CALIFORNIA AIR RESOURCES BOARD FISCAL YEAR 2015-16 ANNUAL RESEARCH PLAN

February 27, 2015: ZERO CARBON BUILDINGS TECHNICAL FEASIBILITY STUDY

An Interdisciplinary Approach to Evaluating Policy Options to Encourage Zero-Carbon Buildings

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DRAFT TECHNICAL PROPOSAL

Zero Carbon Buildings Technical Feasibility Study:

An interdisciplinary approach to evaluating policy options to encourage zero-carbon buildings

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Check if applicable:
Animal Subjects ___
Human Subjects__x_

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ABSTRACT

Executive Order S-3-05 set an aggressive greenhouse gas (GHG) reduction target of 80% below 1990 levels by 2050. In order to meet this target, California needs to virtually eliminate greenhouse gas emissions from buildings in the coming decades. *New* buildings must not only use zero-carbon energy, but also be designed and planned in ways that minimize their associated emissions from transportation, waste, water and building construction. An even more challenging task will be putting policies in place that reduce emissions from the *existing* building stock. A range of mandatory and voluntary zero-carbon building policies may hold promise to make aggressive reductions in California's GHG footprints. In order to be effective, these policies need to integrate state-of-the-art science and engineering, incorporate input from broad stakeholder coalitions, and the policies must be enacted by laws and regulations that enable the broad dissemination of zero-carbon building (ZCB) strategies.

UC Davis proposes to conduct a study to provide technical and stakeholder input support for the pursuit of low-carbon buildings in California as part of the state's long-term climate program, by assessing the feasibility and effectiveness of a range of different technologies and policy elements and scenarios. The analysis will be based on:

- a broad definition of the integrated systems that result in GHG emissions attributable to buildings, including both upstream and downstream effects;
- identification and analysis of effective and appropriate GHG reduction technologies;
- development and evaluation of appropriate models of technical and policy approaches;
- evaluation of a range of policy elements and deployment scenarios, and their potential efficacy and appropriateness; and
- a nuanced and interdisciplinary approach to stakeholder engagement, to ensure that the resulting policies and programs are developed with an awareness and respect for the realities in the industry currently.

Effective stakeholder engagement is a critical component of this proposed project. If stakeholders' concerns are not well represented during the development of a policy, a lack of industry buy-in can defeat even the best policy. This project will employ a wide range of approaches to:

- raising awareness of the activity,
- collecting intelligence from industry sources,
- stimulating constructive dialogue,
- facilitating a group process of brainstorming and prioritization,
- soliciting and obtaining review of written documents, and
- educating stakeholders on the results.

Using the integrated models that we will develop, the study will result in a set of policy scenarios, with identified pros and cons, tradeoffs, cautions, and considerations for the alternatives. Recommended approaches will be developed and documented, and a "straw man" report will be reviewed and revised with significant stakeholder input. The resulting final report will form the technical and policy foundation for policy-development processes by CARB.

INTRODUCTION

Zero Net Energy Policies

California leads the nation in greenhouse gas mitigation policies. Executive Order S-3-05 of 2005 set an aggressive greenhouse gas (GHG) reduction target of 80% below 1990 levels by 2050, while the Global Warming Solutions Act of 2006 sets an intermediate target for 2020 and requires the California Air Resources Board to develop Scoping Plans to realize the needed reductions. Additional complimentary policies such as the Sustainable Communities and Climate Protection Act of 2008; Title 24, California Code of Regulations; the Renewable Portfolio Standard, 2011; and cap-and-trade will contribute to the interim Global Warming Solutions Act's targeted goals while contributing to the 80% reductions as ordered in S-3-05.

The new zero net energy (ZNE) policy is the latest bold approach to regulate emissions and energy use in California' buildings. California's ZNE targets require all new residential buildings in 2020 and all new commercial buildings by 2030, to meet the definition of zero net energy. However, ZNE has important limitations for helping California meet its GHG reduction goals.

Natural Gas in Zero Net Energy Buildings and Related Considerations for Policies

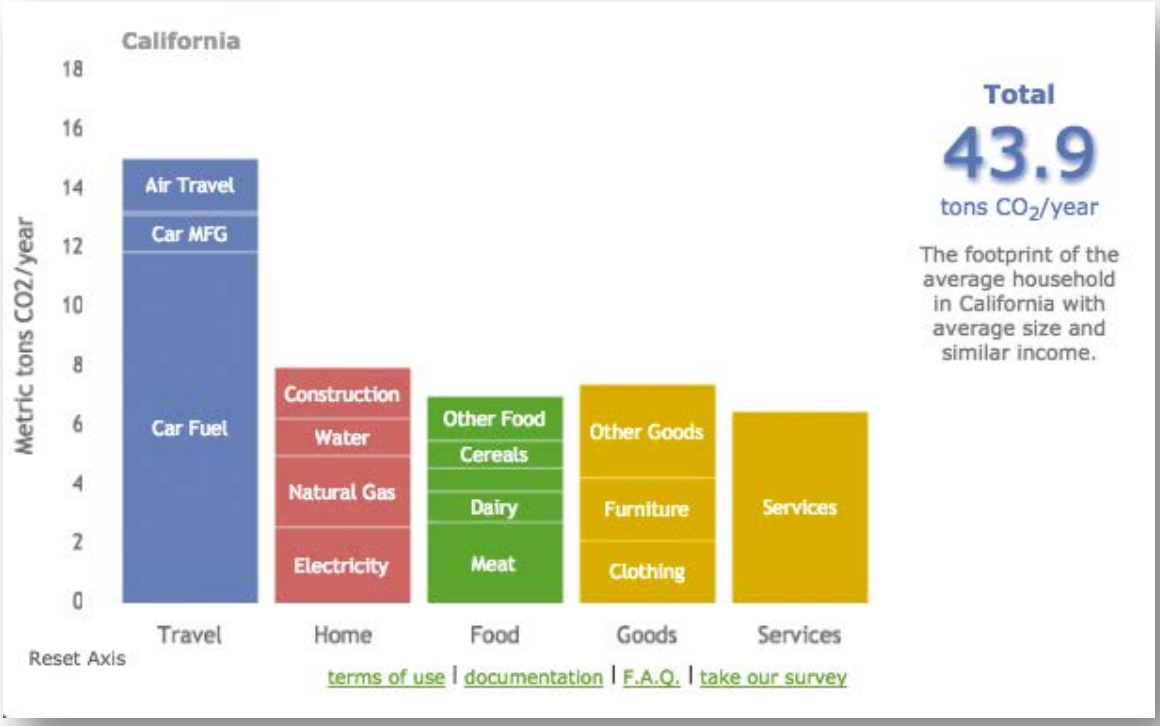
A primary limitation of ZNE is it does not preclude buildings from using natural gas. Under most ZNE definitions buildings can continue to burn natural gas as long as photovoltaic systems are sized large enough to compensate on an energy basis; however, the GHG mitigation potential of additional renewable energy will decline (eventually to zero) as the percentage of renewable energy in the electric grid increases. While such buildings may be technically "zero net energy," the energy they use will not be zero carbon.

This is increasingly problematic. Several recent studies (Long et al. 2011; Wei et al. 2013; Williams et al. 2012) have concluded that California needs to virtually eliminate natural gas from buildings to meet the 80% GHG reduction target of Executive Order S-3-05. Although somewhat more costly, meeting the 2050 target would likely require phasing out natural gas completely by 2030 in new and existing buildings since HVAC systems can be expected to last 20 years or more. At a minimum, it would seem that a bold zero net carbon building standard should require all building energy to be met from zero, or near zero carbon, renewable sources.

Considerations for Zero Carbon Residential Buildings Policies

Another limitation of ZNE is that electricity and energy associated with usage of the building is a relatively small portion (about 10%) of the carbon footprint of residential building occupants. A typical California household contributes roughly 44 metric tons of CO_2 equivalent greenhouse gases (tCO_2e) per year (Jones and Kammen 2011), of which 12 are from motor vehicle fuel, 5 are from energy (2.5 tCO_2e each from electricity and natural gas), 1.7 are from home construction, and 1.25 are from a combination of water, wastewater and municipal solid waste (Figure 1 is a screenshot of the CoolCalifornia.org carbon calculator). Thus, including vehicle fuel, water, waste and construction in a zero-carbon building (ZCB) definition would roughly quadruple the GHG emissions for typical homes compared to considering energy alone (20 vs 5 tCO_2e). Emissions from electricity will also decline over coming decades due to renewable portfolio standards and on-site solar technologies, making the contribution other sources larger in comparison.

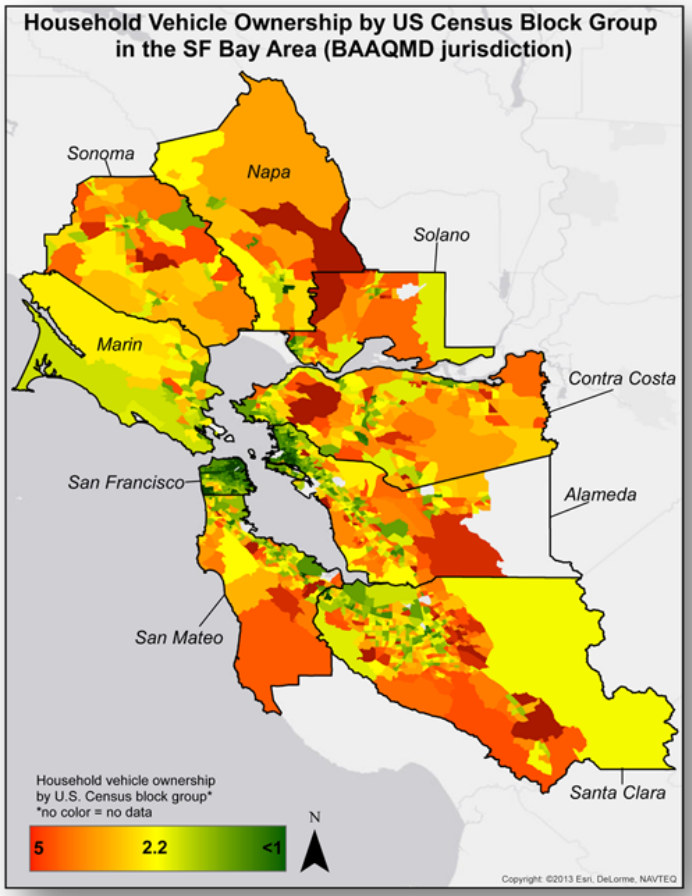
Figure 1. Carbon footprint of typical U.S. household (coolcalifornia.org/calculator)



At the same time, urban planning and building design choices directly and indirectly affect emissions from sectors far beyond just energy. Larger buildings, and buildings with more carbon-intensive materials such as steel and cement, produce more emissions in the production of materials, assembly and demolition. Water consumption is greatly affected by building design choices and the size of irrigated landscaping. The siting of homes also plays a critical role in determining emissions from transportation, waste and water.

Location (or building siting) is the single largest factor contributing to emissions from motor vehicles (Jones and Kammen 2014) and household carbon footprint overall. Figure 2 shows vehicle ownership at the level of U.S. Census Block Groups for the San Francisco Bay Area (U.S. Census). Vehicle ownership is strongly correlated with vehicle miles traveled and emissions. Many neighborhoods in San Francisco and the East Bay have average vehicle ownership of less than one vehicle per household compared to over 4 vehicles in some of the most distant suburbs. The UC Berkeley researchers included in this proposed project team are currently developing household carbon footprint estimates at the scale of U.S. Census Block Groups for the San Francisco Bay Area. Extending this to work to all of California would be particularly useful in estimating transportation-related emissions from new and existing residential buildings throughout the state.

Figure 2. Average vehicle ownership by Census Block Group (U.S. Census data)



If transportation is included, homes sited in rural and suburban, high carbon footprint locations will need to oversize their renewable energy production to partially compensate for higher motor vehicle emissions. Zero carbon homes should probably also have PV systems with inverters and roof space available to charge a sufficient number of electric vehicles. On the other hand, if location of homes is not considered in a ZCB definition, then developers who build homes in distant suburbs, which contribute the most to household GHG emissions, will receive the same emissions score as builders focusing on beneficial urban infill. From this perspective, location and transportation seem highly relevant to a potential zero-carbon building definition.

Location also affects emission from water and waste. Emissions resulting from the extraction, processing and transport of water vary considerably by location; e.g., the GreenPoint Rated Calculator includes a ten-region model for California (Jones et al., 2012). While waste streams largely depend on building occupants, the technologies used to process waste vary by location (e.g. based on the presence of waste to energy technologies).

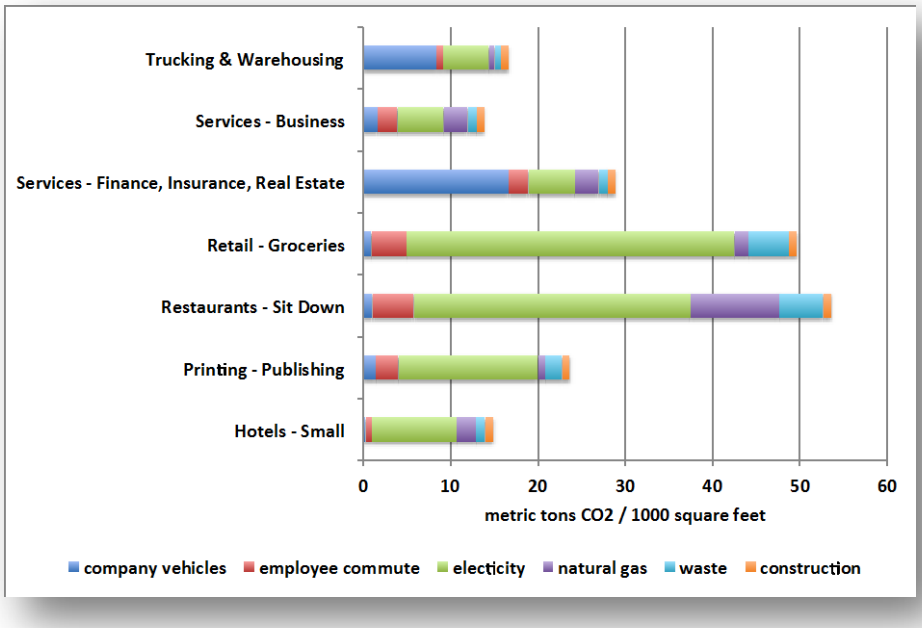
Several tools have been developed for CARB that form a strong foundation for further analytical work relevant to a zero carbon homes. Chris Jones, the Lead Researcher for the UC Berkeley contingent on this proposed project team, led the development of these tools. The CoolCalifornia Calculator produces benchmark carbon footprint estimates for every zip code in California, including emissions from building energy, waste, water, construction and transportation. A second tool, the GreenPoint Rated Calculator, (which was also developed by UC Berkeley researchers for CARB—see (C.M. Jones et al., 2012)), provides a carbon footprint estimate based on the assets of homes, including major appliances, landscaped area, insulation, the size of photovoltaic systems and other important home features.

Considerations for Zero Carbon Commercial Building Policies

The carbon footprint of commercial buildings varies greatly depending on the type of business that occupies the space. When commercial buildings are constructed they typically include HVAC systems and minimal lighting, but equipment and usage will be determined largely by building occupants. Figure 3 shows major components of business carbon footprints (transportation, building energy, waste and building construction) per square foot from for typical businesses in Sacramento, California (CoolCalifornia.org/business-calculator). For example, grocery stores consume over 7 times as much electricity per square foot as commercial businesses, while restaurants consume over 10 times as much natural gas. There are also large differences between waste streams and transportation-related emissions for different business types. Considering that many buildings have multiple business types that change over time it may be very difficult to construct meaningful estimates of zero carbon commercial buildings unless they are updated on a regular basis. Consumption of water for different business types is not well understood, but would also presumably vary considerably by business types (e.g., restaurants vs. offices).

These differences in building carbon footprints make evaluating life-cycle GHG emissions at the construction phase problematic. An initial assessment is certainly feasible for benchmarking purposes and compliance with standards, but ongoing measurement would likely be required to determine whether a building is zero carbon in its operation phase. UC Berkeley developed a CoolCalifornia Small Business Calculator, which could be a starting point for development of tools for commercial buildings.

