Energy Research and Development Division
FINAL PROJECT REPORT

DAVIS FUTURE RENEWABLE ENERGY AND EFFICIENCY

Prepared for: California Energy Commission
Prepared by: Valley Climate Action Center on behalf of the City of Davis, CA

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The Energy Research and Development Division strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

Energy Research and Development Division funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

This report on the *Davis Future Renewable Energy and Efficiency* project is the final report for the DavisFREE project (contract number *PIR-12-011)* conducted by the City of Davis, California. The information from this project contributes to Energy Research and Development Division's Renewable Energy Technologies Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

The Davis "Future Renewable Energy and Efficiency" (DavisFREE) project developed detailed and comprehensive integrated renewable energy and enhanced residential energy efficiency plans to guide the City of Davis in achieving climate action and energy reduction goals related to building energy usage.

The benefits to California ratepayers include contribution to the State of California's goals for greenhouse gas reduction, renewable portfolio standards, and localized renewable energy production. The research provides new information and marketing approaches for the state's interest in zero net energy building design and construction. The research also provides new information for California's Integrated Energy Policy Report updates, cost of generation supply curve modeling, and approaches for development of databases and tools to guide other communities in analyzing the potential for locally-owned renewable energy generation systems.

The primary research tasks for DavisFREE included:

1. Database development using data extracted from the city's Geographic Information System (GIS) specific to building-related energy usage; and integration with the PG&E Green Communities community-wide energy usage database and customer target marketing tools.
2. Analysis of locally-available renewable energy resources, including regional availability of direct solar, wind, biomass, geothermal, and micro-hydro for potential community-scale electricity generation.
3. Cost of generation modeling for locally-available renewable energy resources.
4. Development of zero net energy guidelines for existing residential buildings.
5. Development of a solar thermal water heating deployment plan and marketing materials.
6. Community engagement activity planning to deliver the results of the research.

DavisFREE concluded that locally-owned community-scale renewable energy development is viable for Davis, and that zero net energy conversion for existing residential buildings is feasible and cost effective. The results and products of this work are expected to be delivered to Davis residents through multiple implementation strategies.

Keywords: Energy efficiency, zero net energy, renewable energy, photovoltaics, solar water heating, geographic information system, community scale renewable energy, climate action, existing residential buildings, deployment plan, Davis California.

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The City of Davis has developed an aggressive and comprehensive Climate Action and Adaptation Plan (CAAP) that requires community-wide carbon emissions neutrality by 2050 and a 15 percent reduction below the city's 1990 carbon emissions level by 2015. The CAAP also adopted a 2015 goal of reducing the total energy use in Davis by 5 percent from 2010 levels. While the CAAP includes many options for possibly reaching its goals, it lacks a specific analysis of the optimal paths and milestones for achieving them. The CAAP applies to energy emissions from buildings and local transportation.

The Davis "Future Renewable Energy and Efficiency" (DavisFREE) project was funded by a $300,000 grant from the California Energy Commission's Community Scale Renewable Energy Integration "Exploration" research area and a $75,000 matching funds from the City of Davis. DavisFREE developed detailed and comprehensive integrated renewable energy and enhanced energy efficiency plans to guide the City of Davis in achieving climate action and energy reduction goals related to building energy usage. These plans include interim milestones that will deliver significant results by the end of 2015 to meet the first CAAP goals, and by 2020 for the State of California's goals for greenhouse gas reduction, renewable portfolio standards, and localized renewable energy production.

The DavisFREE initiative built upon the Davis CAAP planning process and the subsequent Net Zero Davis Scoping Study and white paper that evaluated net zero scenarios and documented related data and assumptions. The DavisFREE report defines and describes the more detailed integrated resource planning that can be undertaken by the city to deliver significant results within the next few years or within a decade.

Davis is a settled, low-growth community that is bound by zoned prime agricultural lands. It cannot expect community-scale zero net carbon and energy goals to be strongly influenced through new high-performance building construction. Rather, Davis must focus on the available energy retrofit opportunities for existing building stock that will dwarf the impacts of net zero new construction in the years to come.

