Exhibit A
WORK STATEMENT

TASK LIST

Task #	CPR	Task Name
1.0	N/A	Administration
2.1		Project 1 (Software Platform) Computer Infrastructure for Prototyping and Evaluation
2.2		Project 2 (Interventions - Foundational) Formative Work for Interventions
2.3		Project 3 (Interventions – Technology) Smart Automation
2.4		Project 4 (Intervention – Media) Multiplayer Game
2.5		Project 5 (Intervention – Media) Mobile Interactions.
2.6		Project 6 (Intervention – Policy) Smart Monetary Incentives.
2.7		Project 7 (Interventions – Policy) Nudges to Purchase Energy Efficient Appliances.
2.8		Project 8 (Interventions – Policy) Goals and Collective Action.
2.9		Project 9 (Interventions – Community) School and Community Programs.
2.10		Project 10 (Data Modeling) Energy Consumption Forecasts.
2.11		Project 11 (Data Modeling) Behaviorally Informed Prescriptive Economic Models.
2.12		Project 12 (Energy Sensor Network) Open Extensible Communication Network.

KEY NAME LIST

Task #	Key Personnel	Key Subcontractor	Key Partner
1	Lilian Kamal, Susie Ng		
2.1	Banny Banerjee, Carrie Armel, Scott Klemmer, Byron Reeves, Jeff Shrager, Sebastian Houde, Anant Sudarshan, Jim Sweeney, John Weyant, Martha Russell		
2.2	Carrie Armel, Marilyn Cornelius, Banny Banerjee, Annika Todd, Tom Robinson		Google
2.3	Hamid Aghajan, Andrew Ng, Zico Kolter		
2.4	Byron Reeves & Carrie Armel		
2.5	Banny Banerjee, Abby King		
2.6	Annika Todd, Balaji Prabakhar, Sebastian Houde, Carrie Armel		
2.7	Sebastian Houde, Sam McClure, Annika Todd, Carrie Armel		
2.8	Greg Walton		
2.9	Tom Robinson, Nicole Ardoin		

Exhibit A
WORK STATEMENT

Task #	Key Personnel	Key Subcontractor	Key Partner
2.10	Martin Fisher		
2.11	Jeff Shrager, Sebastian Houde, Anant Sudarshan, Jim Sweeney, John Weyant, Sam McClure		
2.12	Phil Levis		
	Linda Schuck		

GLOSSARY

Specific terms and acronyms used throughout this scope of work are defined as follows:

Term/ Acronym	Definition
API	Application Processing Interface
ARRAe	American Recovery and Reinvestment Act - energy
CO2	Carbon Dioxide
CPR	Critical Project Review
DOE	United States Department of Energy
GHG	Green House Gas
HAN	Home Area Network
PAC	Project Advisory Committee
PG&E	Pacific Gas and Electric company
PIER	Public Interest Energy Research
RD&D	Research, Development and Demonstration
T1, T2…,..TN	Treatment 1, … Treatment N
TCP/IP	Internet network protocols
U.S.	United States

Problem Statement:

There is a significant national investment in smart meters and related sensing technologies, which promise that energy information, will change energy use. However, these devices are critically dependent on human behavior to make them effective. The current problems are numerous: sensor information is complex and dull, incentives are inappropriate, interactions with energy information are poorly designed to modify behavior, and social context is ignored. These problems all involve the intersection of human behavior and technology. Consequently, human behavior must be considered a critical component of smart sensing systems.

Recent research by the American Physical Society and the Intergovernmental Panel on Climate Change concludes that behavioral issues are a major impediment to the adoption and effectiveness of new technology and retrofits. However, Stern and Gardner researcher's review analyses indicate that behavior change has the potential to reduce residential energy consumption by up to 30 percent. This 30 percent of residential represents about 11 percent of the total United States energy consumption.

Much more energy information will soon be available, accentuating the importance of human behavior in determining technology success. In addition to smart meters and plug load monitors, wireless sensing technologies will be available for gas and hot water, and for transportation in the form of sensors that quantify miles per gallon, mode of transportation and number of trips. This project initially focuses on smart meter and home area network (HAN) sensing technologies because of their impending rollouts. The initial research and deployment plans will be transferrable to transportation, gas and hot water as the project progresses.

The most unique contribution of this programmatic program of projects/tasks (projects) is that it will redefine energy technology to highlight the critical role of human behavior in reducing energy use.

This project program initiative has significant support and the project team is comprised of behavioral science leaders that have significant real world experience. Stanford's behavioral research team (team) is supported intellectually by the Precourt Institute for Energy, a new organization that organizes researchers across campus to solve energy problems, and the Human Sciences and Technology Advanced Research Institute, which takes an interdisciplinary behavioral science approach to studying the intersection of humans and technology. With industry, the Recipient has engaged in formal collaborations with new companies building sensor technology, and has initiated projects with the Pacific Gas and Electric Company (PG&E) and Google to collaborate on energy feedback field trials.

