# TOWARD BUILDING SCALABLE LOW CARBON CITIES THROUGH IMPLEMENTATION OF A WHOLE SYSTEMS APPROACH IN SEVERAL LEARNING CITIES IN CALIFORNIA

## AN APPLIED RESEARCH FRAMEWORK BY LAWRENCE BERKELEY NATIONAL LABORATORY IN COLLABORATION WITH EMPOWERMENT INSTITUTE FOR THE COOL CITY CHALLENGE

### INTRODUCTION

Climate change solutions tend to focus on technologically based solutions and advances in technology. For example 13 or more of the original 15 Socolow climate wedges are technology-based[1]. This is not surprising, given that by definition climate change science is largely studied, quantified, and parameterized by scientists and engineers and since technologies can be analyzed and their impact quantified in a relatively straightforward manner. But what about people: the interaction between people and technology and the larger cultural context of issues driving energy demand and climate emissions including consumption, growth and modernity? After all, people are the ultimate consumers of energy and their consumption accounts for 50-70% of greenhouse gas emissions. For example, the degree to which and rate at which people and by extension, society as a whole adopts new technologies can be as important as the development of the technology itself. Concurrently the world is becoming more urbanized and cities are becoming critical entities in which to address climate change both because of their dominant contribution to global climate emissions and because of their potential for mobilization compared to larger and more unwieldy federal or national levels of authority.

Focusing solely on technology, markets, and policy in climate mitigation strategies is incomplete without including human and social factors, which can be a major driver for technology adoption, policy adoption and market creation (Figure 1). Moreover, all of these items reside in and must be understood in a larger cultural context and ultimately biologically based evolutionary setting. This work describes an innovative new framework for addressing the climate change challenge: a whole systems approach which seeks to comprehend human/behavioral factors, technological approaches, and market factors centered in several learning cities with the objective of building a scalable approach to implementing low carbon cities.

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[1] Stephen Pacala, Robert Socolow "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies". Science 13 August 2004: Vol. 305 no. 5686 pp. 968-972.