Figure 3. Annual GHG emissions per square foot from transportation, energy, waste and construction for typical businesses in Sacramento, CA (CoolCalifornia.org Small Business Calculator)



Considerations for Zero Carbon Existing Buildings Policies

Achieving new Zero Carbon Buildings will be a challenge. Once the system boundary is expanded to include transportation and other non-building energy sources, finding opportunities to displace such a significant level of emissions will require innovative motivators, design processes, policies, and technologies. However attractive it is for designers, researchers, and policymakers to focus on these "blank slate" opportunities, it must be recognized that most of the emissions that will occur between now and 2050 will be from buildings that *have already been built*. Reducing emissions from the massive existing building stock is much more challenging than new construction, both technically and in terms of policy options and the requirement for engagement from a wide range of stakeholders.

One difference between new and existing buildings is that the incremental improvements to achieve Zero Carbon new buildings will come at an *incremental* cost. With existing buildings however, most of which have no other reason to be making these significant building modifications, the *full* cost of the improvement will have to be considered in evaluating the cost-effectiveness. The improvements will also disrupt the lives and workplaces of building occupants who are currently comfortably settled into their buildings, which will affect the adoption of the policies.

Similarly, the earlier the new building design process that considers carbon emission reductions, the less expensive they are to implement. For existing buildings, however, consideration must be given not only to implementing the improvements, but also to removal of existing infrastructure and adapting improvements carefully to match the as-found conditions. Anyone who has ever watched *This Old House* knows that existing buildings are a minefield of potential problems that can't be assessed until demolition and construction have begun, requiring adaptive development of on-the-spot solutions. The home renovation industry that has developed to deliver these custom solutions may not adapt well to a "cookie cutter" approach.

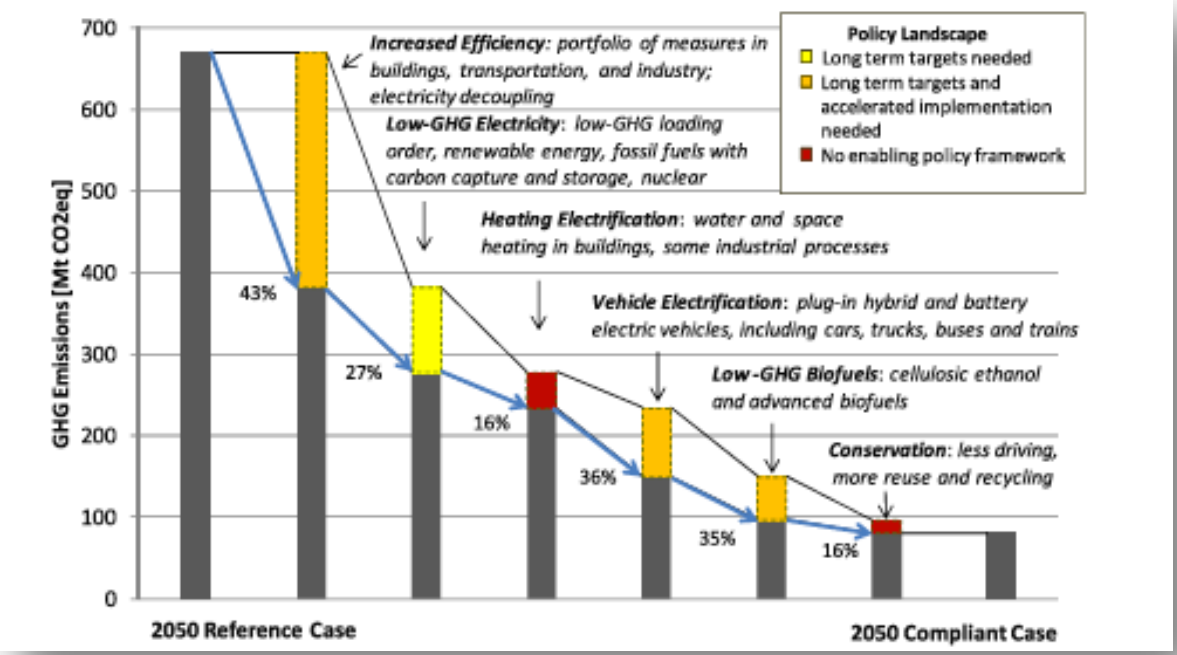
It can be anticipated that a different set of policy alternatives that may be suitable for new buildings will not make sense for existing buildings. For example, California's building code—Title 24 tends to work well for new construction. However, for renovation, it has been much less successful. For example, it has been found that currently on the order of 90% of residential HVAC replacements are done without the required building permit (Heinemeier, 2012). Improvements such as these then will not be influenced by tighter or broader-scoped zero-carbon building standards.

A combination of mandatory and voluntary zero carbon existing building policies and programs will be needed to make aggressive reductions in California's GHG emissions. However, in order to be effective, these policies need not only to integrate innovative state-of-the-technologies, but they must be designed to creatively respond to the reality of the building industry, and take a nuanced view of the barriers and opportunities for zero carbon buildings. For this reason, the proposed project will include a very significant stakeholder engagement element, including asking the system experts on the research team, who have a history of cooperative engagement with the various industries, to lead the design and implementation of effective stakeholder engagement activities.

The Role of Electrification in Zero Carbon Buildings Policies

Meeting the state's 2050 GHG target will require massive improvements in energy efficiency as well as low and zero-carbon electricity, electrification of transportation and building heating, low-GHG biofuels and conservation measures to reduce demand for GHG-intensive behaviors. Figure 4 demonstrates the scale of reductions needed (reprinted from Wei et al., 2013) under a compliance case.

Figure 4. GHG reduction requirements to meet California's 2050 target of 81 MtCO2. Size of reduction expressed relative to previous measures to the left of each bar (reprinted from Wei et al., 2013)



In this figure the size of reductions are relative to all previous measures to the left. The way in which buildings and communities are planned affects potential reductions in all of these areas. Building design and community planning affects energy and water usage as well as access to distributed and community-scale renewable energy.

Electrification of transportation depends on feasible charging as well as shorter distances to urban centers to reduce travel. Heating electrification will only be possible through strong building standards and legislation (e.g., phasing out), while biofuels may be planned to meet heating, cooking and transportation needs. And conservation of energy, transportation, water and waste may be enabled through smart and sustainable building and community design practices. In order to achieve the State's targets in the timeframe provided, all new buildings from now on must not only consume zero energy directly, but also be designed and planned in ways that minimize emissions from transportation, waste, water and building construction.

OBJECTIVES

UC Davis proposes to conduct a study to provide technical and stakeholder input support for the pursuit of low-carbon buildings in California as part of the state's long-term climate program, by assessing the feasibility and effectiveness of a range of different technologies and policy elements and scenarios. The analysis will be based on:

- a broad definition of the integrated systems that result in GHG emissions attributable to buildings, including both upstream and downstream effects;
- identification and analysis of effective and appropriate GHG reduction technologies;
- development and evaluation of appropriate models of technical and policy approaches;
- evaluation of a range of policy elements and deployment scenarios, and their potential efficacy and appropriateness; and
- a nuanced and interdisciplinary approach to stakeholder engagement, to ensure that the resulting policies and programs are developed with an awareness and respect for the realities in the industry currently.

This research will explore the technical feasibility of net zero or near-zero carbon residential and commercial new buildings which will support the development of state goals and a policy and programmatic path towards transitioning to zero carbon building. This proposed project will also identify the most appropriate definition of zero-carbon buildings, explore building configurations that reduce or "pay-back" the GHGs emitted in the process of construction and operation, evaluate their cost effectiveness and market readiness, and recommend a set of policy elements and scenarios that may lead to the most cost-effective GHG savings, including effective integration of technologies and high levels of consumer adoption.

In order to chart a path with achievable zero-carbon buildings goals, the team will first review and outline existing policies. Some existing policies set goals, some are strict mandates, some may incentivize a technology, while others may limit the use of particular technologies. By reviewing and identifying overlaps in policies, the team will be able to chart, describe, and present existing policies that provide opportunities, as well as policies that may act as barriers.

For example, policies like the Global Warming Solutions Act, 2006 and the Renewable Portfolio Standard, 2011 contribute to the fulfillment of Executive Order S-3-05 which sets a goal of an 80% reduction in greenhouse gas emissions (from 1990 levels) by the year 2050. As stated in above, California is home to many aggressive and ambitious policies, strategies, models and regulations though there is a lack of cohesion amongst them.

The team at UC Davis and UC Berkeley will review existing programs in water, waste and transportation; and evaluate how they may be improved upon or expanded to allow for additional greenhouse gas savings.

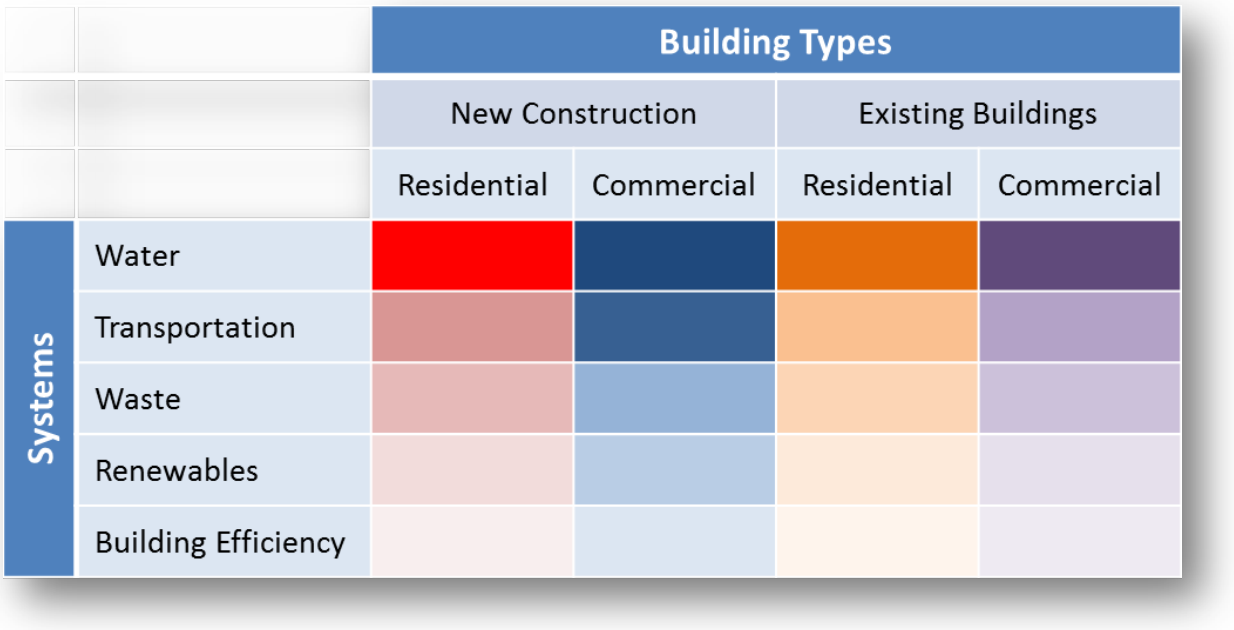
To best support the Board's regulatory programs and potential upcoming policy decisions, the project will provide not only solid technical analysis, but will focus on finding ways to creatively engage a range of stakeholders, to ensure that the policies will be feasible and palatable, and obtain some level of stakeholder buy-in.

TECHNICAL PLAN

Experimental Techniques

The proposed project will incorporate a comprehensive set of research methods that utilize the significant expertise of all of the team members, in order to provide the technical and policy foundation for consideration of programs or policies to effectively promote zero-carbon buildings. The analysis considers a broad definition of the integrated systems that result in GHG emissions from buildings, including both upstream and downstream effects. Because all of the systems are so unique, and their use in different types of buildings will also be unique, we will consider a number of combinations of systems and building types. The analysis is structured to consider the following systems: water, waste, renewable energy, transportation, and building efficiency, as well as the following building types: new residential, new commercial, existing residential, and existing commercial. (This is illustrated in Figure 5).

Figure 5. Matrix of Twenty Combinations Considered in the System- Specific Modeling Stage.



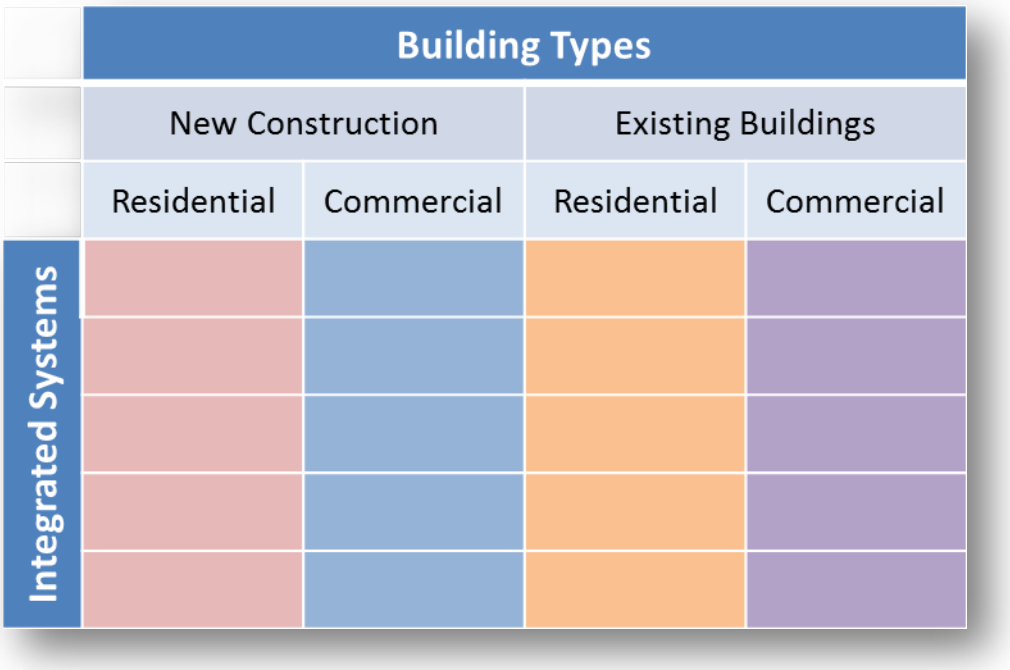
The research methods include the following:

1. An innovative and iterative process of stakeholder engagement will ensure that the identified policy considerations are accurate and well-grounded in the realities of the building industry, as it stands today. A set of System-Specific Panels of Industry Experts ("SPIEs") will be formed, composed of industry, academic, government, and non-profit experts in each of five different systems, in order to provide input on the goals and scope of the project. Broad stakeholder input will be sought through a combination of methods, potentially including online collaborative brainstorming, face-to-face meetings, one-on-one interviews, and webinars. This input will gauge interest in and feasibility of actually implementing voluntary and mandatory zero-carbon building measures. Stakeholder

input will be sought at various points throughout the study as we define the analytic framework, document and analyze the available technologies, models, and verification methods for zero-carbon buildings, and identify policy elements to be considered.

2. The research team's domain-expert System Leads will each be responsible for documenting and evaluating best available and cutting-edge building technologies and design practices for their respective systems and for different building types, to reduce costs and GHG impacts of buildings (see, again, Figure 5). These synopses will form the basis for development of individual system models of GHG emissions. The experts will also evaluate any available models for the system, and the appropriateness of their assumptions, normalizations, and simplifications. Gaps will be identified and addressed in the integration stage.
3. Greenhouse gas modeling will incorporate lessons from the technology evaluations; by adding to existing modeling efforts to develop four integrated spreadsheet tools that will estimate full life cycle building carbon footprints for new and existing residential and commercial buildings (see Figure 6). Modeling will include econometric analyses of available survey data (e.g., Residential Energy Consumption Survey, Commercial Building Energy Consumption Survey, Residential Appliance Saturation Survey, National Household Travel Survey, and other relevant surveys), spreadsheet model development of carbon footprints under different scenarios, and Monte Carlo simulation to estimate the relative sensitivity of model outputs (e.g., total life cycle GHG emissions of buildings) to variations in the inputs, identifying the highest priority policy targets. The resulting models will be validated by the stakeholders, and then used to develop and evaluate various policy options.