Many of the behavior change methods to be used in this series of projects have been validated in the lab or in the field with non-energy behaviors. These projects will address behavior change challenges by using iterative prototyping, large human subject samples, and rigorous methods from the behavioral science and design disciplines. The devices to be used in our preliminary evaluations of projects pose minimal technical risk. However, risks related to the large-scale rollout of sensor technologies do exist and include the following: uncertain interest and willingness to pay by consumers; profitability for companies; innovation in alternative business models; and political, market, and regulatory barriers.

Currently, program evaluation measures intermediate proxies for behavior, such as attitudes, which are poorly correlated with actual behavior. Our information platform will transform program evaluation by knowing who was exposed to what programs, and objectively measuring their specific energy reductions and shifts. This has not previously been done because high resolution sensor data has not been available.

Goals of the Agreement:
The goal of these programmatic energy-related behavioral projects/tasks is to develop a comprehensive human-centered solution that leverages the anticipated widespread diffusion of energy sensors to significantly reduce and shift energy use.

Objectives of the Agreement:

Exhibit A
WORK STATEMENT

The overarching goal is to reduce average residential energy use by 30% with the pilot test groups receiving our interventions. Sophisticated econometric techniques will be employed to determine the effect that the interventions have on the energy use of the pilot test groups.

The likely impact of these programmatic energy-related behavioral projects/tasks specific to the American Reinvestment and Recovery Act - energy (ARRA-e) mission areas is to:

1. Reduce greenhouse gas (GHG) Emissions & Energy Use, and Enhance Energy Security. The research team will provide upper and lower bounds of potential energy reductions ranging from 5% to 30% in the residential sector. Reducing energy demand addresses the security issue of blackouts in times when there is particularly high electricity demand or unexpected reductions in the generated or transmission capacity of electricity.
2. Quickly Implement the Economic Recovery Package. This project could significantly and quickly increase demand for retrofits, efficient devices, and other services and products. Many of these require local labor, and this is especially true of retrofits. This project could significantly and quickly increase demand for HAN devices, and many of the companies designing and producing these devices are located in California.

3. Restore Science Leadership and Maintain a Technological Lead. The nascent field of behavior and energy offers potential for new science and real world impact. The United States is in an excellent position to drive this field, given leadership in the behavioral sciences, energy research, and innovative product design.

TASK 1 ADMINISTRATION

Task 1.1 Attend Kick-off Meeting

The goal of this task is to establish the lines of communication and procedures for implementing this Agreement.

The Recipient shall:

- Attend a "Kick-Off" meeting with the Commission Project Manager, the Grants Officer, and a representative of the Accounting Office. The Recipient shall bring its Project Manager, Agreement Administrator, Accounting Officer, and others designated by the Commission Project Manager to this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting. Prior to the kick-off meeting, the Commission Project Manager will provide an agenda to all potential meeting participants.

  The administrative portion of the meeting shall include, but not be limited to, the following:
  - o Discussion of the terms and conditions of the Agreement

- o Discussion of Critical Project Review (Task 1.2)
- o Match fund documentation (Task 1.6)
- o Permit documentation (Task 1.7)

The technical portion of the meeting shall include, but not be limited to, the following:

- o The Commission Project Manager's expectations for accomplishing tasks described in the Scope of Work
- o An updated Schedule of Products
- o Discussion of Progress Reports (Task 1.4)
- o Discussion of Technical Products (Product Guidelines located in Section 5 of the Terms and Conditions)
- o Discussion of the Final Report (Task 1.5)

The Commission Project Manager shall designate the date and location of this meeting.

Recipient Products:

- Updated Schedule of Products
- Updated List of Match Funds
- Updated List of Permits

Commission Project Manager Product:

- Kick-Off Meeting Agenda

Task 1.2 Critical Project Review (CPR) Meetings

The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and to identify any needed modifications to the tasks, products, schedule or budget.

CPRs provide the opportunity for frank discussions between the Energy Commission and the Recipient. CPRs generally take place at key, predetermined points in the Agreement, as determined by the Commission Project Manager and as shown in the Technical Task List above. However, the Commission Project Manager may schedule additional CPRs as necessary, and any additional costs will be borne by the Recipient.

Participants include the Commission Project Manager and the Recipient and may include the Commission Grants Officer, the Public Interest Energy Research (PIER) Program Team Lead, other Energy Commission staff and Management as well as other individuals selected by the Commission Project Manager to provide support to the Energy Commission.

If DOE is conducting similar meetings, the Recipient shall notify and invite the Commission project manager to participate, either by teleconference or by actual

meeting attendance. The DOE required meetings can be used in place of the Commission's CPR meetings, at the discretion of the Commission project manager.

