REVIEW OF MOTIVATIONS AND STRATEGIES FOR ADDRESSING CLIMATE CHANGE THROUGH THE DESIGN OF NEIGHBORHOODS AND COMMUNITIES

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REVIEW OF MOTIVATIONS AND STRATEGIES FOR ADDRESSING CLIMATE CHANGE THROUGH THE DESIGN OF NEIGHBORHOODS AND COMMUNITIES

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Abstract Climate change creates new challenges for the sustainable design and operation of neighborhoods and communities. Litigation, advocacy, and public policy developments are making it clear that governments and private organizations will be held accountable for their action (or inaction) associated with climate change. The next step in the evolution of this issue will involve a shift from the emerging consensus surrounding the "big picture" to the hard work of achieving results on the ground. This change will place community planners and developers on the frontlines of both climate mitigation and adaptation. They will be asked to consider the implications of neighborhoods and communities for the causes and consequences of climatic change. This paper reviews some of the most important motivations for action associated with local land use decisions and suggests a set of practices that provide meaningful first-steps to addressing the drivers of change and preparing for changing conditions. Key strategies include: (1) conducting an initial screening-level climate change assessment for a specific neighborhood or community, including contributions to the drivers of climate change (greenhouse gases) and exposure to the consequences (e.g., rising temperatures, changing precipitation patterns), (2) developing a quantitative, project-level greenhouse gas emissions inventory, (3) identifying and prioritizing emission reduction strategies associated with specific neighborhood or community design features, (4) identifying and prioritizing opportunities to make neighborhoods or communities less vulnerability and more resilient to changing conditions. Planners and developers who take these actions will reduce the risk of regulatory surprises, hedge against future liabilities, and contribute to their goals for sustainability and environmental responsibility.

Keywords: climate change, neighborhood, community, planning, development, land use policy, mitigation, adaptation, greenhouse gas inventory, energy master plan

1. INTRODUCTION

Climate is changing. Over the last century, the Earth's average surface temperature has climbed nearly 1°C. This has been accompanied by significant changes in wide-range of important climatic metrics, such as extreme precipitation events, daily low temperatures, diurnal temperature range, global sea level, and sea ice extent (IPCC 2007). The scientific community has concluded that these changes are most likely being driven by the emission of greenhouse gases associated with fossil fuel combustion (Stott et al. 2001). Society's continuing contribution to the drivers of change creates new risks, responsibilities, and opportunities.

While the consequences of climate change reach across society as a whole (Pacala and Socolow 2004), the focus here is limited to implications for the design, construction, and operation of neighborhoods and communities. Neighborhoods and communities are the building blocks for human settlement, and they provide a focal point for efforts to improve land use decision making. This focus is particularly important because neighborhoods and communities present immediate opportunities for action with long term consequences. Neighborhoods and communities designed and built today are expected to perform for decades into the future, and they represent an essential component of efforts to mitigate and adapt to climate change (American Planning Association 2006).

This paper considers three important questions facing planners, developers, elected officials, and other stakeholders:

(1) What factors are motivating local land use decision makers to take action to address climate change?
(2) How can neighborhoods and communities be designed and operated to manage risks and opportunities associated with emission of greenhouse gases?
(3) How can the design and operation of neighborhoods and communities prepare for changing conditions and facilitate adaptation?

2. MOTIVATION FOR ACTION

Climate change assessments over the last 30 years have repeatedly reached similar conclusions (e.g., Santer et al. 1995, Karl et al. 1996, IPCC 1995, IPCC 2001, IPCC 2007) (Table 1):

- Climate is changing as the result of human activities.
- Climatic changes are very likely to have significant implications for people and the environment.

- Greenhouse gas emissions associated with the combustion of fossil fuels are believed to be the primary anthropogenic driver of climatic change.
- The accumulation of anthropogenic greenhouse gases in the atmosphere make it very likely that climatic conditions in the years ahead will be substantially different from those observed over the last century.

Increasing knowledge of the drivers and consequences of climate change is necessary but not sufficient to motivate changes in practice for planners and developers. In most cases, key decisions are associated with a dynamic web of policies, regulatory interpretations, and public processes. Over the last year, a number of factors have changed in ways that create a new opportunities for action in the design and operation of built environments (Hendrix et al. 2007). Many of these changes first emerged in California, and they have begun to spread across the United States. The result is that climate considerations have begun to make tangible changes in land use decision making processes. One result has been the rapid emergence of a new mandate for large-scale planning and land use projects to consider the implications of climate change as a part of environmental impact assessment and entitlement processes (EOEEA 2007). The following sections briefly review key proximate drivers of change in California, including rising state policy, on-going public and private legal action, and, as a precursor of continuing developments, findings from the U.S. Supreme Court.

