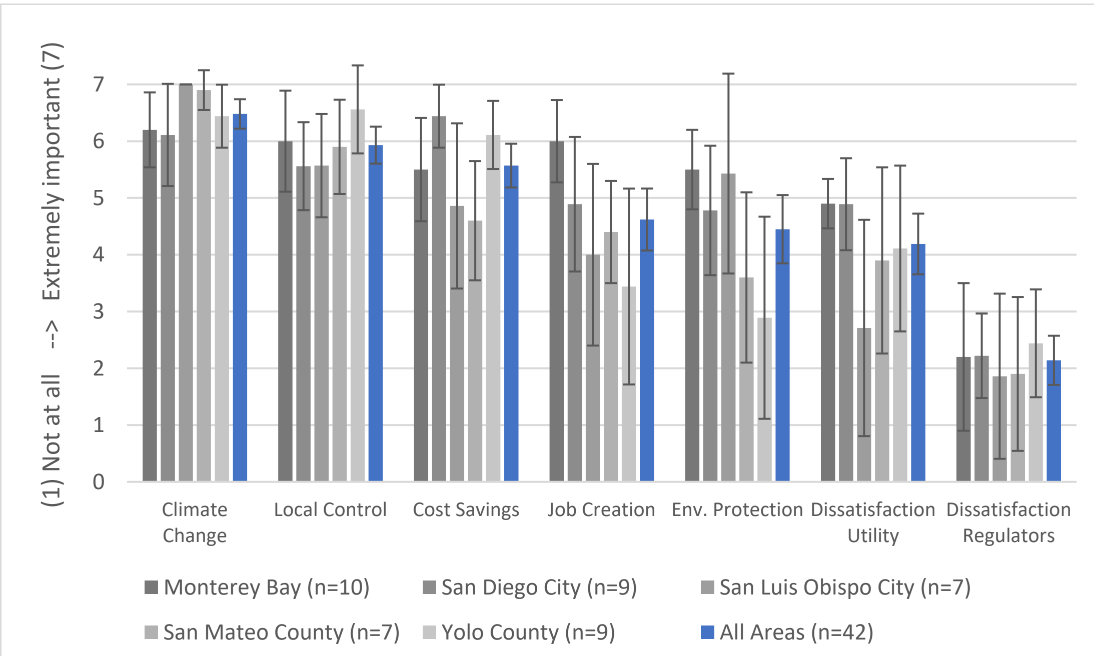

Fig. 3.3: Interview respondents mean rating of concerns motivating the adoption of CCA, with 95% confidence intervals.

Climate change was a very important concern in almost all situations and cases. Respondents often said that CCA was the most significant action that their community could take to mitigate climate change, and CCA was typically considered in the context of local governments' climate action plans. The grassroots groups involved were almost all environmentally focused and cared about CCA, at least in part, as a climate mitigation policy. One elected official characterized the concern driving CCA adoption and stakeholder involvement as, “Climate change is what drew so many people to the discussion. That was a very high, extremely important focus.”

Respondents were asked about environmental protection (e.g., local air pollution), separately from climate change, to determine if it was an important issue, which it was for some. Most saw environmental protection and climate change as overlapping but would say that CCA was primarily a climate issue. Respondents also cited job creation and cost savings as important factors in garnering political support from certain stakeholders and elected officials. Dissatisfaction with the utility was important for some people, but it was not typically a strong concern.

3.3d The role of local control

As Fig. 3.3 shows, local control is a very important concern driving CCA adoption. Many respondents point to local control and climate change together as the central concerns driving CCA adoption. Some point to local control as enabling meaningful climate action. For others, local control is important as a means of achieving community benefits. Respondents cite co-benefits stemming from local control including cost savings, keeping money in their communities, local renewable energy development, job creation, capacity for adaptation and resiliency, increasing capacity for innovation, addressing environmental justice, and democratic goals such as access to decision-makers and local accountability.

One grassroots leader said, “One of the things that was really important was to have local buildout...more solar and create the jobs here, instead of out in the desert. We need to have local jobs... Climate change and local control, for the activists, were really important." A government official said, "For the public to get on board, we really had a message that we are going to have local control... we were going to reinvest any profits back into the community." An elected official said, "[CCA] could really help our region become more self-sufficient while giving us local control over the type and cost of the energy we use."

In all areas studied, media coverage reflects the importance of local control. One newspaper contextualized the issue as "Why do some communities adopt CCAs? Some want more clean sources in their energy portfolios. Others want more local control... Boosters of CCAs say community choice delivers on both fronts." Another wrote, "Supporters say it would also offer greater local control over power rates, offer more transparency, cut greenhouse gas emissions and create local jobs." Characterizing a public hearing, one newspaper wrote that it "featured hours of testimony from dozens of people urging the board to simply move ahead... arguing the county should not miss a key opportunity to assume local control of energy."

3.3e Reasons for policy rejection

San Diego County and San Luis Obispo County considered CCA and then voted not to adopt the policy.[9] Fig. 3.4 shows respondents' mean responses about the importance of several concerns behind those decisions. For both counties combined, there is a statistically significant difference ($F(6,103) = 38.841$, $p < 0.001$) between concerns. Post-hoc comparisons found significant differences ($p < 0.001$) between government overreach and regulatory uncertainty, overly technical, cost savings, and

[9] After this study was completed, San Diego County policymakers voted in October 2019 to move forward with CCA after the city of San Diego and other governments in the area did. As of April 2020, implementation remains paused.

environmental concerns. Government overreach, financial uncertainty, and relationship to the utility are statistically indistinguishable.

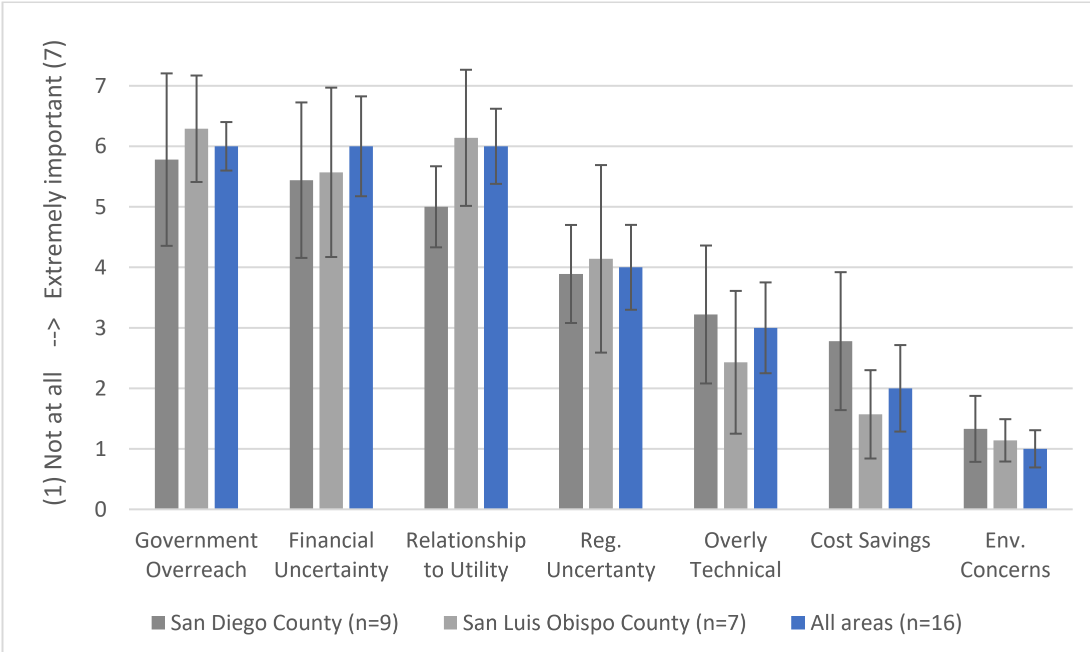

Fig. 3.4: Mean interview respondents' rating of concerns motivating the decision not to adopt CCA, with 95% confidence intervals.

Many respondents described the importance of a small-government ideology and pointed to some elected officials having political connections to the IOUs, which are major industries in both counties. Those interviewed pointed to financial uncertainty as important, although some suggested that both it and regulatory uncertainty served as a rationale to justify the ideological concerns and connection to the IOUs. One grassroots leader characterized the opposition as stemming from being “aligned with the business community and the [utility].” An elected official noted ideology as the core basis of opposition, and that from there, “you get rationalizations that there are technical difficulties with it, financial uncertainty.” Respondents also noted that several elected officials were climate change deniers. One elected official respondent said that for some, “any effort to deal with greenhouse gas reductions is an assault on the economy and personal freedom.”

In both counties, there were active opposition groups associated with the utilities that carried influence. Opposition to CCA was not driven by the public, however, and there were not grassroots groups opposed. Respondents reported (mean estimates) that 85% of the public who participated in the policymaking process in San Diego County, and 83% in San Luis Obispo County, supported CCA.