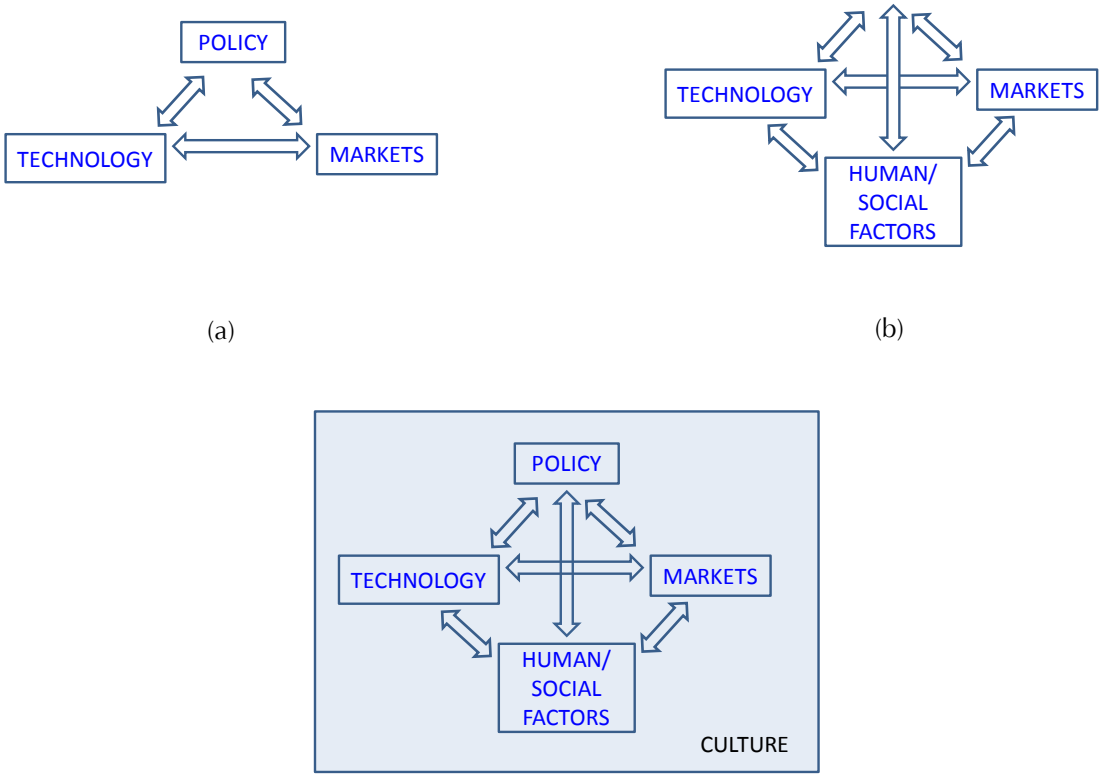


Figure 1. Focusing solely on technology, markets, and policy (a) in climate mitigation is incomplete without including human and social factors (b) which can be a major driver for technology adoption, policy adoption and market creation. All of these items reside and must be understood in a larger cultural context (c).

| | **Technology** | **Markets** | **Policy** |
|---|---|---|---|
| **Human/Social Factors** | To what degree do human/social factors help/hurt technology adoption?<br><br>How do we overcome human/technology barriers? | To what degree is conservation/habitual behavior limited by market adoption factors (ease of adoption, ease of trial, visibility of benefits, etc.)?<br><br>What is the potential for the "collaborative consumption" market? | What is the sensitivity of "strong policy" knobs and habitual behavior change?<br><br>What policies support current consumption habits?<br><br>Education, information |
| | To what extent can community engagement drive technology/market/policy adoption? | | |
| **Technology** | - | Test, pilot, deploy, data, marketing, etc. | Education, information, incentives, financing, risk mitigation, etc. |
| **Markets** | - | - | Carbon price, incentives and regulations |

Table 1. Some interactions and research questions in the interaction of human and social factors with technology, markets and policy. Less explored interactions are shaded.

| | Technology | Markets | Policy |
|---|---|---|---|
| **Human/Social Factors** | Lack of familiarity with technologies; complexity of technology. | Feedback mechanisms for consumption and costs; trust factors and transaction costs; ease of adoption; visibility of benefits | Education and awareness<br><br>Incentives and regulations |
| **Technology** | - | First cost issues; planned vs. unplanned (replacement vs. retrofit) | Building codes and standards. Incentives and regulations |
| **Markets** | - | - | Building codes and standards; innovative financing mechanisms, incentives and regulations |

(a)

| | Technology | Markets | Policy |
|---|---|---|---|
| **Human/Social Factors** | Range concerns; battery safety concerns; lack of engine revving sound; etc. | Collaborative consumption car sharing?<br><br>Charging vehicle-to-grid interactions with driver preferences | Higher gasoline tax<br><br>Education<br><br>Information |
| **Technology** | - | Cost adder; infrastructure – charging, distribution upgrades, etc. | Feebates based on carbon emissions |
| **Markets** | - | - | Carbon price, higher gas tax, incentive and regulations |

(b)

Table 2. The interaction of human and social factors with technology, markets, and policy in (a) Home energy efficiency retrofits; and (b) Electric vehicle adoption—plug in hybrid (PHEV) and battery electric vehicles (BEV).

Global warming is a short fuse issue with the time window for effectual strong action receding with each passing year[2]. There is a lack of coordinated national action or international action. This being the case, much of the leadership in climate change mitigation legislation and policies has devolved to the state and city level. Many cities have climate action plans but lack clear implementation strategies and coordination between disparate agencies (water, utilities, recycling, etc.). Moreover, cities are strapped for resources and budgets are being cut, contributing to persistently high unemployment and a chronic recession since the financial crisis. The net result of all of this is that carbon emissions are not being cut with either the requisite velocity or magnitude needed to meaningfully impact climate change.[3]

2 J. Hansen, Target atmospheric CO2: Where should humanity aim? Open Atmos. Sci. J. (2008), vol. 2, pp. 217-231.

3 "A Daunting Emissions Quest for U.S. Cities," Dylan Walsh, New York Times, April 26, 2012.