2.1 State policy

In the closing hours of the 2006 legislative session, California passed Assembly Bill 32, the Global Warming Solutions Act (AB 32). While not the first state-level action addressing climate change, AB 32 is the most far-reaching. It creates an economy-wide cap on greenhouse gas emissions and lays out legally enforceable emissions reduction goals starting with 25% by 2020. It is important to recognize that AB 32 is essentially a vision for the future – a statement of purpose, goals, and a framework for moving forward. The mechanisms of AB 32 as an actual environmental policy will be developed over a period of years by the California Air Resources Board. However, it is clear that the importance of AB 32 goes beyond the details of its language. It is a tangible symbol that California is ready to take serious action to address climate change.

2.2 Public and private legal action

While AB 32 set the bar for California, this action alone did not create new mandates for planners or developers. The confluence of AB 32 and recent interpretations of the California Environmental Quality Act (CEQA) have tipped the balance from intangible goals to a *de facto* imperative for action. CEQA is intended to protect California's environment by identifying significant environmental issues and identifying opportunities to avoid or mitigate impacts. CEQA applies to activities with a potential physical impact on the environment, such as zoning ordinances or the approval of subdivision maps. A series of legal interpretations, based in part on concepts articulated in AB 32, have suggested the emergence of a new requirement for the consideration of climate change within CEQA documentation (Hendrix et al. 2007). This change has brought climate change to the doorsteps of planners and community developers.

One focal point for this discussion has been a series of actions by Office of the California Attorney General (AG). In a letter dated March 30, 2006, Deputy Attorney General Kathryn Egolf provided a series of comments on the Orange County Transportation Authority (OCTA)'s Draft Program Environmental Impact Report (DPEIR) (Egolf 2006). Egolf noted that the state government has *"acknowledged the true environmental impacts of greenhouse gas emissions on climate change."* This statement is based on Governor Schwarzenegger's Executive Order S-3-05 which includes a series of findings on the implications of climate change for California. The Executive Order concludes that *"…mitigation efforts will be necessary to reduce green house gas emissions and adaptation efforts will be necessary to prepare Californians for the consequences of global warming…"*

The AG's letter indicated that DPEIR's prepared in accordance with CEQA must identify and focus on the "significant environmental effects" of a proposed project. The letter continued that greenhouse gas emissions associated with the projected 45% increase in Vehicle Miles Traveled (VMT) may constitute such a significant impact and "should have been considered and analyzed" in the Environmental Impact Report (EIR). Moreover, the AG concluded that such an analysis was feasible because data are readily available and the proposed action could incorporate mitigation measures. The issue was resolved when the OCTA agreed to: (1) include a discussion of GHG-related impacts in its revised EIR, (2) inventory GHGs within the project area, and (3) work with the State's climate action team. *"Based on these actions, the Attorney General will not pursue legal* *action related to the environmental documentation…"* This AG has repeated this interpretation with subsequent county and city-level actions (e.g., the County of San Bernardino's proposed general plan revision (April 13, 2007) and a specific plan under the jurisdiction of the City of San Jose (June 19, 2007)).

These interpretations of CEQA have broad implications, but it is important to recognize that they are not necessarily new, ground-breaking, or restricted to California. Many states are moving to take similar actions. One of the most important from the perspective of land use decision making is a recent action by the Commonwealth of Massachusetts to establish a greenhouse gas emission policy under the Massachusetts Environmental Policy Act (MEPA) (EOEEA 2007). This policy requires most large development projects to, "identify and describe sources of, and propose measures to avoid, minimize, or mitigate project-related GHG emissions."

These issues are also under consideration at a national scale with respect to the National Environmental Policy Act (NEPA). In 1997, then-chairman of the Council for Environmental Quality, Kathleen McGinty drafted an interpretation of NEPA for federal agency heads (McGinty 1997). McGinty found that: *"(1) the potential for federal actions to influence global climatic change (e.g., increased emissions or sinks of greenhouse gases) and (2) the potential for global climatic change to affect federal actions (e.g., feasibility of coastal projects in light of projected climate change)."* McGinty concluded that NEPA provides an appropriate and feasible mechanism for considering climate change drivers and consequences.

Many of these issues are being tested in court (McChesney 2007). For example, in *Border Power Plant Working Group v. Department of Energy (DOE),* plaintiffs challenged environmental review processes used in the permitting of trans-boundary electrical transmission lines. The transmission lines provided the ability to generate and export electrical power from Mexico to the United States. The District Court found that the pollution associated with increased generation was connected to the federal action, and the DOE should have considered CO2 emissions from the power plants when preparing its environmental review documents. This was a victory for the plaintiffs; however, the actual results were quite limited. DOE responded with a cursory assessment of the emissions and summarily dismissed them as negligible.