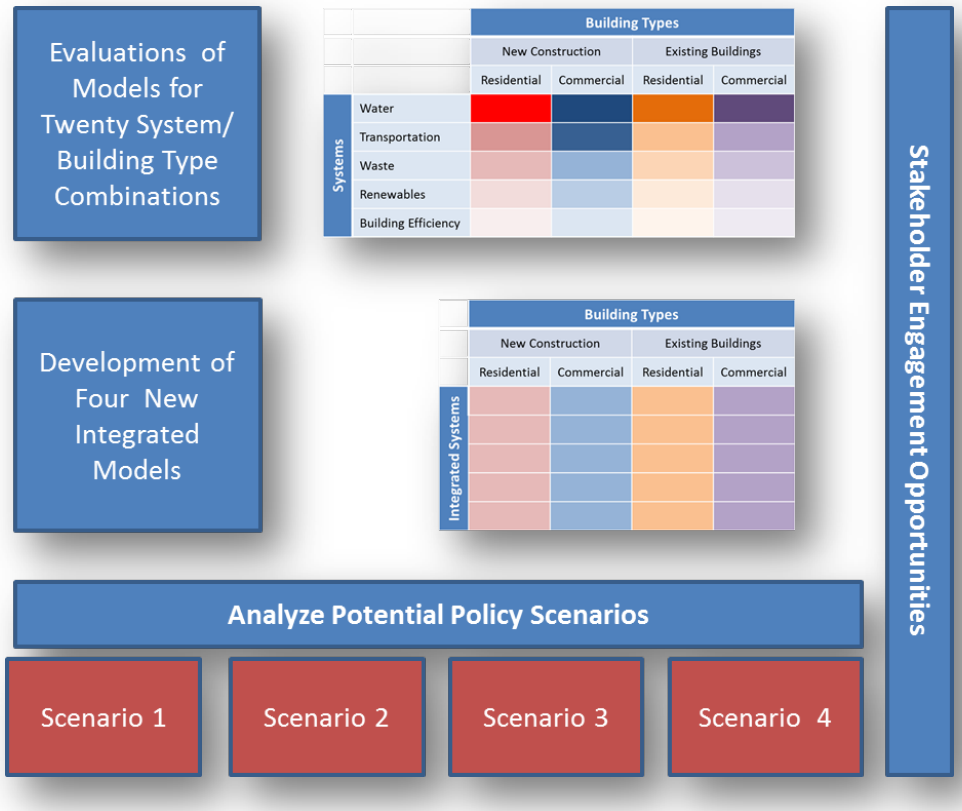
Figure 6. Matrix of Four Building Types Considered in the Integrated Modeling Stage.



4. A range of policy frameworks will be defined. For each, pros and cons will be laid out, cautions will be noted, and factors that must be addressed will be identified. Several alternative straw man policy frameworks will be documented, considering information gathered from technology evaluation, modeling, and stakeholder engagement. It is expected that the output of this task will be a small number of policy "scenarios" that identify the key policy elements, potential barriers, proposed pathways, pros and cons, and other critical issues to address. It is also expected that the result may be in the form of a "menu" of policies that different regions may adopt, to accommodate their varied circumstances. The stakeholder experts will be engaged in various ways to vet and test the policies and model outputs, in order to test the feasibility of implementing policies. A draft final and final report will be produced, and after a period of stakeholder and sponsor review a revised report will be produced.

Although the process outlined above may appear linear, it will actually involve several opportunities for iteration, so that relevant stakeholder engagement opportunities will be provided throughout the process, and they will influence the models and policy scenarios delivered. The eighteen month schedule for the project provides ample time for careful analysis, data collection, model-development, engaging with stakeholders, and developing policy scenarios—as well as iteration among tasks.

Figure 7. Illustration of the Flow of the Entire Zero Carbon Buildings Technical Feasibility Study



Major Tasks

Task 1: Framework for Analysis and Stakeholder Engagement.

Task Lead: Kristin Heinemeier, UC Davis Energy Efficiency Center
In Task 1, a framework for analysis will be developed through stakeholder engagement, including convening of a series of **System-Specific Panels of Industry Experts ("SPIEs")**, to generate dialogue between a range of public and private stakeholders through a range of processes that could include facilitated workshops, on-line collaborative brainstorming and prioritizing, interviews and surveys.

1.1. Project Management

The project will be managed and overseen by both of the Co-Principal Investigators: Elise Brown and Kristin Heinemeier. Specific management responsibilities will be defined for each during this first task, and a Detailed Project Plan will be developed. The plan will identify how project progress will be measured against the plan to ensure that the project remains on-schedule, and how deviations from the planned schedule will be detected and corrected. Each of the quarterly reports and meetings with CARB will be ideal points to step back and assess progress, and plan for getting back on track.

1.2. Define Framework for Analysis

The research team will begin by articulating and refining the objectives of the study and the resulting deliverables, in consultation with CARB. Since the implementation of zero-carbon buildings policies hinges directly on how the boundaries are drawn for the analysis—or the definitions chosen for Zero-Carbon Buildings—one of the first steps will be to lay out the range of possible definitions. Some potential considerations, several example definitions, and discussion of their implications are available in the Supporting Material section of this proposal.

A research approach will be developed, including identifying evaluation criteria for the technology and policy evaluations. These criteria might include metrics and benchmarks. Ensuring that all of the options are considered on a level playing field using the same units of measure will be one of the contributions of this effort. In order to ground this planning, the team will use the results and lessons learned from West Village and the City of Davis as case studies, to help define and validate the analytical framework. This will involve soliciting input from entities involved in both developments, although UC Davis and the specific proposed team members already have substantial experience with West Village through several research projects conducted in this "living laboratory."

1.3. Define Framework for Stakeholder Engagement

Effective stakeholder engagement is a critical component of this proposed project. If stakeholders' concerns are not well represented during the development of a policy, a lack of industry buy-in can defeat even the best policy. This project will employ a wide range of approaches to:

- raising awareness of the activity;
- collecting intelligence from industry sources;

- stimulating constructive dialogue;
- facilitating a group process of brainstorming and prioritization;
- soliciting and obtaining review of written documents; and
- educating stakeholders on the results.

This project proposes to assemble SPIEs for each of the five identified systems, which will be consulted regularly throughout this project. Each SPIE will include stakeholders such as academic experts, California agency staff, industry representatives, utility representatives, building owners and occupants, environmental advocates, and others.

In order to maximize the effectiveness of this engagement activity, the project team will begin by articulating, in terms that are motivating for the different types of stakeholders, the objectives of the study and the resulting policies. Communications will be developed, custom tuned to each type of stakeholder. This may include items such as separate web-pages on a study website, brochures, letters, or PowerPoint slide sets. These communications will also lay out the expectations and responsibilities of membership on the panels. The SPIE members will be expected to review several drafts, to attend a small number of in-person or web-based stakeholder meetings, and to reach out to others in their field.

All of the system leads will leverage their professional networks in their areas of expertise, and select several individuals to be considered for membership in their SPIE. Care will be taken to ensure a balanced representation of different constituencies on the panels. In consultation with CARB, individuals will be selected and invited by the system leads.

In order to launch the study and give the SPIEs an introduction to the study and each other, a team-building activity will be devised, based upon interactive and collaborative brainstorming technologies (such as GroupMap.com).

Task 2: System-Specific Technology and Model Evaluations.

Task Lead: Kristin Heinemeier, UC Davis Energy Efficiency Center
Task Contributors*: *Energy: David Grupp; ***Renewables***: Adam Schultz & Elise Brown; ***Transportation***: Gustavo Collantes; ***Urban and Regional Planning***: Chris Jones; ***Water***: Kendra Olmos; ***Waste***: Jacques Franco; ***Construction Materials***: Chris Jones

In Task 2, a technology evaluation report will be produced for each of the building types: new residential, existing residential, new commercial, and existing commercial. Each report will document and analyze the current state of the art technologies for reducing carbon emissions in the five identified systems (water, waste, renewable energy, transportation, building efficiency).These white papers will identify leading GHG technologies that can reduce GHG emissions beyond existing building energy, water and transportation codes,

2.1. Technical Foundation for Low- or Zero-Carbon Buildings by Type

The team's System Leads will each provide a concise report on the current state of knowledge for their sector. These reports will outline existing and promising tools, data, and analytic approaches for various technologies, and identify research gaps and potential greenhouse gas saving strategies. Essentially, these Technology Evaluations will identify the most critical "knobs" that must be adjusted in order to get the best accuracy in a model of the system.

In the course of this data collection, we will identify promising technologies, assess factors such as high-performance design solutions, technologies, and building operation strategies most likely to enable zero/near-zero GHG emissions. We will identify the "state of the art" for each system, and evaluate the technologies, according to criteria established in Task 1.

2.2. Detailed Review of the Available Models

From this evaluation, gaps will be identified in the availability of suitable models, and where possible, these gaps will be further studied and new data collected. A suitably scoped plan will be developed in consultation with CARB on what information must be collected. This may include things such as:

- identifying more realistic assumed values for variables,
- including functionality to allow the user to specify a factor in richer detail,
- removing unnecessary detail to make it more user-friendly,
- allowing for different levels of aggregation that may be needed in the policy implementation phase, or
- conduct data collection and analysis that are needed to support adaptation of the existing model "pieces" to an integrated model, suitable for policy implementation.

This task will include investigation of building performance simulations for a set of standard building types utilizing the strategies to determine feasibility of achieving zero/near-zero emissions with known technologies and solutions for both residential and commercial buildings in different regions of the state. Estimation of construction cost premium and payback period associated with near-zero-carbon building, to the extent possible.

We will run scenarios for each in the model and document the potential greenhouse gas savings of each measure. The sensitivity to different inputs will be estimated for the system-specific models, which will help to prioritize the inputs necessary for the integrated model.

2.3. Technology and Model Evaluation Reports

Each of these evaluations will be documented in a *Straw man System-Specific Technology and Model Evaluation Report*, to include all elements described above.

A meeting of each of the SPIEs will be convened through either a face-to-face or webinar meeting, to review the findings of the analyses and recommendations. Here the section leads will aim to:

- introduce the policy drivers for a ZCB program;
- discuss opportunities and challenges in achieving near-zero carbon status on new and existing residential and commercial buildings;

- discuss and solicit feedback on the analysis and policy frameworks considered;
- solicit comments on the *Straw man System-Specific Technology and Model Evaluation Reports* for each system; and
- gather information to assist in adapting and evaluating the system-specific models.

Using the feedback from the SPIEs and system leads, the team will revise and finalize the reports, which will constitute the *System-Specific Technology and Model Evaluation* section of the Final Report.

Task 3: Integrated Models of Greenhouse Gas Emissions.

Task Lead: Chris Jones, UC Berkeley Renewable and Appropriate Energy Lab
The goal of this task is to develop greenhouse gas scenario planning models that evaluate the potential of ZCB policies to reduce GHG emissions from 2020 through 2050. Four integrated models will be built: new residential, new commercial, existing residential, and existing commercial. These models will build upon existing research already conducted by UC Berkeley for ARB. The models will then be evaluated by stakeholders and results refined for incorporation into the final report.

3.1. Review and Improve Existing Integrated Models

Several integrated carbon management tools developed by UC Berkeley for CARB will form the analytic foundation of zero-carbon building models developed for this contract. This subtask will review the existing models for their application to ZCB, make needed improvements, and make them available to CARB for use on CoolCalifornia.org and other applications.

The spreadsheet version of the GreenPoint Rated (GPR) Calculator (which was developed by UC Berkeley in collaboration with Stopwaste.org and Build-it-Green) provides benchmark carbon footprint values of any residential building (new or existing) based on the assets of the structure (location, number of rooms, age of appliances, heating fuel, landscaping, etc.). The tool includes emissions from energy, waste, water and building construction. With some minor modifications (e.g., including the size of PV systems) GPR would be appropriate as a scoping tool to estimate compliance with ZCB definitions. Our intention would be to make the spreadsheet version of the tool available to the public (assuming there is agreement from Build It Green and Stopwaste). A much more useful strategy would be to incorporate improvements into the online tool hosted by Build-it-Green. CARB would need to negotiate improvements to the online tool separately with Build It Green. The GreenPoint Rated system is already mandated in dozens of cities and counties across California. GPR could be useful as a vehicle to implement a ZCB standard (either voluntary or mandatory) across the state.

The CoolCalifornia.org carbon footprint calculator for households provides benchmark consumption and carbon footprint values for every zip code, city and county in California (and the U.S.). UC Berkeley researchers are currently extending the spatial resolution of this benchmarking down to Census Block Groups for the San Francisco Bay Area. The same methodology could readily be extended to all of California as a work task for the proposed project. This would be particularly useful for localizing carbon footprint estimates, e.g.,

assessing vehicle miles traveled (VMT) for each building location.

UC Berkeley has developed the CoolCalifornia Small Business Calculator, which would be improved and adapted for use as a benchmarking tool for zero carbon buildings. It may be necessary to construct an asset tool, similar to the GreenPoint Rated Calculator but for commercial buildings. Research and design choices will need to be made in close consultation with research partners and the Steering Committee in order to determine what is feasible in the given timeframe and budget.

In this task, the potential to leverage these tools will be assessed and a development approach will be selected. Depending on the scope of changes needed, some additional GHG reduction measures may also be incorporated into the existing CoolCalifornia tools based on modeling efforts and data provided by each sector in Task 2.

3.2. Develop New Integrated Models

Leveraging wherever possible the extensive work already conducted by UC Berkeley to develop carbon footprint benchmarking tools for residential buildings (GreenPoint Rated Climate Calculator), households (CoolCalifornia.org calculator), businesses (coolcalifornia.org/business-calculator), and communities (Local Government Decision-Support Tool), new tools will be developed.

Four separate simple spreadsheet tools will be developed that will benchmark carbon footprints for new and existing residential and commercial buildings based on key characteristics, at various levels of aggregation. Modeling will include econometric analyses of available survey data (e.g., Residential Energy Consumption Survey, Commercial Building Energy Consumption Survey, Residential Appliance Saturation Survey, National Household Travel Survey, and other relevant surveys), spreadsheet model development of carbon footprints under different scenarios. Monte Carlo simulations will be used estimate the relative sensitivity of model outputs (e.g., total life cycle GHG emissions of buildings) to variations in the inputs, identifying the highest priority policy targets.

It should be noted that we anticipate developing “benchmarking” tools, rather than engineering models. This will provide the best match between the ability to collect the necessary characteristics data and the accuracy of the model. ENERGY STAR Portfolio Manager is an example of such a benchmarking tool: it allows entry of energy use data, and uses simple characteristics data such as zip code, square footage, system type, and number of occupants in order to normalize the usage so that the relative efficiency of different buildings can be compared. Other examples of benchmarking tools include the CoolCalifornia calculators for households, small business, residential buildings (GPR) and communities.

Scenario model inputs will include variables such as scope of policies (e.g., do they include transportation), number of buildings affected, reductions achieved by the policy by sector (energy, waste, etc.), carbon-intensity of technologies and the ramping up of policies over time. The output will be total GHG savings over a thirty-year time horizon (2020 - 2050) compared to baseline. Sensitivity of the models to inputs will be tested using Monte Carlo simulation through thousands of model runs to test the strength of model inputs on end results (GHG savings).

3.3. Review and Refine Integrated Models

The models and results will be presented and tested by stakeholders through the SPIE process, described in Task 1. The models will then be revised based on stakeholder feedback (to the extent possible) and results will be incorporated into the Final Report. The models themselves are also a deliverable of this project.

The results of these scenario runs will inform the policy recommendations and process in Task 4. Again, this will likely be a quite iterative process, where policy considerations will influence the design of the models, and model outputs will be used to evaluate policy options.

Task 4: Recommended Policy Elements and Scenarios.

Task Lead: Elise Brown, UC Davis Policy Institute for Energy, the Environment, and the Economy

The goal of Task 4 is to develop and evaluate feasible policy frameworks to encourage ZCB delivery, and to assess what complimentary policies may be needed to support successful implementation. The team will review existing programs or models in water, waste and transportation; and evaluate how they may be improved upon or expanded to allow for additional greenhouse gas savings. A set of promising policy elements will be evaluated and discussed. The advantages and disadvantages of each will be described, and other considerations essential to the policy-making process will be identified. These elements will be brought together in a set of potential policy "scenarios," which will be developed, reviewed, analyzed, and adoption paths recommended.

4.1. Assess Appropriate Policy Elements

In order to chart a path with achievable zero-carbon buildings goals, the team will first review and outline and assess existing policy elements and scenarios. Some existing policies set goals, some are strict mandates, some may incentivize a particular technology, while others may limit the use of particular technologies. By reviewing and identifying overlaps in policies, the team will be able to chart, describe, and present existing policies that provide opportunities, as well as policies that may act as barriers.

The following are some of the potentially promising policy elements that will be identified and analyzed, though a more thorough list will be developed if funded.