Climate change solutions in leading states such as California tend to be technologically focused e.g. cleaner power or lower carbon fuels and based on carbon intensity standards rather than absolute energy or carbon reductions. Wider scale programs such as the Better Buildings Program tend to be piecemeal or narrowly focused in scope (e.g. residential efficiency retrofits) or narrowly focused in audience (e.g. single family homeowners). Because of the piecemeal, narrow focus of these programs, they are not widely adopted and thus far not viewed as successful.

At the same time, cities and residents in cities are a nexus for energy, resource and carbon consumption with increasing urbanization trends especially in the developing world. Localized climate action plans exist in places such as Berkeley and Davis, California, but often lack implementation strategies with detailed measurements and verification. Instead they tend to focus on high level targets with no methodology for structured implementation, measurement or verification, much less financing. State and local approaches also generally lack strategies that include human and social factors, they focus rather on technology adoption.

Further, a persistent and difficult issue to overcome on the path to deep carbon reduction in cities is the lack of demand for energy efficiency services and products, with uptake of home energy retrofit programs chronically low. The direction of programs in general tend to be top down rather than bottom up, based upon extrinsic appeals (such as saving money or saving energy) rather than intrinsic appeals (such as benefiting the community or deeper motivations such as making a difference), and they tend to be scatter shot rather than focused.

## Toward Achieving Low Carbon Cities: A New Paradigm

The proposed approach is in many ways an inversion of existing paradigms that have met with limited success, with focus on motivations, desires, and psychology rather than conventional policy making based on technocratic and purely economic considerations. This whole system approach rather than piecemeal foci integrates social and human factors such as context, vision and motivations and not just energy efficiency but lifestyle and community factors such as consumption, diet, health, resiliency and safety.

A potentially game changing, bottom-up climate change solution using this whole system approach has been developed by Empowerment Institute – experts in the development and implementation of behavior change, community engagement and large system transformation strategies. Participants in their Low Carbon Diet program achieve a 25% carbon footprint reduction and through their neighbor-to-neighbor outreach process are able to recruit 25% of a block to participate. LBNL will partner with Empowerment Institute in an attempt to scale up their carbon reduction and community engagement methodology in three early adopter cities in California and three neighborhoods in Sao Paulo, Brazil.

Called the Cool City Challenge (see addendum), its goal over a three-year timeframe is to engage a minimum of 25% of the households of these communities to reduce their carbon footprint by 25% while providing a platform for the testing and adoption of technologies to enhance the behavior

change and community engagement. A rigorous applied R&D learning process led by LBNL will maximize this opportunity for knowledge creation and ultimately success.

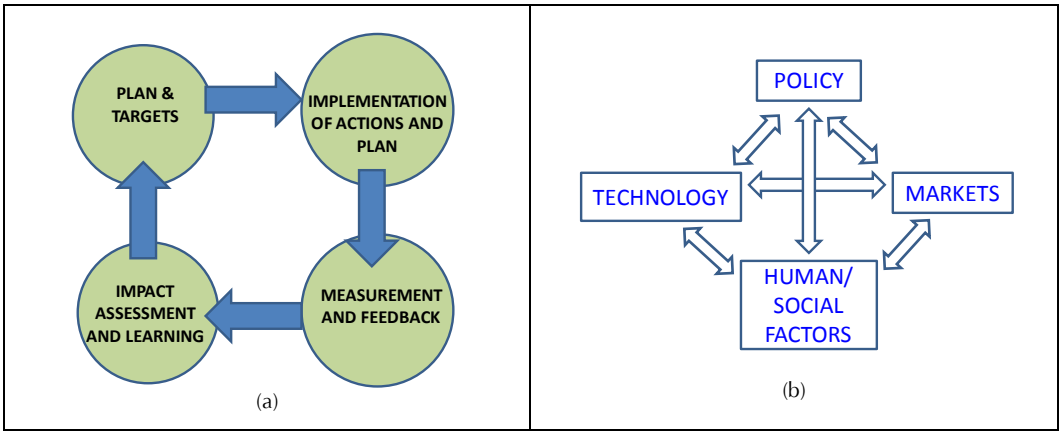


Figure 2. Schematic of climate action plans illustrating the iterative nature of an action plan, an implementation plan, measurement and feedback, and impact assessment and learning (a). Each of the four key elements can be viewed through the lens of coupled technology, policy, markets, and human and social factors interactions (b).

