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Article

A Carbon-Neutral California: Social Ecology and Prospects for 2050 GHG Reduction

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Abstract

How might a large jurisdiction approach carbon neutrality by 2050, and what initiatives might increase the chances of success? This article explores these questions using California as a case study. Current trends as well as multiple modeling studies show that existing policy directions for the state will not be sufficient. Additional initiatives appear needed to accelerate adoption of electric vehicles, reduce driving, reach 100 percent renewable electricity, convert existing buildings to zero-net-carbon status, change diet, and reduce consumption. The state's social ecology does not currently support such changes. Consequently, planners and other professionals need to consider strategic actions to change social ecology as well as climate policy. Potential steps to do this include raising the price of carbon; revising the state's tax system so as to increase public sector capacity; developing a stronger framework of incentives, mandates, and technical support between levels of government; and expanding educational and social marketing programs aimed at behavior change. A main implication of this analysis is that in many contexts worldwide sustainability planners should consider action on both policy and social ecology levels to maximize chances of success.

Keywords

2050; California; carbon neutral; carbon neutrality; climate change; climate planning; GHG mitigation; global warming

Issue

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1. Introduction

Jurisdictions worldwide face the challenge of moving towards carbon neutrality, among other sustainability needs. How can planners and other professionals best help them do this? This article explores this question, using California's climate mitigation planning as a case study. The argument developed here is that new, more explicit attention to shaping social ecologies in constructive directions is needed in order to enable stronger state climate planning as well as the regional, local, corporate, and individual actions that together will be required to reach carbon neutrality.

For an American state with annual greenhouse gas (GHG) emissions averaging 35 metric tons CO₂e¹ per household to reach carbon neutrality by mid-century would seem next-to-impossible. (By carbon neutrality I mean a condition of no net global warming emissions when life cycle impacts of production and consumption are considered.)² Capitalist economics, consumptive lifestyles, elite-driven politics, and institutional inadequacies are daunting obstacles to ending GHG emissions. Large petroleum exploration and refining industries would need to be shut down, motor vehicle use and air travel dramatically reduced, diets changed, and many other lifestyle changes brought about.

¹ CO₂-equivalent; i.e. all global warming emissions measured in terms of CO₂.

² Preferably emitters would not be allowed to purchase emissions offsets which promise to reduce GHGs emitted elsewhere. Major problems exist in verifying that such offsets really occur, that they wouldn't have been done anyway, that they are permanent, and that they didn't lead in turn to other emissions. However, offsets that produced verifiable carbon reduction within California might be desirable if used only to offset unavoidable emissions such as those embodied within otherwise zero-net-energy vehicles and buildings.

However, the State of California has already made substantial progress toward reducing its GHG emissions through actions starting in 2005. The state is likely to meet its initial target of reducing 2020 emissions to 1990 levels, approximately a 20 percent reduction from the peak in 2007 (California Air Resources Board [CARB], 2017). In 2016 the legislature and governor embraced a new goal of reducing emissions 40 percent below 1990 by 2030. The eventual aim is 80 percent below 1990 levels by 2050. So despite the difficulty of moving toward carbon neutrality, California has embarked upon an ambitious program to achieve it. With the sixth largest economy in the world, California's success or failure in this effort will have lessons for many other jurisdictions worldwide.

This article takes a unique perspective on climate mitigation planning by asking not only what additional policy initiatives might be needed for carbon neutrality, but what fundamental steps to shape the state's social ecology might maximize the chances of success. Such an analysis has not been attempted before and is admittedly exploratory and broad-brush. Many events over a 30-year period are unpredictable. However, other important trends can be foreseen with reasonable certainty. Future demographic changes in the state are relatively predictable, institutions of state government have well-known strengths and weaknesses, and many political forces, values, and lifestyles are relatively stable. We have more than a decade of data on the state's current climate policies, and several modeling groups agree on the necessity of new steps to reduce emissions (e.g., Yeh et al., 2016). So support can be found for this large scale of analysis, which on both climate policy and social ecology levels can suggest near-term steps to increase the likelihood of long-term climate planning success.

2. Social Ecology

A starting point here is the assumption that a jurisdiction's policy options and its social ecology evolve hand-in-hand. "Social ecology" as used here refers to interwoven human systems co-evolving under the influence of environmental, social, cultural, economic, technological, institutional, political, racial, gender, and cognitive factors. Over the past two centuries many social scientists have theorized various versions of social evolution, including Spencer (1864/2002), Marx (1867), the Chicago School of urban sociology in the early 20th century (e.g. McKenzie, Park, and Burgess, 1925/1967), Bookchin (1982), Bateson (1972), and Norgaard (1994). This sort of systemic, holistic analysis is particularly called for when contemplating strategies for sustainable development, which must cross disciplines and time scales while meeting environmental, economic, and social goals (Wheeler, 2013).

Another historical foundation for social ecology has been public health. Bronfenbrenner (1977) was among the first to emphasize that the individual should be

seen as embedded within interpersonal influences (the family, peers, local networks), organizational influences (schools, churches, workplaces), broader community structures, and large-scale policy frameworks. Stokols (1992) emphasized the dynamic relations between elements of these systems, writing that "Social ecological analyses incorporate a variety of concepts derived from systems theory (e.g., interdependence, homeostasis, negative feedback, deviation amplification) to understand the dynamic relations between people and their environments."

Other contemporary disciplines such as political ecology, environmental history, natural resource management, and resilience theory take a similarly social ecological view, but unlike public health do not place the individual at the core. Ostrom, for example, comments that "All humanly used resources are embedded in complex, social-ecological systems (SESs)...composed of multiple subsystems and internal variables within these subsystems at multiple levels analogous to organisms composed of organs, organs of tissues, tissues of cells, cells of proteins, etc." (2009, p. 419). Writers such as Fabinyi, Evans and Foale (2014) within the growing field of resilience science emphasize factors of social diversity, institutions, power, and values within social-ecological systems.