Mayo Foundation v. Surface Transportation Board returned to these issues with a challenge to an environmental impact assessment for new and upgraded rail lines. The action was anticipated to result in increased coal consumption. The Service Transportation Board claimed that all relevant pollutants were regulated by the Clean Air Act (CAA) under which rules the emissions were found to be not significant. However, the court disagreed finding that the lack of analysis for emissions was “irresponsible”.

These examples illustrate some of the past and pending litigation seeking to compel the consideration for the drivers of climate change through existing environmental impact assessment requirements (Gerrard 2007). Even though only a fraction of these cases have been successful in court, they are becoming increasingly common and sophisticated

(Gerrard 2007). They illustrate the type of legal actions possible in connection to local land use decisions – new risks that may become increasingly difficult and costly for planners and developers to ignore.

NGOs have asked courts to consider the responsibility of planners, developers, and permitting authorities to consider the consequences of increasingly well-known trends, such as sea level rise. For example, the Natural Resources Defense Council (NRDC) filed what may be a first-of-its-kind lawsuit against the California Reclamation Board for approving a development project in the Sacramento-San Joaquin Delta. The issue centered on a plan to build hundreds of homes on a levee on an island in the Delta. The lawsuit asserted the Reclamation Board violated CEQA when it failed to consider the implications of sea level rise for levee protection. A study by the California Department of Water Resources found that 1 foot of sea level rise would flood the area – a rise well within the range of predictions for the next century (IPCC 2007). It is interesting to note that a former Reclamation Board member commented publicly on the lawsuit, saying *"The decision that the Reclamation Board is making today may not be durable in the face of climate change…People should be factoring that into their thinking when they're building these projects."*

This line of legal action is particularly important for neighborhood or community planners and developers since developments are expected to perform for decades into the future. The traditional design process is littered with potentially problematic assumptions regarding future climatic conditions, such assumptions about sea level rise that are at issue on the *NRDC v. Reclamation* Board case. For example, concepts such as the 100-year flood plain, design storm, low flow return intervals (e.g., 7Q10), or historic peak summer temperatures are key benchmarks for permitting and engineering (Pyke and Pulwarty 2006). However, it is increasingly clear that these traditional metrics are unlikely to be reliable guides to future conditions (Najjar 1999). The courts are beginning to consider whether circumstances warrant changes in the standard-of-care applied to these issues (Table 2).

The confluence of factors linking AB 32 and various legal actions associated with CEQA are built on circumstances in play during 2006-2007. On April 2, 2007, the U.S. Supreme Court made a landmark decision, ruling in favor of the state of Massachusetts and compelling U.S. EPA to reconsider its decision not to regulate CO2 emissions under the Clean Air Act. The Supreme Court's decision addressed a number of more common obstacles to legal action directed to increasing consideration for climate change.

The Court found that, *"…the harms associated with climate change are serious and well recognized*." The court found that EPA's *"… refusal to regulate greenhouse gas emissions presents a risk of harm to Massachusetts that is both 'actual' and 'imminent…"* Moreover, the Court believes that action by EPA could reduce the risk of such damage, and the Court "*...attaches considerable significance to EPA's espoused belief that global climate change must be addressed."*

The implications of the ruling are still unfolding; however, it is already clear that it is likely to increase the chances of success for future CEQA (and NEPA-related) litigation and add to the political momentum for policy action. These findings are likely to increase the chance of success in future legal challenges, and increase the likelihood that planners and developers are willing to take preemptive action to avoid the risk of legal challenges to plans and projects.

2.3 Summary of policy and legal motivations for action

Taken together, we can draw at least three conclusions relevant to neighborhood and community planners and developers:

- Climate change is now a potentially important issue in the preparation of environmental impact documentation.
- Challenges to the adequacy of climate change-related assessment and mitigation are likely to continue as the legal and advocacy community develops more comprehensive and sophisticated arguments.
- Failure to explicitly consider the implications of a program or project for the causes of climate change and exposure to its consequences may create new risks and liabilities.

3. CLIMATE CHANGE STRATEGIES FOR PLANNERS AND DEVELOPERS

The convergence of progressive public policy, strategic legal actions, and continuing public concern about the issue of climate change has created an increasingly strong foundation for action. In California, these circumstances have created pressure to improve the standard-of-care applied to these issues and a *de facto* requirement to consider greenhouse gas emissions and the implications of climate change for the performance of neighborhoods and communities. In Massachusetts, there is now a legal requirement for action for certain projects. Current circumstances suggest four elements of due-diligence for planners and developers, including general assessment of risks and opportunities, preparation of greenhouse gas emissions inventories, development and evaluation of emissions reduction strategies, and consideration of potential adaptation strategies. The following sections discuss each in more detail.