The Commission Project Manager shall:

- Determine the location, date, and time of each CPR meeting with the Recipient. These meetings generally take place at the Energy Commission, but they may take place at another location.
- Send the Recipient the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.
- Conduct and make a record of each CPR meeting. One of the outcomes of this meeting will be a schedule for providing the written determination described below.
- Determine whether to continue the project, and if continuing, whether or not modifications are needed to the tasks, schedule, products, and/or budget for the remainder of the Agreement. Modifications to the Agreement may require a formal amendment (please see the Terms and Conditions). If the Commission Project Manager concludes that satisfactory progress is not being made, this conclusion will be referred to the Energy Commission's Research, Development and Demonstration (RD&D) Policy Committee for its concurrence.
- Provide the Recipient with a written determination in accordance with the schedule. The written response may include a requirement for the Recipient to revise one or more product(s) that were included in the CPR.

The Recipient shall:

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other products identified in this scope of work. The Recipient shall submit these documents to the Commission Project Manager and any other designated reviewers at least 15 working days in advance of each CPR meeting.
- Present the required information at each CPR meeting and participate in a discussion about the Agreement.
- Recipient will provide copies of any DOE correspondence (emails, reports, letters, etc.) that relate to the project status. This includes copies of project performance reviews on Recipient work and summaries and results of project review meetings with DOE.

Commission Project Manager Products:

- Agenda and a list of expected participants
- Schedule for written determination
- Written determination

Recipient Product:

- CPR Report(s)
- DOE correspondence and reporting

Task 1.3 Final Meeting

The goal of this task is to closeout this Agreement. If DOE is conducting a similar final meeting, the Recipient shall notify and invite the Commission project manager to participate, either by teleconference or by actual meeting attendance. The DOE required meeting can be used in place of the Commission's final meeting, at the discretion of the Commission project manager. However, all items listed in this task will need to be covered in the meeting.

The Recipient shall:

- Meet with Energy Commission staff to present the findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.

  This meeting will be attended by, at a minimum, the Recipient, the Commission Grants Office Officer, and the Commission Project Manager. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the Commission Project Manager.

  The technical portion of the meeting shall present an assessment of the degree to which project and task goals and objectives were achieved, findings, conclusions, recommended next steps (if any) for the Agreement, and recommendations for improvements. The Commission Project Manager will determine the appropriate meeting participants.

  The administrative portion of the meeting shall be a discussion with the Commission Project Manager and the Grants Officer about the following Agreement closeout items:
  - o What to do with any equipment purchased with Energy Commission funds (Options)
  - o Energy Commission's request for specific "generated" data (not already provided in Agreement products)
  - o Need to document Recipient's disclosure of "subject inventions" developed under the Agreement
  - o "Surviving" Agreement provisions, such as repayment provisions and confidential Products
  - o Final invoicing and release of retention
  - o Prepare a schedule for completing the closeout activities for this Agreement.
  - o Copies of all correspondence and reports discussing DOE's findings on the project, and future disposition of the project, if

applicable. When directed by the Commission project manager, recipient will provide copies of any DOE correspondence (emails, reports, letters, etc.) that relate to project performance.

Products:

- Written documentation of meeting agreements
- Schedule for completing closeout activities
- DOE correspondence on project findings and results

Task 1.4 Quarterly Progress Reports

The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the research objectives of this Agreement on time and within budget.

The objectives of this task are to summarize activities performed during the reporting period, to identify activities planned for the next reporting period, to identify issues that may affect performance and expenditures, and to form the basis for determining whether invoices are consistent with work performed.

With Commission project manager approval, the Recipient can submit a DOE Progress Report in lieu of the required Commission report if contains the information listed in Attachment 1 of the Terms and Conditions.

The Recipient shall:

- Prepare Quarterly Progress Reports which summarize all Agreement activities conducted by the Recipient for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the Commission Project Manager within 10 days of the end of the reporting period. The recommended specifications for each progress report are contained in the terms and conditions of this Agreement.
- Unless otherwise directed by the Commission project manager, each Progress Report must contain any reports made to DOE, including summaries of meetings with DOE, as it that relates to the project outcome and performance. Include names and contacts of DOE representatives.

Products:

- Quarterly Progress Reports
- Copies of DOE reporting and meeting summaries

Task 1.5 Final Report

The goal of the Final Report is to assess the project's success in achieving its goals and objectives, advancing science and technology, and providing energy-related and other benefits to California.