The DavisFREE position is that significant renewable energy capacity (on-site solar thermal water heating and photovoltaics) can be employed almost immediately; rapidly "moving the needle" toward energy and carbon reduction goal achievement, while incremental "deep" energy efficiency improvements proceed using the Zero Net Energy Neighborhood Volume Marketing approach developed under DavisFREE. In the longer term, Davis intends to develop local community-scale renewable energy systems that will offset utility grid energy usage for groups of residents or businesses that, for whatever reason, are not able or willing to install on-site generation.

The project philosophy differs somewhat from the conventional net zero carbon strategy, which generally suggests that the best approach, is to drive down energy demand as far and as fast as economically possible through energy efficiency, and then use renewable resources to serve reduced demand. The general approach is conceptually correct, but not always the most practical approach for a community. Davis, for example, is a settled, low growth community that has been improving energy efficiency for many years and cannot expect community-scale zero net energy and carbon neutrality goals to be strongly influenced through new high-performance building construction. The prevalent "efficiency first" strategy is largely dependent on what incumbent utilities offer in terms of incentives, and therefore essentially puts and keeps one community on the same limited track as every other community. The Davis philosophy intends to move the city more aggressively forward with renewable energy as its best path to achieving net zero carbon goals.

Project Purpose

The goal was to formulate a preliminary energy efficiency and long-term renewable energy deployment roadmap for Davis. The ultimate CAAP goal is to directly or indirectly replace all electricity and natural gas delivered by utilities with renewable sources that are possible locally accessible, rather than from centralized electricity generation facilities and interstate pipelines.

The objectives of the project were: (1) to develop databases, supply curves, and net zero energy building guidelines to determine which initiatives recommended in previous analyses should receive priority attention in the next phase of CAAP implementation, and (2) to develop methodologies and community energy flow models that will be used in planning subsequent community renewable energy technology deployment phases.

DavisFREE conducted multiple research activities and formulated renewable energy development plans specific to the most prevalent locally-available renewable energy resources, which are direct solar (electric and thermal) and wind. Geothermal, agricultural biomass, and in-conduit micro-hydro were found to not currently be viable resources for community-scale renewable energy development.

The project approach provides individual investors, such as building owners and ratepayers, with latitude in selecting advanced energy efficiency and renewable energy options that are most appropriate, desirable, and cost-effective for them, while alleviating environmental issues. Solar water heating greatly reduces natural gas combustion as a source of greenhouse gas emission and local air pollution, and has great appeal for people wanting to immediately reduce their carbon footprints.

DavisFREE also assumed an approach that is different than that normally considered by communities considering community choice aggregation programs, also known as community choice energy. Community choice aggregation / community choice energy entities have tended to focus on increasing renewable energy supply by purchasing imported (utility scale) energy immediately and leaving the matter of build out of local renewables until later.

Instead, DavisFREE investigated a pragmatic approach to the development of locally available renewable energy resources and properly scoping out the building-integrated, cost-effective renewable energy technology options that can be owned and operated by individual homeowners, businesses, and institutions.

Project Results

With the direction of DavisFREE, the city developed a geographical information system (GIS) spatial analysis tool and database that integrated aerial rooftop imagery, residential construction histories, parcel-based ownership, and energy system improvement information that elicited significant data on the energy-related aspects of existing buildings, which were listed by decade built. Other communities will also be able to take advantage of this approach.

Combining the GIS data with community-wide PG&E energy usage data, the project was able to identify buildings, city properties, and neighborhoods that are the best candidates for solar water heating, on-site photovoltaic (PV), distributed renewable generation and "deep" whole-building energy efficiency improvements. The PG&E tool will also help identify target marketing opportunities for neighborhood groups of 20-30 homes.

The project researched and developed detailed deployment plans for solar water heating and photovoltaic installations, and the zero net energy retrofit guidelines to encourage and enable Davis residents and businesses to invest in renewable energy and enhanced energy efficiency that are specifically linked to the goals and milestones in the CAAP.