| | **Human/Social Factors** | **Technology** | **Markets** | **Policy** |
|---|---|---|---|---|
| **Plan and Targets** | Role of conservation/ habitual behavior change?<br><br>Education/ Awareness e.g. Eco-driving | Role of key technologies (e.g. controls, networks, end use technologies, energy supply technologies) | Human/social factor intervention and technology cost effectiveness? What are market adoption barriers and relative importance? | What policies can encourage social factor participation and technology adoptions? What is optimal policy trajectory? |
| | Key Barriers Identified? | | | |
| **Implementation Plan** | How best to do outreach?<br><br>How to identify early adoption blocks and neighborhoods? | Test/Pilot/ deployment plans.<br><br>Education | Financing issues | Policies for human/social factors and technology and markets? |
| | Plan to overcome Key Barriers? | | | |
| **Measurement and Feedback** | How to monitor/verify changes? How to capitalize on feedback? | Sensor, feedback, networks | Demand reduction/ demand shift; more comprehensive product labeling | Policies for more feedback |
| **Impact Assessment and Learning** | Impact of implementation and changes? | Total cost of ownership with lifecycle analysis impacts | Impact of implementation on markets e.g. contractor employment | Policy responses |
| | Market Analytics: outreach, response, adoption, penetration metrics and quantification | | | |
| | What are integrated impacts to local economy, to local health, environment? How might these be integrated into an "urban quality index?" | | | |

Table 3. Some interactions and research questions for the dynamics of climate action plans and human/social factors, technology, markets and policy. Human and social factors are usually not included in the implementation plan beyond generalized "outreach plans", and measurement, feedback, impact assessment and learning are not generally addressed.

The Cool City Challenge implementation plan is unique in that it will provide a closed loop learning system. Learning by design, rather than a top down approach of "build it and they will come," e.g. building technology demonstrations and deployments without concomitant seeding of demand at the community level for these new technologies through creating interest in low carbon choices and lifestyle impacts.

LBNL and Empowerment Institute's partnership around the Cool City Challenge brings together for the first time the world-class technology R&D of LBNL in buildings, energy efficiency and energy analysis, IT and technology corporations, and the behavior change, community engagement, large system transformation and scaling strategies championed by the Empowerment Institute. Moreover, the initiative focuses on implementation of carbon reduction plans through specific and quantifiable behavior changes, technologies, and infrastructure in contrast to plans that focus on end states. Similarly, the initiative provides timeframes, locations, and detailed strategies for how to achieve aggressive carbon reduction targets.

Further, the Cool City Challenge initiative provides a platform and test bed for deployment of new technologies, behavior change, community engagement and scaling strategies in cities. In particular it provides a learning lab for technology/human interactions and a tie-in to behavioral change experiments. It also extends the more usual "top down" framework to a "whole system" framework that integrates citizen participation, new technologies, and green economic development with the traditional policy tools of legislation and financial incentives. And the initiative offers the opportunity to design a replicable framework for scaling up low carbon implementation plans to other cities.

The LBNL/Empowerment Institute Cool City Challenge initiative has six key research areas:

1. *Whole System Approach:* How to best integrate citizen carbon reduction actions, community engagement tools, green economic development strategies, a scaling mechanism, technology adoption, market development, and public policy tools.

2. *Adoption Analytics:* How to quantify adoption and penetration for low carbon actions, energy efficiency and technology.

3. *Technology/Human Interface:* How to maximize the human/technology interface to enable the development of new markets for low carbon technologies.

4. *Behavior Change:* How to maximize the quality, quantity and magnitude of citizen carbon reduction actions.