3.4 Discussion

Focusing on local government adoption of CCA in California, this study found that effective climate policy adoption is driven by local elected officials and local grassroots groups. Grassroots groups were important in providing an impetus for the policy, educating and engaging the public, and building support. Stakeholders were motivated by concerns about climate change and a desire for local control to realize co-benefits in their communities such as job creation. Local control can help local governments overcome free-rider problems by allowing them to design policies to address their unique priorities and maximize co-benefits. As a result, local control may help increase local government participation with effective climate policies.

The findings offer new insight into the policymaking process and the stakeholders behind effective climate policy adoption. Although the local government climate policy literature has noted public support and interest groups as factors in policy adoption (Portney and Berry 2016; Yeganeh, McCoy, and Schenk 2020), the role of stakeholders and their concerns has not been clear. Prior research points toward top-down policy processes (Kousky and Schneider 2003) and state and national organizations and networks being responsible for policy adoption (Betsill and Bulkeley 2006; Betsill and Rabe 2009). This study found that CCA adoption was not driven by such entities but rather was a bottom-up process.

CCA policy adoption was led by an interconnected effort of local elected officials who were leaders on the issue and grassroots groups that championed the policy, demonstrating that grassroots groups can serve a critical role in effective climate policymaking. Grassroots groups held educational events, garnered support from the public and other elected officials, and built stakeholder coalitions. While prior studies have not assessed their role, the sustained effort of such stakeholders may be necessary in many cases for the adoption of policies like CCA that are new undertakings, require significant costs, and are more likely to garner opposition. In contrast, general support for the environment may be enough impetus for many policymakers to take relatively easy policy actions like joining a climate network (Krause 2011).

Grassroots groups also propelled substantial public participation (ranging from hundreds to close to two thousand in different areas). Interview respondents estimated that a majority of those who participated had a basic or high level of technical understanding about the policy, which studies show is important for effective participation and public participation to support meaningful policy outcomes (Coenen, Huitema, and O'Toole Jr 2012; Fischer 2000; Yang et al. 2011). The fact that many educational events and meetings were held as part of the CCA policymaking processes likely helped participants understand the issue better.

In the cases where CCA was voted down, opposition stemmed primarily from an anti-government ideology, relationship with the private utility, and financial uncertainty. No grassroots groups opposed the policy, and most members of the public who participated in the policymaking process supported it. This dynamic is somewhat similar to climate change at the federal level, where polls indicate that a substantial majority of the American public support policies to mitigate climate change but where the opposition is driven by ideology and well-financed special interests, principally the fossil fuel industry (Brulle 2018; McCright, Xiao, and Dunlap 2014).

Climate change was a top concern behind CCA adoption. The significant commitment to reduce GHG emissions is indicative of a climate change culture emerging within grassroots communities and among some local elected officials. This culture may further propel bottom-up climate policymaking at the local level, particularly given frustration at federal inaction in the United States (Byrne et al. 2007). Yet climate change was not the only important concern; so was local control, along with related factors including job creation, local renewable energy development, keeping money in local communities, resilience, and others.

The breadth of concerns motivating CCA adoption demonstrates the importance of climate policy co-benefits. This aligns with prior research that has identified the value of connecting GHG emission reductions to air quality improvements, cost savings, and other local issues (Bedsworth and Hanak 2013; Bulkeley 2010; Kousky and Schneider 2003). Research has also found that local frames increase the effectiveness of messaging around climate change (Scannell and

Gifford 2013; Wiest, Raymond, and Clawson 2015). In line with these prior findings, this study suggests that a local-oriented approach to climate policy adoption is effective and can complement a focus on GHG emission reductions.

Local control allowed governments to design and shape policies to their unique priorities, letting them maximize policy co-benefits in their communities. Policymakers and stakeholders were able to utilize local control to address climate change and achieve other gains (e.g., local renewable energy development) as they created and implemented the policy. This overlap, where local control helped facilitate both the desire to address climate change and realize co-benefits, helps resolve the free-rider problem associated with local government climate mitigation policies (Trisolini 2010).

Most climate policies at any level of government yield co-benefits (Karlsson, Alfredsson, and Westling 2020), but individual communities may see no direct benefits from a state or national climate policy. With local control, governments can be certain that they will realize the co-benefits in their communities. Not only does this provide greater incentive to enact policies, but it also gives policymakers greater latitude to design policies that will benefit stakeholders in their communities. This may allow policymakers and advocates to garner support from broader coalitions, as they did in the CCA policy process, making policy adoption more likely.

This study shows that a broader reconsideration of local control is warranted. Changing demographic and political conditions, as well as an emerging climate change culture, may be increasingly common. Even in conservative areas where higher-level governments are unlikely to address climate change, there tend to be cities with elected officials and concentrations of residents who may be inclined to adopt effective climate policies (Tausanovitch and Warshaw 2014). If those local governments can assert local control over GHG emissions, their policy actions may be of heightened importance given the absence of a high policy floor like California and other environmentally inclined governments have set.

Conversely, local control could be a drawback for climate mitigation if communities opt to increase fossil fuel-based energy or reduce standards. They could do so to maximize cost savings or increase fossil fuel-related jobs. Whether this would occur is unclear, however, and may be unlikely given literature demonstrating that a “race to the bottom” on environmental regulation is not common (List and Gerking 2000; Millimet and List 2003; Potoski 2001). Even if it occurred, however, the effects of local control-based race to the bottom would be relatively minimal in areas where state regulations set a floor on pollution or renewable energy standards.

While this study focused on specific climate policy in California, the findings are widely applicable to other areas and issues. As local governments throughout the world adopt climate policies (Hughes 2017), recognizing the role of stakeholders and their concerns is important in fully understanding past and future policy processes. While there is an element of frustration with the United States federal government's inaction on climate change, various stakeholders and grassroots groups are looking to their local governments everywhere. Local control is likely to be an important factor in many places and for other environmental issues, and its role and effects should be considered in policy formulation, implementation, and governance.

Several future research directions are apparent. Future studies should focus on the policymaking processes and stakeholders behind effective local government climate policy adoption. Farther-reaching and comprehensive investigations that do so would be especially valuable. Studies should examine other instances of bottom-up policymaking and contrast outcomes with top-down policy efforts. Future research should investigate the effects of local control in a variety of locations and climate and environmental policies. Lastly, scholars should analyze how much latitude local governments have in conservative areas to enact climate policies that may be at odds with the priorities of higher level (e.g., state) governments.

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Chapter Four

Urban renewable energy and ecosystems: integrating vegetation with ground-mounted solar arrays increases arthropod abundance of key functional groups

*Note: This study is co-authored with Andy J. Kulikowski II and Dr. Stacy M. Philpott.

Abstract

Cities are increasingly developing renewable energy within urban areas, yet the implications for ecosystems have not been explored. This study brings together climate change mitigation policies and ecosystem conservation in urban areas by investigating how ground-mounted solar arrays in parking lots affect arthropod abundance and biodiversity. We assess which arthropods are present under these solar arrays and investigate how integration of vegetation under the solar arrays affects arthropod abundance, abundance of different functional groups, and family richness. We sampled arthropods, collected data on habitat characteristics, and evaluated landscape cover within 2km of eight study sites around San Jose and Santa Cruz, California. We found substantial abundance and diversity of arthropods underneath ground-mounted solar arrays in urban area parking, and that arrays integrated with vegetation have significantly greater arthropod abundance, more detritivores and parasitoids, and more family richness. The results indicate that ground-mounted solar arrays in parking lots, especially when integrated with vegetation, can be a win-win-win for climate mitigation, arthropod richness, and ecosystem functioning.

Keywords: urban solar energy; arthropods; urban ecology; reconciliation ecology; urban biodiversity

4.1 Introduction

Urban areas simultaneously face the direct impacts and the challenges of addressing climate change and biodiversity loss. In response to the climate crisis, a growing number of cities are enacting greenhouse gas (GHG) emission mitigation policies and are looking to develop renewable energy within their jurisdictional boundaries (Armstrong 2019; Rosenzweig et al. 2010; Yi 2013). In addition to rooftop solar panels, ground-mounted solar arrays are increasingly being built in urban parking lots, fields, parks, and other spaces (Gagnon et al. 2016). Many cities are in biodiversity-rich areas such as floodplains, estuaries, and coastlines. By 2030, urban land cover in biodiversity hotspots is expected to increase significantly and urbanization is projected to affect more than 25% of all endangered or critically endangered species (CBD 2012; Elmqvist et al. 2013; Wilkinson et al. 2013). Given the importance of urban ecosystems and urban biodiversity, it is critical that ecologists and planners consider the ecosystem effects of urban renewable energy development and undertake proper planning to minimize impacts.

This study brings together climate change mitigation strategies and biodiversity conservation in urban areas by investigating how ground-mounted solar arrays in parking lots affect arthropod biodiversity. With mounting solar energy development, these ‘solar parking canopies’ (also known as solar carports), under which cars park, are increasingly common. Parking lots comprise up to 20% of the surface area of typical cities (Akbari and Rosa 2008; Gilbert et al. 2017) and these parking lots have a great deal of potential for future solar development (Gagnon et al. 2016). At the same time, as impervious surfaces span large areas throughout urban areas, parking lots are associated with negative environmental and ecosystem impacts including habitat fragmentation, water runoff, pollution, and heat island effects (Davis et al. 2010). Parking lots without built structures or green spaces are harmful to urban ecosystems and biodiversity.