Project Benefits

The DavisFREE program developed information and deployment plans that will encourage and enable Davis residents and businesses to invest in renewable energy and enhanced energy efficiency. The plans also provide detailed information for local city-endorsed energy marketing and implementation teams to enable rapid and comprehensive outreach activities.

The project's plans can contribute to the cost-of-generation data for the state's Integrated Energy Policy report and to the further development of the local community energy balance and optimization model called the Regional Energy Planning Optimization program and other California communities. They can be used to assess the ability of various local supply portfolios to adequately meet demand, the overall cost of the supplied energy, and the resulting greenhouse gas impacts.

The DavisFREE results will also directly contribute to the carbon reduction goals of Assembly Bill 32 (Nunez, Chapter 488, Statutes of 2006), the Global Warming Solutions Act, and various components including (but not limited to):

- AB 32 requires California to reduce its greenhouse gas (GHG) emissions to 1990 levels by 2020 — a reduction of approximately 15 percent below emissions expected under a "business as usual" scenario; and to achieve 80 percent GHG reduction by 2050.
- The Renewables Portfolio Standard program requires investor-owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 33 percent of total procurement by 2020, and 50 percent by 2030.
- The Renewable Electricity Standard that requires the State's electricity load serving entities to deliver 20 percent of retail sales from renewable energy by the end of 2013, 25 percent by the end of 2016, and 33 percent by the end of 2020.

- The Green Tariff Shared Renewables Program (Senate Bill 43, Pavley, Chapter 413, Statutes of 2013)that establishes a 600 Megawatt statewide program that will allow the customers of investor-owned utilities to purchase up to 100 percent of their electricity from a renewable energy facility.
- The Million Solar Roofs Initiative for photovoltaics which provided the vision that resulted in the California Solar Initiative (CSI).
- Solar Water Heating (Assembly Bill 1470, Blumenfield, Chapter 24, Statutes of 2012)with a goal of 200,000 hot water systems on businesses and homes, which spawned the California Solar Incentive-Thermal program
- Zero Net Energy (ZNE) building design research and construction initiatives, currently being proposed by the California Public Utilities Commission.

CHAPTER 1: Introduction to DavisFREE

1.1 Background

The City of Davis has developed an aggressive and comprehensive Climate Action and Adaptation Plan (CAAP) that requires community-wide carbon emissions neutrality by 2050 and a 15 percent reduction below the city's 1990 carbon emissions level by 2015. The CAAP also adopted a 2015 goal of reducing the total energy use in Davis by 5 percent from 2010 levels. While the CAAP includes many options for possibly reaching its goals, it lacks a specific analysis of the optimal paths and milestones for achieving them. The CAAP applies to energy emissions from buildings and local transportation.

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1.2 Primary Project Tasks

The primary California Energy Commission contract tasks for DavisFREE are described in the following sub-sections.

- Task 1: Administration
  This task included activities and reporting required by the California Energy Commission to manage the contract agreement.
- Task 2: Project Management and Direction
  Task 2 covered activities and reporting required for internal management of the research project team, budget, and schedule.
- Task 3: GIS Development
  This task provided for the development of a Geographical Information System (GIS) suitable for spatial analysis of the rooftop renewable energy production potential and increased energy efficiency potential of existing single-family homes in Davis. The products of this work were based on City of Davis databases such as construction histories, building remodeling permits, and property use covenants, and GIS mapping technology.
- Task 4: Local Renewable Energy Resource and Technology Supply Curve Development
  This task activity examined the cost of renewable energy electricity generation and natural gas offset for building-scale and community-scale applications specific to the local renewable resources available to the city.
- Task 5: Zero Net Energy Guidelines
  Task 5 was for conducting research and development for a report on "Zero Net Energy Retrofit Guidelines for Existing Residential Buildings".
- Task 6: Technology Selection
  Under Task 6 the research team determined the most cost-effective renewable resource mix and the specific renewable energy technology options that will guide renewable energy investment decisions by residents of the Davis.
- Task 7: Deployment Planning
  Task 7 was for the development of goals, milestones, and action plans needed for the renewable energy-related components of the Climate Action and Adaptation Plan; including specific on research solar thermal water heating.
- Task 8: Community Engagement
  Task 8 included the development of methods for ongoing communication and collaboration with local policy-makers, stakeholders, and partners to improve the DavisFREE program design and delivery; communicate project results and recommendations of the project to other communities that seek to emulate it; and establish confidence in the energy action plans developed for the CAAP.