Despite this widespread interest in "social ecology," there is still no well-accepted contemporary framework with which to employ it. Hence in this article I've tried to flesh out the concept. As illustrated by Ostrom's quote, social ecological systems can be very complex. A main question is how to conceptualize them simply so that multiple audiences can understand important elements of these systems. One graphic depiction of how socio-ecological factors interrelate from a social science point of view is shown in Figure 1. This graphic is intended to illustrate the dynamic nature of what Norgaard and others have termed "co-evolution." It is necessarily a simplification; in the text of his book Norgaard conducts a far more wide-ranging exploration of topics related to international development than represented by Figure 1 (Norgaard, 1994).

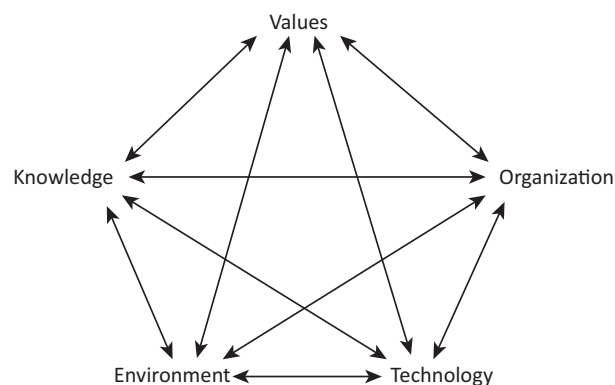


Figure 1. Norgaard's diagram of co-evolutionary factors.

To consider social ecological forces within a state such as California, I would like to cast a somewhat broader net as shown by Figure 2, adding several important dimensions while trying to keep the overall number of variables limited. In putting forth such a graphic as a basis for analysis, I don't want to imply that people haven't thought about how many of these dimensions, separately or in combination, relate to climate planning. Instead I want to suggest that a systematic approach to socio-ecological analysis can be useful, and that these are some of the most important dimensions to be considered.

We may define the components of Figure 2 in the following ways:

- *Ideology*: Any overarching belief system or world-view
- *Cognition*: An individual's mental processes of understanding
- *Behavior*: Individual or collective actions, including patterns of consumption and lifestyle
- *Politics*: Systems of power, in particular through elected office and political parties
- *Institutions*: Social structures including laws, organizations, and channels of communication
- *Economics*: Systems of production and exchange
- *Technology*: Techniques, skills, methods, and machines to achieve particular purposes
- *Environment*: The physical context, including ecological systems and human-created settings
- *Class*: Systems of inequality based on wealth
- *Race*: Systems of inequality based on physical traits and ancestry
- *Gender*: Characteristics related to masculinity and femininity
- *Values*: Individual or collective priorities whether based on belief or action

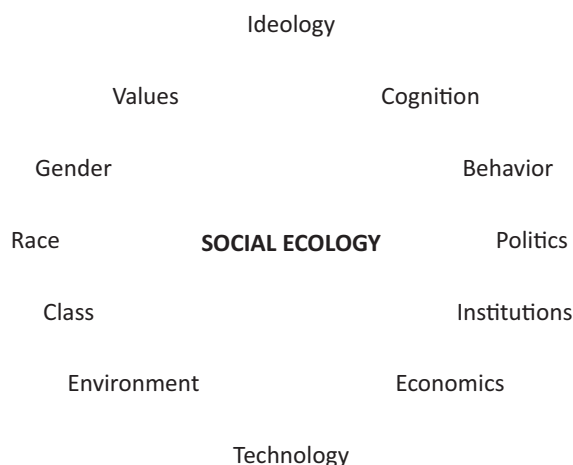


Figure 2. Socio-ecological factors affecting climate policy in California.

Within social ecologies, the relative influence and priority of these elements will be constantly changing and dependent on the particular times, scales, and places being analyzed. Race, for example, is a strong constituent of American social ecology that has been overlooked at times but has re-emerged time and again. Gender was considered relatively little as a dimension of analysis within most societies until social reform movements gave women the vote and advanced a variety of feminist histories and social critiques. Dimensions of social ecologies are often linked to one another. To take one example, the ideology (one dimension of Figure 2) of the Republican Party in the United States (an institution active in the political dimension of Figure 2) consists in part of denial of climate change (an environmental influence within Figure 2) through rhetoric derived from particular types of cognition and values (two further dimensions of Figure 2). To put it another way, the influences between elements of social ecology move in multiple directions, involve synergies, and are highly dynamic.

As California's social ecology evolves, its climate planning options will change as well. Conversely, successful policy innovations may change the state's social ecology so as to pave the way for additional breakthroughs. For example, a growing state identity as a global climate leader (a combination of "politics," "values," "ideology," and "cognition" in Figure 2) may inspire politicians to take additional steps. For climate mitigation, political support is perhaps the most relevant product of social ecology changes. If sufficient political support exists, far-reaching GHG reduction policies can be adopted. Conversely, if it doesn't exist, movement toward carbon neutrality is unlikely. But other variables are of course important as well, and many influence politics.

3. California's Climate Mitigation Planning

California has a long history of actions linked to reducing GHG emissions, enabled by a relatively favorable social ecology. The state adopted the first version of its best-in-nation building energy efficiency standards in 1977, and began studying global warming risks in the late 1980s. During the 1990s cities such as San Francisco, San Jose, and Santa Monica initiated sustainable city programs with a focus on energy conservation. Senate Bill (SB) 1771 (2000) established the California Climate Action Registry, a state-affiliated non-profit agency which pioneered emissions reporting protocols and allowed institutions to voluntarily record their emissions. Assembly Bill (AB) 1493 (2002) mandated that vehicles sold in the state have reduced CO₂ emissions, in an effort to get around the federal government's unwillingness at that time to raise fuel efficiency standards for cars and light trucks. Sixteen other states then adopted the California standard. This measure required a waiver from the U.S. Environmental Protection Agency; after the George W. Bush Administration denied this waiver, California sued

the federal government and eventually won the right to set such standards.