5. *Co-Benefits:* How to measure and quantify the economic, environmental, social and health co-benefits.

6. *Carbon Neutral City:* How to create a structured pathway to a carbon neutral city.

The research focus will include the following case study areas: transportation – vehicle miles traveled (VMT) reduction, residential energy efficiency – household retrofit adoption, and dietary change – eating lower on the food chain and local food. These three areas are chosen because they have either been very difficult to crack as market areas (residential uptake for energy efficiency is smaller than commercial uptake); they represent a large energy and carbon savings opportunity (residential retrofits, VMT reduction, dietary change); and they have not been highly studied or well quantified through citizen participation efforts in the past (VMT reduction and dietary change).

## KEY LBNL RESEARCH TASKS

### Start-up Phase

The methodology for robust data collection and measurement of savings will be developed in this phase. This will include the definition of an appropriate control group for each city and provisions for collecting both spatial (block level) and temporal quantification (persistence) of behavior actions and community participation. Key household action items to be quantified on a pre- and post- program basis will include VMT, energy efficiency retrofits, carbon reduction actions, purchases, dietary habits, water usage and solid waste generation.

Baseline data will be collected and local partnerships established to support the research study. Existing baseline data or statistics from the participating cities will be utilized wherever possible. Partnership with local utilities and/or technology provider companies will be made to collect pre- and post program utility customer data for base lining and ongoing data collection. VMT data collection will rely either on manual data entry or wireless data collection via cell phone/vehicle linkage. Data collection methodology and measurement of savings will be integrated into the Cool City Challenge information management system ("CAPTIN") and LBNL will coordinate partner input for CAPTIN.

One framework that will be employed in the program design is the investigation and possible mitigation of key barriers for actions in transport and energy efficiency (Table 4). For example, neighborhood-based carpooling barriers may include coordination gaps and trust issues and this could be addressed in the EcoTeam framework of increased community trust and a technology partner providing carpooling software integrated into IT and cell phone networks.

During this phase, LBNL will also develop relationships and partnerships for technology demonstrations and pilot projects with industry or other technology stakeholders. This might include technology demonstrations for home energy management systems, advanced lighting products or controls, advanced window coatings, or pilot deployment of heat pump based space heating and water heating or integrated systems with thermal storage. Such technology demonstrations would explore issues and/or barriers with technology adoption and leverage the early adopter population segment to provide a seeding area for promising new applications.

| Barrier | Transport: Barrier Mitigation | Residential Home Energy Efficiency Retrofit: Barrier Mitigation |
|---|---|---|
| Motivation | EcoTeam framework vs. Control (non-EcoTeam framework) | |
| Implementation barriers: coordination/ infrastructure | Neighborhood carpooling software | Demand reduction like programmable or graphical thermostat |
| Culture | Free public transit days | City government marketing to create a new social norm |
| Transactional/time | Public transport lanes and privileges | Utility mandatory audit |
| Financial | Incentives/rebates for public transportation | Free audits for home energy efficiency |
| Trust | Local, dynamic carpooling with EcoTeam or neighborhood | Trusted certified contractors recommended from EcoTeam neighbors |

Table 4. Investigation and possible mitigation of key barriers to citizen carbon reduction actions and technology adoption is enabled with the Cool City Challenge framework and could include some of the above elements in a matrix exploring barriers.

Campaign Phase

Key issues to be studied include measurement and evaluation of behavior changes, community participation, energy efficiency retrofits, and voluntary technology demonstrations. Central to this is the quantification of overall energy and carbon savings by action as part of the structured data collection plan. Effort will also be made to quantify the spatial distribution of EcoTeams, of savings within and across neighborhoods, as well as across time (persistence effects). Semi-annual feedback of results to city and program partners will be provided for program adjustment and improvement and an annual progress report with quantified progress to data will be written for stakeholders, participants and funding sources.

Other issues to be studied include how the behavior change and community engagement tools promulgated by this initiative can help catalyze the full spectrum of GHG reduction interventions spanning technology adoption, policy adoption, and market development; scenario development for what it would take for the participating cities to become carbon neutral by 2025; and the potential GHG and economic development impact of scaling the Cool City Challenge across the state of California and the United States.