The final report shall describe the following at a minimum: a) original purpose, approach, activities performed, results and conclusions of the work done under this Agreement; b) how the project advanced science and technology to the benefit of California's ratepayers and the barriers overcome; c) assessment of the success of the project as measured by the degree to which goals and objectives were achieved; d) how the project supported California's economic recovery in the near term and number of jobs created or sustained; e) how the project results will be used by California industry, markets and others; f) projected cost reduction impact and other benefits resulting from the project; g) discuss the project budget, including the total project cost and all the funding partners and their cost share; h) discuss how the Energy Commission funding was spent on the project, including any unique products and benefits; i) observations, conclusions and recommendations for further RD&D projects and improvements to the PIER project management process.

If a final report is required by DOE, the Recipient will include a copy of it along with the Energy Commission's final report requirements. In addition, the Recipient shall submit the draft final DOE report to the Energy Commission for review at the same time it submits it to DOE.

The Final Report shall be a public document. If the Recipient has obtained confidential status from the Energy Commission and will be preparing a confidential version of the Final Report as well, the Recipient shall perform the following activities for both the public and confidential versions of the Final Report.

The Recipient shall:

- Provide a draft copy of the Final Report including a copy of the draft submitted to the U.S. DOE in response to the American Recovery and Reinvestment Act Funding Opportunity Notice for which an award was received. The Final Report must be completed on or before the end of the Agreement Term.
- Submit written correspondence from DOE regarding acceptance of the final report.

Products:

- Draft Final Report, including a copy of the draft report submitted to DOE
- Final Report, including a copy of the final report submitted to DOE
- Written correspondence from DOE regarding acceptance of final report

Task 1.6 Identify and Obtain Matching Funds

The goal of this task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. Although the PIER budget for this task will be zero dollars, the Recipient may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds for each task during the term of this Agreement. Match funds must be identified in writing and the associated commitments obtained before the Recipient can incur any costs for which the Recipient will request reimbursement.

The Recipient shall:

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. The letter needs to identify the following at a minimum:
  - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.
  - Amount of each in-kind contribution, a description, documented market or book value, and its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Recipient shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.
- Provide a copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured.
- Discuss match funds and the implications to the Agreement if they are reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.
- Provide the appropriate information to the Commission Project Manager if during the course of the Agreement additional match funds are received.
- Notify the Commission Project Manager within 10 days if during the course of the Agreement existing match funds are reduced. Reduction in match funds must be approved through a formal amendment to the Agreement and may trigger an additional CPR.

Products:

- A letter regarding match funds
- Copy(ies) of each match fund commitment letter(s)
- Letter(s) for new match funds (if applicable)
- Letter that match funds were reduced (if applicable)

Task 1.7 Identify and Obtain Required Permits

Exhibit A
WORK STATEMENT

The goal of this task is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track.

Permit costs and the expenses associated with obtaining permits are not reimbursable under this Agreement. Although the PIER budget for this task will be zero dollars, the Recipient shall budget match funds for any expected expenditures associated with obtaining permits. Permits must be identified in writing and obtained before the Recipient can make any expenditures for which a permit is required.

The Recipient shall:

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Project Manager at least 2 working days prior to the kick-off meeting. If there are no permits required at the start of this Agreement, then state such in the letter. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:
  - A list of the permits that identifies the:
    - Type of permit
    - Name, address and telephone number of the permitting jurisdictions
    - or lead agencies
  - The schedule the Recipient will follow in applying for and obtaining these permits.
- Discuss the list of permits and the schedule for obtaining them at the kick-off meeting and develop a timetable for submitting the updated list, schedule and the copies of the permits. The implications to the Agreement if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in the Progress Reports and will be a topic at CPR meetings.
- If during the course of the Agreement additional permits become necessary, provide the appropriate information on each permit and an updated schedule to the Commission Project Manager.
- As permits are obtained, send a copy of each approved permit to the Commission Project Manager.
- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Project Manager within 5 working days. Either of these events may trigger an additional CPR.

Products:

- Letter documenting the permits or stating that no permits are required
- A copy of each approved permit (if applicable)
- Updated list of permits as they change during the term of the Agreement (if applicable)

- Updated schedule for acquiring permits as changes occur during the term of the Agreement (if applicable)

TECHNICAL TASKS

TASK 2 STANFORD PROJECTS

Task 2.1 Project 1 (Software Platform) Computer Infrastructure for Prototyping and Evaluation

The goal of this task is to develop a platform or "test-bed" for prototyping and experimentation.

The Recipient shall:

- Perform final assessments of plug and home level energy sensors.
- Deploy sensors in 5 homes for pilot testing with feedback data accessible through a web interface.
- Design and create a database infrastructure along with a query layer for use by multiple interface solutions. The creation of a simple malleable prototype interface that closes the loop between data sensing, uploading to database, data query, and feedback to the user.
- Collect data on energy usage in multiple homes with plug level sensors and pilot test back end infrastructure.
- Create software Application Programming Interface's (API's) for interface design, event logging, data feeds, data manipulation, pre-processing sensor data, system diagnostics, and reporting outage. Test software with real sensor feeds. Design for scaling up to 1000 homes.
- Design and development of software tools for data analysis and automated reporting.
- Continue to develop and maintain data analysis software and diagnostic
- Place hardware order for initial work.
- Deploy system in 5 homes and verify that the systems are working.
- Demonstrate database and simple infrastructure that enables interface prototyping and data manipulation.
- Analyze pilot data and report at a group meeting.
- Make software API's accessible to participants.
- Supply documentation for API to groups.
- Demonstrate software tools to project groups.
- Revise documentation for tools.