Although many of these early actions were significant in their own right, California's climate action planning entered a new, more comprehensive stage in the mid-2000s. In 2005 Governor Arnold Schwarzenegger signed Executive Order S-3-05 setting emissions reductions targets for several future dates, including 80 percent reductions below 1990 levels by 2050. The following year the legislature passed AB 32³ directing the powerful CARB to lead planning efforts toward the goal of lowering GHGs to 1990 levels by 2020. CARB collaborated with other state agencies to form an interagency working group known as the Climate Action Team, and by 2008 had approved a list of 40 early action items. Of these, state officials expected by far the largest GHG reductions from GHG emissions standards for new vehicles, increased energy efficiency standards for new appliances and buildings, a renewable energy portfolio standard requiring utilities to produce 33 percent of electricity from renewable sources by 2020, reformulated motor vehicle fuels, and programs to reduce emissions of refrigerants and other non-CO₂ GHGs.

To further reduce GHG emissions from motor vehicles, in 2008 the legislature passed and Schwarzenegger signed SB 375⁴ requiring the Air Board to set vehicle miles traveled (VMT) reduction targets in each of the state's metropolitan regions. Metropolitan planning organizations (MPOs) were required to produce Sustainable Community Strategies (SCSs) with spatial development and land use policies that would achieve these reductions. By the early 2010s most had done so, though in practice these SCSs were simply rebranded Regional Transportation Plans with modest land development targets integrated. Local compliance is voluntary since the MPOs have no statutory authority over land use. One evaluation found that "very little progress has been made toward actually changing the regional transportation system and land use patterns" with the result that "total CO₂ emissions increase over time at historical rates" (Niemeier, Grattet, & Beamish, 2015, p. 1600). Another analysis concluded that "given MPOs' limited resources and authority, the state and federal government must take on larger roles if outcomes are to change substantially" (Barbour, 2016, p. 24).

A major strengthening of California's climate planning framework took place in 2016 as the AB 32 end-date of 2020 approached. The strongly Democratic legislature passed a new bill, SB 32, with a goal of 40 percent reductions below 1990 by 2030, even though the state's population was expected to increase about 10 percent between 2020 and 2030 and its economy was expected to grow by about 30 percent (Megerian & Dillion, 2016). CARB set to work in 2017 to develop a scoping plan of programs to reach the new target, but with the intent of relying only on existing policy directions.

To provide a broad economic mechanism for emissions reductions, leaders decided early on to adopt a cap-and-trade program in which a gradually lowering cap would be established on overall emissions and large emitters made to buy or trade for permits. Emitters would need to reduce cumulative 2013–2020 emissions at least 10 percent compared to business-as-usual projections. Permit auctions would establish a funding stream useful for other GHG mitigation purposes. Applied to 360 large institutions responsible for 85 percent of the state's emissions, this system went into effect in 2013, and annual auction proceeds rose to \$1.8 billion in 2015–16. However, corporate interest declined due to a business lawsuit and uncertainties about whether the program would be continued beyond 2020. Proceeds fell and the allowance price hovered around the floor of \$12/ton, a level unlikely to encourage large emissions reductions. Environmental justice advocates also criticized the program for allowing continued pollution of minority communities. However, in 2017 with strong support from Governor Jerry Brown the state legislature extended the cap-and-trade system through 2030 with a two-thirds vote.

4. California's Social Ecology

California has been able to take leadership on climate planning in large part because of the nature of its social ecology. Historians such as Starr (2004, 2005) and writers such as Didion (1968, 2003) and Davis (1990, 1998) have provided extensive background on the state's history and culture. Here I will focus on the main factors shaping the state's ability to initiate climate change planning, referring back to particular elements within Figure 2.

An initial set of socio-ecology factors relates to the state's geographic location and natural environment ("environment" variables in Figure 2). On the far western edge of the continent, California is spatially distant from many eastern and midwestern centers of population, separated from them by mountain ranges and deserts. From the beginning of European settlement it has been a place apart, a destination for those with independent spirits ranging from gold rush pioneers to aspiring filmmakers, dot-com entrepreneurs, and New Age seekers (thus developing a population with certain dominant values, ideologies, and forms of cognition and behavior according to the categories of Figure 2). The resulting diverse, dynamic political culture is more characterized by individualism and moralism than the traditionalism of many mid-Western and southern U.S. states (Elazar, 1966/1984).

California's landscapes are also well-known for their unique beauty and fragility, and have helped give the state its identity and environmental sensitivities (more influence of "environment" variables). Since the nineteenth century Californians have rallied to protect old-

³ Global Warming Solutions Act of 2006.

⁴ Sustainable Communities & Climate Protection Act of 2008.

growth redwoods from logging. In the middle of the twentieth century they voted to protect much of the state's stunning coast from development and oil drilling, and the legislature enacted environmental review processes for development and the nation's toughest air quality regulation (in response to Southern California's air pollution problems caused in part by geography). The state's mild, Mediterranean climate is quite different from that of most other U.S. regions, contributing to the state's identity as a balmy haven from cold and snows, and its ample sunshine and warm winters greatly facilitate prospects for carbon neutral buildings in the future. Since much of the state is arid or semi-arid, residents are also highly conscious of the scarcity of water and risk of drought.

Social factors further distinguish California from the rest of the U.S. It is the most urban state in the country (Cox, 2016), and in recent decades has become among the most diverse. Diversity can play out many different ways in politics. Much depends on which demographic groups are involved and what degree of mixing has occurred and for how long. However, a case can be made that within relatively well-mixed urban regions where different types of people live together on a daily basis, diversity leads to both tolerance and progressive politics. Hero (1998, p. 9) distinguishes between homogenous states, bifurcated states, and heterogenous states; the latter often verge on "an ethnic or racial polyglot" society without the extreme racial divisions of bifurcated states. He places California within this category. Intolerance and racism have often been present, certainly, and led to divisive politics through much of the twentieth century as the heavily white, Republican state experienced waves of immigration. However, many parts of the state, especially urban areas, have now been highly diverse for generations and have become more tolerant (e.g. Talbot, 2012). The state is also known globally for alternative lifestyles, and "live and let live" values which occasionally merge into libertarianism. Although a full discussion of this topic would require more space than we have here, a case can be made that Figure 2's dimensions of "race," "gender," "ideology," "behavior," and "values" in California have all provided support for tolerance and progressive politics in recent years.