- Building Measurement and Certification Systems
    - Mandatory Rating System (e.g., part of Title 24)
    - Voluntary Rating System (e.g., new standard for GreenPoint Rated program)
- Enabling Policies
    - Feed-in-tariff
    - Community Solar / Community Choice Aggregation
    - Community Financing (PACE, etc.)
    - Cap-and-trade

    - Carbon tax
- Behavioral Approaches
    - Group Buy Discounts
    - Competitions (e.g., the CoolCalifornia City Challenge)
    - Incentives for various efficient or generation technologies
    - Energy scheduling
    - Smart charging
- Policies that may act as barriers
    - Net energy metering rules
- Regional and Urban Planning (the roles of local planning jurisdictions, MPOs, air districts, associations of local governments, etc.)
    - Development of robust charging station infrastructure

The advantages and disadvantages of each element will be discussed, and other considerations will be pointed out, such as potential issues with equity across the state, adaptability of current industry processes, unforeseen costs, potential unintended consequences, and critical implementation considerations.

4.2. Assess Appropriate Policy Scenarios

We will develop and evaluate several scenarios for the years 2020 through 2050. One scenario, for example, might be to provide a "menu" of possible approaches, allowing different buildings, communities, or regions to identify the most appropriate policy given their local conditions. Other examples of scenarios that might be developed include a baseline or business-as-usual case, aggressive mandatory or voluntary building standards, a strong community-based educational emphasis, a carbon-tax, etc.

Using the integrated models developed in Task 3 to estimate the potential GHG reduction of different ZCB policy scenarios will help us to provide pros and cons, tradeoffs, cautions, and other considerations. The team will work with stakeholders to identify possible program design and structures that may encourage the adoption of specific technologies or programs as a whole. We will assess the practicality and appropriate timeframe for a state policy or program. By comparing existing policies (both in California and elsewhere) the team can evaluate their adoption rates and effectiveness. These will be included in the final report as recommendations for any program development and quantification protocols.

4.3. Develop and Review Recommendations for Policy Elements and Scenarios

Based upon the evaluations in the first two sub-tasks of Task 4, we will develop recommended approaches, including discussion of considerations for their implementation and justification for the selected elements. These recommendations will be documented in a *Recommended Policy Elements and Scenarios* "Straw man" report, to include all elements described above.

A joint meeting of the five SPIEs will be convened through either a face-to-face or webinar meeting, to review the findings of the analyses and recommendations. We will aim to:

- Discuss and solicit feedback on the recommended policy framework.

- Provide comments on the *Recommended Policy Elements and Scenarios* "Straw man" report.
- Gather input on taking the next steps to adopt and implement policies.

Using the feedback from the SPIEs and system leads, the team will revise and finalize the report, which will constitute the "*Recommended Policy Elements and Scenarios"* section of the Final Report.

Task 5: Draft Final Report on Zero Carbon Buildings Technical Feasibility Study.

5.1. Draft Final Report

We will compile the different sections into a unified *Final Report on Zero Carbon Buildings Technical Feasibility Study*" and submit to CARB for review and comments.

Task 6: Amended Final Report & Seminar on Zero Carbon Buildings Technical Feasibility Study.

6.1. Final Report & Seminar

We will continue to work with CARB and the stakeholders to assist in dissemination and review of the Final Report, and will deliver a *Revised Report on Zero Carbon Buildings Technical Feasibility Study*.

Deliverables

Task 1: List of SPIEs and their members

Task 2: Straw man System-Specific Technology and Model Evaluation Reports

System-Specific Technology and Model Evaluation section of the Final Report

Task 3: Integrated Models of Greenhouse Gas Emissions section of the Final Report

Electronic Versions of the Integrated Models of Greenhouse Gas Emissions

Task 4: Straw man Recommended Policy Elements and Scenarios Report

Recommended Policy Elements and Scenarios section of the Final Report

Task 5: Draft Final Report on Zero Carbon Buildings Technical Feasibility Study

Task 6: Amended Final Report & Seminar on Zero Carbon Buildings Technical Feasibility Study

Administrative Deliverables: Quarterly progress reports and conference calls

Data Management Plan

All research will be conducted at University of California facilities at Davis and Berkeley. The experimental design does not require large sample sizes or special equipment, and data management is not expected to be difficult. Human Subjects protocols will require various methods of ensuring privacy of data collected from human subjects, including safeguarding the data files that contain confidential information.

Inclusion of Human Subjects

In this project, we are placing a large emphasis on stakeholder engagement, recognizing that policies that are developed in a vacuum can be ineffective if they do not reflect the current market structure accurately.

We expect to be interacting with a range of stakeholders, from homeowners and HVAC technicians to policymakers and manufacturers. This will probably constitute “research with human subjects,” depending on how personal the questions will be, and the method of obtaining input. Although this study will likely be exempt from requiring approval of a detailed protocol for protection of human research subjects, it will have to be submitted to the University’s Institutional Review Board (IRB) to make that determination.

A proposed protocol will be developed early in the project. It will lay out many factors of the study, including the number of subjects, the type of subjects and criteria for inclusion or exclusion (including exclusions for any vulnerable populations), the nature of the questions that will be asked, the format in which the responses will be provided (for example, stakeholder workshop, interview, survey, or focus group), recruitment methods, compensation to subjects (if provided), how informed consent will be obtained and documented, and methods used to reduce risks to participants, such as ensuring confidentiality.

Review by the IRB ensures ethical research and appropriate use of human subjects, and is an important safeguard for a study such as this. There will be no animal subjects.

References

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Williams, James H. et al. 2012. "The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity." *Science* 335(6064): 53–59.

Qualifications

The team assembled at UC Davis for this proposal is uniquely qualified to perform the work described in this proposal, this is a "dream team" of individuals with expertise, contacts, judgment, and knowledge about the whole range of systems considered. and includes professionals with expertise in energy policy (Policy Institute for Energy, Environment and the Economy), stakeholder engagement and industry transformation processes (Energy Efficiency Center), efficient building design (Western Cooling Efficiency Center), the water-energy nexus (Center for Water Efficiency), and transportation (Zero-emissions Market Acceleration Project). Co-located in West Village (a zero-net energy development), the aim of these centers and institutes is to inform government and industry decision-making regarding vehicles, fuels, infrastructure, and mobility on key sustainable transportation and energy issues. Specialists from UC Berkeley's Renewable and Appropriate Energy Laboratory will round out the team.

The two lead organizations on the project--the Policy Institute for Energy, Environment & the Economy, and the Energy Efficiency Center—have proven track records of effective facilitation,

strong public-private partnerships, stakeholder engagement, energy expertise and information transfer to decision makers. If funded, this team will leverage their previous research and use their skills and existing data sets to optimize models, engage stakeholders to delineate a zero-carbon building definition, develop metrics, and identify key policies and programs that will be most effective for any one region in California.

All of the team-members are currently available for participation on this project, and their contributions will be well planned so that they are providing the highest possible level of expertise in the minimum amount of time.

The team is outlined below, along with a few relevant highlights of their qualifications, while more detailed qualifications are provided in the Supporting Material section of the proposal.

Contributor	**Role**	**Research Center (UCD, except *RAEL at UCB*)**	**Qualification Highlights**
Elise Brown, MAppSC	Co-PI, Policy	Policy Institute for Energy, Environment and the Economy	Facilitated and participated in many stakeholder activities concerning renewable energy, resulting in state rule development, model wind and solar ordinances, incentive programs, Utah Renewable Energy Zones Phase II, and 10- and 20-year transmission plans throughout the Western Interconnect.
Kristin Heinemeier, Ph.D.	Co-PI, Stakeholder Engage-ment	Energy Efficiency Center	Co-founder of the Western HVAC Performance Alliance, facilitator of the California Commissioning Collaborative, the 2009 Industry Roundtable on HVAC Energy Efficiency (Heinemeier, HVAC Energy Efficiency Roundtable: Volume 1. Summary Report, 2009), and several other technical committees and interest groups. Specialist in HVAC industry efforts at transformation.
Chris Jones, Ph.D.	Modeling	*Renewable and Appropriate Energy Lab (UC BERKELEY)*	Developer of multiple models and calculators for CoolCalifornia, including Green Point Rated, Small Business Carbon Calculator, Household Carbon Calculator, etc. Expert in community based social marketing. Chair of Behavior in Energy conference.
David Grupp, Ph.D.	Energy	Western Cooling Efficiency Center	Broad expertise in lab testing, field demonstrations, modeling, and policy related to buildings energy efficiency.
Kendra Olmos	Water	Center for Water-Energy Efficiency	Consulting background in alternative water strategies, including wastewater, graywater, and rainwater reuse, and system design.
Adam Schultz	Renewables	Energy Institute	Manager of Energy Institute; Prior experience managing stakeholder processes at CPUC as lead staff for wholesale renewable DG procurement.
Gustavo Collantes	Transporta-tion	Policy Institute for Energy, Environment and the Economy	Expert in transportation climate and energy policy and analysis. Experience in stakeholder processes in CA and other states.
Jacques Franco	Waste	Policy Institute for Energy, Environment and the Economy	Twenty years of Environmental Science experience in California. Expert on waste management, energy recovery from waste and their environmental performance

SUPPORTING MATERIALS

Zero Carbon Buildings Technical Feasibility Study:

An interdisciplinary approach to evaluating policy options to encourage zero-carbon buildings

Principal Investigators:

Elise Brown, Kristin Heinemeier

Submitted: February 27, 2015

University of California, Davis
One Shields Drive
1605 Tilia St.
Davis, California 95616

PROJECT SCHEDULE

The period of performance for this project is 18 months. (Tentatively beginning September 1, 2015).

Task 1: Framework for Analysis and Stakeholder Engagement
Task 2. System-Specific Technology and Model Evaluations
Task 3: Integrated Models of Greenhouse Gas Emissions
Task 4: Recommended Policy Elements and Scenarios
Task 5: Draft Final Report on Zero Carbon Buildings Technical Feasibility Study.
Task 6: Amended Final Report & Seminar on Zero Carbon Buildings Technical Feasibility Study.

	MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Stakeholder Engagement																		
2	System Models																		
3	Integrated Models																		
4	Policy Elements																		
5	Draft Final Report																		
6	Final Report and Seminar																		
		M			P		M	P			P	M	D		P	F		P	R

P= Quarterly progress report
M= Meeting with CARB staff
D= Deliver draft final report
F= Deliver final report
R= Revised final report

TEAM SHORT BIOS

The team assembled at UC Davis and UC Berkeley for this proposal is uniquely qualified to perform the work described in this proposal, and includes professionals with expertise in the water-energy nexus (Center for Water Efficiency), transportation (Zero-emissions Market Acceleration Project), efficient building design (Energy Efficiency Center), and energy policy (Policy Institute for Energy, Environment and the Economy).

Co-located in West Village (a zero-net energy development), the aim of these centers and institutes is to inform government and industry decision-making regarding vehicles, fuels, infrastructure, and mobility on key sustainable transportation and energy issues. The two leads on the project: The Policy Institute for Energy, Environment & the Economy and the Energy Efficiency Center, have proven track records of effective facilitation, strong public-private partnerships, stakeholder engagement, energy expertise and information transfer to decision makers. If funded, this team will leverage their previous research and use existing data sets to optimize models, engage stakeholders to delineate a zero-carbon building definition, develop metrics, and identify key policies and programs that will be most effective for any one region in California.

A summary of the qualifications of the contributors is provided below, and full resumes follow at the end of this section.

Dr. Kristin Heinemeier, Co-PI and Stakeholder Engagement Lead

Kristin Heinemeier is a Principal Engineer with UC Davis' Western Cooling Efficiency Center, where she is responsible for projects related to post-occupancy energy efficiency in buildings, as well as human factors and their impacts on building performance. Recent work includes research in the areas of Fault Detection and Diagnostics, maintenance behavior (both the end user and the contractor), technician sales and service practices that affect efficiency, and measurement and verification of savings. The common thread behind all her research and outreach projects spanning over 25 years has been making buildings work correctly, in the real world. Her thought-leadership in this area is recognized by the research community and buildings industry as a result of numerous publications and her leadership positions on several industry committees. Kristin has a PhD in Building Science from UC Berkeley, and a Bachelor's degree and PE in Mechanical Engineering. She has formerly worked for PECI, Texas A&M, Honeywell, and Lawrence Berkeley National Laboratory.

Elise Brown, MAppSci., Co-PI and Policy Lead

Elise Brown is Assistant Director for the Policy Institute for Energy, Environment and the Economy and oversees the Institute's renewable energy work and overall outreach programs. Elise brings 10 years of experience in academia and various sectors of government. Prior to her joining the Policy Institute she was the Associate Director for the California Geothermal Energy Collaborative and Program Manager for the California Renewable

Energy Center. She has also served as the Renewable Energy Coordinator for the State of Utah, and currently holds seats on two Western Electric Coordinating Council's Transmission Expansion Planning and Policy subcommittees.

Elise's experience, as it relates to this project ranges from leading stakeholder committees, including the Governor's Task Forces on renewable energy (Utah) and model ordinance development (Wind Working Group); writing and implementing renewable energy regulations and code; and conducting applied research. Elise holds a Bachelor of Science from the University of Utah in Environmental Studies, and a Master of Applied Science in Natural Resource Management from James Cook University in Queensland, Australia.

Dr. Christopher M. Jones, Modeling Lead

Dr. Christopher M. Jones leads the CoolClimate Network, a division of University of California, Berkeley's Renewable and Appropriate Energy Laboratory (RAEL). CoolClimate research provides the analytic foundation for "smart" greenhouse gas management software and behavior-based programs that engage, educate, and motivate individuals, businesses, and communities to adopt low carbon technologies and practices. Versions of CoolClimate tools have been adopted by the state of California via the CoolCalifornia.org partnership, non-governmental organizations, businesses, and communities throughout the United States. Several CoolCalifornia tools will be useful in the development of the current project, including carbon management tools for households and businesses, the GreenPoint Rated calculator for residential buildings, the Local Government Decision-Support Tool, and high spatial resolution maps of household carbon footprints across California and the nation. Jones serves as co-chair of the Behavior, Energy and Climate Change (BECC) Conference (5th year as program chair). He has also co-instructed an undergraduate course at UC Berkeley on behavior and sustainability. He received his Ph.D. in Energy and Resources at UC Berkeley in 2014. He also holds an M.S. in Energy and Resources and an M.A. in Latin American Studies, both from UC Berkeley, and a B.A. in Politics from UC Santa Cruz.

Dr. Gustavo Collantes, Transporation Lead

Dr. Gustavo Collantes is Assistant Director for the Policy Institute for Energy, Environment and the Economy and has responsibility over the Institute's work on mobility policy. He brings over 15 years of experience in academia, government and the private sector using interdisciplinary approaches to tackle complex questions related to clean transportation, energy innovation and policy. Prior positions include a two-year fellowship at Harvard's Kennedy School of Government where he made significant contributions integrating the transportation sector into climate and energy policy, informing policymakers and regulators in Washington, D.C. and states about policy mechanisms, fuel economy standards, technology innovation, and renewable fuels. In Washington State, Gustavo chaired the state's plug-in electric vehicle task force convened under Governor Gregoire and led first-of-their-kind initiatives, including the planning of regional electric vehicle corridors. As an entrepreneur, he founded a company dedicated to clean energy and advised clients at federal, state and local levels. He has lived and worked on four different continents.

Gustavo holds an Aeronautical Engineering degree from the Universidad Tecnológica Nacional, a M.Sc. in Aerospace Engineering from the Israel Institute of Technology and a Ph.D. in Transportation Technology and Policy from the University of California at Davis.

Dr. David Grupp, Buildings Energy Lead

For more than 15 years Dr. Grupp has worked in academic, research, corporate and startup settings incorporating advanced energy technology and efficiency into product R&D and policy. His doctoral work at UC Davis to design, construct and study fuel cell powered transportation and refrigeration systems led to the construction of two working demonstrations and a SAE award winning publication. Other work has included hybrid electric vehicle and hydrogen engine development at the Ford Motor Company, and ground up development of zero emissions fuel cell power backup equipment at a California startup company. His ongoing passion for advancing energy technology has led him to the WCEC where he continues working towards a greener, more sustainable, and altogether cooler planet.