3.1 Assessment of risks and opportunities

The first step in navigating these changing conditions is to assess climate change-related risks and opportunities associated with specific neighborhoods or communities. Such an assessment can range from a high-level, qualitative screening exercise (e.g., a climate sensitivity charrette) to a detailed, quantitative analysis based on mathematical modeling. One useful intermediate approach is called a “decision assessment” (Pyke et al. 2007). A decision assessment entails considering each programmatic and project design “decision” and making a preliminary evaluation of its consequences for greenhouse gas emissions and its potential sensitivity to changing climatic conditions. By analogy, one might consider such an assessment an initial climate audit. The goal of the process is to identify both risks and opportunities associated with specific decisions. In practice, the results of such a decision assessment can be presented as a narrative or series of tables used to guide project design and inform the environmental impact assessment process.

3.2 Greenhouse gas inventories

After a high-level assessment of risks and opportunities, the next step is to consider contributions to the drivers of climate change in more detailed with a quantitative greenhouse gas (GHG) emissions inventory. A GHG inventory involves estimating emissions based on energy use and the characteristics of energy supply. General approaches for such inventories have been outlined in documents such as the World Resources Institute (WRI) and World Business Council for Sustainable Development's (WBCSD) widely-used Greenhouse Gas Protocol. The WRI/WBCSD protocol provides specific guidelines for conducting and reporting information from a GHG inventory.

The WRI/WBCSD protocol provides a procedural foundation for estimating emissions, but it does have significant limitations for planners and developers. Most critically, the WRI/WBCSD protocol is designed for corporate-level accounting – not necessarily local land use projects. In practice, neighborhood and community project teams supplement the WRI/WBCSD protocol with a rapidly changing mixture of tools, including historic performance data for comparable situations and model capable of estimating future energy use and associated emissions (Table 3). Depending on the circumstances, project teams may extend the scope of a greenhouse gas inventory to include additional indirect sources of emissions, such as the embodied energy of water, solid waste, construction phase emissions, construction materials, and changes in carbon storage associated with land use/land cover conversions.

3.3 Emission reduction strategies

An emissions inventory is a starting point for efforts to reduce greenhouse gas emissions. Achieving reductions requires planners and developers to consider a portfolio of strategies, including: (i) energy efficiency improvements, (ii) changes in energy supply (e.g., green power purchasing), and (iii) greenhouse gas offsets.

3.3.1. Energy efficiency associated with project location

Energy efficiency improvements are available across a range of spatial and organizational scales (Figure 1), and decisions build on each other from the inception of a project. Energy use and greenhouse gas emissions in many communities are roughly evenly divided between operation of buildings and transportation, and regional location sets the foundation for emissions and mitigation opportunities (Figure 2). High density, compact, regionally-connected, mixed-used land use patterns contribute directly to relatively low per capita energy consumption and greenhouse emissions. Residents live in relatively efficient building configuration and typically have much lower per capita transportation-related CO2 emissions (Feigon 2003). A case study for King County in Washington

State found that net residential density was one of the most important factors in individual greenhouse gas emissions (Frank et al. 2005).

3.3.2. Energy efficiency associated with site design

Efficient regional land use patterns set the stage for success for important site design decisions. The configuration of a site has a direct bearing on greenhouse gas emissions and the impact of climate change. Several of the most important factors include local connectivity, contributions to urban heat islands, and considerations for solar orientation (Table 4).

3.3.2.1 Energy efficiency associated with local connectivity

The big picture of transportation is clearly set at the regional scale (and even national and global scales) through choices about infrastructure, demand, jobs-housing balance, technology, and myriad of other factors. However, site design choices can make a significant different. For example, the California Department of Transportation recently noted that local design factors may influence 10-30% of residential driver behavior (Caltrans 2006), and researchers have repeatedly found that well-connected communities with diverse land uses and safe opportunities for non-automobile transportation have higher rates of walking and bicycling (e.g., Greenwald and Boarnet 2001, Handy 2007). These factors can contribute to reducing the number of vehicle trips generated, the total number of miles driven, and emissions of greenhouse gases (Southworth 2005, Cervero and Duncan 2006).

3.3.2.2 Energy efficiency through heat island reduction

The design of neighborhoods and communities can also play a key role in exacerbating or mitigating urban heat island impacts. Opportunities to mitigate heat islands through site design include attention to shading, building form (e.g., massing), and applications of cool paving and roofing materials (e.g., high reflectivity). For example, plants can lower air temperatures by providing shade and cooling through evapotranspiration. Shaded walls may be up to 40 degrees F cooler than peak surfaces observed for unshaded surfaces. The cooler surfaces lower ambient air temperature and reduce cooling demand (Frank et al. 2007).