Economically, California, like the rest of the United States is firmly wedded to laissez-faire capitalism (a combination of "economics," "politics," and "ideology" in Figure 2), and from the gold rush to the dot-com boom has exemplified the wealth-obsessed, speculative tendencies of that system (influencing "values," "cognition," and "behavior" within this social ecology model). Railroad, oil, real estate, agribusiness, and construction industries have produced deeply conservative elites ("class" and "politics" within Figure 2) who often oppose public sector efforts to plan and regulate for environmental protection (Davis, 1990; Starr, 2005; Walker, 2004). Not surprisingly given this background, the state's Chamber of Commerce has litigated the cap-and-trade program, and petrochem-

ical interests including Koch Industries and Valero Energy, the nation's largest independent oil refiner, sponsored a 2010 Proposition 23 to suspend the entire AB 32 framework. However, these players are counterbalanced by film, finance, electronics, internet, media, and clean tech economic elites, which at times have spent freely to defend and expand the state's climate leadership. Billionaire Tom Steyer for example contributed \$5 million to help defeat Proposition 23, which lost by a wide margin, 61–38 percent (Roosevelt, 2010). At the state level pro-GHG-reduction economic forces have helped support GHG reduction efforts so far; at the local and regional levels, especially concerning land development and motor vehicle infrastructure, business-as-usual interests more often hold sway.

In terms of "politics" in Figure 2, the state's history was conservative or middle-of-the-road for much of the twentieth century, with a long series of business-oriented governorships (Starr, 2005). Political reform movements had only limited success or, as in the case of the early-twentieth-century good government movement, resulted in reforms like the initiative and referendum process that have at times backfired, being abused by special interests. Late twentieth-century and early twenty-first century politics has become more progressive, aided by many strong organizations of civil society, but is far from radical. Unions, including ship workers, Pullman porters, farm workers, teachers, and prison guards, have at times played a significant role but have not had the same breadth and strength historically as in the Midwestern U.S.

Institutionally California is also similar to other parts of the U.S., but with some important differences. As elsewhere, local government exerts primary control over land use and economic development, and at least in terms of suburban expansion is easily captured by pro-development interests (e.g. Davis, 1990; Pincetl, 2003). Local capacity to undertake new programs is weak, in large part due to Proposition 13 in 1978, which reduced local property taxes by two-thirds and made local governments more dependent on development fees and state funding sources. Regional government is also relatively weak, as is the case in the U.S. generally, being mainly focused on distributing funds for transportation and governed by boards of local elected officials often dominated by conservative suburban and exurban jurisdictions (e.g. Bollens, 1997; Fulton & Shigley, 2012). State government in contrast has strength in areas such as environmental protection and transportation, with large, experienced regulatory agencies.

California has seen strong organizations of civil society from relatively early times ("institutions" in Figure 2, linked in turn to "politics" and "values"). The Sierra Club got its start in the Bay Area in 1892, and countless other environmental groups are active within the state. In the 1960s and 70s the human potential movement was particularly strong in California, with leaders such as psychologist Abraham Maslow and legislator John Vascon-

cellos. This movement touches upon social ecological dimensions of “cognition,” “behavior,” and “values,” and is linked in turn to liberal politics. From early times social institutions ranging from the Bohemian Club to the Esalen Institute have promoted the spread of avant-guard ideas among a variety of networks. Although many of these networks have been liberal or progressive, the state has also been on the cutting edge of conservative ideology as well. The John Birch society was strong within it in the early twentieth century; Richard Nixon and Ronald Reagan got their starts in the state; and the modern anti-tax movement arose in southern California.

Technology (a major force within social ecology) has played a leading role in California’s social evolution from the arrival of hydraulic mining and the railroad in the nineteenth century to the private motor vehicle in the twentieth and the internet in the twenty-first. Although aerospace, electronics, and semiconductor industries have transformed the state’s economy in recent generations, perhaps the largest technological influence upon the state’s social evolution has been communications media. Radio, television, movies, and the internet were to a large extent pioneered in California, and have helped shape both California and global society. A century before the rise of electronic media, William Randolph Hearst’s “yellow journalism” was a precursor both of later tabloid journalism and of Fox News and Breitbart. The state’s film, television, and advertising industries have also helped shape consumptive lifestyles worldwide.

Overall, California’s values have dovetailed with other dimensions of its social ecology in recent years to support climate action planning. To be sure many of the state’s social values are inconsistent and conflictual. Individualism and environmentalism, for example, conflict when environmental regulations impinge on individual property owners’ desire to exploit natural resources. The state also has strong spatial political divisions that sometimes complicate decision-making. Difficult questions of behavior change and economic tradeoffs (for example more costly consumer goods with a high price on carbon) have yet to be tackled. But climate policy and the state’s social ecology have worked relatively well together to date.

5. The Need to Go Beyond Current Policy Directions

With this background, we can turn to the future policy challenges California faces in reaching its 2030 and 2050 goals. In 2014 a team from the University of California, Davis, the University of California, Berkeley, Stanford, and other institutions reviewed nine models of deep emissions reductions for the state, and warned that “without new policies, emissions from non-energy sectors and from high-global-warming-potential gases may *alone* exceed California’s 2050 GHG goal” (Morrison et al., 2015, p. 546; emphasis original). Yang, Yeh, Zakerinia, Ramea and McCollum (2015) found the 2050

goal potentially achievable, but only by assuming rapid adoption of questionable technologies including biofuels and carbon capture and sequestration (large-scale use of biofuels might interfere with food production; carbon capture and sequestration has not been shown to be technically or financially feasible). Greenblatt (2015) found that none of three modeled scenarios met the 2050 goal, and that only a very strong policy scenario going well beyond existing initiatives met the 2030 goal. Yeh et al. (2016) reviewed six leading models, finding that in order for the state’s 2030 goal to be achieved new initiatives are needed related to energy efficiency, renewable electricity, use of biomass for liquid fuels, aggressive adoption of zero emissions vehicles, reduction in vehicle miles traveled (VMT), and reduction of non-energy-related GHGs. Although such steps would be difficult politically, the models showed that these strategies could bring potential net economic benefit to the state. Finally, Jones, Greenblatt, Wheeler and Kammen (2017) and Jones, Wheeler and Kammen (2017) argue that the state’s existing sector-based GHG accounting leaves out emissions due to residents’ consumption of goods and services produced outside the state.