Interest in urban solar energy has come from city governments seeking to deploy renewable energy locally and amidst concerns about the impacts of rural utility scale solar energy, including harm to ecosystems and species like the desert tortoise (Hernandez et al. 2014, 2016). Hernandez, Hoffacker, and Field (2015) found that solar energy in the built environment in California – in urban and semi-urban areas – could exceed the state's energy needs, with open and green space comprising a third of the compatible areas. As of November 2019, California already had 17,365 completed ground-mounted solar installations and applications for 17,634 more, demonstrating that there is significant prior and future development.[10]

From a reconciliation ecology perspective, which seeks to create urban-natural habitats where flora and fauna are incorporated into the built environment (Handel, Saito, and Takeuchi 2013; Rosenzweig and Michael 2003), solar parking canopies introduce a structure into impervious parking lot surfaces. Sometimes green spaces such as garden areas are incorporated with solar parking canopies, which is a small

[10] These numbers reflect a count of all interconnected solar energy projects and applications listed as "ground" in data available from the California Solar Initiative, a program of the California Public Utilities Commission and other partners. The data are publicly available at californiadgstats.ca.gov (last accessed February 12, 2020). We were not able to distinguish between urban and rural settings or the percentage in parking lots.

design choice that is likely aesthetically driven. Solar parking canopies may offer habitat areas and the potential to "green" parking lots (U.S. EPA 2008) if integrated with vegetation such as flowers, grasses, and shrubs.

In general, green spaces can help reduce negative environmental effects of urban development and high concentrations of impervious services (Solecki et al. 2005; Spronken-Smith and Oke 1998). In various forms, green spaces contribute to environmental sustainability, ecosystem services, and provide aesthetic appeal (Breuste et al. 2013; Haq 2011). Reconciliation ecology and other ecosystem- and biodiversity-minded approaches are important to consider in a variety of applications as the pace and scale of urbanization increases.

Solar parking canopies, especially if integrated with vegetation, may serve as habitat area for arthropods, which are affected by urbanization and which serve critical roles in urban ecosystems (McIntyre 2000; McKinney 2008). Arthropods are the fundamental components of trophic networks and provide essential ecosystem services (Bolger et al. 2000; Sanford, Manley, and Murphy 2009). Accordingly, various arthropod functional groups (e.g., predators and pollinators) – and richness generally – are important for a range of services such as pest control and nutrient cycling (Buchori and Sahari 2008; Nsengimana, Francis, and Nsabimana 2018; Sattler et al. 2010).

While characteristics vary, small and informal urban habitat areas and green spaces can support substantial arthropod abundance including diverse arthropod communities (Bolger et al. 2000; Gibb and Hochuli 2002; Noordijk et al. 2010; Rupprecht et al. 2015). Landscape and local factors can also be important in driving arthropod abundance and diversity in these urban habitat areas (Magura, Horváth, and Tóthmérész 2010; Philpott et al. 2014; Rudd, Vala, and Schaefer 2002). Landscape factors known to affect arthropod communities include habitat connectivity, habitat fragment size, extent of development, and distance to natural areas (Egerer et al. 2017; Faeth, Saari, and Bang 2012; Magura, Horváth, and Tóthmérész 2010; Philpott et al. 2014; Rudd, Vala, and Schaefer 2002; Yamaguchi 2004). Important local habitat characteristics include vegetation characteristics such as height and floral availability (Bennett and Gratton 2013; McKinney 2008; Uno, Cotton, and Philpott 2010). These landscape and local characteristics can also affect arthropod richness, which can be important for biodiversity and ecosystem services in urban areas (Egerer et al. 2017; Philpott et al. 2014).

Here, we address how solar parking canopy presence may affect arthropod communities in urban areas. Because arthropod response to solar canopies remains unexplored, we wanted to assess which groups of arthropods are using such canopies and in what abundance, and determine how integration of vegetation and landscape context may affect overall arthropod abundance, abundance of different functional groups, and arthropod richness. Specifically, we ask, (1) What arthropod groups are found under urban solar parking canopies and in what abundance? (2) How does integration of vegetation with urban solar parking canopies affect arthropod abundance and abundance of key functional groups? (3) Does landscape context influence how integration of vegetation under solar parking canopies affects arthropods? And (4) are there differences in arthropod family richness between solar parking canopies with and without vegetation? We hypothesized that there would be greater arthropod abundance and richness under solar parking canopies integrated with vegetation and that there would be an interaction effect between landscape factors associated with biodiversity, such as forest cover, and vegetation under solar canopies. Thus, we assessed what arthropod groups are present and the potential for this kind of renewable energy development to provide urban ecosystem conservation opportunities. This general assessment serves to evaluate the overall habitat potential under these structures to inform ecosystem and biodiversity planning.

4.2 Methodology

4.2a Study sites

We identified eight paired study sites (Fig. 4.1) in urban areas that met three criteria: 1) presence of both a vegetated solar parking canopy (vegetation at least 3m x 3m under or immediately adjacent to the solar canopy) and an isolated solar parking canopy (no vegetation under the solar canopy and at least 15m from the nearest vegetation); 2) solar parking canopies that had been present for at least three years; and 3) each site must be at least 2km from the nearest site. The presence or absence of vegetation under or adjacent to the solar canopies comprise our two treatments (‘vegetated’ and ‘isolated’ solar canopies). Vegetation under/adjacent to solar canopies includes areas of grasses and weeds, flower arrangements, and bushes.

To find sites that met these criteria, we used Google Satellite and Street View to review major schools and colleges around the cities of San Jose and Santa Cruz, California, and then went in person to evaluate whether they met the criteria. We looked at schools because many of them in the region installed such solar canopies in the last ten years and because we could assume that human activities at schools are relatively similar. We selected seven sites in and around San Jose (37.3382° N, 121.8863° W) and its suburbs (within Santa Clara County), and one site in Santa Cruz (36.9741° N, 122.0308° W). The site in Santa Cruz is Harbor High School and the seven sites around San Jose are Andrew P. Hill High School, Foothills College, Freemont High School, Homestead High School, Lynbrook High School, Santa Theresa High School, and William C. Overfelt High School.

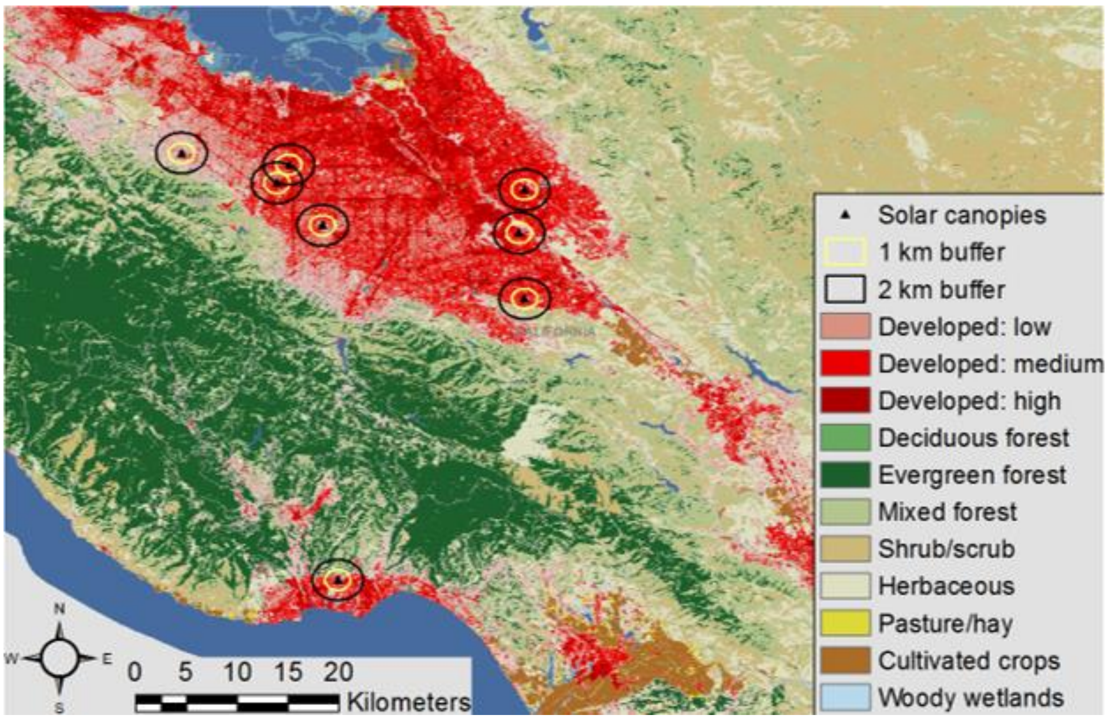

Fig. 4.1: Map of study sites in the San Jose and Santa Cruz, California areas. The landscape characteristics included in the study are all listed (data are from the National Land Cover Database, 2016).