1.3 Contractor Team

The City of Davis was the prime contractor for DavisFREE. The project was managed by Valley Climate Action Center (VCAC), a non-profit organization. Pacific Gas & Electric Co. was a voluntary participant in providing community-wide aggregated energy usage data and collaboration on community engagement activities. Experts from the organizations listed below provided leadership on the respective research tasks.

a. GIS and Energy Usage Database Development
   City of Davis, UC Davis, PG&E, Valley Climate Action Center

b. Local Renewable Energy Resources / Cost of Generation
   DNV-KEMA, UC Davis

c. Zero Net Energy Building Guidelines
   BIRAenergy

d. Renewable Energy Technology Selection
   DNV/GL-KEMA, UC Davis, IRES Network

e. Deployment Planning
   Aztec Solar, BIRAenergy, Valley Climate Action Center

f. Community Engagement
   Valley Climate Action Center, PG&E

The following chapters discuss the research tasks, approaches, results, and recommendations.

CHAPTER 2:
Database Development (Task #3)

2.1 Goal and Purpose of Task 3

The goal was to develop a geographic information system (GIS) suitable for spatial analysis of rooftop renewable energy production potential and increased energy efficiency potential of existing single-family homes and businesses in Davis. Additionally, to acquire and integrate sufficient data from Pacific Gas & Electric Co. (PG&E) on customer electricity and natural gas energy usage and billing history data to allow projections of energy reduction potentials from increased efficiency as well as new generation capacity from locally-available renewable energy resources. The project could then also estimate the building-related greenhouse gas (GHG) reduction potential for Davis as a result of the proposed DavisFREE interventions, using PG&E greenhouse gas baselines and calculator tools.

The purpose was to:

- derive databases for use in whole-house energy modeling.
- identify residential energy efficiency improvements made over the past 15 years by date, location, technology, and frequency.
- locate existing solar energy systems.
- determine potential sites for community-scale utility renewable energy generation systems.
- develop illustrative maps for use in energy improvement marketing planning, including technical and market potentials for photovoltaic and solar thermal systems.

Additionally, to establish community-wide energy usage and greenhouse gas emission baselines and trends over past eight or more years against which to assess future improvements.

Task 3 activities were led by Richard Flood, Project Manager, with direct involvement of all other DavisFREE Task leaders. The primary coordinator for PG&E was Nichoel Farris. The City of Davis GIS analysts were Bruce Boyd and Matt Wolf.

2.2 Database Sources

2.2.1 City of Davis GIS

The city's enterprise GIS system was initiated in 2000 as a technology project to support city projects and to provide maps and geographic information to the public. GIS integrates spatial information with tabular data to create maps and to provide insight on trends and metrics to support the various city programs. Davis has integrated GIS into programs that formerly had no mapping component or that relied primarily on printed maps that were infrequently updated.

A detailed plan for extracting selected data from the GIS to accommodate the building-related energy analysis needs of DavisFREE was co-developed by the city's GIS administrator and DavisFREE team members. The plan was proven successful and can serve as a model for other communities. More detailed information on the data extraction and uses specific to DavisFREE can be found in the technical research task descriptions of this report. The data assembled came from multiple tabular databases. It was processed (extracted and re-organized) by DavisFREE subcontractors and returned to the GIS administrator with instructions for development of illustrative maps and archiving of the new databases.