These studies provide evidence that California’s existing policy directions are inadequate to meet long-term goals. Several non-academic critiques make the same point, including Porter (2017), Saha and Muro (2016), and PricewaterhouseCoopers (2015). The latter study argues that a global decarbonization rate (decline in the carbon intensity of economies) of 6.3 percent annually is necessary to avoid dangerous climate change, and estimates California’s decarbonization rate at only around 2 percent.

The targets set by state government, in other words, go far beyond what current policies can achieve. However, these policies appear to be at the limit of what the state’s social ecology will support, as shown by the mid-2010s legislative struggles to establish 2030 policy and re-authorize the cap-and-trade system. The climate planning literature offers little guidance towards addressing this disconnect, which affects not just California but most societies worldwide. Authors such as Socolow and Pacala (2005), Brown (2015), and Hawken (2017) present lists of ambitious strategies that could dramatically reduce GHG emissions, but fail to address the underlying need for social ecological changes that could support such policies. Brinkley (2014) surveys policies in countries with proven track records of decreasing GHG emissions. However, none of these countries is anywhere near carbon neutrality. Others such as Bulkeley (2013), Boswell, Greve and Seale (2012), and the International Council for Local Environmental Initiatives (ICLEI, 2017) discuss more modest and achievable policies at the local government level to reach short-term goals. Yet these are unlikely to produce the necessary level of long-term change. In light of the fundamentally new challenges produced by climate change planning, Hill (2016) and Wheeler (2010) argue that new planning approaches are necessary.

6. A Potential Policy Path to Carbon Neutrality

To address this conundrum, I will first consider what expanded climate mitigation policies might be sufficient to make California carbon-neutral by mid-century, starting with the highest-emitting economic sectors. These are summarized in Table 1 below. Then we will turn to social ecology changes that might make such policies more feasible.

Transportation is the largest emissions contributor within California's existing GHG inventory framework, responsible for 37 percent of total emissions (CARB, 2017). Although past state policies requiring reformulated fuels and low-emission vehicles plus the post-2008 recession managed to lower transportation emissions 12 percent between 2000 and 2011, these then stabilized and edged back up 5 percent by 2017. So new steps are needed. Two strategies embraced by CARB in its draft 2030 scoping plan and endorsed by many researchers (e.g. Wei et al., 2013) are to move to an all-electric

fleet with electricity generated from renewable sources and to adopt policies reducing driving in general. Even if both were successful, emissions embodied in vehicle components and production would remain (about 15 percent of the total according to Delucchi, 2005, p. 99). Carbon sequestration within forests and soils (discussed later) could help offset those. CARB's draft 2030 scoping plan has only modest ambitions for reducing transportation emissions, aiming for only a 15 percent reduction in light-duty VMT by 2050 and only 4.3 million electric vehicles by 2030 out of approximately 15 million. Much stronger policy seems needed. Experts have proposed steps such as a strong feebate system (which would levy steep fees on high GHG-emitting vehicles but provide rebates for those with few emissions), pay-as-you-drive insurance, buy-back programs for high-emitting older vehicles, and strong state mandates for better local land use planning that could reduce driving (e.g. Jones, Wheeler, & Kammen, 2017; Sperling & Egert, 2014). Carbon fees applied to air tickets and rapid

Table 1. Carbon neutrality policy strategies and obstacles. Emission percentages retrieved from CARB, 2017.

Challenge	Potential Strategies	Potential Obstacles
Transportation (37% of sector-based emissions)	Vehicle electrification brought about through feebates, other incentives, strong carbon pricing, and/or regulation. Better alternative modes of transport; more compact, balanced land use; lifestyle change.	Opposition from motor vehicle, petrochemical, airline, and development interests; local government opposition to land use requirements; difficulty of raising funds for improved transit; difficulty of behavior change.
Industrial emissions (21%)	Regulation (e.g. building and process efficiency); strong carbon pricing through cap-and-trade or carbon tax.	Industrial and political opposition; social equity concerns over economic burden and allowing continued pollution of disadvantaged communities.
Electricity-related emissions (19%)	Increase renewable portfolio standards to 100%; community choice energy; incentives for renewables and battery storage within buildings.	Reluctance of investor-owned utilities to embrace decentralized renewable energy systems; developer opposition to ZNE home requirement.
Non-electric building emissions (11%)	Require all-electric buildings and ZNE construction; require and subsidize upgrades upon sale of existing buildings.	Building industry opposition; legal and code barriers; expense and political difficulty of retrofitting existing buildings.
Agriculture (8%)	Increased regulation of the dairy industry and agriculture; strong carbon pricing; lifestyle change around diet.	Political opposition from farmers; difficulty of changing behavior (diets).
High Global Warming Potential Gases (4%)	Phase-out following current regulatory trends.	
Landfills and recycling (2%)	Stronger programs to capture methane and reduce waste.	Funding; behavior change.
Consumption (out-of-state products not counted currently)	Behavior change campaigns; aggressive carbon pricing extended to consumer products; regulation to reduce energy use/carbon content of products.	Economic, political, and cultural opposition; difficulty of lifestyle change.
Carbon sequestration	Pursue maximum possible sequestration within farmland, grassland, and forests.	Farmer and landowner opposition to mandates; cost; difficulties of managing and verifying long-term sequestration.

development of biofuels for aircraft could help reduce emissions from air travel.