3.3.2.3 Energy efficiency through solar orientation

Site design is also a key control on building orientation. This has impact on local temperature (e.g., heat islands) as well as energy consumption and production. Optimally oriented buildings maximize passive solar heating during cool seasons, avoid solar heat gain during hot periods, enhance natural ventilation, promote effective use of daylighting, and create opportunities for on-site energy production (Frank et al. 2007).   For example, an effective roof-top solar system requires direct (unshaded) access to sunlight, sufficient area for photovoltaic cells, and roof orientations that help capture solar energy during the day. These features are critical elements of solar preparation efforts, such as New Mexico’s 2007 “Solar Ready Roof” program.

3.3.3 Energy efficiency through building design

Careful consideration of regional location and site design create the foundation for energy efficiency at the building scale where there are a myriad of energy saving and energy generating options available for residential, commercial, and public buildings. So many, in fact, that the array of interrelated options can become overwhelming. Fortunately, there are a variety of tools available to help planners and developers identify and prioritize efficiency improvements based on their relative expense and energy use reduction benefits. This can be done for individual features or collections (or packages of features).

For communities in California, the current benchmark for residential and commercial energy performance is the Title 24 California Building Standards Code. In practice, it is possible to achieve at least a 25% improvement over code through cash-flow neutral measures (i.e., decreases in monthly energy costs offset payments required to service a larger mortgage incorporating energy efficiency improvements) (USDOE 2005). Some of the most important energy efficiency features include high-albedo roofing (a.k.a., cool roof technology), high-performance windows, improved building insulation, and efficient mechanical systems. These structural features can be complemented with building specifications such as Energy Star™ appliances and programmable thermostats. Models can be used to identify packages of features that optimize energy performance for different building design (e.g., BEopt, DOE-2, eQUEST).

Efficiency measures do not end when the building, neighborhood, or community is occupied. It is essential to educate facility managers and occupants in the operation of their buildings and its systems and monitor performance over time. This means conducting post-construction and continuous commissioning to establish baseline energy usage and track improvements over time (Mills et al. 2004).

3.4 Energy supply

Built environments consume natural gas, purchased electricity, and possibly other fuels such as diesel, gasoline, and propane. Each of these is associated with a different level of greenhouse gas emissions, and, in many cases, it is possible to identify opportunities to switch to fuels with lower emissions or, potentially, no emissions. The U.S. Department of Energy has promoted the development of so-called zero-energy homes. DOE’s concept of zero-energy homes are buildings that use aggressive energy efficiency improvements to reduce energy demand to the level at which it can be cost-effectively met through on-site energy production (Torcellini et al. 2006). Zero-energy homes are typically designed to be connected to the electrical grid so that surplus power can be sold to the utility and periods of low on-site generation can be addressed through grid purchases (e.g., nighttime energy demand). Despite important benefits, it is important to note that DOE’s zero-energy concept addresses only a subset of greenhouse gas emissions; most importantly it does not consider transportation-related energy use. Consequently, it is possible to have a “zero-energy” home in a location that requires disproportionate use of energy for transportation (e.g., a rural residence).

Electricity-producing solar photovoltaics (PV) are the most common form of on-site energy generation. They reduce greenhouse gas emissions by displacing purchased electricity. Current PV systems supply 1.2-2.4 kW at a cost of approximately $10,000 per installed kW. These installations are encouraged through government incentives such as the California Solar Initiative as well as incentives from local utilities and the federal government. Other on-site energy generation strategies include solar thermal (for water heating), wind power and geothermal or geo-exchange (using the constant temperature of the earth for heating/cooling), or sewer waste-gas cogeneration. High efficiency generation systems, such as fuel cells and microturbines combined with co-generation to utilize the waste heat can also reduce greenhouse gas emissions, particularly when effectively incorporated into the design of high density mixed use communities. Some developers are finding it cost effective to either partner with a third party financing organization who will provide, own and maintain the energy generation technologies and sell power back to the community at competitive rates, or to form their own utilities based on on-site generation strategies.

An alternative approach is to change the mix of energy supplied from the electrical grid. While it is not typical for a community to directly change the source of the actual delivered electrons, a community can ensure that the utility purchases renewable power to offset the community’s use. This is accomplished through renewable energy certificates or so-called green power purchasing. Where available, green power purchasing is very simple, and it typically involves relatively modest marginal costs. The additional cost of green power creates some additional incentive for energy efficiency and accelerates pay-back schedules.

3.5 Greenhouse gas offsets

The third greenhouse gas mitigation option is to pay a third-party to provide greenhouse gas reductions, so-called “offsets”. Neighborhoods and communities may be involved in both buying offsets to reduce their greenhouse gas footprint and selling offsets through additional improvements in energy efficiency or on-site energy production.

3.5.1 Buying greenhouse gas offsets

Many consumers are interested in buying so-called GHG offsets. The idea is that a neighborhood or community could continue to emit greenhouse gases, but pay to create equivalent, offsetting reductions elsewhere. Consequently despite increasing emissions associated with a project, offsets result in no net increase of GHG emissions globally.