<u>Google Platform & Analytics</u>

- Design 1,000-person trial with Google. Draft experimental design document. Discuss the feasibility of a program design and evaluation tool, and a policy simulation tool with Google.

- Determine if ideas of Stanford researchers regarding Google PowerMeter features will be feasible to test.
- Implement Google trial and data collection.
- Complete first analysis of Google data (for Phase 1: Effectiveness of Current Google PowerMeter).
- Complete second analysis of Google data (for Phase 2: Manipulation of Specific Interface Features).
- Complete third analysis of Google data (for Phase 3: Effectiveness of Revised Google PowerMeter and Generalizability to Overall Population).
- Conduct final analysis of Google data and write up results.
- Complete design document. If feasible, provide a timeline and milestones for these tools.
- Provide written suggestions of Google PowerMeter features if feasible to test.
- Conduct presentation of first analysis at group meeting.
- Conduct presentation of second analysis at group meeting.
- Conduct presentation of third analysis at group meeting.
- Prepare a paper that describes the evaluation of the Google power meter.

Products:

- Final Paper (no draft)

- **<u>Social Media Analytics</u>**

  - Collect benchmark data to establish baseline measures of social media.
  - Collect T1 comparison data.
  - Compare social media metrics T1 to benchmark.
  - Collect T2 data.
  - Analyze second social media metrics comparison T2 to T1 to benchmark.
  - Collect T3 data, prototype integration of social media metrics with software platform.
  - Conduct third social media metrics comparison T3 to T2 to T1 to benchmark.
  - Collect T4 data, modify analytic tools, prototype integration of social media metrics with software platform; baseline data collection for prototype participants.
  - Conduct fourth social media metrics comparison - T4 to T3 to T2 to T1 to benchmark.
  - Collect baseline social media metrics for prototype participants.
  - Collect T5 comparison data, integrate with platform analytics, and adapt analytic tools.
  - Carry out fifth social media metrics comparison T5 to benchmark.
  - Collect T6 data – social media and platform.
  - Conduct sixth social media metrics comparison T6 to T5 to benchmark.
  - Collect T7 data – social media and platform.

- Conduct seventh social media metrics comparison T7 to T6 to T5 to benchmark.
- Collect T8 data – social media and platform.
- Eighth social media metrics comparison - T8 to T7 to T6 to T5 to benchmark.
- Prepare a report that describes the social media benchmarks

Products

- Final report (no draft)

Task 2.2 Project 2 (Interventions - Foundational) Formative Work for Interventions

The goal of this task is to segment and analyze the target audience, determine compelling feedback displays and visual prototypes.

The Recipient shall:

- **Project 2A**
  - Review existing literature. Finalize ethnography script. Assess whether additional ethnographies or segmentation work is necessary.
  - Perform ethnographies.
  - Complete analysis and write up. Assess whether additional ethnographies are necessary.
  - Prepare a paper describing the ethnographic findings.

- **Project 2B**
  - Prepare for trial to implement hardware systems in five homes to ensure effectiveness, ease of use, and reliability. Evaluate disambiguation system to assess whether or not this system can be used as a substitute for sensors. Develop user instructions and deployment strategy. Finalize research design.
  - Install hardware and begin data collection.
  - Order full set of hardware and hire electricians. Submit human participants protocol. Recruit participants.
  - Install hardware in all study homes and provide participants with instructions. Initiate feedback and record data.
  - Prepare a report that contains the analysis and write up of the results.
- **Project 2C**
  - Review existing sources of information such as smart phones and computer screen channels with dedicated information channels (e.g., the Ambient Orb used for market and weather data), energy monitors, control systems, and low fidelity systems (switches and thermostats).
  - Develop concepts and detailed designs of other interfaces based on findings from ethnography, selected behavioral economics framing configurations and iterative prototyping.
  - Pilot test in a small number of homes.

- Test multiple interfaces at scale in partnership with Utility/ Industry partner, variations on interfaces based on initial findings.
- Gather data and analyze studies, deployment of new interfaces for continued studies.
- Analyze and report on findings.
- Review report at group meeting.
- Demonstrate preliminary interface.
- Demonstrate final interfaces for evaluation.
- Report to group meeting of effectiveness of new interfaces for continued studies.
- Prepare a report on the development, testing and evaluation of the interfaces used in project 2C

Products:

- **Project 2A**
  - Final paper (no draft)
- **Project 2B**
  - Final report (no draft)
- **Project 2C**
  - Final report (no draft)

Task 2.3 Project 3 (Interventions – Technology) Smart Automation

The goal of this task is to create algorithms to detect complex but unobvious schedule regularities that automatically control devices in a HAN.