Through survey frameworks as well as through EcoTeam member participation data, the research team will seek correlations between population segments, demographics or other characteristics with carbon reduction actions and levels of participation. Comparative cost/benefit analyses of behavior change interventions in comparison to other energy efficiency and carbon reduction programs will be done in terms of baseline adoption rates, energy savings and carbon savings versus program costs. A key question to be addressed is the deployment rate and scope of energy

efficiency retrofitting for Cool City Challenge participants vs. other programs such as the Better Buildings or Energy Upgrade California.

Other key research activities include community-scaling scenarios and non-energy related impact assessments around health, environment, social capital, market development, and local economic development. For example, if higher rates of local energy efficiency retrofits are achieved how would this impact the local rate of employment among contractors and local sales of energy efficient products?

Scenarios will also be built to explore the case where Cool City Challenge results are scaled to larger communities and regions for energy, carbon, and economic impacts. Analysis and recommendations for community engagement "best practices" will be summarized based on quantified dissemination results. Finally carbon neutral scenarios or city-specific requirements will be developed for 2025.

## About Lawrence Berkeley National Labratory

Lawrence Berkeley National Laboratory addresses the world's most urgent scientific challenges including the advancement of more sustainable energy technologies and climate change research. Founded in 1931, LBNL's scientific expertise has been recognized with 13 Nobel Prizes and dozens of Nobel Laureates have either trained at the Lab or had significant collaborations with staff there. Thirteen Lab scientists have won the National Medal of Science, our nation's highest award for lifetime achievement in scientific research.

One of LBNL's major initiatives is "Carbon Cycle 2.0" – a multidisciplinary approach to accelerate discovery and innovation in creating global climate change solutions. The Cool City Challenge fits under this broad initiative and LBNL will lead the research and development effort. LBNL will coordinate research efforts at participating universities and with corporate sponsors as well as support technology demonstrations and pilots with industry and other stakeholders. LBNL will also assist in securing the financing for the Cool City Challenge.

## Core Research Team

*Douglas Davenport* leads strategic partnership initiatives for the Lawrence Berkeley National Laboratory's Environmental Energy Technology Division, an integrated applied sciences research program in energy efficiency and environmental quality, energy resources and storage, and energy policy. Doug's focus is on the value of LBNL's R&D programs to their partners in addressing some of the world's most pressing technical challenges. He's spent the past 23 years as an engineer, leader of a climate consulting practice, renewable energy developer, and business manager. He is currently leading new innovation programs and partnerships on behalf of LBNL for urban sustainability, smart grid, battery technology, and materials science. Doug will be responsible for management of LBNL's core team and will assist with Cool City Challenge financing. He will also serve as lead R&D liaison between industry partners and local government programs and coordinate technology demonstrations and pilots.

*Tom McKone* Ph.D. is the leader of the Sustainable Energy Systems Group and Deputy for Research Programs in the Energy Analysis and Environmental Impacts Department in the Environmental Energy Technologies Division at LBNL. Tom has several decades of experience in scientific analysis and technical management and is an authority on the life cycle analysis/health impacts of energy production. He was a co-author of the recent National Academy report, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. He is also an Adjunct Professor in the Environmental Health Sciences group in the Department of Public Health at the University of California, Berkeley. Tom will lead LBNL's overall R&D activities and coordinate the impact assessment analysis team.

*Jeffery Greenblatt* Ph.D. is a staff scientist at Lawrence Berkeley National Laboratory's Environmental Technologies Division where he leads work on California's energy future analysis for the California Energy Commission, and leads the Environmental Energy Analysis Team for LNBL's Carbon Cycle 2.0 initiative. He was a major author of California's Energy Future report. Prior to his work at LBNL, he was a Climate and Energy Technology Manager at Google.org, where he screened renewable energy grants and investments. Before coming to Google, Jeff was a High Meadows fellow at Environmental Defense Fund where he evaluated the technical, economic and environmental aspects of a wide range of energy technologies. He helped develop the original "wedge" climate stabilization research and has developed scenarios for California, the Midwest, and the US. Jeff will be responsible for community and national scaling scenarios, health and resource impact assessment analysis, and the development of carbon neutral city scenarios.