Kendra Olmos, Water Lead

Kendra has a background in engineering consulting for water and wastewater system design, onsite wastewater management, and alternative water systems including wastewater, graywater, and rainwater reuse. During her undergraduate studies in Environmental Resources Engineering at Humboldt State University Kendra focused on sustainable systems and natural wastewater treatment. At Humboldt she co-directed the Campus Center for Appropriate Technology, a sustainable living demonstration and education center where she developed an interest in graywater treatment and reuse. As a graduate student in Civil and Environmental Engineering at UC Davis, Kendra investigated the zero-net water potential and the water-energy nexus of a proposed zero-net energy development. Kendra now works as a Program Manager for the UC Davis Center for Water-Energy Efficiency.

Adam Schultz, Renewable Energy Lead

Adam Schultz is the manager of the UC Davis Energy Institute where he oversees daily operations of a campus-wide energy research institute and has led the development of a proposal to create an interdisciplinary M.S./Ph.D. program in energy. He has also led the development of proposal teams around education, renewable biofuels, vehicle to grid integration, microgrids, and bioenergy, among others. Prior to joining UC Davis, Adam was a senior analyst at the California Public Utilities Commission where he oversaw stakeholder processes and the development and implementation of several statewide renewable distributed generation procurement programs. He has also served as a legal fellow focused on energy issues for Senator Ron Wyden (OR) in Washington, D.C., and was the Director of Environmental Policy for JD Energy, Inc., an electric sector consulting firm. Adam has a J.D. from the Benjamin Cardozo School of Law (Yeshiva University) and a B.A. in political science from Tufts University.

Jacques Franco, Waste Lead

With over twenty five years of experience in environmental science in California, Jacques is a Science and Policy Fellow at the UC Davis Policy Institute for Energy, Environment and the Economy. At CalRecycle, he was the lead technical staff for urban biomass to fuels and energy conversion technologies. Jacques was responsible for emerging technology assessment, research and analysis and provided technical support to jurisdictions and other stakeholders deploying waste conversion projects in California.

At the California Department of Food and Agriculture from he started and managed the Fertilizer Research and Education (FREP) program and was responsible for technology development and transfer to reduce nitrate groundwater contamination related to fertilizer use. His private sector experience includes independent technology evaluation, market research and business development. Mr. Franco is a graduate of the University of California, Davis, School of Management. He earned a Master of Science in Conservation Ecology from the same institution and holds a B.S. in Environmental Horticulture. He has authored and edited over forty technical and peer reviewed publications.

The acronyms for the different research centers are:

- PIEEE: Policy Institute for Energy, Environment & the Economy
- EEC: Energy Efficiency Center
- WCEC: Western Cooling Efficiency Center
- CWEE: Center for Water Energy Efficiency
- EI: Energy Institute
- UCB: University of California, Berkeley Renewable and Appropriate Energy Laboratory

PRELIMINARY COST PROPOSAL

	Salaries	Benefits	Subcontracts	Miscellaneous	Materials	Travel	Indirects	Total
Task1	**37,496**	**13,513**	**10,000**	**3,903**	**498**	**1,808**	**5,351**	**72,568**
PIEEE	21,968	8,678	-	1,687	296	810	3,186	36,625
EEC	13,107	3,973	-	1,912	143	810	1,810	21,753
WCEC	743	282	-	175	23	63	111	1,396
CWEE	811	317	-	64	20	63	121	1,396
EI	868	264	-	64	16	63	121	1,396
UCB	-	-	10,000	-	-	-	-	10,000
Task2	**64,242**	**23,008**	**16,000**	**7,462**	**1,258**	**4,163**	**9,300**	**125,432**
PIEEE	16,272	6,428	-	1,250	219	600	2,360	27,130
EEC	9,709	2,943	-	1,416	106	600	1,341	16,113
WCEC	11,738	4,450	-	2,763	365	988	1,760	22,063
CWEE	12,814	5,010	-	1,014	317	988	1,919	22,063
EI	13,709	4,178	-	1,019	250	988	1,919	22,063
UCB	-	-	16,000	-	-	-	-	16,000
Task3	**21,907**	**7,891**	**56,000**	**2,303**	**303**	**1,088**	**3,130**	**92,622**
PIEEE	12,204	4,821	-	937	165	450	1,770	20,347
EEC	7,281	2,207	-	1,062	79	450	1,005	12,085
WCEC	743	282	-	175	23	63	111	1,396
CWEE	811	317	-	64	20	63	121	1,396
EI	868	264	-	64	16	63	121	1,396
UCB	-	-	56,000	-	-	-	-	56,000
Task4	**34,898**	**12,576**	**10,000**	**3,636**	**465**	**1,688**	**4,980**	**68,243**
PIEEE	20,340	8,035	-	1,562	274	750	2,950	33,912
EEC	12,136	3,678	-	1,770	132	750	1,676	20,142
WCEC	743	282	-	175	23	63	111	1,396
CWEE	811	317	-	64	20	63	121	1,396
EI	868	264	-	64	16	63	121	1,396
UCB	-	-	10,000	-	-	-	-	10,000
Task5	**5,350**	**1,923**	**3,000**	**582**	**84**	**293**	**768**	**12,000**
PIEEE	2,441	964	-	187	33	90	354	4,069
EEC	1,456	441	-	212	16	90	201	2,417
WCEC	446	169	-	105	14	38	67	838
CWEE	487	190	-	39	12	38	73	838
EI	521	159	-	39	9	38	73	838
UCB	-	-	3,000	-	-	-	-	3,000
Task6	**14,443**	**5,203**	**5,000**	**1,515**	**198**	**713**	**2,063**	**29,135**
PIEEE	8,136	3,214	-	625	110	300	1,180	13,565
EEC	4,854	1,471	-	708	53	300	670	8,057
WCEC	446	169	-	105	14	38	67	838
CWEE	487	190	-	39	12	38	73	838
EI	521	159	-	39	9	38	73	838
UCB	-	-	5,000	-	-	-	-	5,000
TOTAL	**178,336**	**64,116**	**100,000**	**19,401**	**2,806**	**9,750**	**25,592**	**400,000**

EXAMPLE ZERO CARBON BUILDING DEFINITIONS

Basic definitions:

- *A zero-carbon building (ZCB) meets all its energy needs from renewable energy.*

  This definition precludes buildings from having natural gas, essentially a requirement to meet CA's 2050 GHG target.

- *A zero-carbon building (ZCB) meets all its (expected average annual) energy needs from on-site renewable energy, or equivalent.*

  This definition emphasizes on-site energy, but allows for offsite energy. It also makes explicit that some modeling is required to estimate expected average annual energy consumption)

A broader definition (but still flexible):

- *A zero-carbon building (ZCB) meets all its energy needs from renewable energy, and may also produce sufficient additional renewable energy to offset greenhouse gas emissions from water, waste and/or building construction/demolition.*

  This definition emphasizes the importance of water, waste and embodied emissions, but does not require inclusion – although local jurisdictions could require this).

A broader definition (not flexible):

- *A zero-carbon building (ZCB) meets all its energy needs from renewable energy, plus produces sufficient additional renewable energy to offset greenhouse gas emissions from water, waste and/or building construction/demolition.*

  This definition requires inclusion of emissions from water, waste and embodied emissions.

The broadest definition for residential buildings (homes):

- *A zero carbon home (ZCH) meets its entire household and motor vehicle energy needs from renewable energy, and (may also produce) produces sufficient additional renewable energy to offset greenhouse gas emissions from water, waste and/or building construction/demolition.*

  This definition requires homes to have sufficient on-site renewable energy to power motor vehicles. The amount should vary by location. We have called it a ZCH since transportation is a household activity that is not directly affected by the design of homes (although it is influenced by the siting of homes)

- *A zero carbon home (ZCH) meets its entire household energy needs from renewable energy, and may also produce sufficient additional renewable energy to power electric vehicles and/or offset greenhouse gas emissions from water, waste and/or building construction/demolition.*

  This definition makes on-site charging for electric vehicles optional.

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OFFICE OF RESEARCH
SPONSORED PROGRAMS, 1850 Research Park Dr., #300
DAVIS, CALIFORNIA 95618

TELEPHONE: (530) 754-7700
FAX: (530) 752-0333

February 26, 2015

Bart E. Croes, P.E.
Chief, Research Division
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Research Proposal: "Zero Carbon Buildings Technical Feasibility Study: A framework for utilizing stakeholder engagement and modeling to encourage zero-carbon buildings"
UC Davis Principal Investigator: Elise Brown
Requested Funds: $400,000
Period Requested: 07/01/2015-06/30/2018

To Whom This May Concern:

On behalf of the Regents of the University of California, Davis campus (UC Davis), it is a pleasure to forward institutional support and approval for the project being submitted to the Cal EPA Air Resources Board (CARB) as referenced above. In the event that this proposal is selected for funding, we will expect to agree to standard UC-CARB interagency terms and conditions as allowed in previous contracts between UC Davis and the CARB.

Please call on Elise Brown for programmatic information. Administrative questions may be directed to me by telephone or facsimile at the numbers specified above or via email at pbbell@ucdavis.edu. We request that correspondence pertaining to this proposal and a subsequent award be sent to the Office of Research, Sponsored Programs and to the principal investigator.

Send Award Notice to:

Office of Research
Sponsored Programs
1850 Research Park Drive
University of California
Davis, California 95618
(530)754-7700/ Fax: (530)752-0333
awards@ucdavis.edu

Send Checks (Payable to The Regents of the University of California) to:
Cashier's Office
University of California Davis
PO BOX 989062
West Sacramento, California 95798-9062

Sincerely,

Patrick Bell
Contracts and Grants Analyst

SPO #201502781

ELISE BROWN

415 17th St.
Sacramento, CA 95811
(801) 750-2746
elisebrown@gmail.com

EDUCATION

Master of Applied Science	James Cook University	Natural Resource Management	2008
Bachelor of Science	University of Utah	Environmental Studies	2004

EMPLOYMENT HISTORY

2014 - Current	**Assistant Director, Policy Institute for Energy, Environment & the Economy**	*University of California, Davis*
2011 - Current	**Associate Director, California Geothermal Energy Collaborative**	*University of California, Davis*
2012 - 2014	**Program Manager, California Renewable Energy Center**	*University of California, Davis*
2011 Spring	**Adjunct Faculty, Alternative Energy Technology Course**	*Salt Lake Community College*
2010 – 2011	**Business Development Manager, Energy Comm. Center**	*University of Utah*
2008 – 2010	**Renewable Energy Coordinator**	*Utah State Energy Program*
2007 – 2008	**Field Director, Corroon for County Mayor**	*Utah Democratic Party*
2006 – 2007	**At Sea Observer**	*NC Div. of Marine Fisheries*
2006 Spring	**Climate Protection Officer**	*City of Thuringowa*
2005	**Coral Research Assistant**	*Orpheus Island Research Ctr.*
2004	**Campaign Manager & Legislative Intern**	*Utah State Legislature*

SYNERGISTIC ACTIVITIES & PROFESSIONAL DEVELOPMENT

- WECC Scenario Planning Steering Group Member & Environmental Data Task Force Member (subcommittee of Transmission Expansion Planning Policy Committee)
- NREL Expert Review Panel member: Standard Scenarios and Annual Technology Assessment Project
- Solar Energy International PV101: Solar Electric Design and Installation course (2009)
- Solar Energy International ST101: Solar Hot Water Design and Installation course (2010)
- Geothermal 101: Geothermal Energy Association (2012)
- German courses, Goethe Institute San Francisco & Hamburg (Level A2.2)
- Industry seminars and conferences such as WINDPOWER, Solar Power International, Intersolar North America, Intersolar Europe, Geothermal Energy Association forums and meetings
- Director of Terra Firma and the University of Utah Wind Power Campaign (2002-2004)

AWARDS

- Outstanding Wind Working Group 2010, for Utah Wind Working Group Management. Awarded by Department of Energy's Wind Powering America program.
- Pollution Prevention Award 2006, for U of U Wind Power Campaign. Awarded by the Utah Dept. of Environmental Quality.

AREAS OF EXPERTISE

Project, Program, Technology and Grant Management

- Managed budgets, faculty, and relationships for California Renewable Energy Center's contracts with the California Energy Commission and City of Davis' Net-Zero Project ($2M+)
- Developed business plan and sought patent protection and investment for various technologies at the Energy Commercialization Center at the University of Utah to achieve commercialization
- Designed and managed 'Solar for Schools Grant Program' (Utah, $3M); 'Large Scale Solar Grant Award' (Utah, $4M); 'Competitive Grants for Renewable Energy' (Utah, $1M) and ARRA funded rebate program for solar PV, solar thermal and wind installations (Utah, $3M). These grants resulted in at least one solar system per school district and K-12 renewable energy curriculum implementation; and more than tripled the previously installed solar capacity in Utah
- Facilitated and ran Utah's Wind, Solar and Geothermal Working Groups
- Lead staff on Utah Governor's Renewable Energy Zones Task Force Phase I & II (UREZ)

- Managed Utah's Anemometer Loan Program both administratively and in the field
- Managed SOLRMAP Pyranometer Program in coordination with the National Renewable Energy Lab
- Served as renewable energy expert selection committee for Rocky Mountain Power Blue Skies Grants 2009 & 2010 and multiple ARRA grants

Public Speaking Sample

- Renewable Energy Policy Forum Series (California); California Assembly & Utah House, Natural Resources Committees; Governor's Energy Summits (Utah); Community & City/County Council Meetings; guest lecturer at McGeorge School of Law (Sacramento, CA), UC Davis, University of Utah; STEM outreach with Congresswoman Matsui; California Geothermal Energy Collaborative Forum; Geothermal Energy Association National Summits & CGEC Forums; Keynote speaker at Center for Advanced Energy Studies Symposium; Keynote Speaker American Planning Association State Conference (keynote speaker). *Full list of speaking engagements available upon request*

Policy Analysis and Development

- Made recommendations in transmission planning studies for the western interconnect with the WECC's Scenario Planning Steering Group, Technical Advisory Subgroup and the Environmental Data Task Force
- Primary staff for Utah Renewable Energy Zones Task Force and Working Groups. Facilitated all meetings and co-authored the Policy and Funding Barriers and Pathways document included in Final UREZ II Report
- Developed *Utah Model Wind Ordinance (SJR1, Utah 2009)* through stakeholder consensus building process *Award was given for this effort at the 2010 Wind Powering America Summit*
- Recommended, wrote and implemented rule changes concerning renewable energy rebates and tax credits.
- Volunteered for Nature Conservancy sponsored initiative to approve bonds for open space acquisition and preservation and assisted Rep. Becker in HJR15. *2004, Utahns for Clean Air, Clean Water & Open Space*
- Advised California Assembly members, staff and non-profits on geothermal heat pump legislation
- Formulated action plan for greenhouse gas mitigation for Thuringowa City Council in Queensland, Australia.
- Conducted legislative research for open space, gift limits, tenant rights, and regional planning issues at the Utah State House of Representatives
- Researched renewable energy alternatives for Utah and ran a student Wind Power Campaign which was successfully implemented at the University of Utah

Public Outreach & Education

- Chair of Policy Institute Forum Series *"Renewable Energy Beyond 33%"* 2014 - 2015
- Chair of UC Davis Energy Institute Fall Seminar Series, 2012
- Advised on special topics undergraduate course on renewable energy policy at UC Davis 2012, 2013, 2014
- Presented to Utah Legislature, and several city and county councils regarding wind & solar ordinances and geothermal development implications
- Taught Renewable Energy course at Salt Lake Community College's Green Academy Program
- Organized Governor's Energy Breakfast Briefings with Utah's Governor's Energy Advisor
- Organized 2008 Solar Tour with Utah Solar Energy Association
- Co-Directed the Wind Power Campaign at the University of Utah resulting in the 6th largest renewable energy purchase in the country (EPA) at the time, and the largest in Utah and the surrounding region.
- Organized all campaign activities for Ralph Becker's 2004 Utah House & Peter Corroon's County Mayor re-election campaigns and various Utah Democratic Party campaigns

Field Research & Technical Experience

- Review of technical and market viability of renewable energy technologies
- Managed Anemometer Loan Program including application review, coordination with landowners, installation of 20- & 50-meter towers, data analysis and report writing
- Managed SOLRMAP program in coordination with National Renewable Energy Lab including contracting, reporting, and pyranometer installation and maintenance
- Divemaster for at sea sampling of soft and hard corals, for speciation study on the Great Barrier Reef
- At sea sampling on commercial fishing vessels for sea turtle bycatch reduction study

PUBLICATION & MANUSCRIPT SAMPLE

- Assessment of Geothermal Resources in Under-Served Regions, *California Energy Commission. September, 2014*
- Assessment of California's Low Temperature Geothermal Resources: Geothermal Heat Pump Efficiencies by Region, *California Energy Commission. February, 2013*
- Energizing Southern California's Economy: The Economic Benefits and Potential for Geothermal Energy in Southern California, *Geothermal Energy Alliance. 2011*
- Utah's Renewable Energy Resource and Reserve Analysis: *Governor's 10-Year Energy Plan. 2010*
- Policy and Funding Barriers and Pathways to Renewable Energy Development in Utah – *Utah Renewable Energy Zones Task Force. 2010*

Kristin Heinemeier, Ph.D., P.E.