2.2.1.1 Yolo County Assessor

The county assessor land use data that has two tables tied together by address, and includes broader info about residential property type, year built, lot size, property ownership and transfers, use changes, major remodel history, and building characterization (which for residential includes number of bedrooms and baths, building footprint and occupy able space area, HVAC type, and amenities). Other land use type parcels, such as multi-family and commercial, are also available from the assessor.

2.2.1.2 City of Davis

The city's GIS databases are public information. Davis uses the proprietary ArcGIS data analysis and mapping software platform. The database components that were used for DavisFREE energy research included:

a. Subdivision development filing histories.

b. Parcel-based GIS data such as a master list of addresses (to the sub-parcel level), property use types, zoning covenants (use and construction restrictions), square footage of floorspace, square footage of rooftops, numbers of bedrooms and bathrooms, and histograms on lot sizes (lot-to-building size ratio).

c. Residential development standards on a property-by-property basis that lists characteristics such as property age, size, heating type, and so forth, and the construction attributes of all premises, such as shell material and roof material, that were needed to conceptualize DavisFREE energy modeling parameters.

d. Number and location of residential properties by type, such as single-family detached or attached, and multi-family by number of units in the complex (but not by number of units per building).

e. Census tracks, including 8-10 datasets with 2,000-4,000 residents each. These are then divided into "block groups" of a few hundred residents, which is generally the minimum mapping area the city uses. The GIS data extraction can be focused all the way down to individual structures (for example, homes).

f. Building construction permits that are organized by year and are very general but provide basic information regarding improvements to building shell and roof, plumbing and electrical, new construction on the parcel, room additions and other major remodeling, HVAC systems, pools, and so forth that have occurred since 2000 for every

Davis address. Permits from 1991 to 2000 were all manual-entry documents and have been archived and were not available for DavisFREE. Over 105,000 construction permits have been issues since 1991. Guided by DavisFREE, the GIS administrator was able to extract much more energy-related information than anticipated, including roofs, windows and doors, insulation, HVAC, PV and solar thermal, and other components that assisted the research.

- The permit application form is a two-part application. The cover page contains primary category fields about the application date, location of the activity, owner of record, contractor, contact information, and cost of the activity.
- The second part has "free form" activity fields that can be queried independently of the category fields. The activity fields entered by the permit office staff during an interview with the customer regarding the intent and details of the construction.
    - Permit office staff try to use standardized activity field descriptors but DavisFREE found variation when conducting keyword searches for energy-related applications. For example, although PV permits have been specifically tracked since 2001, querying for records with *PV* identified many fewer photovoltaic installations than expected. Searches for records with '*SOLAR*' and '*PHOTO* helped, but eventually a manual review was needed to identify and differentiate solar technologies (solar electric or solar thermal) by looking for other keyword entries, such as "solar, PV, photovoltaics (with various spellings), solar electric, pool with solar, solar hot water", and others. Many of the forms included the electrical capacity or number of PV panels of the intended system, but this was inconsistent. DavisFREE will recommend minor changes to office procedures to more easily and clearly capture the desired attributes of the permits.
    - Similarly, queries for *HVAC* revealed multiple and sometimes inadequate descriptors, including central heating or air conditioning, packaged or split systems, furnaces, heat pumps, radiant floors, and others.
    - The extraction of data on energy equipment assists target marketing because the information can show neighborhoods where more or fewer energy improvements have been constructed. In a few years it may also encourage technology-specific efficiency marketing campaigns; for example, permit records can show how many HVAC units were installed in the year 2000. Assuming a 17-year equipment lifespan, in 2017 notices could be sent to those homeowners to have them consider HVAC replacement with new, higher efficiency equipment.

g. Business licenses are updated annually and identify business type and business owner/manager, building ownership, and contact information. One value of this was locating businesses that are high users of hot water, such as apartment complexes, hotels, restaurants, laundries, and commercial pools that may realize economic value by installing solar thermal water heating systems. Existing PV and solar water heating systems installations were also located and mapped.