The concept of third-party offsets is based on a solid foundation of economic theory. The concept behind offsets is based on recognition that the cost of achieving greenhouse reductions varies across the economy. Consequently, offsets can help maximize emissions reductions per dollar. For many California communities, a substantial percentage of emissions can be mitigated through the choice of regional location, site design, and building-level energy efficiency improvements. However, higher levels of reduction often incur substantially higher costs per unit reduction. Consequently, under some circumstances it may be cost effective to pay for reductions in other locations rather than pay rapidly escalating prices for additional incremental emission reductions. In theory, such third-party offsets offer theoretically sound and cost-effective mechanisms for achieving aggressive greenhouse gas reduction goals, such as carbon neutrality.

However, the utility of greenhouse gas offsets is entirely dependent on the availability of credible third-party offsets with low transaction costs. California's AB 32 legislation allows for emissions trading of offsets, stipulating that they be *permanent*, *additional*, and *verifiable*. Each of these terms is subject to ongoing discussion. Greenhouse gas offsets are a relatively new commodity, and markets are still establishing trading procedures and standards. Key issues include a lack of standardizing accounting protocols, inconsistent monitoring and verification, short-term contractual relationships, and relatively low prices. These issues mean that the current voluntary offset market in the United States is not the system promoted by economic theorists. The current market would be significantly challenged to provide the large amounts of high-quality offsets that would be needed for wide-spread use in the building sector. Project teams must also recognize significant reputational risks associated with uncertainty about third-party performance (e.g., ability of offset providers to deliver a credible product).

3.5.2 Creating and selling greenhouse gas offsets

While many planners and developers are interested in using offsets to address community emissions, it is also possible that communities could be sources of greenhouse gas offsets. The design and operation of neighborhoods and communities may ultimately create significant opportunities for the creation of just the kind of high-quality greenhouse gas offsets needed by the emerging market.

However, neighborhoods and communities face significant barriers to market. Creating a GHG offset requires a clear procedure for assessing emissions before and after an intervention (e.g., installation of an energy saving device). For existing facilities, this is fairly straightforward process. One measures the composition of energy inputs (i.e., fuels), measures energy consumption, and calculates net emissions. The situation is more complex for a neighborhood or community that does not yet exist. In this case, the value of an offset is the difference between what is built and what would have been built if not for some efficiency or process change improvement. In California, it may be that Title 24 building energy performance standards provide a practical benchmark. However, despite its current utility, it has numerous limitations. Building-scale benchmarks such as Title 24 capture only a fraction of real world energy performance, change over time, and neglect important elements of site design and regional location. The lack of widely accepted performance benchmarks is a significant barrier to the creation of offsets.

3.6 Adaptation strategies

Mitigating the magnitude and rate of climate change through reductions in greenhouse gases is currently the center of attention for policymakers and the public. However, past and present emissions have committed the Earth's system to substantial environmental change regardless of near-term policy interventions. This means that future conditions are likely to be significantly different from those experienced over the past century.

This finding has substantial consequences for the design, construction, and operation of built environments (Shaw et al. 2007). New or redeveloped neighborhoods or communities represent long-term, capital-intensive investments that are expected to perform for decades into the future. We have ample reason to suspect that conditions at that time will be warmer and subject to greater climatic extremes, such as storm events and droughts. These changes are likely to undermine key assumptions used in the design, operation, financing, and insurance of individual buildings and whole communities. Some of these changes may jeopardize occupant comfort and productivity; others may pose threats to health and property. All of these changes create new risks.

These risks are not just academic theory. The experience of the Gulf Coast during the 2005 hurricane season shows that many communities are ill-prepared for even the most well known environmental extremes. Moreover, the consequences of this vulnerability are measured in billions of dollars and thousands of lives. Climate change is likely to bring such issues even closer to home, and we must consider what constitutes a reasonable standard of care in the design, construction, and operation of a community. For example, global sea levels have risen steadily over the past 50 years and future increases are very likely. These changes are driven by two processes: (1) thermal expansion of the oceans, and (2) inputs of freshwater, primarily from melting glaciers (Overpeck et al. 2006). Thermal expansion is a long-term process that occurs in response to global heat balance. Increases in global mean temperature observed over the last century are predicted to result in up to one foot of rise by the end of this century. Inputs of freshwater will add to this increase, but the amount of increase remains a wildcard. The IPCC has concluded it is not possible to assign an upper bound for sea level rise. Extrapolation from past trends suggests that melting ice could add another 0.7 feet by 2100; however, scientists have identified a number of processes that could accelerate – perhaps dramatically – glacial melting and, by extension, sea level increases. Recent work puts the overall increase by 2100 in range of 1.6 to 4.5 feet (Rahmdorf 2007). These lines of evidence support an increasingly clear conclusion: continued anthropogenic warming will lead to substantial increases in sea level that will continue for decades, probably centuries, into the future.