Industry represents California's second largest source of emissions, at 21 percent. While the carbon intensity of the state's economy (tons of CO₂e/million \$ GDP) fell about 28 percent between 2000 and 2015, total industrial emissions declined only a few percent and plateaued after 2009 (CARB, 2017). Oil, gas, and hydrogen industries are by far the largest industrial sources, providing further argument for making both vehicles and buildings all-electric. Emissions for manufacturing fell in the 2000–2015 period but those for food services, rail transportation, aviation, petroleum refining, landfills, livestock operations, and commercial facilities rose significantly (CARB, 2017). Thus far the cap-and-trade system appears to have had only limited influence. The needed policy direction appears to be a much higher price on carbon, which could occur either under a strengthened cap-and-trade system or through a carbon tax. High minimum prices on carbon have been proposed by climate activists globally, and were in fact envisioned by a 2017 bill introduced into the state Senate, SB 775, which would have put a minimum price on carbon of \$20/ton, rising by \$5 plus inflation each year while disallowing offsets (Roberts, 2017). However, facing political opposition and desiring a two-thirds vote in order to avoid legal challenge under the state constitutional requirement for a 2/3 vote on taxes, Governor Brown and legislative leaders opted for the milder step of continuing the current cap-and-trade system with modest improvements.

Electricity generation is the third largest sector of emissions, comprising 19 percent, and represents the biggest success story in California's climate planning to date. Emissions declined 22 percent between 2000 and 2015 mainly as a result of increases in solar and wind energy due to renewable energy portfolio standards (CARB, 2017; California Public Utilities Commission, 2016). Renewably generated electricity reached 35 percent of the total in 2015, and the 2030 mandate for 50 percent should be easily made. The necessary goal would seem to be 100 percent renewable electricity, with appropriate storage systems to manage supply and demand. Bills requiring this have been introduced in the legislature but have failed to pass. The rapid spread of Community Choice Energy (CCE) programs across the state, through which cities and counties develop contracts with electricity generators directly on behalf of their residents rather than going through utilities, is another potential means to approach 100 percent renewable electricity, since usually these contracts emphasize renewable energy.

Building energy use—spread across several categories of the state's accounting system—is also a large source of emissions. Non-electricity-related emissions from commercial and residential buildings accounted for 11 percent of the state's emissions in 2015. With the state's building energy code being strengthened every three years, new buildings are approaching zero net en-

ergy (ZNE). However, two large barriers to carbon neutrality of buildings remain. First, most ZNE buildings use natural gas for heating, cooking, and/or hot water, with sufficient solar to offset the energy content of the gas with renewable power. Yet on a carbon basis the solar panels will progressively offset fewer emissions over time as the electric grid becomes lower carbon. Plus any use of natural gas produces direct emissions that are not in the spirit of carbon neutrality. So the real goal should be zero net carbon (ZNC), with 100% renewable energy and no gas. The second major challenge is how to retrofit the large stock of existing buildings. Past building retrofit programs have underperformed; a \$98 million California Comprehensive Residential Retrofit program between 2009 and 2014 reached only 8,100 single-family homes and 5,700 multifamily units (out of 12 million housing units in the state) (Metoyer, Gaffney, Hoover, & Yang, 2014). Some jurisdictions have adopted Property Assessed Clean Energy (PACE) programs through which homeowners can pay for energy upgrades through property tax surcharges over time rather than upfront payments. However, residential PACE programs funded only 148,000 energy upgrades nationally in the 2009–2016 period (PACENation 2017), so in their current form these are not likely to be a solution either. Since voluntary retrofit programs seem not to be working, one potential policy direction would be to require and subsidize building energy efficiency upgrades at time of sale, or within a mandatory time frame. This would require major state investment and political support.

Agriculture generates 8 percent of California's emissions, mainly from methane and nitrous oxide. Dairies account for 60 percent of agricultural GHGs, an amount that increased by 23 percent between 2000 and 2015 as production rose (ARB, 2017). Strong regulation to control emissions from manure, feed supplements for ruminants, and other farm programs can help somewhat (Hristov et al., 2013). However, the state will probably need to mandate or incentivize dietary changes, perhaps through strong carbon pricing of dairy products and meat (Wirsenius, Hedenus, & Mohlin, 2011). Major resistance can be expected.

High Global Warming Potential gases (mainly HFCs used in air conditioners) account for 4.3 percent of California's emissions. These emissions declined about 44 percent between 2000 and 2015, and existing policy directions seem sufficient to meet long-term goals. Landfill (and to a much lesser extent recycling) operations account for an additional 2 percent of emissions, and stronger programs to cap landfills and retrieve methane may be needed. Finally, the state will need to reduce its residents' consumption of high-carbon goods and services produced elsewhere (including air travel). Very strong new educational and social marketing campaigns will probably be needed, along with high carbon pricing.

A wild card within California's carbon accounting is the potential for carbon sequestration. Programs to store carbon within soils, trees, or geology can potentially off-

set some of the state's emissions. Accelerated research into these strategies seems called for. However, sequestration is unlikely to reduce the need for carbon mitigation policies such as those above; rather, it may help offset unavoidable emissions, for example, those embodied in motor vehicles and buildings.

7. Future Prospects for the State's Social Ecology

What can trends in various dimensions of California's social ecology tell us about the prospects for such next-generation climate policies? In terms of the "politics" and "institutions" dimensions of Figure 2's model, prospects are mixed. Climate leaders have been able to keep the legislative and regulatory process moving forward to date, but with great effort and multiple setbacks. Fossil fuel industries successfully derailed a 2016 attempt by Governor Brown to secure a legislative mandate for a 50 percent reduction in motor vehicle emissions by 2030. They also forced a relatively weak compromise in terms of reauthorizing the cap-and-trade framework in 2017. Democratic leaders in the state Senate had developed the much stronger alternative mentioned above, SB 775. But hamstrung by the perceived need for a 2/3 vote (an institutional constraint put in place decades previously by conservative political forces), Brown and others decided to negotiate a much weaker bill and gave up many concessions in exchange for a few Republican votes.