University of California, Davis Western Cooling Efficiency Center
215 Sage St, Suite 100, Davis CA 95616 530/754-7667 kheinemeier@ucdavis.edu

Education

University of California, Berkeley
Doctor of Philosophy, Architecture, emphasis in Building Science, 1988 - 1994.
Degree awarded Dec., 1994. Minors in Energy and Buildings, Mechanical Systems.

University of California, Berkeley
Bachelor of Science, Mechanical Engineering, 1982 - 1986.
Degree awarded May, 1986.

Massachusetts Institute of Technology
Attended 1979 - 1980.

Professional Experience

University of California, Davis; Western Cooling Efficiency Center (WCEC)
Principal Engineer, May 2012 – Present.
Senior Engineer, May 2007 – May 2012.
Part of the Senior Management team of a University Research Center, focused on advancing innovative and efficient cooling technologies that are well-suited to Western climates. Specific projects include investigating the impact of human behavior in HVAC performance, studying the practices of contractors and technicians in installation and maintenance of HVAC systems, evaluating technologies for possible incorporation into codes and standards, studying why contractors so often fail to comply with building codes, bringing together industry stakeholders to discuss the market for automated Fault Detection and Diagnostics, and measuring the accuracy of field technician toolkits. University responsibilities include seeking out funding opportunities, working with affiliates to define projects, writing proposals, planning projects, research and writing, working with and directing internal staff to complete deliverables, tracking project performance, reporting to clients, preparing deliverables, presenting findings in private and public forums, assisting the Center's director in managing Center activities, and helping develop Center procedures and management tools.

Portland Energy Conservation, Inc. (PECI)
Senior Engineer, November 2004 – May 2007.
Managed and conducted research and technology transfer projects related to new building commissioning and retrocommissioning. PECI is a non-profit organization that provides a range of services to help its customers promote energy efficiency, including: program design, program marketing and promotions, program implementation and demonstration, market research and analysis, commissioning research and engineering, tools and resource development, policy and standards development, and training and education. Specific projects included providing training for commissioning providers, technical management of the California Commissioning Collaborative, managing a project to develop guidelines for commissioning and retrocommissioning for California, providing technical assistance to a publicly funded monitoring-based commissioning program, and drafting of sections of a Functional Test Guide. Management responsibilities included working with customers to define projects, writing proposals, planning projects, research and writing, working with and directing internal staff to complete deliverables, tracking project performance, reporting to customers, preparing deliverables, and presenting findings in private and public forums.

Brooks Energy and Sustainability Laboratory (BESL)
Texas Center for Applied Technology, Texas Engineering Experiment Station.
Technical Director, June 2001 – November 2004.

Managed all technical aspects of laboratory that is a part of Texas A&M system. Responsibilities included carrying out research and technology transfer projects, as well as providing program management for a number of concurrent projects. These projects included commissioning of new school facilities, investigating the costs and benefits of commissioning, providing third-party review of measurement and verification activities for military facilities, assisting in gaining LEED™ certification for sustainable facilities, providing technical services and guidance to municipalities in conducting energy management, assessing the regional economic development potentials for renewable energy industry, evaluating the local municipal utility's conservation potential assessment, and assisting in creating a region-wide energy partnership. Management activities included providing team leadership, writing proposals, tracking budgets, managing tasks, preparing deliverables, communicating with customers, staff procurement and supervision, and outreach to customer base and local community.

Honeywell International
Home and Building Controls, R&D, Program Manager. Jan 1999 – Jun 2001.
Honeywell Technology Center, Principal Research Engineer. Oct 1995 – Dec 1998.
Program Manager for Analysis Tool Development for Honeywell Atrium™.
Managed multiple research and development projects in the Service and Solutions Products area. Projects managed had a combined budget of over two million dollars. These projects included development of new software tools for use by customers, internal engineers, technicians, and sales representatives. Management activities included providing team leadership, writing proposals, tracking budgets, managing tasks, preparing product documentation, overseeing domestic and overseas software developers, reporting to management, communicating with customers, coordinating with related efforts, and working with field and marketing organizations—domestic and international. Activities focused on energy management, energy monitoring, building information tools, measurement and verification, commissioning and fault-detection and diagnostics in commercial buildings.

Lawrence Berkeley Laboratory *Energy Analysis Program*
Postdoctoral Fellow Engineer, December 1994 - October 1995.
Graduate Student Research Associate/Senior Research Associate,
April 1991 - December 1994, and June 1986 - December 1988.
Conducted research in the Building Energy Analysis, and Buildings Energy Data Groups. This included activities such as assessing the use of Energy Management and Control Systems for monitoring of building energy consumption, developing integrated methods to diagnose building and system performance, developing tools for commissioning of building systems, investigating life-cycle information support systems, and developing algorithms to analyze monitored consumption data in support of program evaluation and demand forecasting efforts. Projects were sponsored by California utilities, the California Energy Commission, the Department of Energy, and the University-wide Energy Research Group.

Professional Registration and Training

Registered Professional Engineer. Mechanical Engineer, California License #27320
LEED™ 2.0 Accredited Professional, with the U.S. Green Buildings Council. 2002.
Building Commissioning Association training for Building Commissioning Practitioners. 2002.

Service

American Society of Heating Refrigerating and Air-Conditioning Engineers
Building Commissioning Association
National Research Council
American Council for an Energy Efficient Economy
Metropolitan Partnership for Energy
Women Energy Associates
International Energy Agency
City of Berkeley Energy Commission/Community Energy Services Corporation

Christopher M. Jones

Staff Research Associate
Energy and Resources Group
University of California
Berkeley, CA 94720
Phone: (510) 643-5048
e-mail: cmjones@berkeley.edu

Professional Preparation

2010 – 2014	Ph.D. Energy and Resources Group, University of California, Berkeley
2002 – 2005	M.S. Energy and Resources Group, University of California, Berkeley
2002 – 2005	M.A. Latin American Studies, University of California, Berkeley
1989 – 1995	B.A. Politics, University of California, Santa Cruz

Appointments

10/2009 –	Staff Research Associate Renewable and Appropriate Energy Laboratory, Energy and Resources Group, University of California, Berkeley
2011, 2012, 2013 (Spring)	Co-instructor, ER190-002, Behavior and Sustainability (unpaid) Energy and Resources Group, University of California, Berkeley
1/2006 – 9/2009	Staff Research Associate Berkeley Institute of the Environment, University of California, Berkeley
7/2005 – 12/2005	Graduate Student Researcher Energy and Resources Group, University of California, Berkeley
1/2005 – 7/2005	Graduate Student Researcher Beahrs Environmental Leadership Program, University of California, Berkeley
8/2003 – 12/2004	Graduate Student Instructor Sociology / College of Natural Resources, University of California, Berkeley

Peer-Reviewed Academic Publications

1. Christopher M. Jones, Daniel M. Kammen. The "Coolest California City:" Results from a Pilot Inter-City Carbon Footprint Reduction Competition. *Environment & Behavior* (revision in preparation)

2. Robert Miehe, Rene Scheumann, Christopher Jones, Daniel Kammen, Matthias Finkbeiner. Regional Carbon Footprints of Households: A German case study. *Environment, Development and Sustainability*. In press

3. Christopher M. Jones, Daniel M. Kammen. Spatial Distribution of U.S. Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density. *Environ. Sci. Technol., 2014, 48 (2), pp 895–902*

4. Rebekah Shirley, Christopher M. Jones, Daniel M. Kammen. A Household Carbon Footprint Calculator for Islands: Case study of the United States Virgin Islands, *Ecol. Ecological Economics 80 (2012) 8–14*

5. Max Wei, James H. Nelson, Michael Ting, Christopher Yang, Daniel M. Kammen, Chris Jones, Ana Mileva, Josiah Johnston, Ranjit Bharvirkar. Deep Carbon Reductions in California Require Electrification and Integration Across Economic Sectors. 2013 *Environ. Res. Lett.* 8 014038

6. Christopher M. Jones, Daniel M. Kammen. Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities, *Environ. Sci. Technol., 2011, 45 (9), pp 4088–4095*

Other Academic Publications

7. Christopher M. Jones. *Enabling Low Carbon Communities: The Roles of Smart Planning Tools and Place-Based Solutions*. Doctoral Dissertation. Energy and Resources Group, University of California, Berkeley. December 2015.

8. Christopher M. Jones, 2005. *A Life Cycle Assessment of U.S. Household Consumption*. Masters Project. Energy and Resources Group, University of California, Berkeley. May 2005.

9. Christopher M. Jones, 2005. *Emissions of CO_2 and Criteria Pollutants from U.S. – Mexico Overland Freight*. Masters thesis. Latin American Studies, University of California, Berkeley. December 2005.

Peer-Reviewed Professional Reports

10. Christopher M. Jones and Daniel M. Kammen. A *Greenhouse Gas Local Government Decision-Support Tool*. Research report prepared for the California Air Resources Board under contract 09-359 (revisions in preparation)

11. Christopher M. Jones and Daniel M. Kammen. *The CoolCalifornia Challenge: A Pilot Inter-City Household Carbon Footprint Reduction*. Report prepared for the California Air Resources Board under contract 10-325. November 2014. 90 pages.

12. Christopher M. Jones, Wes Sullens, Amy Dryden and Joe Kantenbacher. Measuring the Climate Impact of Residential Buildings: GreenPoint Rated Climate Calculator Version 2. Report prepared for the California Air Resources Board under contract 09-344. September 2012. 122 pages.

13. Christopher M. Jones, Daniel M. Kammen, Gang He, Corinne Reich-Weiser, Devon Lake, Chris Erickson. Greenhouse Gas Emissions and Reduction Opportunities In Pacific Gas & Electric Company's Products and Services Supply Chain. Unpublished report. 69 pps. January 2012.

Papers in Preparation

14. Christopher M. Jones and Edward Vine. The Design, Implementation and Evaluation of Community-based Social Marketing Programs. Research report prepared for the California Public Utilities Commission (in preparation)

15. Christopher M. Jones and Edward Vine. The Design, Implementation and Evaluation of Energy Reduction Competitions. Research report prepared for the California Pubic Utilities Commission (in preparation)

Working Papers

16. Christopher M. Jones, Daniel M. Kammen, Daniel T. McGrath, 2008. Consumer-Oriented Life Cycle Assessment of Food, Goods and Services. Berkeley Institute of the Environment. Energy and Climate Change.

17. Christopher M. Jones, 2007. UC Berkeley Climate Footprint, in Fahmida Ahmed, UC Berkeley Climate Action Partnership, Feasibility Study 2006-2007 Final Report.

18. Christopher M. Jones, 2005. A Lifecycle Assessment of U.S. Household Consumption: The Methodology and Inspiration Behind the "Consumer Footprint Calculator". University of California International and Area Studies. Breslauer Symposium. Paper 8.

19. Christopher M. Jones. Headwinds for Climate Change Policy. *Latin American Studies Review. Fall 2009.* University of California, Berkeley

Student Advising / Supervision

Graduate Students: Monica Testa, Josiah Johnston, Jan Porvaznik (visiting scholar), Alina Koch Lawrence, Robert Mehra (visiting scholar), Rebekah Shirley, Anders Nilsson (visiting scholar), Joseph Kantenbacher, Jeremy Eddy, Gang He, Hazel Onsrud, Won Young Park, Kate Foreman, Sally Maki, Michael Hajjar, Anita Milman, Seung-Hyun Rhee.

Undergraduate students: Steven Chen, Beau Ryck (West Chester U.), Winnie Chan, Sandy Yip, Kamini Iyer, Jason Khoe, Ciaran Roberts, David Suh, Kelley Doyle (2012 AASHE sustainability research awardee), Alan Miller, Steven Nagy, Lydia Chang, Atheana Fulgencio, Chun Man Chow, Rosanna Neuhausler, Michelle Change, Rachel Bubb, Crystal Sun, Kathryn Lie, Katy Nomura, Dominic Molinari, Varun Mehra (UCLA), Kamyar Kaviani, Bernadette Le, Anurag Shyamala, Hieu Pham, Steve Wang, Sophia Ashton, Betsy Phillips, Mia Yamauchi, Christina Oatfield, Kimberly Lam.

Synergistic Activities

1. Co-Chair, Behavior, Energy and Climate Change Conference, 2011, 2012, 2013, 2014, 2015
2. Lead developer, CoolClimate Network, U.C. Berkeley (2005-present), funding: ~$2M

3. Lead designer, implementer and evaluator: CoolCalifornia City Challenge: a statewide competition between California cities to reduce household GHG emissions and name the "Coolest California City."
4. Lead developer/inventor: CoolClimate Calculator, CoolClimate Calculator for Small Busineses, California Local Government Decision-Support Tool. Coolclimate.berkeley.edu
5. Reviewer: Journal of Industrial Ecology, 2012, 2015; Environmental Science and Technology, 2009, 2012, 2014; Environmental Management, 2014; Environmental Modeling & Software, 2014; Energies, 2014; Earth's Future, 2014; Environmental Research Letters, 2012, 2013, 2014; Resources, Conservation & Recycling, 2012; Journal of Cleaner Production, 2010; Journal of Infrastructure Systems, 2007
6. Conference speaker: American Planning Association, California 2015 (invited); ASHRAE High Performance Buildings Conference 2015 (Invited); Behavior, Energy and Climate Change Conference, 2010, 2011, 2012; West Coast Forum on Climate Change, 2009, 2012; California Resources Recovery Association, 2011; ISIE 2011, Haagen-Smit Symposium, 2009; Japanese Universities in the Bay Area Conference, 2009; Sustainable Supply Chain Summit, 2008.
7. Conference posters: Behavior, Energy and Climate Change, 2007, 2008. California Climate Change Research Conference, 2008; Governor's Summit on Climate Change, 2008, 2009.
8. Guest Lectures: environmental courses at U.C. Berkeley (>25)
9. Project manager of $1.5M grant from the Gordon and Betty Moore Foundation (2005-2008)
10. Judge, Sustainability Specialist, California Cleantech Open, 2008, 2009
11. Member of technical advisory committees: PG&E Commercial Behavioral Advisory Committee; ICLEI Community Greenhouse Gas Protocol, 2011, 2012; Environmental Defense Fund Climate Justice project, 2009
12. Member, Board of Advisors: Climate Earth. http://climateearth.com (2008-present), Oroeco (2012-present), Empowerment Institute (2012-presesnt)

Awards & Recognition

1.	1/2008	"25 Brilliant California Ideas", California Magazine, for carbon footprint calculator
2.	4/2002	1st place, A. Lorne Weil Business Plan Competition, Columbia University, for "Este World, Ltd."
3.	4/2001	Finalist, Haas Social Venture Competition, University of California, Berkeley for "Este World, Ltd"
4.	2001-2014	Work cited in public media including: New York Times, Los Angeles Times, Smart Planet, Discovery Channel News, National Public Radio, Magazine, Wall Street Journal, Discover Magazine, San Francisco Chronicle, San Jose Mercury News, Sacramento Bee, California UNEP, and many others.