Given this information, what is the proper standard of care for planning coastal communities? It is increasingly difficult to claim ignorance of these changes, as the scientific community and popular press have provided fair warning about the implications of climate change. Consequently, when future “disasters” occur it will be hard to claim lack of knowledge. The question is when inaction tips toward negligence and, more importantly, whether changes in practice will occur in time to prevent unnecessary damage to property, threats to public health and safety, or unanticipated degradation of the environment.

Private groups have already recognized the implications and brought suit against developers for not considering sea level rise in the design of levees surrounding new communities on the Sacramento delta. These suits have yet to be successful, but they are clearly only the tip of the iceberg. The implications go far beyond sea level rise. The size of stormwater management systems is often based on the concept of a 100 year flood. Yet, we know that the statistics underlying such calculations rely on a station set of climate observations. Observations of the past become increasingly meaningless as we better understand that conditions are changing. As a result the assumptions upon which systems are designed are becoming invalid. When lives are lost and property is damaged, will it be acceptable to have relied on patently inaccurate statistics? Similarly, rising temperatures are one of the most consistent findings associated with climate change. Are buildings being designed to maintain occupant comfort under more extreme peak summer temperatures? In France, we saw that heat waves cost the lives of thousands of citizens (Stott et al. 2004). By 2050, such “extreme” temperatures may happen every other year (EEA 2006).

Fortunately, we can identify such vulnerabilities and take action to create sustainable buildings and communities that are resilient to changing conditions. We can take sea level rise into account with adequate coastal set backs and well designed shoreline defenses. We can map floodplains under future precipitation regimes and develop more robust stormwater management systems. Most important all, we can identify assumptions regarding climatic conditions and evaluate the consequences of changes that undermine or alter expected conditions. This will help us design more resilient and adaptable systems, such as fail-safe stormwater management systems and buildings with provisions for the installation of more capable cooling systems. This kind of planning is a necessary prerequisite for achieving long-term sustainability.

4. CONCLUSIONS

Climate change is a daunting challenge for community planners and developers. It is a global problem rooted in local actions. Addressing it requires recognizing that local land use choices have consequences for the causes and consequences of climate change. Inaction is an increasingly untenable position. Society is beginning to understand the general scope of these issues and demand substantial responses. We are currently in a period where crucial, large-scale policy choices loom on the immediate horizon. However after the smoke clears from the inevitable policy making battles, it will quickly become clear planners and developers will be on the front lines of changing practices on the ground. Fortunately, we have a solid foundation of theory and tools for understanding the implications of climate change for neighborhoods and communities and acting to mitigate drivers of change and prepare for the consequences. Moreover, many of these benefits can be achieved through cost-effective mechanisms that provide a myriad of co-benefits and contribute positively to a community’s overall quality-of-life.

Practical steps for addressing climate change include:

1. Consider the contributions of a community to the drivers of climate change and the consequences of changing conditions for the sustainability of the community.

2. Conduct a quantitative greenhouse gas inventory to provide the foundation of information needed to reduce emissions.

3. Use the inventory to identify greenhouse gas reduction opportunities, take action to implement project design features, and monitor and verify the results.

4. Examine assumptions involving climatic conditions and consider the implications of climate change for a community. Use this information to take action to develop and implement project design features that prepare for changing conditions, plan for adaptation, and reduce threats to people or the environment.

These four actions provide due diligence, reduce emissions and performance risk, and contribute meaningfully to society's response to the global challenge.

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Table 1. Sample of key findings from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, Working Groups I and II.

Climatic changes	Impacts of change
• *Temperature:* warmer temperatures, fewer cold days, increasing frequency of warms spells and heat waves • *Precipitation:* increasing frequency of heavy precipitation events, expansion of areas affected by drought, intensification of tropical storms • *Sea level:* rising sea levels and increasing incidence of extreme high sea levels	• *Water resources:* changes in water availability, increased water stress • *Ecosystems:* increasing risk of species extinction, shifts in species ranges • *Food production:* changes in productivity and crop viability • *Coastal environments:* increased damage from floods and storms • *Human health:* increasing burden from cardio-respiratory and infectious disease, morbidity and mortality associated with heat waves, floods and droughts

Table 2. Comparison of legal standards of evidence and standard-of-care expected of planners and developers.

	Regulatory codes	**Professional standards**
Concept	Minimum specifications established by government, typically to protect health and safety	Services should be provided in a careful and prudent manner that is consistent with the level of skill practiced by other members of the profession
Process of change	Extensive technical analysis and, often, industry consensus	Response to changing market conditions, technology, and customer expectations
Educational process	Publication of definitive public documents	Professional education, including reading of industry publications, product literature, attending training, professional practice

Table 3. Typical sources of greenhouse gas emissions associated with neighborhood and community developments.