In terms of the "institutions" dimension, other challenges face the state besides the 2/3 vote requirement. In California, as in most other parts of the U.S., electricity is generated and distributed by investor-owned utilities, which have primary responsibility to shareholders rather than the public. Regulation by the state's Public Utilities Commission has been weak, and utilities have built unnecessary fossil fuel-fired power plants and been slow to support decentralized renewable energy (Penn, 2017). So changes to energy-providing institutions are probably needed, either through stronger regulation or public sector take-over. Another set of institutions, the state's metropolitan planning organizations (MPOs), manage regional transportation systems and were directed by SB 375 to reduce motor vehicle-related emissions. However, these MPOs are frequently dominated by more conservative suburban and exurban jurisdictions and have been unable to implement strong policies for compact, mixed-use urban development that might reduce motor vehicle use. The board of the Sacramento Area Council of Governments, for example, consists of 26 representatives of suburban cities and counties and 5 representatives of the relatively urban jurisdictions of Sacramento, Davis, and West Sacramento. Although board votes are weighted by population, these progressive cities represent only about 555,000 out of 2.7 million regional residents, and board politics is dominated by the suburban jurisdictions. Like similar entities everywhere else in the U.S. (except Oregon), California's regional agencies also lack statutory au-

thority over land use, which could help them override local zoning codes that keep out affordable housing. Partly as a result, California's SB 375 mandate has not been effective. A stronger land use planning framework seems needed. Meanwhile, the state's anti-tax movement of the 1970s and 1980s has constrained government revenues at state, regional, and local scales, making new programs difficult and encouraging local governments to zone for suburban sprawl so as to maximize local tax revenues. This political movement has been based on particular "values," "ideology," and "cognition" within Figure 2, and arguably is rooted in "race" and "class" dimensions of social ecology through which voters come to believe that public sector revenues will go to support social groups different than themselves.

Economic influences (yet another dimension of social ecology) both hinder and help climate planning. As previously mentioned, petrochemical interests, the Chamber of Commerce, and other interests associated with corporate capitalism continue to push back strongly. The Chamber frequently adds climate-related bills to its annual list of "job killer" legislation, and litigated the cap-and-trade system for much of the 2010s. However, California's economy has done relatively well despite the Chamber's predictions of doom, even leading the nation in GDP growth in 2015 (Hiltzik, 2016). Silicon Valley and Hollywood are two economic dynamos many of whose leaders support climate planning. The state's rapidly growing clean tech industries may tilt the balance toward support for climate action in the future. In 2015 California generated more than 25 percent of all energy efficiency patents in the US and received 68 percent of total U.S. clean tech investment (Next 10, 2016); in 2016 clean energy alone accounted for 508,000 jobs in the state (Roosevelt, 2016). As such green economic forces expand, their ability to influence state climate policy is likely to increase. Whether this economic force can be mobilized politically remains to be seen.

In terms of the "technology" dimension of social ecology, California is well-known as a global center of innovation and technological change, which can in turn influence GHG emissions (by developing low-carbon technologies) and political and institutional dimensions of social ecology (by allowing policy innovation). For example, home storage batteries such as Tesla's PowerWall, introduced in 2015, could greatly reduce the state's need for imported electricity if they allow homes to store their afternoon surplus of photovoltaic-generated electricity for evening use. California companies such as Tesla, Google, and Apple are also pioneering autonomous and electric vehicles that have the potential to reduce GHGs from vehicle ownership and driving. However, successful adoption of such technologies is highly dependent on institutions adopting effective incentives and regulation. Meanwhile, an overemphasis on technology as the main source of solutions to climate change can have negative results, such as distracting attention from the need for institutional, political, and lifestyle reforms.

Social movements (combining social ecology dimensions such as “values,” “ideology,” and “politics” within Figure 2) within California could also support reducing emissions, and are likely to further build the state’s identity as a climate leader and model of progressive politics. Elected officials have positioned California as a national and global leader in opposition to conservative national politics, and civil society organizations such as Move On, Equality California, and the nation’s largest chapter of the American Civil Liberties Union have helped organize this resistance. In other ways movements for environmental justice, bicycle activism, LGBT empowerment, and farmworker safety hold positive implications for climate change planning, for example by advocating reduced pollution and alternative lifestyles. Environmental justice movements have played a major role to date in supporting climate planning but insist that equity considerations be included (London et al., 2013; Mendez, 2015). However, growing inequality of wealth and power (“class” in Figure 2) works against climate progress within California as within the nation as a whole. Members of disempowered communities often withdraw from civic engagement and hold resentments that can be harnessed by populist right-wing politicians. Meanwhile, stakeholders on the winning end of inequality often see little reason to seek common solutions to problems, instead withdrawing into their entitled enclaves. Along this line Holmberg (2017) argues that high social inequality works against climate solutions by promoting short-term personal and corporate profit maximization rather than longer-term collective values.

A major challenge for the state has to do with the “behavior” dimension of social ecology. California for many decades has exemplified high-consumption, motor-vehicle-oriented American lifestyles. These preferences combine with a hands-off approach to lifestyle questions will make carbon neutrality difficult. However, there are signs that lifestyles are changing for at least some residents. Relative to the generation before, the state’s Millennials (like those in many other parts of the

world) live in more urban locations, own motor vehicles at lower rates, and more frequently walk, bike, carpool, and use on-demand services such as Uber and Lyft (Circella et al., 2016, 2017). Although Millennials’ vehicle ownership is expected to rise as they age and start families, their current behavior may lead to lower long-term vehicle use and willingness to live in smaller, more urban dwellings. Economic factors such as the loss of manufacturing jobs, the rise of contingent employment, and high real estate prices may also encourage behavioral evolution. Such changes may at least in part counterbalance traditionally consumptive behavior.

The most hopeful social ecology trend for California’s climate planning has to do with racial diversity (“race” in Figure 2). Future demographic trends appear strongly positive for progressive politics, as shown in Tables 2 and 3.