Professional Development Activities

1/2001 – 8/2002 Co-founder, *Este World Ltd.*, Sustainable Forestry. Belem, Brazil

Professional Skills

1. Economic and environmental data analysis and modeling
2. Languages: fluent in Spanish and conversational in Portuguese

Gustavo Collantes

530.848.1564 (mobile)
gcollantes@ucdavis.edu

EDUCATION

Ph.D. Transportation Technology and Policy University of California, Davis 2006
Emphasis on clean energy technology, policy and economics

Business Development Certificate University of California, Davis 2006

M.Sc. Aerospace Engineering Israel Institute of Technology, Technion 1998
Emphasis on mathematical modeling and aerodynamics

Aeronautical Engineering Universidad Tecnológica Nacional, Argentina 1991

PROFESSIONAL EXPERIENCE

Assistant Director, UC Davis Policy Institute for Energy, Environment and the Economy, Davis, CA 2013 –

- Responsible for projects on transportation, including transportation electrification, climate change, and innovation.
- Development, implementation and management of Zero Emission MAP, an initiative to provide assistance to states and cities to implement programs on zero emission mobility
- Engagement and support of multi-stakeholder policy processes on clean energy and climate change
- Fundraising and project development

President and Founder, Logios, LLC, Cambridge, MA 2011 – 2013

Started up Logios (www.logios3i.com), a company dedicated to clean energy through technology innovation, integration, and implementation. Projects include

- Development of technologies and financial models for the efficient integration of wind and solar energy
- Technical and financial analysis for clean energy and transportation applications
- Support of multi-stakeholder policy processes on clean energy and climate change
- Development of models for the efficient regional planning of clean fuel infrastructure
- Advising on regional clean transportation policy and planning strategies

Senior Energy Policy Adviser, Washington State Department of Commerce, Seattle, WA 2008 – 2011

Management and Strategy

- Department Lead, transportation climate change and energy policy
- Coalition building at the state level on clean transportation and climate change strategies
- Chair, State Plug-in Electric Vehicle Task Force: www.ElectricDrive.wa.gov
- Member, State Cabinet on Energy, Transportation, and Climate
- State Representative, Western Governors Association Transportation Fuels Council
- Member, Governor's Advisory Team on clean transportation
- Liaison with automotive and clean energy industries
- Communications responsibilities: testimonies, presentations, media interviews, and community outreach
- Chair, State Committee to develop regulations for the installation of electric vehicle support infrastructure

- Developed $1.5 million program to implement the first regional network of electric vehicle infrastructure in the United States
- Developed $3 million program to support clean transportation projects

Analysis

- Data analysis and planning for the deployment of an integrated electric vehicle charging network
- Economic risk analysis of plug-in vehicle markets in the State of Washington
- Economic and environmental quantitative analysis of clean energy policies, including the State Low Carbon Fuel Standard, the State Renewable Fuel Standard, and electric vehicle strategies
- Development of best practices for the installation of electric vehicle charging infrastructure
- Econometric time series analysis of fuel demand and vehicle miles travelled
- Lifecycle analysis of transportation fuels
- Integration of geographical, economic and technical data for the planning of fuel infrastructure

Research Fellow, **Kennedy School of Government, Harvard University,** Cambridge, MA 2006 – 2008

- Lead researcher on climate and energy policy with an emphasis on the transportation sector, with the Energy Technology Innovation Policy group at the Belfer Center for Science and International Affairs
- Led research groups on low-carbon fuels, vehicle electrification, and carbon management
- Effectively engaged stakeholders at the federal and state levels in dialog to develop strategies for clean-technology innovation, reduce oil consumption, and reduce greenhouse gas emissions
- Collaborated with stakeholders in Latin America on assessing climate impacts of biofuel production
- Performed in-depth analyses of the federal fuel economy program in the United States
- Participated of analyses of market-based carbon policies in the United States
- Performed economic and econometric analyses of markets for advanced vehicle platforms such as hybrid electric, fuel cell, and flex-fuel
- Performed lifecycle analyses of greenhouse gas emissions for different vehicle-fuel systems
- Briefed policymakers in Washington, D.C. and California on climate and energy policy questions
- Represented Harvard's Energy Technology Innovation Policy group at conferences and meetings
- Organized and led workshops with senior representatives of key stakeholders

Co-founder, RENERGH 2006 – 2009

- Co-founded and managed a small consulting firm
- Led projects on low-carbon energy technology and policy assessment in several countries
- Clients include private sector and government organizations

Lead Researcher, **Institute of Transportation Studies, University of California,** Davis, CA 2003 – 2006

- Managed multi-year research project on policy and business strategies to adopt hydrogen as transport fuel in the United States
- Member, Hydrogen Highway blue ribbon panel to advise the Governor of California
- Assisted U.S. Senate during process of the Energy Policy Act of 2005, producing analysis of the impact of hydrogen fuel on climate change
- Conducted outreach to federal and state policymakers to discuss strategies for adopting renewable hydrogen in the United States
- Conducted scientific quantitative and qualitative survey analyses
- Wrote grants that generated research funds

Researcher, **Institute of Transportation Studies, University of California,** Davis, CA 2000 – 2003

- Investigated strategies to reduce amount of vehicle travel, such as transit use and telecommuting
- Developed land use strategies to reduce vehicle travel and promote use of public transit in California
- Analyzed impact of land use, transport, and vehicular emissions for California Department of Transportation
- Conducted scientific quantitative and qualitative survey analyses

AWARDS

Massachusetts Clean Energy Center Summer Internships Award to Logios	2012
Harvard University, Kennedy School of Government Fellowship	2006 – 2008
Pan American Advanced Studies Institute on Transportation Sciences, National Science Foundation Fellowship	2005
University of California Transportation Center, Dissertation Fellowship	2004
Technion, Ralph Levitz Fellowship	1995 – 1997
Technion, Summer Research Fellowship	1995 – 1996
Delta Airlines Fellowship for graduate studies on Aerospace Engineering	1994
National Technological University, Aerodynamic Research Scholarship	1989 – 1991

LANGUAGES

Spanish	Native speaker
English	Fluent
Hebrew	Intermediate (speaking)
Italian, French, Polish	Basic (speaking)
Portuguese	Intermediate (reading)

SELECTED PEER-REVIEWED PUBLICATIONS

Collantes, G. and Paul Sabatier (2013) Long-term coalition stability in technology-forcing policy processes: The case of the California Zero-Emission Vehicle mandate. Manuscript under revision.

Collantes, G. and Foss A. (2013) Stochastic characteristics of international carbon emission from natural gas flaring. Submitted for review.

Collantes, G. and Melaina, M. (2010) The co-evolution of alternative fuel infrastructure and vehicles: A study of the experience of Argentina with compressed natural gas. *Energy Policy*, 39: 664-675.

Collantes, G. (2010) Do green techs need to pass the consumer test? The case of ethanol fuel. *Energy Economics,* 32:1235-1244.

Morrow, W. Ross, Gallagher, K., **Collantes, G.** and Lee, H. (2009) Analysis of policies to reduce oil consumption and greenhouse-gas emissions from the U.S. transportation sector. *Energy Policy*, 38: 1305-1320.

Collantes, G. (2008) Electrifying our way to fuel economy: Regulatory perspectives on hybrid vehicles. *Society of Automotive Engineers,* 2008-21-0013.

Collantes, G. and Sperling, D. (2008) The origin of California's Zero Emission Vehicle mandate. *Transportation Research Part A*, 42: 1302-1313.

Collantes, G. (2008) The dimensions of the policy debate over transportation energy: The case of hydrogen in the United States. *Energy Policy*, 36(3): 1059-1073.

Collantes, G. (2008) Incorporating stakeholders' perspectives into models of new technology diffusion: The case of fuel-cell vehicles. *Technological Forecasting and Social Change*, 74: 267-280.

BOOK CHAPTERS

Collantes, G. and Gallagher, K. (2008) Transportation–Specific Challenges toward a Climate Policy. In D. Sperling and J. Cannon (Ed.) *Reducing Carbon Impacts in the Transportation Sector*. Springer.

Mokhtarian, P., **Collantes, G.**, and Gertz, C. (2004) Telecommuting, residential location, and commute distance traveled: Evidence from State of California employees. In D. Hassenpflug and Tegeder G., *City.net: Städte im Zeitalter der Telekommunikation*. Tectum Verlag: Marburg, Germany.

SELECTED REPORTS

Lessons from Early Deployments of Electric Vehicle Charging Stations: Case Studies from the Northeast and Mid Atlantic Regions. Prepared for the Transportation and Climate Initiative. 2013.

Regional Electric Vehicle Corridors: An Analysis for Missouri-Kansas. Prepared for the Kansas City Metropolitan Energy Center. 2012.

International Resources Group, co-author (2009) Biofuels in Asia: An Analysis of Sustainable Options. Prepared for the United States Agency for International Development (USAID). March.

Collantes, G. (2008) Biofuels and the Corporate Average Fuel Economy Program: The Statute, Policy Issues, and Alternatives. Discussion Paper 2008-05, Cambridge, MA: Belfer Center for Science and International Affairs, Harvard University. May.

Gallagher, K., **Collantes, G.**, Holdren, J., Lee, H., and Frosch, R. (2007) Policy Options for Reducing Oil Consumption and Greenhouse Gas Emissions from the U.S. Transportation Sector. Discussion paper. Energy Technology Innovation Policy research group, Kennedy School of Government, Harvard University.

Collantes, G. (2006) The California Zero-Emission Vehicle Mandate: A Study of the Policy Process, 1990-2004. Ph.D. Dissertation. Institute of Transportation Studies Report UCD-ITS-RR-06-09. June.

Collantes, G. (2005) Stakeholders' Perspectives on Hydrogen Policy: A Factor Analysis. Institute of Transportation Studies Report UCD-ITS-RR-05-22. December.

Collantes, G. (2005) The Hydrogen Policy Survey: Descriptive Statistics of the Study Sample and Their Policy Perspectives. Institute of Transportation Studies Report UCD-ITS-RR-05-21. December.

Governor's Blueprint Plan Team, co-author (2005) Societal Benefits Topic Team Report: California 2010 Hydrogen Highway Network. March.

Governor's Blueprint Plan Team, co-author (2005) Economy Topic Team Report: California 2010 Hydrogen Highway Network. January.

Collantes, G. (2005) Foreseeing the Market for Hydrogen Fuel-Cell Vehicles: Stakeholders' Perspectives and Models of New Technology Diffusion. Institute of Transportation Studies Report UCD-ITS-RR-05-27. December.

Collantes, G. and Mokhtarian, P. (2002) Determinants of the Subjective Assessment of Individual Mobility. Research Report UCD-ITS-RR-02-11, Institute of Transportation Studies, University of California, Davis. August.

SELECTED INVITED PRESENTATIONS

Wind energy integration into transportation applications. Presentation at the California Air Resources Board. 2012.

Partnerships to Electrify Road Transportation. U.S. Department of Energy, State Energy Plans and Energy Efficiency Community Block Grant programs meeting. May 18, 2011.

Electric Vehicle Corridors: Rationale, Planning, Implementation. Plug-in EV Infrastructure USA 2011. San Diego, USA, March 31, 2011.

Toward the Electrification of Transportation. Webinar hosted by the National Governors' Association. February 4, 2011.

Electric Vehicles in Washington: A Policy Perspective. Future Energy Conference, Seattle, USA, November 10, 2010.

The Regulation of Electric Vehicle Charging Infrastructure. Testimony before the Utilities and Transportation Commission, October 28, 2010.

Carbon Impacts of Soy Biodiesel: A U.S. Regulatory Perspective. Presentation at the Conference on Biofuels and Renewable Energy, Buenos Aires, Argentina, June 9, 2009.

Perspectives on the California Low Carbon Fuel Standard. Presentation at the Business of Renewable Energy Conference, Northwest Environmental Business Council. Portland, OR, April 16, 2009.

Policies to Reduce Carbon Emissions from the Transportation Sector. Presentation at the Clean Heavy Duty Vehicle Conference, CALSTART. Long Beach, CA, March 16, 2009.

Electrifying Our Way to Fuel Economy: Regulatory Perspectives on Hybrid Vehicles. Presentation at the SAE Convergence 2008 conference. Detroit, MI, October 2008.

The Fuel Economy-Biofuels Connection. Seminar at the Kennedy School of Government, Harvard University, October 2007.

The Corporate Average Fuel Economy Program. Seminar at the Kennedy School of Government, Harvard University, February 2007.

The California Zero Emission Vehicle Mandate. Seminar at the Kennedy School of Government, Harvard University, October 2006.

Hydrogen as a Transportation Fuel: Technology and Policy. Seminar at the World Bank, November 2005.

Hydrogen Policy and Stakeholders' Beliefs. Presentation at the Fall Conference of the Association of Public Policy Analysis and Management. Washington, DC, November 2005.

Adam C. Schultz

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EDUCATION

BENJAMIN N. CARDOZO SCHOOL OF LAW New York, NY
Yeshiva University
Juris Doctor (J.D.) | *Corporate Law* | May 2011

- Staff Member, *Cardozo Public Law, Policy & Ethics Journal*
- Participant, Negotiation Competition
- Energy and environmental law coursework: Climate Change and the Law; Introduction to Environmental Law; Land Use Law; Environmental Business Concerns; Administrative Law

TUFTS UNIVERSITY Medford, MA
Bachelor of Arts (B.A.) | *Political Science* | May 2004

- Dean's List (4 semesters)
- Member, Pi Sigma Alpha (Political Science Honor Society)
- Senior Staff Writer, *The Tufts Daily*

ENERGY EXPERIENCE

2014 - Present **ENERGY INSTITUTE, UNIVERSITY OF CALIFORNIA DAVIS** Davis, CA
Program Manager

- Led campus-wide effort including multiple Deans and faculty from more than a dozen academic departments to develop a proposal for an interdisciplinary M.S. and Ph.D. program in energy.
- Organized interdisciplinary faculty, postdoc, and student teams to develop and pursue grant funding for research from the California Energy Commission, National Science Foundation, University of California Office of the President, and others.
- Engaged faculty to develop strategies for increasing the visibility and profile of energy research at UC Davis.

2011 - 2013 **CALIFORNIA PUBLIC UTILITIES COMMISSION** San Francisco, CA
Public Utilities Regulatory Analyst, Lead Analyst, Wholesale Renewable DG Programs

- Reviewed utility filings and authored Commission Resolutions to approve 1,199 MW of renewable generation from 138 projects (132 of the projects were DG projects sized < 20 MW).
- Oversaw the Renewable Auction Mechanism (RAM) for projects sized up to 20 MW, including drafting several Commission Resolutions to modify RAM program rules and contract terms.
- Lead staff developer of the SB 32 Feed-in Tariff Program and its innovative market-based pricing mechanism, the renewable market-adjusting tariff (ReMAT). Implemented through Commission Decisions (D.) 12-05-035 and 13-05-034.
- Lead staff developer of the SB 1122 Bioenergy Feed-in Tariff Program. Implementation pending.
- Regularly briefed senior Energy Division management, Commissioners, and their staff on market and policy issues concerning wholesale renewable energy development.
- Lead contact for public, utility, and market inquires concerning California's wholesale renewable distributed generation procurement programs.

2009 **THE OFFICE OF U.S. SENATOR RON WYDEN (OREGON)** Washington, D.C.
Wayne Morse Legal Fellow (summer)

- Provided policy support to the Senator's senior Energy Committee staff on issues ranging from the Senate Energy Bill, to renewable energy eligibility, to energy efficiency incentives.

2007 - 2009 **JD ENERGY, INC.** Frederick, MD
Director, Environmental Policy & Markets

- Lead developer of short- and long-term forecasts of the emission markets for SO2, NOx, and

CO2 for a diverse client base including electric utilities, energy companies, and investment firms.

- Provided clients with comprehensive analysis of markets, environmental policy, and pollution control technologies.
- Directed special client-driven projects such as the development of a comprehensive review of the nuclear power industry in the United States.

POLITICAL EXPERIENCE

2006 / 2010 **KAI HAGEN FOR COUNTY COMMISSIONER** Frederick, MD
Campaign Manager

2005 - 2006 **ANDREW DUCK FOR U.S. CONGRESS** Frederick, MD
Campaign Manager

- Secured national media exposure for candidate (FOX News Channel, *Vanity Fair*, The Army Times, BBC Radio, and others) and several statewide endorsements.

2006 - 2008 **DEMOCRATIC STATE CENTRAL COMMITTEE** Frederick, MD
Elected Member

- Elected countywide (Frederick Co., MD) on the 2006 Democratic gubernatorial primary ballot.

2004 **PAUL BABBITT FOR U.S. CONGRESS** Flagstaff, AZ
Regional Field Organizer, Navajo Nation

2003 - 2004 **WES CLARK FOR PRESIDENT** Boston, MA
Volunteer

2003 **GARY HART FOR PRESIDENT EXPLORATORY COMMITTEE** Boston, MA
Volunteer

INTERNSHIPS AND TRAININGS

2006 **DCCC CAMPAIGN FINANCE TRAINING** Washington, D.C.
Participant

2004 **EMILY'S LIST** Washington, D.C.
Campaign Corps

2002 / 2003 **U.S. DEPARTMENT OF STATE** Washington, D.C.
Summer Intern

- Granted Secret level clearance (inactive) for an internship focused on developing counterterrorism and crisis simulation training exercises for U.S. Embassies and Consulates worldwide.