4.2b Landscape and habitat characteristics

Using geographic information system (GIS), we assessed landscape characteristics surrounding each site using 2016 data from the National Land Cover Database (see Fig. 4.1) (Jin et al. 2013; Wickham et al. 2014). We created four major land-use categories: a) agriculture, combining pasture/hay [NLCD number 81] and cultivated crops, [82]; b) developed land, combining low, medium, and high intensity [22, 23, 24]; c) developed open space [21]; and d) natural land use, combining deciduous forest [41], evergreen forest [42] mixed forest [43], shrub/scrub [52], and herbaceous [71] and woody wetlands [90]. We used spatial analysis tools in ArcMap (v 10.7.1) to calculate the percentage of each land cover type within 100m, 1km, and 2km, buffers surrounding each site.

In addition to these factors, we quantified a variety of local characteristics at all sites (Table 4.1). We measured the distance from the center of the solar parking canopies to the nearest other vegetation (e.g., a row of trees or a field). We measured temperature under each solar canopy using temperature loggers (Onset HOBO UA-001-08), placed approximately 20cm under the center end of each solar canopy and set to record temperature data (°C) every hour for the entire time of all sampling. We measured solar canopy incline using an inclinometer. Under the eight vegetated solar canopies, we also measured the vegetation area, floral availability, and shortest and tallest vegetation present.

Table 4.1: Solar parking canopy characteristics.

Variable	Treatment	Mean (± SE)	Minimum	Max
Distance to other vegetation (m)*	Vegetated	19.926 ± 3.829	0	36.576
	Isolated	28.804 ± 2.511	17.069	38.71
Temperature (°C) (June)	Vegetated	19.667 ± 0.354	6.37	42.282
	Isolated	19.506 ± 0.266	7.08	41.575

Solar canopy incline (°)	Vegetated	4.587 ± 0.212	3.8	5.8
	Isolated	4.812 ± 0.251	3.8	5.8
Vegetation area (m^2)	Vegetated	35.393 ± 5.793	20.246	62.154
	Isolated	n/a	n/a	n/a
No. flowers	Vegetated	118.25 ± 90.73	0	742
	Isolated	n/a	n/a	n/a
Vegetation height (m)	Vegetated	n/a	0.00762	2.1336
	Isolated	n/a	n/a	n/a

**Other vegetation is a vegetated area that is separate from the solar canopy and any vegetation under the vegetated solar canopies*

4.2c Sticky trap sampling and arthropod identification

Given that arthropod emergence and activity varies across seasons, we sampled at three different times during 2017: April, June, and August.[11] At each site and during each sampling period, we used yellow sticky traps (15.24cm x 20.32cm) to collect arthropods to identify and measure abundance. We placed six traps under each vegetated and isolated solar canopy during each sampling period for a total of 18 traps per canopy over the three sampling periods. Sticky trap placement was standardized for consistency across sites, with four sticky traps hung 30cm beneath the top of each solar canopy on each side of the two major support stanchions (posts) and two sticky traps hung approximately 75cm above the ground by each of the stanchions. Sticky traps were left out for 7 days each time. When collected, we covered sticky traps with wax paper and stored them in a refrigerator and later

[11] At one site, Harbor High School, we were only able to sample in April and June.

identified arthropods. As expected, some sticky traps were lost at each site due to wind, birds, or human activity, but a majority were successfully collected.

We identified arthropods on one side of each sticky trap (standardized based on whether the side pointed to the middle of the canopy) to order and family when possible, following Borror and White (1970) and Marshall (2006). We classified arthropods to six functional groups (detritivores, herbivores, parasitoids, pollinators, predators, and sanguivores) based on Borror and White (1970), Marshall (2006), and additional literature sources (Bellamy et al. 2018; Kenneth, Beaver, and Heumier 1991). We assessed functional groups to consider how ecosystem roles might be affected by different canopy types or placement within the landscape.

4.2d Data analysis

To determine what arthropod groups were under solar parking canopies and in what abundance, we present descriptive results about the number of arthropods collected and common orders and functional groups. This provides a general assessment of the habitat potential of solar parking canopies and which arthropods utilize them.

We used generalized linear mixed models (GLMMs) to compare overall arthropod abundance and abundance within functional groups (response variables) between vegetated and isolated solar canopies. Because models with Poisson distributed errors were overdispersed, we used negative binomial errors distributions for all analyses. We included a random blocking effect to account for unexplained variance between sites and sampling periods (nested within sites). We also examined the influence of landscape variables (distance to other vegetation, temperature, solar canopy incline, and percentage of the surrounding landscape in agriculture, developed land, developed open space, and natural land use at 100m, 1km, and 2km buffers) on each response variable by constructing models that included solar array treatment (vegetated or isolated), each landscape variable separately, and the interaction between the two. We assessed model fit using Akaike Information Criterion (AICc) and for each response, chose the models that had the lowest AICc score. In all cases, the best fit model included only solar canopy treatment.

Among the vegetated canopies, we used the same GLMMs to examine the influence of vegetation characteristics (floral abundance, vegetation area, minimum vegetation height, and maximum vegetation eight) on arthropod abundance and arthropod functional groups (response variables), and to assess the interaction between vegetation characteristics and landscape variables.

To investigate differences in arthropod richness depending on solar canopy treatment, we calculated family accumulation curves by treatment using the 'vegan' package in R (Oksanen 2013), as well as non-parametric richness estimator Chao1 values (Chao and Chiu 2001). We used generalized linear models (GLMs) to compare Chao1 values for estimated arthropod family richness (response variable) between vegetated and isolated solar canopies at the site level using a gamma distribution.

4.3 Results

4.3a Arthropod abundance

We collected a total of 3,318 arthropods from the 199 sticky traps recovered. We were able to identify 3,294 of the arthropods to order and 2,137 to family, representing a total of 12 orders (10 under vegetated solar canopies, 10 under isolated solar canopies) and 63 families (54 under vegetated solar canopies, 40 under isolated solar canopies). Common orders (more than 60 individuals collected) included Araneae (65 individuals, 1.96% of arthropods collected), Coleoptera (60, 1.81%), Diptera (961, 28.96%), Hemiptera (1080, 32.55%), Hymenoptera (565, 17.03%), and Thysanoptera (488, 14.71%).

We found that vegetated solar parking canopies had significantly greater arthropod abundance than isolated solar canopies ($F_{1,197} = 7.645$, $p = 0.006$) (Fig. 4.2). Overall, vegetated solar canopies (sticky trap n=101) accounted for 1,989 arthropods compared to 1,285 from isolated solar canopies (sticky trap n=98), or 43% more under vegetated solar canopies (40.1% accounting for the difference in the number of sticky traps).

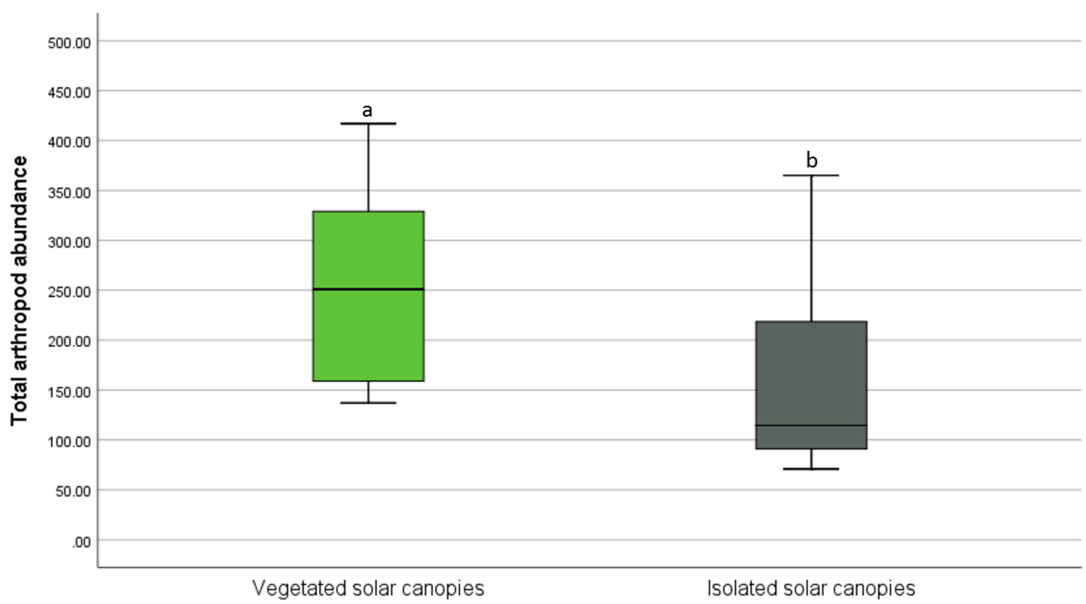

Fig. 4.2: Arthropod abundance (number of individuals collected) under vegetated solar parking canopies and isolated solar parking canopies. Abundance was

significantly greater under vegetated solar parking canopies. Data from sticky traps collected during three sampling periods in 2017.