The Recipient shall:

- Establish sensor data streams containing user context and power usage data
- Set up a prototype smart room lab embedding technologies in sensing, processing, networking, and wireless light control
- Develop and test algorithms for detection of user's location and inference of user activity in home, to be used by the energy management unit as contextual data
- Deploy a wireless sensor network for control of light settings and collecting power usage data
- Test the system for real-time operation with adequate granularity and precision for energy-optimal light control application
- Analyze the test results
- Create a user data set based on sensor and inference data
- Add a handheld user device to the system as the interface to acquire user preferences in energy setting, and to register and record the preferences as they are provided by the user over time
- Create a database containing user-based history relating context, preferences, and the corresponding power usage and light settings

- Run tests for several weeks with a group of test users to collect data into the database
- Develop evaluation methods to verify and model convergence of the system behavior to user's preferences
- Develop user-specific behavior models
- Based on saved user profiles, develop models for the behavior of individual users in the form of statistical relational models
- Develop prediction methods based on the user model to infer user's intention and render services proactively
- Create algorithms to compare the behavior prediction results and system settings with user context and any new input of preferences in the user interface device
- Test the predictive model with user test group and analyze the results
- Develop adaptive control techniques
- Develop optimization formulations for balancing energy usage for lighting and user comfort using utility functions for different user activities (such as reading, watching television, exercising, working in kitchen, or eating).
- Develop methods to adaptively change the utility functions over time based on stated user preferences and the results of optimization
- Evaluate the adaptation of services to user preferences by analysis of the convergence behavior with the test user group data
- Test different energy usage profiles for activities and contexts in order to produce a balanced generic set of utility functions as starting points for user adaptation
- Establish a set of sensor data inputs streams.
- The research team plans to investigate a wide variety of possible data sources, such as user energy consumption reports, user location data, home and office sensor network data, building heating and cooling data, and others, with preliminary experiments into their efficacy for automated energy usage modeling and control.
- Create a user data set based on sensor data. Here the research team will take the data sources determined by the previous phase and create a unified database cataloging this data from a single user (or multiple users) over a time span of 3-4 months. This database will be the primary result of these quarters.
- Develop user-specific behavior models that are able to model and predict individual user activity and power usage using Markov Decision Processes, and create and test energy usage profiles for different activities and contexts. The goal for these quarters is to use the aforementioned database in a modeling context, investigating to what degree different elements of a user's behavior and energy usage can be predicted based on past behavior and concurrent sensor inputs.
- Develop adaptive control techniques (using the predictive models) that minimize user power consumption while obeying user comfort constraints. Here the research team will use the model described above to make

probabilistic predictions about the user's energy usage given his or her current situation and history.
- Demonstrate database.
- Prepare a document that discusses the results of the project and implications for potential energy use reductions.

Products:
- Final document (no draft)

Task 2.4 Project 4 (Intervention – Media) Multiplayer Game

The goal of this task is to create a game platform to enable empirical research about how games can change consumer decisions about energy consumption.

The Recipient shall:
- Select game design company to produce research quality multiplayer interactions using smart meter data embedded into game play.
- Complete design conversations, written description of game narrative and backstory.
- Complete arrangements to collect data
- Complete game prototype
- Test game software
- Complete pre-testing with test sample where ~50 people play the game for one week; recording of game play; personal interviews about experience and problems; summary report submitted
- Test game play using web interface
- Completion of data gathering for field tests launched from partner websites; total sample size undetermined at this point; planing for 1,000+.

- Accumulate, sort and prepare all data for analysis.
- Prepare figures and tables with appropriate descriptions of research methods.
- Conduct data analysis
- Complete technical tests of connections between Powermeter and PG&E.com, and game servers.
- Sign a contract with a professional game company
- Receive a working game from the game company for testing and evaluation
- Complete game testing and game error fixes.
- Prepare a paper that describes the testing, evaluation and results of deploying the game.

Products:
- A final paper (no draft).

Task 2.5 Project 5 (Intervention – Media) Mobile Interactions

The goal of this task is to create behavioral applications delivered via smart mobile phones that can be disseminated across the United States.