DAVID J. GRUPP

David Grupp
1525 ½ 24th St.
Sacramento, CA 95816

Mobile: (916) 642 2538
E-mail: djgpro@gmail.com
Citizenship: US

Education

UNIVERSITY OF CALIFORNIA - Davis, CALIFORNIA
Doctor of Philosophy, Mechanical Engineering – December 2005

UNIVERSITY OF WISCONSIN - Madison, WISCONSIN
Masters of Science, Mechanical Engineering – November 1999

MICHIGAN TECHNOLOGICAL UNIVERSITY - Houghton, MICHIGAN
Bachelors of Science, Mechanical Engineering – May 1997

Advanced Coursework

Intermediate Thermodynamics, Intermediate Gas Dynamics, Intermediate Fluid Dynamics, Intermediate Heat Transfer, Chemical Kinetics of Combustion Systems, Solar Energy Technology, Advanced Mechanical Design Series, MEMS Design, Microsensor Design and Fabrication

Research Interests

Advanced power and hybrid system design for efficiency and low emissions utilizing fuel cell technology, renewable energy, and heat engines. Instrumentation and experimental methods for power system characterization and model development. Building system efficiency for zero net energy construction and ground source heat pump technology. Complete system considerations for efficient and clean energy utilization in both a technical and societal context.

Research / Academic Experience

January 2012 to Present

WESTERN COOLING EFFICIENCY CENTER, University of California**,** Davis, CALIFORNIA
Technical Project Manager / Associate Engineer, *Professor Mark Modera, PhD*
- Developed research proposals, managed program execution, and prepared program deliverables and reporting for various research efforts related to building energy efficiency.
- Managed CEC subcontract deliverables for the PIER SPEED Technology Program. Led research efforts and authored reports for building efficiency technologies including Demand Control Kitchen Ventilation, RTU Retrofit Controllers, and Laboratory Efficiency measures.
- Managed CEC and SMUD contract deliverables for Ground Source Heat Pump projects.

Fall 2001 to Winter 2005

INSTITUTE OF TRANSPORTATION STUDIES, University of California**,** Davis, CALIFORNIA
Graduate Researcher, Heavy Vehicle Fuel Cell Group, *Professor Harry Dwyer, PhD*
Designed, developed and built PEM fuel cell hybrid power systems to eliminate the need for a conventional diesel engine. Research activities included developing and building a gas analyzer system, hybrid systems model development, and custom power electronics development.

Fall 1997 to Fall 1999

ENGINE RESEARCH CENTER, University of Wisconsin, Madison, WISCONSIN
Graduate Researcher, Mercury Marine Research Engine Lab, *Professor Jay Martin, PhD*
Designed, developed and built an engine ignition system capable of ignition feedback control to detect and prevent engine misfire. Performed research to quantify performance of this system.

Summer 1997

LAWRENCE LIVERMORE NATIONAL LABORATORY, Livermore, CALIFORNIA
Research Engineer, National Ignition Facility (NIF) Operations, *Detlev Tizsaur, PhD*
Developed a statistical tolerance model and constructed/supervised experiments to verify the design of the NIF Bottom Loading Transporter and related operations.

Fall 1995 to Summer 1997

MTU FUTURECAR TEAM, Michigan Technological University, Houghton, MICHIGAN
Group Leader, Auxiliary Power Unit Group, *Professor Carl L Anderson, PhD*
Group Leader, Motor / Alternator Group, *Professor Carl L Anderson, PhD*
Lead a team of engineering students in the design of a hybrid electric powertrain, and the implementation of motor, alternator, and engine into a working hybrid vehicle system.

DAVID J. GRUPP

Professional Experience

April 2005 to December 2011 — **ALTERGY SYSTEMS,** Sacramento, CALIFORNIA
Project and Systems Engineering Team Leader, Product and Process Engineering
Led the Systems Engineering team, directed the activities of consultants, and supported the growth of junior level engineers in the application of systems engineering methodologies to the first generation of Altergy fuel cell products meant for high volume production.

April 2003 — **SCALED TECHNOLOGIES,** Davis, CALIFORNIA
Co-founder, Consultant

September 2001 – July 2001 – December 1999 — **FORD MOTOR COMPANY,** Dearborn, MICHIGAN
Product Development Engineer, TH!NK – *Energy Storage Systems*
Worked on various programs and projects within Fords advanced alternative vehicle organization. Projects included fuel cell vehicle, hydrogen internal combustion engines, HEV Escape, engine design, and component and assembly plant experience.

Summer 1996 — **FORD MOTOR COMPANY, Engineering Intern**, Milan Plastics Plant
Summer 1995 — **FORD MOTOR COMPANY, Engineering Intern,** Test Operations
Summer 1994 — **BARTECH, Vehicle Evaluator,** Production Prototype Vehicle Verification Team

Teaching Experience

2001 to 2002 — **Teaching Assistant,** University of California, Davis**,** *Mechanical and Aeronautical Engineering*
1996 to 1997 — **Learning Center Coach**, Michigan Technological University, *Engineering Learning Center*
1994 to 1995 — **Lab Consultant**, Michigan Technological University, *CCLI Computer Lab*

Awards / Professional
Licensed Professional Engineer, State of California, License #34919
2004 SAE Vincent Bendix Automotive Electronics Engineering Award for Best Electronics Paper
2002 – 2004 National Science Foundation IGERT Research Fellowship

Publications / Presentations

1) **D. Grupp**, H.A. Dwyer, C. Kulkarni, M. Soloman, and M. Miller, "Design, Testing, and Demonstration of a Hybrid Fuel Cell Powered APU/TRU System", *Society of Automotive Engineers Technical Paper*, (07PFL-404).
2) **D. Grupp** and P.A. Erickson, "The Potential Use of Liquid Oxidizer in PEM Fuel Cells", *American Society of Mechanical Engineers, Proceedings of FuelCell2006 The 4th International Conference on Fuel Cell Science, Engineering and Technology*, (ASME FUELCELL2006-97040).
3) **D. Grupp**, M. Forrest, P. Mader, C.J. Brodrick, M. Miller and H.A. Dwyer, "Development of a Retrofit Fuel Cell Auxiliary Power Unit for Truck Idle Reduction", *Society of Automotive Engineering Technical Paper*, (SAE 2004-01-2629).
4) **D. Grupp**, M. Forrest, P. Mader, C.J. Brodrick, M. Miller, H.A. Dwyer (2004) "Design Considerations for a PEM Fuel Cell Powered Truck APU". *Institute of Transportation Studies, University of California, Davis, Research Report* (UCD-ITS-RR-04-16).
5) **D. Grupp**, "Assessing Transport Refrigeration Unit Emissions: From Measurement to Model", *SMUD/EPRI Workshop: Electric Material Handling / Electric Idle Reduction for Trucks*, The Garden Pavilion, Sacramento, California – September 16, 2003. [Oral Presentation]
6) **D. Grupp** and J.K. Martin, "Ignition System Characteristics and Effects on Combustion for a Two-Stroke Engine", *Society of Automotive Engineering Technical Paper*, (SAE 2002-01-0644).
7) M. Hortop, D. Savage and **D. Grupp,** "MTU FutureCar '97: The Conversion of a Dodge Intrepid into a Concept New Generation Vehicle", *Society of Automotive Engineering Special Publication – 1997 FutureCar Challenge*, (SAE SP-1359).

KENDRA OLMOS

823 Shadyoak Dr.
Santa Rosa, CA 95404
(707) 834-3435 (cell)
kcolmos@ucdavis.edu

ENGINEERING QUALIFICATIONS

- **E.I.T registered** July 2007 (#127965). Sitting for October 2014 PE Exam
- **M.S. Civil & Environmental Engineering**; University of California, Davis**,** September 2011
- **B.S. Environmental Resources Engineering**; Humboldt State University, Arcata**,** December 2006
- Specialize in water treatment and reuse, water management, water and water-energy efficiency, water quality analysis, regulatory permitting, land development, and sustainable planning and design

PROFESSIONAL EXPERIENCE

Program Manager August 2014 – Present
Center for Water-Energy Efficiency *University of California, Davis*

- Manage projects and grants
- Coordinate, lead, plan, and participate in research project and project development activities
- Develop proposals and grant applications

Project Engineer May 2012 – August 2014
Summit Engineering Inc. *Santa Rosa, CA*

- Design of residential/commercial sanitary wastewater systems and winery process wastewater systems
- Preparation of water and wastewater feasibility studies
- Design and permitting assistance for public water systems, wastewater treatment and reuse systems
- Project development and construction assistance
- Managed projects and mentored junior staff

Design Engineer April 2011 – May 2012
Carlile Macy *Santa Rosa, CA*

- Designed integrated water management and reuse systems for domestic and process wastewater, graywater, storm water, rainwater, potable water and zero-net water projects
- Provided water management consultation
- Developed improvement plans, schematic designs, design calculations, specifications, and water reuse feasibility studies
- Managed all aspects of permit compliance from preparing regulatory reports to negotiation
- Managed projects, develop new projects and proposals

Project Engineer April 2007 – June 2009
Lescure Engineers Inc. *Santa Rosa, CA*

- Designed decentralized wastewater treatment systems for residential, commercial, and industrial applications
- Prepared improvement plans, regulatory reports, and water reuse feasibility studies
- Performed site reviews, soil evaluations, and percolation tests
- Stormwater Pollution Prevention Plan development and BMP selection

ACADEMIC/LEADERSHIP EXPERIENCE

Graduate Researcher August 2009 – April 2011
Center for Water-Energy Efficiency *University of California, Davis*

- Researched the connection between water and energy
- Performed a case study to achieve zero-net water for a proposed residential development through water conservation and reuse strategies, and the resulting reductions in energy use and greenhouse gas emissions
- Analyzed residential water-use efficiency and water-energy reductions for the City of Davis
- Presented research locally and at national conferences

Graduate Teacher September 2009 – April 2011
Department of Civil & Environmental Engineering *University of California, Davis*

- Taught engineering lab classes including Green Engineering for Sustainability, Water Quality Management Treatment and Design, and Static Mechanics
- Designed the lab curriculum and assignments for Water Quality Management Treatment and Design

Director June 2003-June 2004
Campus Center for Appropriate Technology (CCAT) *Humboldt State University, CA*

- Co-managed CCAT, a sustainable living educational center
- Managed design and construction projects, supervised 22 employees, prepared yearly budget, negotiated with administrators, and wrote articles for CCAT's magazine and website
- Maintained the center's graywater wetland and composting toilet systems
- Organized and presented workshops and classes focused on sustainability

JACQUES FRANCO
Mobile 530-848-3256 - jzfranco@ucdavis.edu

HIGHLIGHTS OF QUALIFICATIONS

Experienced evaluating environmental and GHG emissions from waste management systems
Former CalRecycle lead technical staff - Waste to Energy and Conversion Technologies
Experienced in R&D Program Development, Management and Technology Assessment
Extensive knowledge integrating technology, policy and markets

RELEVANT EXPERIENCE

Waste Management, Renewable Energy & Climate Change

Manage Waste to Energy and Climate Research and Development projects
Lead Waste to Energy technical consultant to cities, project developers and stakeholders
Develop interagency partnerships and cooperation to fulfill program mission
Develop and maintain Waste to Energy technologies web site and mailing list
Familiar with State, Federal Climate and Renewable energy policies and goals

Research Program Development and Management

Started and managed State R&D program and secured multiple funding sources
Implemented effective proposal review evaluation and management system
Developed partnerships with State and Federal agencies to advance program goals
Authored and edited over thirty technical and peer reviewed publications

EMPLOYMENT HISTORY

2015	**Science and Policy Fellow,** Policy Institute for Energy, Environment and the Economy, UC Davis
2006 - 2014	**Environmental Scientist,** CalRecycle, Sacramento
1997 - 2006	**Independent Technology Transfer Consultant,** Davis, CA
1989 - 1997	**Research Analyst II**, California Dpt. of Food & Agriculture
1985 - 1989	**Consultant,** (Concurrent with graduate studies), UC Davis
1980 - 1985	**Technology Transfer Consultant,** Tel Aviv, Israel

EDUCATION

M. Administration, Finance & Marketing, School of Management, UC Davis, 1989
Master of Science, Conservation Ecology, UC, Davis, 1987
B.S., Horticulture, Hebrew University of Jerusalem, 1977

Contributions to State of California Publications

Bioenergy Action Plan 2012, **California Energy Commission**, August 2012
www.resources.ca.gov/docs/2012_Bioenergy_Action_Plan.pdf

Low Carbon Fuel Standard Pathway for the Production of Biomethane from High Solids Anaerobic Digestion of Organic Wastes, **California Air Resources Board**, **June 2012**

www.arb.ca.gov/fuels/lcfs/2a2b/internal/hsad-rng-rpt-062812.pdf

Bioenergy Action Plan 2011**, California Energy Commission**, March 2011
www.energy.ca.gov/bioenergy_action_plan/documents/index.html

Statewide Anaerobic Digester Facilities for Treatment of Municipal Organic Waste, **CalRecycle**, June 2011
www.calrecycle.ca.gov/SWFacilities/Compostables/AnaerobicDig/PropFnlPEIR.pdf

Conversion Technologies Status Survey, 2009. **CalRecycle**, pub. No. 2009-008, April 2009
http://www.calrecycle.ca.gov/Publications/Detail.aspx?PublicationID=1323

Emission Testing of Volatile Organic Compound from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley, 2007. **CalRecycle**, pub. No. 442-07-008, Dec 2007
http://www.ciwmb.ca.gov/Publications/default.asp?pubid=1263

Refereed Scientific Journal and State of California Publications

Franco, Jacques and Casey Walsh-Cady, 1997. **Preventing Nitrate Contamination of Groundwater in California: A Nonregulatory Approach,** Journal of Production Agriculture, Jan- Mar 1997.
http://cat.inist.fr/?aModele=afficheN&cpsidt=2662123

Franco, Jacques, Walsh-Cady, Casey and Stephan Schad, 1994. **A Voluntary Approach to Reducing Nitrate Contamination of Groundwater in California.** Journal of Soil and Water Conservation, Jan- Feb 1994.

Franco, Jacques and Casey Walsh-Cady, Eds. 1993. **Proceedings: Second Annual Fertilizer Research and Education Program Conference**, State of California Department of Food and Agriculture.

Franco, Jacques and Casey Walsh-Cady, 1993. **The Fertilizer Research and Education Program: A Progress Report 1990-92**, State of California Department of Food and Agriculture. – Web link - http://www.calwater.ca.gov/Admin_Record/D-039588.pdf

Franco, Jacques and Casey Walsh-Cady, Eds. 1992. **Proceedings: First Annual Fertilizer Research and Education Program Conference**, State of California Department of Food and Agriculture.

Franco, Jacques and Casey Walsh-Cady, 1992. **Nitrate Contamination of Groundwater from Fertilizer: A Review of State Program** State of California Department of Food and Agriculture.

Franco, Jacques, 1992. **Nitrate Management Program - Fertilizer Research and Education Program: Progress Report 1991**, Communications in Soil Science and Plant Analysis, pgs 2111-2134, Vol 23 numbers 17-20, 1992.

The Nitrate Management Program - Progress Report, 1990, California Department of Food & Agriculture.

Vision 2010: California Agriculture, State of California Department of Food & Agriculture, 1990 - Contributor.

Franco, Jacques, 1989. **Organic Food and Sustainable Agriculture.** Contemporary Policy Issues, Vol VII number 4, October 1989 with B. Baker, D. Hall and D. Jolly.

Franco, Jacques, 1989. **An Analysis of the California Market for Organically Grown Produce,** American Journal of Alternative Agriculture, Vol 4 issue 1, September 1989.

Franco, J., Cervinka, V., Shaffer S. & D. MacIntosh 1989. **Vision 2010: California Agriculture -Preliminary Report**, - State of California Department of Food & Agriculture.

The Agroforestry Demonstration Program in the San Joaquin Valley - Progress Report, March 1989, with V. Cervinka - State of California Department of Food & Agriculture.

Potential Gains in Water Utility Value by the use of Agroforestry Systems in the San Joaquin Valley. 1989 , with V. Cervinka. - State of California Department of Food & Agriculture, working paper.
Rural Development Policy - **California Rural Development Committee, 1989, with V. Cervinka.**

Agriculture Water Policy, July 1989 - Agriculture Water Advisory Committee (AWAC). A subcommittee of the State Board of Food and Agriculture -with V. Cervinka.