h. Apartment complex data provided size, number of living units, owner/manager contact information, and more. DavisFREE conducted 60 interviews to determine whether central boilers or separate unit water heaters provided hot water, whether the complexes had heated swimming pools, and obtain other facility mechanical and operational information

i. Tree Canopy GIS layers display shade coverage on rooftops and open land parcels during full leaf-out conditions, which is important for PV and solar thermal placement. These were derived from the National Agricultural Imagery Program data using semi-automated techniques to extract tree canopy cover, and to derive rooftop orientation information on a parcel basis. This information indicated whether the structure on the parcel has a primary orientation to the south, north, east, or west. Aerial imagery from 2012 was the primary source for this data.

j. Number of rentals by property type (single family or multi-family). The City of Davis Water Department sends water and sewer bills to the building owner of record rather than the household itself, allowing the city to infer which homes are rental units; if the bill does not go to the service address, it is probably a rental unit. Energy improvement investment decisions and opportunities are very different between owner-occupied and leased residences. Davis has many rental units to accommodate university student housing.

k. Aerial photographs (digital imagery) are periodically procured by the city, which allow digital close-up views of home and business rooftops (as well as open spaces that may be considered for future solar installations) so that roof area, orientation, shading, angle, and other factors can be identified. This enabled team members to locate (a) existing PV and solar water heating systems to establish a baseline of the number and geographic distribution of the modules as well as estimated current output, and (b) rooftops that appear suitable for PV and solar water heating systems, to identify specific target candidate sites and also estimate output potential.

l. ArcGIS Maps were produced for many of the database products to ease visualization. Initially over 20 basic maps were developed to display data on city-wide growth patterns (year of construction), population density, rental versus owner-occupied units, locations of solar energy systems, local renewable energy resources (solar, wind, biomass), potential local community-scale electricity generation sites, and other graphic information that will be invaluable for community engagement on energy and GHG topics.

- Many of the Davis city-wide maps were also magnified for each of the ten individual neighborhoods allowing better resolution and usefulness for neighborhood marketing planning purposes. Along with the PG&E Green Communities data, it should be possible to create neighborhood maps showing ranked potential for cost effective energy efficiency and solar upgrades.

m. The DavisFREE proposal to the California Energy Commission suggested creation of a special GIS layer for customer interview data from the Cool California Challenge, which anticipated having over 350 Davis participants, to map concentrations of households that are most likely to have interest in making energy efficiency improvements. However, Cool Davis was selected for a lead role in developing the city's competitive bid for the Georgetown University Energy Prize and their efforts will be integrated into that program. The DavisFREE databases, analytical approaches, and maps will be transferred to Cool Davis to support Georgetown University Energy Prize planning and implementation.

Four sample GIS maps developed by Davis city staff follow. A list of all tables and maps obtained through the GIS process is included as Appendix A.