The Recipient shall:

- Develop concepts and detailed designs of interfaces based on findings from ethnography, selected behavioral economics framing configurations and iterative prototyping.
- Test software in pilot test in a small number of homes, revision of interfaces.
- Refine multiple (2-3) interfaces, deployment and testing (data collection) at wider scale with partnership with utility.
- Conduct data analysis and report on findings.
- Conduct ethnographic formative studies, design process, prototyping (Phase 1)
- During the Phase 1 period, develop a prototype of the mobile phone application using a participatory, ethnographic approach to program development consisting of structured interviews with experts in the field as well as members of the target audience, along with target audience informal focus groups and “cognitive walk-throughs” to formulate key features of the smart phone platform. Once formative testing has occurred for the different elements of the system, the research team will conduct pilot testing of the overall system to evaluate system fidelity.
- Finalize the most appropriate and feasible pilot study design, target audience characteristics, audience-specific recruitment strategies, and the assessment tools and protocols to be applied in Phase 2 of the project.
- Write up intervention evaluation and refinement activities (Phase 2)
- Conduct analysis and write-up
- Clean and maintain data collected throughout the project period for data analysis, including ongoing checks for data completeness and accuracy, by project staff.
- Prepare a paper for publication that describes the behavior applications delivered via smart phones and the results of the data analysis from deploying the application in the test.

Products:

- Final paper suitable for publication (no draft)

Task 2.6 Project 6 (Intervention – Policy) Smart Monetary Incentives

The goal of this task is to develop incentive mechanisms that stretch the value of monetary rewards so that the energy behavior change is maximized for a given amount of money.

The Recipient shall:

- Develop incentive mechanisms to reward households that reduce their energy use.
- Determine a randomization strategy to allocate households into different treatment groups. The households will be pulled from a population that already has smart meters installed.
- Implement intervention and deliver appropriate incentives using the web-based platform developed in earlier stage of project.
- Conduct analysis and write-up. Data will be analyzed using appropriate statistical models to determine variance from baseline household energy use. The purpose of this statistical analysis will be to determine whether the incentive mechanisms have an effect on household energy use.
- Prepare a final report that describes and analyzes the project and contains project conclusions that is suitable for publication.

Products:

- Final report that is a paper suitable for publication (no draft).

Task 2.7 Project 7 (Interventions – Policy) Nudges to Purchase Energy Efficient Appliances

The goal of this task is to provide information and use framing in order to shift purchasing decisions to energy efficient appliances and electronics.

The Recipient shall:

- Evaluate of existing recommendation systems and prototypes (Phase 1)
- Collect data from online sellers of appliances such as eBay and Amazon in order to estimate existing consumer preferences for energy efficiency. Basic pricing and market share data will be coupled with observations of existing online recommendation systems to estimate the effect of recommendations on consumer purchases of household appliances. The data collection effort will focus on websites such as Amazon.com and the eBay Marketplace.
- Use appropriate statistical techniques to determine the nature of online demand for appliances and how specific features of online commerce affect consumer preferences. Different statistical techniques will be developed and tested with the goal of identifying a sound methodology to analyze data in the next two phases.

- Prototype an online recommendation systems for energy-efficient appliances will be developed and test in a controlled lab environment with a small sample of users. The goal will be to determine a portfolio of framing effects that will be the most powerful to nudge consumers to purchase energy-efficient appliances.
- Implement a Recommendation System (Phase 2)
- Develop and implement a recommendation system for energy-efficient appliances. The recommendation system will be part of the web-interface used for the feedback systems. Sensor data that provides information about electricity use in the whole home or appliances specific will be used to tailor the recommendation system to the consumers.
- Deploy recommendation system in a real-world setting, using techniques from randomized controlled trials, in a population of consumers receiving energy feedback.
- Analyze data and policy simulations (Phase 3)
- Analyze the data obtained from the deployment in Phase II. Using the statistical techniques developed in Phase I, policy simulations will be performed to provide estimates of the large adoption of our recommendation system.
- Prepare a report that describes the results of the experiments that contains policy recommendations.

Products:

- Final report (no draft)

Task 2.8 Project 8 (Interventions – Policy) Goals and Collective Action

The goal of this task is to use goal setting and collaboration, two powerful non-monetary incentives, to motivate energy reductions.

The Recipient shall:

- Select partner to manage and present electricity usage feedback to consumers.
- Begin to develop first stage experiments.
- Conduct mini workshop on collective goals.
- Complete development of first stage experiments.
- Modify a previously-developed Smart Meter interface for first stage experiments.
- Collect data for first stage experiments.
- Conduct mini workshop on adaptive learning algorithms.
- Analyze data from first stage experiments.
- Develop second stage experiments.
- Modify Smart Meter interface for second stage experiments.
- Begin data collection for second stage experiments.

- Collect data for second stage experiments.
- Analyze data from second stage experiments.
- Prepare a report that contains data from the first and second stage experiments.

Products:

- Final report (no draft)

Task 2.9 Project 9 (Interventions – Community) School and Community Programs

The goal of this task is to perform community-based intervention to influence home energy efficiency behaviors.