None of the landscape variables or the interactions between them and treatment had a statistically significant effect on arthropod abundance. Among the vegetated solar canopies, floral availability had a significant positive effect on arthropod abundance ($F_{1,99} = 4.491$, $p = 0.037$) and a significant positive effect on herbivore abundance ($F_{1,99} = 13.972$, $p = <0.0001$). None of the other vegetation characteristics or interactions between them and landscape characteristics had a significant effect on arthropod abundance or abundance of any other functional groups.

4.3b Arthropod functional group abundance

There were significantly more detritivores and parasitoids under vegetated solar canopies (Fig. 4.3). Abundance of other functional groups did not differ with canopy type (Table 4.2).

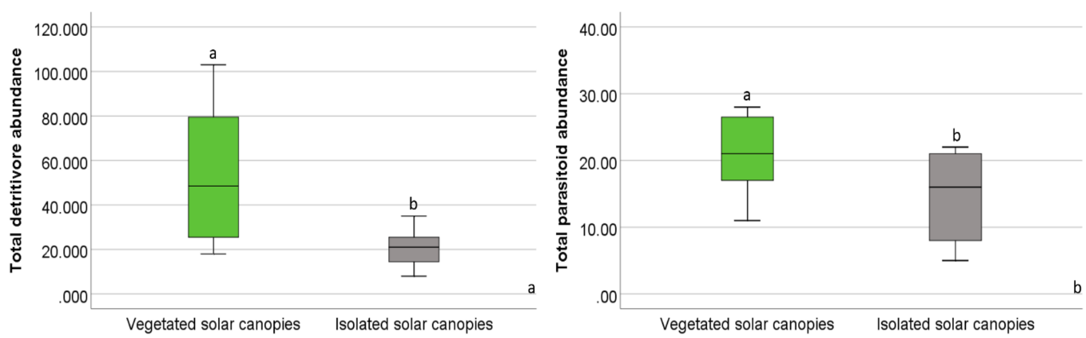

Fig. 4.3: Detritivore (panel a) and parasitoid (panel b) abundance were significantly greater under vegetated solar parking canopies than isolated solar canopies. Data are from sticky traps collected during three sampling periods in 2017.

Table 4.2: Total abundance of arthropods by functional role across all sites under vegetated and isolated solar parking canopies, and mean abundance (±SE) per sticky

trap. Degrees of freedom and p values based on functional group abundance analysis using GLMMs comparing vegetated and isolated solar canopies.

Functional role	Vegetated (total)	Isolated (total)	Vegetated (per trap)	Isolated (per trap)	df	*p*
Detritivore	428	165	4.17 ± 0.616	1.68 ± 0.181	1,197	<0.0001
Herbivore	1010	668	9.68 ± 2.149	6.82 ± 0.839	1,197	0.136
Parasitoid	209	117	2.07 ± 0.352	1.19 ± 0.144	1,197	0.007
Pollinator	27	12	0.27 ± 0.056	0.12 ± 0.042	1,197	0.547
Predator	59	55	0.59 ± 0.097	0.56 ± 0.098	1,197	0.950
Sanguivore	16	16	0.16 ± 0.039	0.16 ± 0.056	1,197	0.782

4.3c Arthropod family richness

Family accumulation curves among all vegetated and isolated solar canopies appear to be reaching their asymptotes (Fig. 4.4), indicating that sampling was exhaustive enough to make comparisons. The combined isolated solar canopy curve crosses over the vegetated solar canopy curve, which is increasing but flattening out. Based on Chao1 estimates, family richness was significantly greater ($p = 0.001$) among vegetated solar canopies.

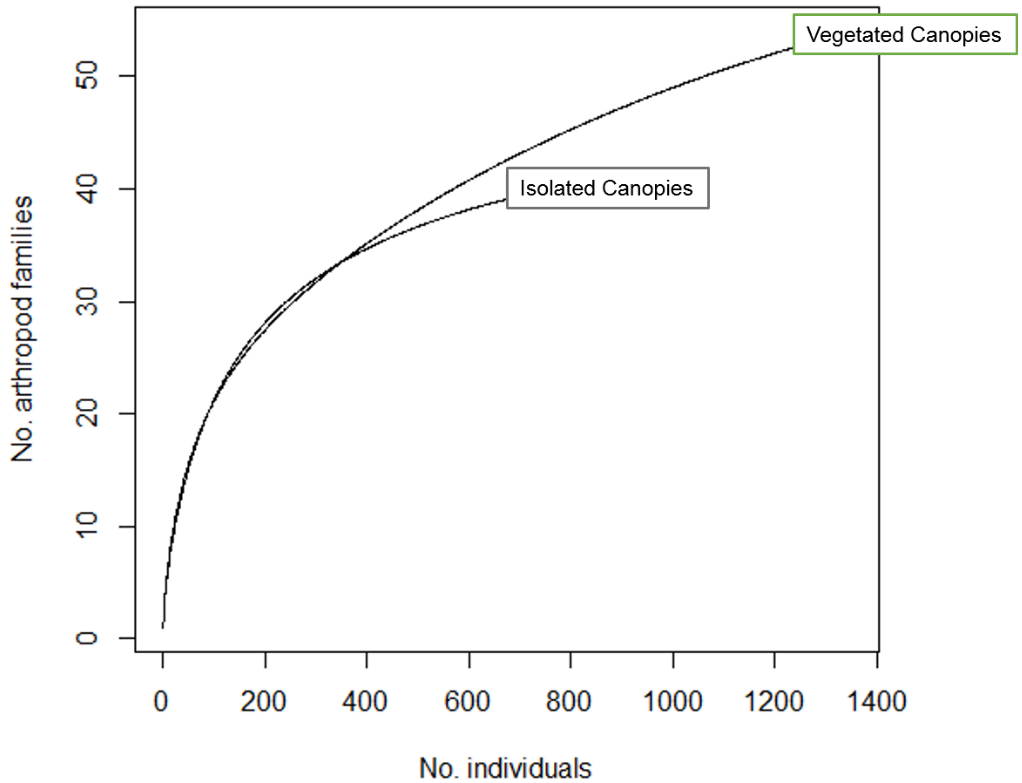

Fig. 4.4: Arthropod family accumulation curves for all isolated and vegetated solar parking canopies.

4.4 Discussion

To the authors' knowledge and based on a comprehensive review of renewable energy and biodiversity by Gasparatos et al. (2017), no studies have examined arthropod, ecosystem, or biodiversity implications of urban ground-mounted solar energy. This is the first study to examine how vegetation and landscape context influence arthropods under solar canopies. The most relevant research comes from a study in London, where Nash et al. (2015) found that integration of rooftop solar arrays with green roofs enhances biodiversity by providing a microhabitat for insects and birds, and by providing shade that increases diversity in vegetation patches. While green roofs and the solar panels placed on them are different, these findings generally align with ours. So do findings from a study in a rural desert setting in Chile, where Suuronen et al. (2017) found that ground-mounted solar arrays created shady conditions and microclimate changes that provided habitat for arthropods.

We found that arthropod abundance was significantly greater under urban solar parking canopies that are integrated with vegetation than those isolated from vegetation. Vegetated solar canopies had over 40% more arthropods than isolated solar canopies. The presence of vegetation under the solar canopy was significant in explaining arthropod abundance regardless of landscape characteristics. The strong influence of vegetation integration on arthropod abundance, regardless of landscape context, is surprising given that in other urban systems, landscape factors strongly drive arthropod abundance (Magura, Horváth, and Tóthmérész 2010; Philpott et al. 2014; Rudd, Vala, and Schaefer 2002).

Among the vegetated solar canopies and vegetation characteristics, floral availability had a significant positive effect on arthropod abundance overall and on herbivore abundance. The role of floral abundance is not surprising given that some arthropod functional groups rely on flowers. The strong positive effect of floral availability on herbivore abundance, and not on other functional groups, indicates that herbivores were driving the effect, although abundance of herbivores likely supports other arthropods. Likewise, in other vegetated urban habitats, such as community gardens, flowers support pollinators, parasitoids, and arthropod richness generally (Bennett and Gratton 2012, 2013; Matteson and Langellotto 2011), although effects vary among some arthropods (Burks and Philpott 2017).

There was a variety of arthropods under solar parking canopies including 12 orders and 63 families. We found that vegetated solar canopies host significantly greater abundance of parasitoids and detritivores. Looking to literature about arthropods in urban environments (Free et al. 1975; Hogg, Bugg, and Daane 2011; E. L. Jones and Leather 2012; Matteson and Langellotto 2011), both parasitoids and detritivores are beneficial arthropod groups for ecosystem functioning and ecosystem services. Parasitoids are especially important for ecosystems given that they function at high trophic levels and promote diversity and stability in insect communities (Fenoglio and Salvo 2010; Shaw and Hochberg 2001). They are important in maintaining ecosystem functions and regulating insect pest populations (Buchori and Sahari 2008). The presence of parasitoids naturally translates to having more organisms being parasitized, indicating greater ecosystem integrity (Buchori and Sahari 2008).