Figure 1: Sample Davis GIS Map: Dwelling Units per Assessor Parcel

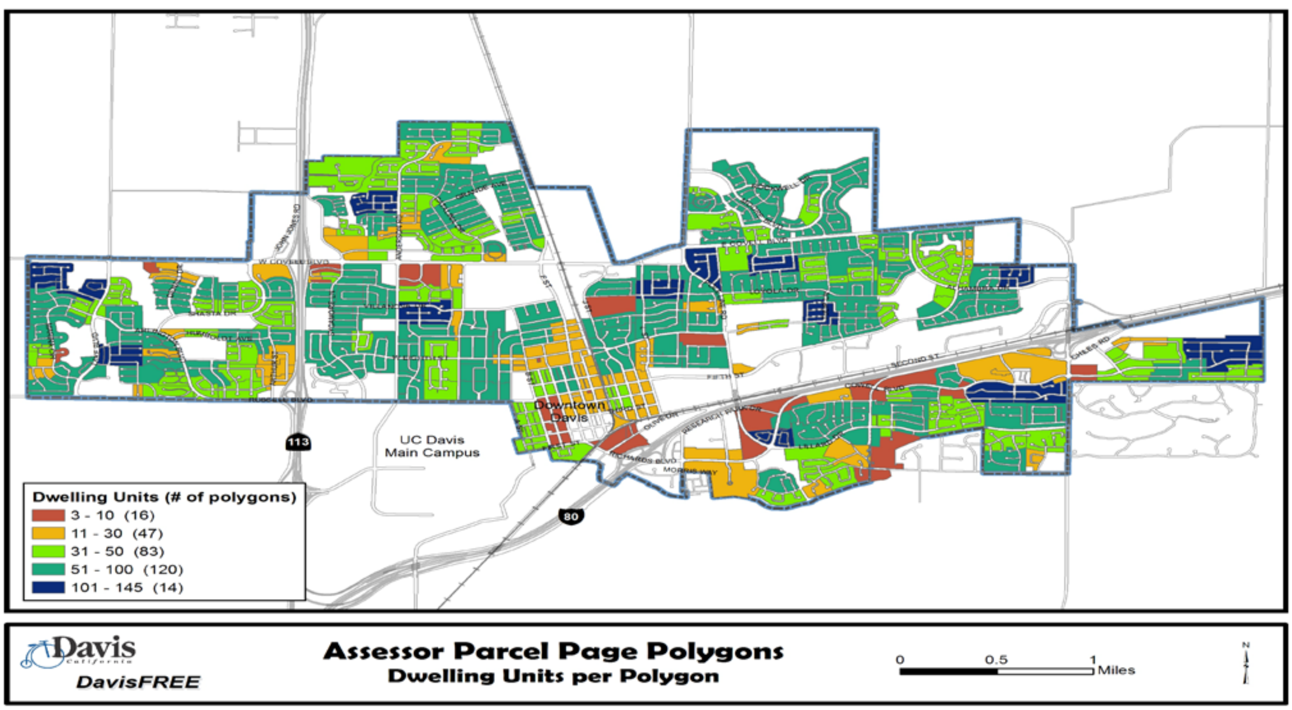

Photo Credit: City of Davis

Figure 2: Sample Davis GIS Map: Lot Sizes

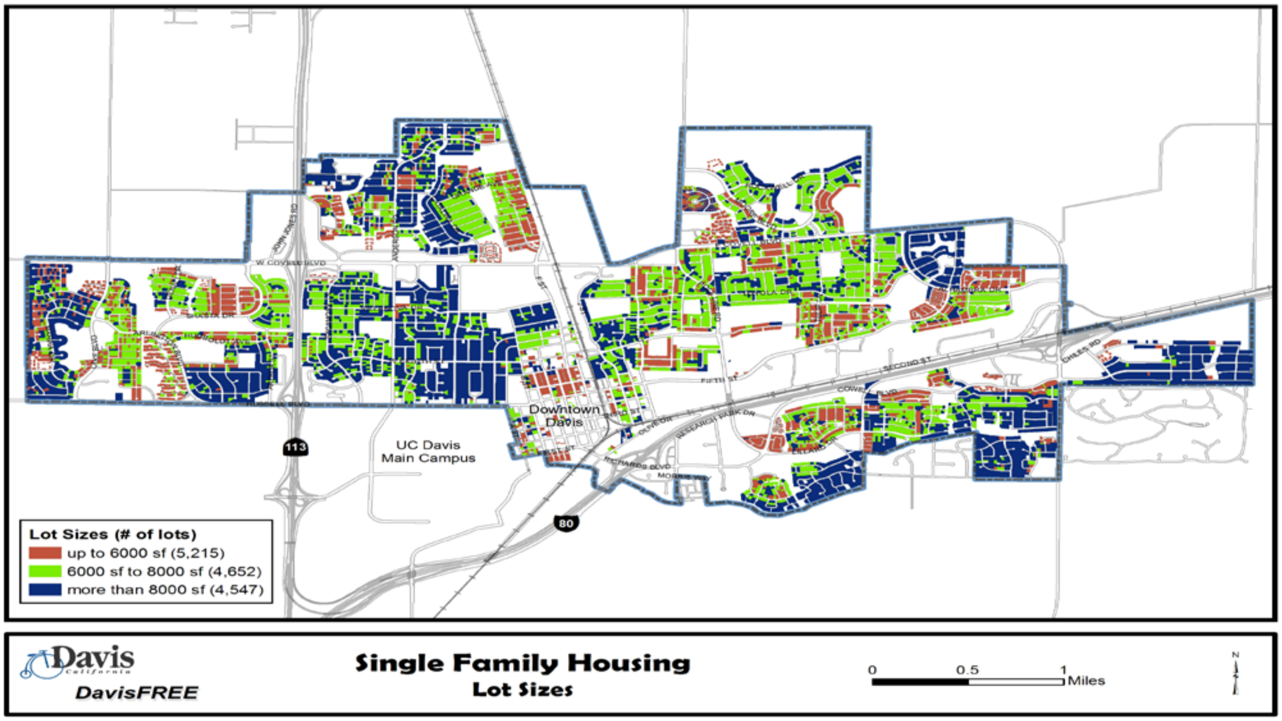