The Recipient shall:

- Form research team.
- Review theory and extant literature.
- Formative studies: ethnographic interviews/focus groups, initial pilot testing of concepts, messages and measures.
- Identify attitude and behavior goals and key approaches.
- Draft the material for interventions and curriculum.
- Draft curriculum for pilot testing.
- Complete draft of measures of intervention effects.
- Pilot test of curriculum lessons and measures with representative students and revision of curriculum and measures as needed.
- Identify community entities for randomized trial.
- Obtain parental informed consents.
- Baseline assessments and randomization
- Begin intervention (curriculum) delivery
- Complete intervention delivery
- Post-test assessments completed
- Conduct data cleaning and data quality assurance procedures performed
- Begin data analysis and write-up of results
- Revise curriculum and prepare for dissemination
- Prepare paper that evaluates the curriculum
- Prepare curriculum materials

Products:

- Final paper (no draft)
- Final curriculum materials (no draft)

Task 2.10 Project 10 (Data Modeling) Energy Consumption Forecasts

Exhibit A
WORK STATEMENT

The goal of this task is to segment the customer base into groups that exhibit similar energy consumption behaviors based on the detailed history of energy consumption data and additional information about building locations, demographics, and weather conditions at the time of consumption.

The Recipient shall:

- Prepare energy consumption data
- Develop an understanding of data available now and data that could be available.
- Develop an understanding of purpose of consumption forecasts and current practices and their data needs.
- Develop a rough draft of the envisioned consumption forecasting method and system.
- Define metrics for a good consumption forecasting method.
- Segment initial data
- Work on obtaining additional data as necessary (per findings from -10).
- Based on the draft forecast method and the available data develop and try a range of categories to segment the data.
- Refine method and test against test data
- Further develop the envisioned consumption forecast method and test it against the current method with the segmented data.
- Incorporate the new data into the segmentation method.
- Document the performance of current forecasting methods.
- Develop final version of segmentation method
- Enhance the method to segment consumption data, using insights about the performance of the segmented data to enable forecasting,.
- Provide guidance to utility in implementing method, rapid prototyping of the prediction method
- Recommend data to be collected, including frequency. Refine the forecasting method.
- Develop prediction method, test against new test sets
- Test the forecasting method against new data sets from the previous two quarters.
- Finalize prediction method
- Test the forecasting method against the comparable, current method.
- Document and disseminate
- Build website for the method or add to project website.
- Hold workshop.
- Prepare a report that describes the forecasting methods
- Prepare dissemination documents suitable for use in training events.

Products:

- A final report (no draft)
- Dissemination documents (no drafts)

Task 2.11 Project 11 (Data Modeling) Behaviorally Informed Prescriptive Economic Models

The goal of this task is to model heuristics and decision strategies that are systematic in the context of energy decisions, such as learning, behavioral rules (heuristics and biases) and community interactions.

The Recipient shall:

- Select modeling approaches (Phase 1)
- Review literature and select modeling approaches that will be used in the subsequent phases.
- Hold meeting with researchers participating in this project and other researchers with relevant expertise will be organized. The goal of this meeting will be to discuss the relevant merits and the integration of different modeling methodologies.
- Produce a post-meeting summary report.
- Engage in Phase 2 Model development.
- Develop models based on the approaches selected in the first phase. Model development includes several activities such as the development of simulation algorithms, estimation strategies and mathematical formulation of the models.
- Implement Phase 3 which involves estimations and simulations.
- Use data from field experiments involving feedback technologies to estimate the key parameters of the models. Perform simulations to identify key parameters of interests.
- Conduct analysis and write-up (Phase 4)
- Use the model to analyze and simulate policies.
- Prepare a report that describes the modeling approaches used, the results of field experiments (evaluation) and policy recommendations.

Products:

- Final report (no draft)

Task 2.12 Project 12 (Energy Sensor Network) Open Extensible Communication Network

The goal of this task is to expand opportunities for flexibility and innovation in HANs with an open and extensible communications protocol that will allow for unforeseen behavior change opportunities.

The Recipient shall:

- Evaluate pilot wireless sensor network deployment and extend it.
- Evaluate the deployment of 80 wireless power meters to understand network properties such as topology and data delivery ratios. This will

- Complete third board revision and full low-level software stack.
- Complete transmission control protocol/internet protocol TCP/IP networking stack & release software
- Complete services for data collection and actuation
- Optimize collection services to handle large amounts of data. In addition, the research team will investigate the best ways to make data available to the community. The research team will also develop tools for actuation. These will take advantage of the board relay finished in and will allows us to control when devices consume power.
- Research new network services and protocols for HANs
- Review the design and deployment decisions made over the course of the project. With lessons learned in mind the research team will investigate what new services and protocols can HANs benefit from.
- Prepare a report on what new services and protocols can benefit home area networks.

Products:

- Final Report (no draft)