*Max Wei* Ph.D. is a Program Manager in the Environmental Energy Technologies Division at LBNL. His work is focused on modeling medium- and long-term greenhouse gas reduction scenarios for California, including the potential of long-term habitual behavior change as a resource for carbon reduction. He was a key contributor to two recent reports: *California's Energy Future – The View to 2050*, for the California Council on Science and Technology, and *California's Carbon Challenge: Scenarios for Achieving 80% Emissions Reduction in 2050*, for the California Energy Commission. In 2011 he completed a report on the job creation potential from sustained investment in energy efficiency and low carbon energy sources, co-led successful passage of SB77, a clean energy financing bill in California, and co-authored a study on the economic impacts of a state feed-in-tariff. Max will be responsible for the Cool City Challenge behavior change and community participation measurement and assessment, quantification of carbon savings, and lead analysis of economic and social impact assessment.

For Further Information:

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## ADDENDUM

### COOL CITY CHALLENGE
**REINVENTING OUR CITIES FROM THE BOTTOM UP TO ACHIEVE DEEP CARBON REDUCTION, RESILIENT NEIGHBORHOODS AND GREEN PROSPERITY**

**AN INITIATIVE OF EMPOWERMENT INSTITUTE**

*"The world's cities are responsible for 70% of greenhouse gases and have become the battleground in the fight against climate change. What goes on in cities and how they manage their impact on climate change, lies at the core of the problem."*
UN-HABITAT 2011 Global Report

**PURPOSE**: To scale up a proven community-based social innovation to achieve deep carbon reduction while building a low carbon economy and resilient neighborhoods first in three early adopter California cities (the five city finalists, from which we will chose three, are **San Francisco, Palo Alto, Davis, Sonoma, and San Rafael**) and then throughout California, nationally and worldwide. The ultimate goal of the Cool City Challenge is to change the game around GHG reduction in cities and provide a viable path forward to address climate change.

**NEED AND OPPORTUNITY:** With international climate change legislation failing to get traction and the long timeframe required to scale up new technological solutions and renewable energy, the world is searching for a feasible and scalable strategy for addressing global warming. Since cities represent 70% of the planet's carbon emissions and citizens' daily lifestyle choices represent between 50 and 90% of these emissions, cities and their citizens provide the world with an unparalleled opportunity to address global warming. Further, this serves as a demand-side driver to increase the pace of renewable energy, energy efficiency and new technology adoption.

**STRATEGY:** Empowerment Institute—the world's pre-eminent expert in environmental behavior change and community engagement—over the past two decades has developed a proven methodology to help cities empower citizens to reduce their carbon footprint by 25% through the Low Carbon Diet EcoTeam program (a peer support group of 5 to 8 households) and a block-by-block recruitment strategy to achieve between 25 and 75% household participation. This methodology has now spread to over 300 US cities and 6 countries including China. The Cool City Challenge is designed to bring this transformative social innovation to scale.

**PROJECT SUMMARY:** A full proposal is available upon request.

Phase 1: Start-up (one year) – build program and technology infrastructure.

Phase 2: Campaign (three years) – support cities to achieve their carbon reduction, neighborhood resiliency and green economic development goals.

**TEAM:** The Cool City Challenge is headed up by David Gershon, co-founder and CEO of Empowerment Institute, and one of the world's foremost authorities on behavior change, community engagement and large system transformation. He has led a number of large-scale change initiatives integrating the public, private and civic sectors and his clients have included NYC, Philadelphia and Portland. David has assembled a world-class team of experts and institutional partners to support implementation, research and scaling of the Cool City Challenge including Lawrence Berkeley Laboratory, Stanford, UC Berkeley, UC Davis and the participating cities.

**CONTACT INFORMATION:** David Gershon, dgershon@empowermentinstitute.net