Of course, it makes sense that vegetated solar canopies have more detritivores considering the presence of organic matter to decompose, but this also points to the benefit of those green spaces given the importance of detritivores. Detritivores serve foundational ecosystem functioning roles in bottom-up interactions and nutrient cycling (Seastedt and Crossley, 1984). Their abundance and diversity are instrumental in maintaining soil quality and organic material turnover (Nsengimana, Francis, and Nsabimana 2018; Paoletti et al. 2007). In their consumption and transformation of detritus, detritivores have a substantial effect on food webs and have consequences for community structures (Yang 2006).

Arthropod family richness was significantly greater at vegetated solar canopies, reflecting the greater number of families we collected there (54 versus 40 at isolated solar canopies). Arthropod diversity is important in supporting broader ecosystem biodiversity and functioning (Lagucki, Burdine, and McCluney 2017; McIntyre 2000). As urban biodiversity planning proceeds, including restoration ecology in urban areas, arthropod richness is an important consideration (Handel, Saito, and Takeuchi 2013). Future research with larger datasets should seek to identify specifically what vegetation best supports arthropod diversity in these settings.

Our findings align with other research showing that relatively small urban green spaces and habitat areas can be important for conserving arthropods and supporting biodiversity, and that these areas can provide resources for foraging and habitat dispersal (Goddard, Dougill, and Benton 2010; Noordijk et al. 2010). A high amount of vegetated areas in urban areas, even small and isolated patches, can increase abundance and richness of arthropods (Turrini and Knop 2015). Vegetated solar parking canopies may serve such functions. Parking lots are often relatively large urban areas that break up and disconnect small and large vegetation patches. In addition to serving as habitat area, by providing built structures that provide shade and integrating vegetation with those structures, solar canopies may act as steppingstones that help to alleviate habitat fragmentation. Other research has found that green roofs in urban areas can serve such a function by increasing habitat connectivity for arthropods (Braaker et al. 2014).

Urban green spaces – whether small and informal areas such as green roofs and those integrated with solar parking canopies, or parks and community gardens – are important in providing ecosystem services (Rupprecht et al. 2015). These green spaces and their integration with the built environment support ecosystem functioning and are part of urban ecological infrastructure that provides essential services such as air purification, moderation of climate extremes, biodiversity preservation, and human health benefits (Gomez-Baggethun et al. 2013; Maas et al. 2006). Our findings demonstrate that solar canopies – especially vegetated ones – are beneficial in this urban ecological infrastructure, providing habitat for and supporting arthropods that serve important functional roles in urban ecosystems.

While parking lots with solar canopies may not be as important for biodiversity conservation as other urban green spaces (e.g. natural habitat fragments), this study indicates that the management of solar canopies may be important for enhancing arthropod abundance and connectivity between other vegetated areas. The presence of vegetated solar canopies likely offers more habitat than parking lots without such solar arrays that offer little to no habitat for biodiversity. It is important to note that no evidence indicates, and we see no reason to believe, that arthropods under solar canopies damage them or affect their operation or energy output.

This study has several implications for urban ecosystem management, planning for ecosystem services, and biodiversity conservation. The expansion of urban renewable energy, and especially of solar parking canopies, is an opportunity for a proactive reconciliation ecology approach. As urban area governments build solar energy in their own parking lots and as they consider permits for such development from businesses, schools, and other entities, they have an opportunity to transform large impervious surfaces from being ecologically detrimental to providing ecosystem benefits. Whereas finding the impetus and resources to “green” parking lots and integrate vegetation may be unlikely from an ecological interest alone, factoring in such goals to renewable energy development that would occur regardless is a minimally burdensome addition. As our search for study sites demonstrated, some solar parking canopy installations already integrate vegetation. Our findings demonstrate that this design choice is worthwhile for the sake of arthropods that are beneficial for urban ecosystems, and that integrating flowering plants with solar canopies may be particularly worthwhile.

Other research demonstrates that integrating vegetation in parking lots, including small patches like we studied, is beneficial to keep water in the ecosystem, increase filtration rates, and reduce runoff and pollutant loads (Rushton 2001, 2002). Specific rain garden and bioretention designs can make such areas even more effective (Revitt et al. 2014). The presence of vegetation, as well as the solar canopies themselves, may also help alleviate heat island effects associated with parking lots (Aniello et al. 1995; Onishi et al. 2010).

Scholars have pointed to serious governance and management challenges facing cities in making progress on biodiversity conservation (Puppim de Oliveira et al. 2011). While renewable energy is just one of many considerations for urban areas and biodiversity planning, our findings indicate that solar parking canopies are an opportunity to link climate change policymaking, local economic development, and ecosystem conservation. Developed with an eye toward such matters, urban solar parking canopies can make solar energy valuable not only in terms of GHG emission reductions but also for urban ecosystems.

With urban governments increasingly looking to expand renewable energy development, we believe it is important for urban planners, ecologists, and researchers to proactively consider and plan what that means for urban ecosystems and biodiversity. This study demonstrates that there is a possibility for renewable energy development to be beneficial. Yet urban renewable energy development could also pose a range of challenges for urban ecosystems, particularly if it encroaches on existing and often limited green spaces. Just as parking lots are an easy place to site ground-mounted solar arrays, so are parks, fields, and other undeveloped places in urban areas. As policymakers set increasingly ambitious renewable energy goals, pressure may mount to build renewable energy in such areas, especially since governments often own them, making project siting easier.

We want to be clear that we are not saying any urban renewable energy development is necessarily bad, but rather that ecological effects should be considered and opportunities for co-benefits should be sought out. In that interest, we hope this study helps to begin a dialogue and further research into ecosystem implications and opportunities of increasing urban renewable energy development. We call for further studies about the effects and conservation opportunities of urban renewable energy development and best management practices. Specifically related to solar parking canopies, future research should investigate how to best integrate vegetation, including what vegetation is ideal from both an ecological and management perspective. Beyond solar parking canopies, researchers should study ground-mounted solar arrays in other urban areas including parks, fields, and brownfield sites. More broadly, researchers should take a holistic approach to studying and modeling how renewable energy (including wind and other technologies) can best be integrated in urban areas and conservation approaches to ensure the best possible ecological outcomes.

Acknowledgements:

Thanks to Jess Fan Brown for her meticulous work identifying arthropods and to Monika Egerer for advice and use of field equipment. We thank the eight schools for giving permission to conduct the arthropod sampling, and Chip Odom from Live Oak School District for permission and assistance with pilot testing the study at several other sites around Santa Cruz. John Armstrong would also like to thank the Hammett Fellowship, awarded by the Department of Environmental Studies at UC Santa Cruz, for support.

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Chapter 5

5.1 Conclusion and future research

This dissertation investigated the adoption and spread of effective local government climate policies. The focus on effective policies is a critical new direction for the literature, which has not distinguished between minimally effective policies and those that can reduce substantial amounts of GHG emissions. Focusing on CCA in California, the dissertation examined the characteristics of local governments that adopted the policy, its diffusion, the policymaking process and stakeholders, and the role and potential of local control. Additionally, the dissertation included a study about the ecosystem implications of urban renewable energy development, which is increasing in part because of local government climate policies. The study assessed how ground-mounted solar arrays in parking lots affect arthropod abundance and diversity and analyzed the effects of integrating vegetation with these solar arrays.

This concluding chapter provides an overview of the dissertation and the importance of the findings. It begins by summarizing each chapter, focusing on the key results. The next section discusses the contributions and how the findings help advance the literature. The final section assesses gaps in the literature and draws on the findings to offer several directions for future research.

5.1a Dissertation summary

The introductory chapter situated the research within the context of international, national, and state climate change policymaking trends and politics. The

U.S. federal government's failure to pass meaningful national climate legislation has left policymakers, stakeholders, and scholars looking to other governments for assistance. States have emerged as important hubs for climate policymaking, some of which have taken significant actions to reduce GHG emissions. Amidst this, and especially more recently, many local governments have enacted climate policies, generating increasing interest and optimism about their role and capability to reduce emissions. Whether and which local governments can have a meaningful role in climate mitigation, however, depends on the effectiveness of the policies they adopt.

Chapter 2 investigated local governments' potential to take a significant role in mitigating climate change and their ability to affect changes at the statewide level. The study analyzed the renewable energy procurement and GHG emission effects of CCA in California, finding that local governments have procured substantially more renewable energy than required by the state's renewable portfolio standard. By procuring high levels of renewable energy with CCA, as well as initiating and expanding other energy-related programs, local governments are reducing substantial amounts of GHG emissions. They are affecting the statewide energy system, including the major private utilities, and serving an important role in advancing climate mitigation in California.