Source	Possible calculation method
Residential building energy use	Building performance data (e.g., CEC 2003) and energy models
Public building energy use	Building performance data (e.g., CEC 2003) and energy models
Commercial building energy use	Building performance data (e.g., California Building Energy Reference Tool)
Transportation	Traffic demand models or per capita estimates
Public infrastructure	Estimates based on fixture specifications for street lighting
Embodied energy in water	Empirical estimates (e.g., Wolff 2005)
Embodied energy in solid waste	Observations about residential and commercial waste streams (e.g., California Integrated Waste Management Board) and life-cycle models (e.g., U.S. EPA WARM model)
Construction-phase GHG emissions	Model-based predictions (e.g., URBEMIS)
Embodied energy in construction materials	Empirical estimates of the embodied GHGs in a construction project (e.g., www.becarbonneutral.org)
Change in carbon sequestration	Empirical estimates (e.g., CITYgreen)

Table 4. Neighbor design elements that promote local connectivity and help reduce transportation-related greenhouse gas emissions (Sources: Feigon 2003, Berke et al. 2007, Lee and Moudon 2006).

Factors promoting connectivity between a neighborhood and surrounding areas	**Factors promoting connectivity within a neighborhood**
• Compact land use patterns that place diverse land uses within walking distance (e.g., ¼ to ½ miles for walking, 2 miles for bicycling) • Minimizing gates, fences, and other barriers to pedestrians and bicycles • Number of connecting roads, sidewalks, and trails • Safe connections between areas (e.g., adequate street lighting, connected sidewalks) • Provisions for bicycle and pedestrian circulation	• Relatively short block lengths (e.g., <400 feet) • Relatively small block sizes (e.g., <10 acres) • Relatively high block density • Relatively high density of streets and intersections • Limited the use of cul-de-sacs • Safe connections between areas • Provisions for bicycle and pedestrian circulation

Figure 1. Three primary components of greenhouse gas reduction for neighborhoods and communities: regional location, site design, and building features.

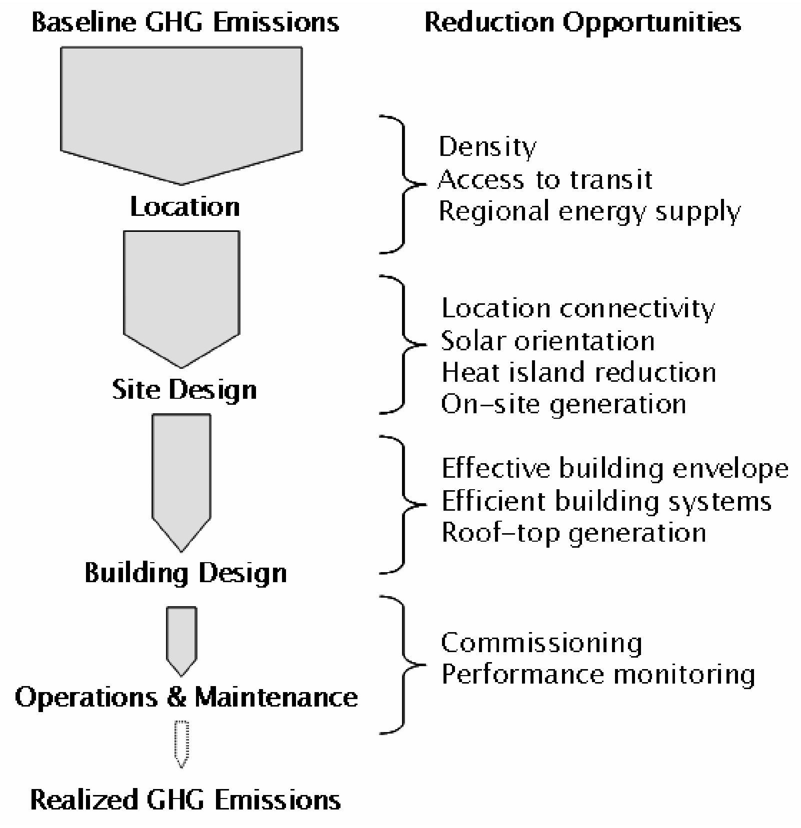

Figure 2. Breakdown of greenhouse gas emissions for an idealized Southern California community (90% residential/10% commercial). Natural gas and electricity are used for residential and commercial uses. Water represents an estimate of the embodied energy of delivered potable water, including transmission, pre-consumption treatment, and sewage treatment. Transportation reflects emissions from private vehicles, primarily those associated with residences.