Over the past 50 years the state’s steady progress toward greater diversity has correlated remarkably well with increasingly progressive politics. Democrats have controlled both houses of the state’s legislature since 1992 with the exception of the Assembly during 1994–1996. The state does not feature the strongly partisan gerrymandering of legislative districts found in many other U.S. states, and indeed approved ballot initiatives in 2008 and 2010 to set legislative and congressional districts through a nonpartisan Citizens Redistricting Commission, a significant reform to the “institutions” dimension of the state’s social ecology. Despite the climate denial stance of the national Republican Party, the state’s most recent Republican governor, Arnold Schwarzenegger, earned a reputation as a strong climate action champion. Greenhouse gas reductions are closely correlated with local air quality improvements, a top concern of many state constituencies including the state’s medical establishment and Latino organizations.

8. Conclusion: Evolving California’s Social Ecology

We have seen that within California’s social ecology there are factors supporting strong climate action but also sig-

Table 2. Changing California Demographics (%). Source: California Department of Finance. California’s population has become far more diverse since 1970, with the trend projected to continue through at least 2030.

	1970	1980	1990	2000	2010	2020 (p)	2030 (p)
White	77	67	57	47	40	38	36
Black	7	7	7	7	6	6	6
Hispanic	12	19	26	32	38	40	42
Asian/Pacific Islander	3	5	9	12	13	13	13
Native American	0	1	1	1	0	0	0

Table 3. California Presidential Voting (%). Source: LA Times. At the same time the state’s electorate has become far more Democratic as shown by its voting in Presidential election.

	1980	1984	1988	1992	1996	2000	2004	2008	2012	2016
Democrat	36	41	48	46	51	54	54	61	60	62
Republican	53	58	51	33	38	42	44	37	37	32

nificant countervailing forces. Particularly promising are the state's progress toward greater social diversity and progressive politics ("race" and "politics" dimensions of Figure 2), its institutional strength around environmental policy and regulation ("institutions"), its recent improvements to democratic institutions such as redistricting (also "institutions"), its culture of innovation ("technology," "cognition," and "economics"), its progressive identity ("ideology" and "cognition"), and its growing environmentally related economic sectors ("economics" and "politics"). Particularly challenging are institutional constraints on public sector capacity, the continued political power of fossil fuel industries and other conservative economic forces, growing social inequality, and highly consumptive lifestyles (forces within the "institutions," "politics," "class," "ideology," and "behavior" dimensions of social ecology).

A number of near-term strategic moves might strengthen the state's social ecology in terms of climate and sustainability planning. To start with, a high and increasing price on carbon (an "economic" initiative within Figure 2), in addition to directly discouraging fossil fuel use, would have ripple effects throughout California's social ecology, encouraging technology and behavior change. Strengthening the state's cap-and-trade system or adopting a direct carbon tax will likely be needed to produce such pricing.

Overhauling the state's tax system (an important "institution" within Figure 2) would be another positive influence on social ecology, increasing public sector capacity to deal with challenges such as achieving carbon neutrality. Specific steps might include eliminating Proposition 13 constraints on property taxes and the two-thirds requirements for tax increases. Such changes could be phased in if necessary. Regional tax base sharing could also discourage high-GHG types of suburban and exurban development while improving social equity (Chapple, 2016). A severance tax on oil and gas production could produce revenue for GHG reduction programs and help change behavior (unlike other oil producing states, California currently has no such tax). Since these changes won't be easy, strong leadership ("politics" in Figure 2) would be needed to make the case to the public for such changes.

A stronger framework of climate planning incentives, mandates, and technical support between levels of government is another potential "institutional" step. One of the lessons from Oregon, the nation's leader in terms of urban growth management, is that such a framework of governance can produce more successful results than if any single level of government acted alone. The State of Oregon established 19 Statewide Planning Goals in 1973, and since that time has worked with lower levels of government to facilitate local implementation (Wheeler, 2000). Maryland has employed similar strategies under its smart growth framework beginning in 1998 (Hanlon, Howland, & McGuire, 2010; Shen & Zhang, 2007). Revisions to California's SB 375 framework could follow this

model by setting stronger GHG reduction goals related to transportation, housing, and consumption, providing more extensive state support and funding to local governments, and conditioning local receipt of state infrastructure funds on compliance with state GHG-reduction goals. Making regional planning agencies directly elected and giving them power to approve large development projects and review local zoning codes could also help. Meanwhile, state funding for affordable housing and mandates that local governments zone for it could reduce GHGs and social inequities by ensuring sufficient affordable housing near workplaces. The state legislature took initial steps in this direction in 2017.

Evolving "values," "cognition," and "behavior" within Figure 2 is perhaps the largest challenge of all. Arguably such change has already occurred within American society with regard to issues such as smoking, civil rights, and gay rights. Those changes typically required goal-setting by high levels of government as well as massive intervention through legal, educational, and public health systems. In addition to the other strategies mentioned earlier, a great deal of research now exists on effective communication methods around climate change (a "technology" of spreading information so as to change "behavior"), particularly to help overcome individuals' defenses against depressing science or lifestyle change. Moser (2016) provides an overview of climate change communication, and Stern et al. (2016) review the potential of behavior change for households and organizations. The State of California will likely need to lead new educational efforts on this front. Previous campaigns on smoking, drunk driving, healthy eating, and the like may provide models.

In order to bring such social ecology changes about, planners and other professionals will need to articulate the need for them and help the public understand how such fundamental reforms are crucial to making progress on climate planning, social equity planning, and other important sustainability needs (to use the language of the model, planners can use communication "technology" to help change "cognition," "values," "ideology," "politics," and "institutions"). Public debates often focus on a few, limited policies. However, emphasizing the big picture of how the state can move towards carbon neutrality in 2050 (a particular communications approach) may help the public and decision-makers see how such change can come about. To put it another way, planners need to combine systems thinking with advocacy planning.

Although this discussion has focused on California, jurisdictions worldwide face similar needs to shape their social ecologies so as to support climate action or sustainability generally. Existing social ecologies rarely support the level of action required. The needs in any given place will depend on context, but the process will be similar. Planners can identify both policies that can directly address the problem in the long term, and underlying social ecology changes that can increase the chances of successful action. Bringing about change on both levels will

not be easy, but in a world in which political polarization and dysfunction are increasingly common, such strategic thinking related to social ecology is crucial.

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Conflict of Interests

The author declares no conflict of interests.

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