The study also examined local government adoption and diffusion of CCA, drawing on data about a variety of social, political, and economic characteristics of all counties in the state. Communities with high levels of environmental support, a high proportion of Democratic and Green party voters, and more education were most likely to adopt CCA. However, CCA spread over time to areas with lower levels of these characteristics as the policy’s efficacy was proven. These trends in diffusion indicate the possibility for strategic policymaking approaches that seek to target areas likely to adopt an innovative policy first, gradually build support for it, and spread the policy along social and political lines to more areas.

Chapter 3 investigated why local governments and communities adopt effective climate policies and the role and effects of local control. The study built on the statewide assessment of CCA in Chapter 2, conducting an in-depth examination of five areas of California that adopted the policy and two areas that voted it down. From semi-structured interviews with policymakers and stakeholders, as well as analysis of policy documents and news coverage, Chapter 3 analyzed which stakeholders were important in CCA adoption, what their motivations were, and the extent of public participation.

CCA policy adoption was driven by an interconnected effort of local elected official leaders and grassroots groups, with substantial public participation. These stakeholders were concerned about climate change but also a range of other issues, including local control and policy co-benefits such as job creation and economic development. In contrast, CCA rejection was driven by elected officials concerned about government overreach, financial uncertainty, and their relationship with the private utilities.

The third chapter found that local control can help communities overcome free-rider problems associated with the global nature of GHG emissions and can be a pathway to effective climate policy adoption. Local control allowed policymakers and stakeholders to maximize policy co-benefits according to their priorities and ensure that those benefits are realized in their communities. In contrast to climate policies from a higher level of government, where co-benefits such as renewable energy development would occur but not necessarily in their communities, local control allows local governments to address their unique priorities. Local control helped them frame the policy and its benefits with diverse stakeholders, building support among a broader coalition than those concerned primarily about climate change.

Demographic and political shifts in recent years are also important in understanding why local control can lead to effective climate policy adoption. The ideological makeup of urban areas is trending increasingly liberal, with high concentrations of Democratic party voters for whom the issue of climate change has become more important. Elected officials in those areas are more likely to prioritize climate change in response to citizen concerns. In addition to shaping policies to ensure co-benefits, these demographic shifts may point to why local control can help governments adopt climate policies.

Chapter 4 brought together local government climate policies and urban ecosystem conservation. Climate policies like CCA are partially responsible for increasing urban renewable energy development. The study investigated how ground-mounted solar arrays in parking lots ("solar canopies") affect the abundance and diversity of arthropods, which provide essential roles and services in urban ecosystems. Solar canopies are built structures introduced to impervious parking lot surfaces, which are associated with negative environmental outcomes such as habitat fragmentation and heat island effects. With increasing urban renewable energy development, solar canopies have the potential to affect ecosystems and provide conservation opportunities.

At eight sites around San Jose and Santa Cruz, California, the study assessed arthropod presence under solar canopies and analyzed the effects of integrating vegetation and a variety of habitat and landscape characteristics. Solar canopies had substantial abundance and diversity of arthropods under them, and integration of vegetation significantly increased overall arthropod abundance, abundance of parasitoids and detritivores, and arthropod family richness. These findings demonstrate that ground-mounted solar arrays can be beneficial for GHG emission reductions and urban ecosystems, especially if integrated with vegetation.

5.1b Contributions and importance

This study addressed the critical need in the literature to focus on effective climate change policies at the level of local government. Although many scholars have studied which local governments adopt climate policies and why, most research has not differentiated between minimally effective policies and those which are truly impactful in reducing emissions (Kalafatis 2018; Krause 2011; Millard-Ball 2012; Yi, Krause, and Feiock 2017). Researchers have not addressed whether and why a broad set of governments would adopt impactful policies. Additionally, while scholars have conducted large quantitative assessments of the characteristics of governments that have adopted policies (Krause 2010; Sharp, Daley, and Lynch 2011), few studies have examined policymaking comprehensively, including assessments of political, social, and economic characteristics (Sovacool 2014). In-depth analyses of the stakeholders, politics, and policymaking processes are even rarer (Sovacool 2014).

The investigation into CCA addressed these critical gaps and made several new contributions to the literature.

In Chapter 2, a statewide assessment of what local governments in California have adopted CCA found that diverse areas – socially, politically, economically, and demographically – are able to enact impactful climate policies. While it may be expected that liberal, environmentally inclined areas would do so (Krause 2011; X. H. Wang et al. 2012), CCA surprisingly spread to parts of the state below the mean for such characteristics. For the first time in the literature, the study demonstrates that a variety of communities and governments can adopt burdensome, effective climate policies. These findings have implications not just for scholars but also for policymakers and advocates, who may reconsider what policies are possible in their communities.

The analysis of CCA diffusion over time raised the potential for strategy in climate policy adoption. Prior research has not addressed strategy in this type of policy adoption and diffusion, focusing instead on planning, regulation, and competition among governments (Cohen 2013; Cohen, Kamieniecki, and Cahn 2005; Hofer and Schendel 1978; MacMillan and Jones 1986). Additionally, prior policy diffusion research points to geographic proximity and similar ideology as important drivers of adoption (Berry and Berry 1999; Grossback, Nicholson-Crotty, and Peterson 2004; Nicholson-Crotty and Carley 2016; Volden 2006).

The diffusion of CCA along social and political grounds, following adoption first by very environmental and liberal areas, suggests that strategy may be applied to targeted policy adoption to increase government participation with effective policies.

By focusing first on areas likely to adopt a policy, and then scaling and targeting diffusion to certain areas, support for a policy may build as its efficacy is proven. This process can allow governments to enact a policy that they would not have if they had considered the policy earlier.

The mixed-methods approach taken in this investigation – pairing an assessment of quantitative variables about social, political, and economic characteristics with a qualitative analysis based on interviews and news media analysis – is notable for allowing an in-depth understanding of the policymaking process. Most of the evidence about why local governments enact climate policies comes from broad assessments of the characteristics of areas that enact some form of climate policy or join a climate network (Krause 2010; Sovacool 2014). This traditional line of inquiry has found that environmentally inclined and liberal areas tend to adopt climate policies (Krause 2011; X. H. Wang et al. 2012), in part as a response to interest groups (Krause 2012; Portney and Berry 2016). Additionally, local governments with more capacity (Zahran et al. 2008; Zahran, Grover, and Brody 2008) and areas with greater vulnerability to climate impacts (Sharp, Daley, and Lynch 2011; Sippel and Jenssen 2009; R. Wang 2013) are more likely to adopt climate policies. While these trends and explanations are important, they do not fully explain the policymaking process.

The in-depth investigation of CCA policymaking in Chapter 3 revealed several significant findings about why local governments and stakeholders adopt effective climate policies. The investigation demonstrated the importance of bottom-up policymaking and that an interconnected effort of local elected official leaders and grassroots groups led CCA policy adoption. The grassroots groups were essential in providing the impetus for policy consideration, educating policymakers and the public, and building support. Bottom-up policymaking propelled substantial public participation, which can be helpful in policymaking generally (Coenen 2009; Coenen, Huitema, and O'Toole Jr 2012; Fischer 2000).

It is surprising that, although the policy has spread rapidly, CCA was not driven by a state or other high-level entity. Previous research has found that this type of environmental policy adoption rarely occurs from the bottom up but rather emanates from top-down mandates and incentives (Bulkeley and Kern 2006; Conroy and Iqbal 2009; Homsy and Warner 2015). In the case of CCA, the state government did not push or incentivize local governments. Instead, the state government may have discouraged CCA adoption with regulatory changes and uncertainty, which local elected officials and stakeholders pointed to as obstacles.

The investigation into CCA policymaking revealed a climate change culture within grassroots communities and among some local elected officials that is important in explaining policy adoption. Many stakeholders responsible for driving policy adoption were motivated by climate change, a trend that may further drive bottom-up climate policymaking at the local level. While research has noted grassroots movements and climate activists and their role in policy, the emergence of this climate culture leading to significant policy adoption at the local level is an important new finding (Brown 2012; Hughes, Chu, and Mason 2018). Interview responses and news media analysis indicated that this dynamic is also responsible for increasing public participation.

The study found that local control is a significant factor behind CCA adoption. This is surprising given that the literature has associated local control with negative environmental outcomes in the past (Oyono 2005). Yet the study demonstrated that local control – in this case of energy decision-making – was critical to many stakeholders. While local control was the mechanism by which they could realize the climate change mitigation gains they cared about, it was also important as a means of achieving a variety of policy co-benefits in their communities.

In this way, local control can help local governments overcome the free-rider problem with GHG emissions (Olson 1965; Trisolini 2010). With CCA, local governments prioritized GHG emission reductions, but they also sought to build support for the policy among diverse stakeholders based on co-benefits. Climate policies at a federal or state level also yield co-benefits, but those benefits may not go to some communities. Local control lets local governments shape policies to their unique priorities and be sure that they will realize the benefits such as economic revenue and jobs from local renewable energy development.[12]

By allowing local governments certainty about the effects of policies, local control may give more governments the ability to make policies work for themselves. As demonstrated in Chapter 2, the first governments to adopt CCA had a very high level of support for the environment and a high percentage of Democratic party voters. Over time, the policy spread to governments closer to and below the state mean for these variables. While they all enacted CCA, the specifics of the policy and

[12] Other research has identified a movement of "clean-energy conservatives" who point to benefits of local renewable energy for job creation (Hess and Brown 2017).

its implementation differ among those governments, such as different thresholds of renewable energy and variations on other programs enacted (e.g., energy efficiency, local renewable energy development, local air pollution measures). These differences reflect local governments prioritizing particular policy preferences that make the policy favorable for their communities.

The findings warrant a broader reconsideration of the effects of local control for climate change policymaking and other environmental issues. Changing demographics and politics around climate change and environmental issues are also important to consider. As noted in Chapter 3, many urban areas have high concentrations of Democratic party voters, for whom climate change and environmental matters have become an increasingly important issue (McCright and Dunlap 2011; McCright, Xiao, and Dunlap 2014; Tausanovitch and Warshaw 2014). In these areas, there may increasingly be the political will and capacity to enact environmental policies. Even in conservative states where state governments are unlikely to enact effective climate policies, there tend to be cities that may be inclined to do so (Tausanovitch and Warshaw 2014). Given these factors and the ability to achieve policy co-benefits, local governments may be able to assert or increase local control as a pathway to impactful environmental policy adoption.

Federal and state policymakers may consider taking some lessons from local government climate policymaking. Focusing on the local effects of climate change and the varied outcomes of climate policies can be important. While this is more difficult to do with state and federal policymaking, elected representatives and advocates may be able to frame policies around the effects for the communities they represent. Indeed, other research has found that local frames increase the effectiveness of messaging around climate change (Scannell and Gifford 2013; Wiest, Raymond, and Clawson 2015). CCA policymaking indicates that this local-oriented approach to climate policy adoption is crucial, even amidst a focus on the importance of global GHG emission reductions.

While policymakers and scholars have traditionally seen states as the laboratories of democracy (Fowler and Breen 2013; Osborne 1988), cities and other local governments can also be laboratories for creativity and innovation. They can experiment with new policy systems and bold approaches. If policies prove effective at local levels, policymakers may look to them in developing state and federal policies. Additionally, just as state policies can diffuse and work their way up to the federal government, such as clean air standards in California that led to the Clean Air Act of 1970 (Oates 2001), policies that spread among local governments may garner increased support and make adoption of the same or similar policies at a state or federal level more likely.

The study of urban solar energy and arthropods in Chapter 4 linked climate change policy with urban ecology, addressing for the first-time the ecosystem effects and potential conservation implications of urban renewable energy expansion. With increasing urban development, the ecosystem and biodiversity effects of increasing urban renewable energy deployment need to be understood and considered. This need is underscored by rural utility-scale solar energy in the U.S. desert southwest, which developed rapidly and with little holistic ecosystem planning, leading to negative impacts on fragile ecosystems (Hernandez et al. 2014, 2016).

The study's findings about urban ground-mounted solar energy indicate the potential for urban renewable energy development to be a win-win for climate mitigation and ecosystem conservation. The analysis points to specific management approaches that can be especially beneficial. The study also serves to begin a dialogue about the ecosystem implications of urban renewable energy development more broadly, and potential opportunities for reconciliation ecology and conservation approaches.

5.1c Future research directions

Drawing on the findings of this investigation, several areas of future research are apparent. At an overarching level, there is a pressing need to study further effective climate policies and their adoption, diffusion, and policymaking processes. The findings within this dissertation are a start, but future research should investigate a diversity of effective climate policies in a variety of places.

Focusing on effective policies marks a transition to the second generation of climate policymaking and accompanying research. The first generation was characterized by modest policies like increasing municipal building efficiency and joining climate networks. Now, as more governments are beginning to enact impactful policies like CCA, scholars should focus on understanding which governments are doing so, which governments may be able to adopt effective policies, and the underlying policymaking processes and politics.

The lack of a prior focus on effective policies underscores the need to assess policy outcomes (Kalafatis 2018; Millard-Ball 2012; Yi, Krause, and Feiock 2017). Now that many local government climate policies and plans have been in place for years, research should evaluate their effects. Studies should consider the GHG emission implications of policies as well as social, economic, behavioral, and equity implications. Not only is this important to understand what local governments have done but also to inform best practices and policy changes. Developing standard metrics and indicators, both within the U.S. and throughout the world, to evaluate such policies would be especially beneficial.

Future research should analyze the transition from modest policies to impactful policies. Studies should identify a spectrum of policies over time and assess the shift to effective policies among a broad set of governments. This area of inquiry should seek to understand the conditions and factors that explain the transition. The effectiveness of local government climate policymaking depends on many areas adopting effective policies, and researchers can help understand the barriers to doing so as well as how a variety of governments can overcome them.

In analyzing the transition to effective policies, studies should examine whether modest policies can and do act as steppingstones. Are policy actions like joining climate networks, and minor efficiency improvements, primarily symbolic actions? Or do such actions help lead governments toward more extensive commitments to reducing GHG emissions and adopting effective policies?

Scholars should further examine strategy in local government climate policy adoption and diffusion. How can policymakers and advocates design policies, undertake policymaking processes, and spread policies in a fashion that allows the greatest number of local governments to adopt effective policies? With modern communication and connectivity, how important is geographic proximity now, as opposed to decades ago, in policy diffusion compared to ideological, demographic, and economic similarity? While this work found that diffusion occurred along political and social grounds, studies targeting these questions with larger datasets are needed.

In addition to studying what local governments have done, scholars should analyze local governments' ultimate climate policy capability, helping to map out their future potential. This should be considered not only in terms of reducing GHG emissions but also how policies affect different communities, and how policies can support other sustainability objectives. Climate policies inherently interact with and affect other policy areas, including energy systems, transportation, and housing. Achieving sustainability objectives will require comprehensive policy approaches (Armstrong and Kamieniecki 2019), and future research should examine how climate policies factor into those efforts.

Regarding the effects and implications of climate policies beyond GHG emissions, there is a great need to investigate environmental equity and social justice issues related to climate policies. Despite their importance, few studies have considered these issues (Burke and Stephens 2017; Castán Broto and Bulkeley 2013; London et al. 2013). Research should assess the inclusion of environmental justice in existing climate policies, investigate how climate policies affect environmental justice issues, and explore how to include equity and justice goals in a meaningful way.

Prior research has found that vulnerability to climate change can increase the likelihood of policy adoption (Sharp, Daley, and Lynch 2011; Sippel and Jenssen 2009; R. Wang 2013). Yet research has not examined how a community's direct experiences with impacts of climate change affect policymaking. How does the reaction to extreme storms and other climate impacts affect policymaking and energy decision-making? Research has not addressed how communities respond to impacts beyond recovery and immediate adaptation. Are there differences in climate mitigation policymaking – in approaches, participation, and goals – before and after people directly experience significant impacts? Not only is this important to inform policy adoption, but also because there are critical environmental justice components to these issues given that low-income areas and people of color tend to be affected most by climate change (Althor, Watson, and Fuller 2016).

Given this study's findings about local control, future research should undertake a broader reconsideration of local control for climate change policymaking and a variety of environmental issues. Has local control been a factor in other climate policymaking processes? How do changing demographics and politics affect the role of local control with other environmental matters? In conservative states, how much latitude do liberal, environmentally inclined cities and other local governments have to enact policies that are at odds with the priorities of state governments? This is undoubtedly occurring, and not just in the context of environmental issues, but research should explore these cases and the potential for local governments to gain or assert greater local control.

Support for state and local control is traditionally associated with conservative ideology (Scribner 2016). As such, the link between local control and climate mitigation policies found in this investigation represents a paradox given general conservative opposition to climate policymaking. But conservative support for local control may only be the case up to a certain point. Future research should investigate instances where the outcome of local control has been ideologically at odds politically with conservative viewpoints and priorities. Studies should seek to understand these policymaking processes and whether there are circumstances where conservatives would support efforts to utilize local control for policy issues contrary to their agenda.

This dissertation's findings of the ecological implications of urban renewable energy are a critical starting place for future research. As urban areas deploy renewable energy at an increasing rate, it is essential to understand the effects and conservation opportunities. Whereas rural renewable energy spread in many areas in a haphazard manner that unnecessarily harmed important ecosystems, there is an opportunity for proactive planning of urban renewable energy development. Future research should examine the ecological effects of various renewable energy sources in a range of settings and determine best practices, including comprehensive assessments that can help guide city biodiversity and conservation planning.

Finally, there is a need for bold and ambitious research that considers policymaking and the effects of interconnected issues together, including climate change, sustainability, urban development, transportation, environmental justice, and ecological effects. Governments often consider several issues together, which makes sense considering that they almost always have overlapping effects. For example, many climate action plans address transportation in some fashion. Although doing so poses challenges, researchers should seek to undertake studies that consider issues together and comprehensively. Such research would reflect the scale and complexity of the issues and would likely be immensely helpful to policymakers and urban planners. Interdisciplinary approaches and research teams will be essential to this work.

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