Photo Credit: City of Davis

Figure 3: Sample Davis GIS Map: Single Family Home Year of Construction

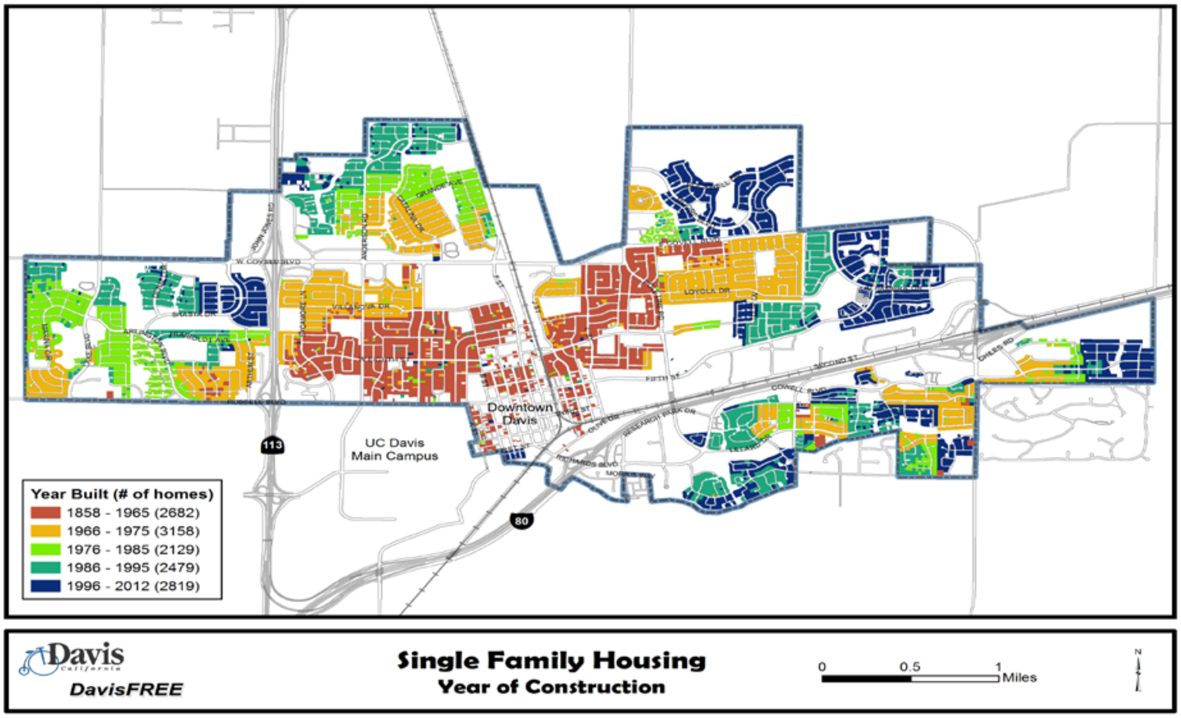

Photo Credit: City of Davis

Figure 4: Sample Davis GIS Map: Renter Vs. Owner-Occupied

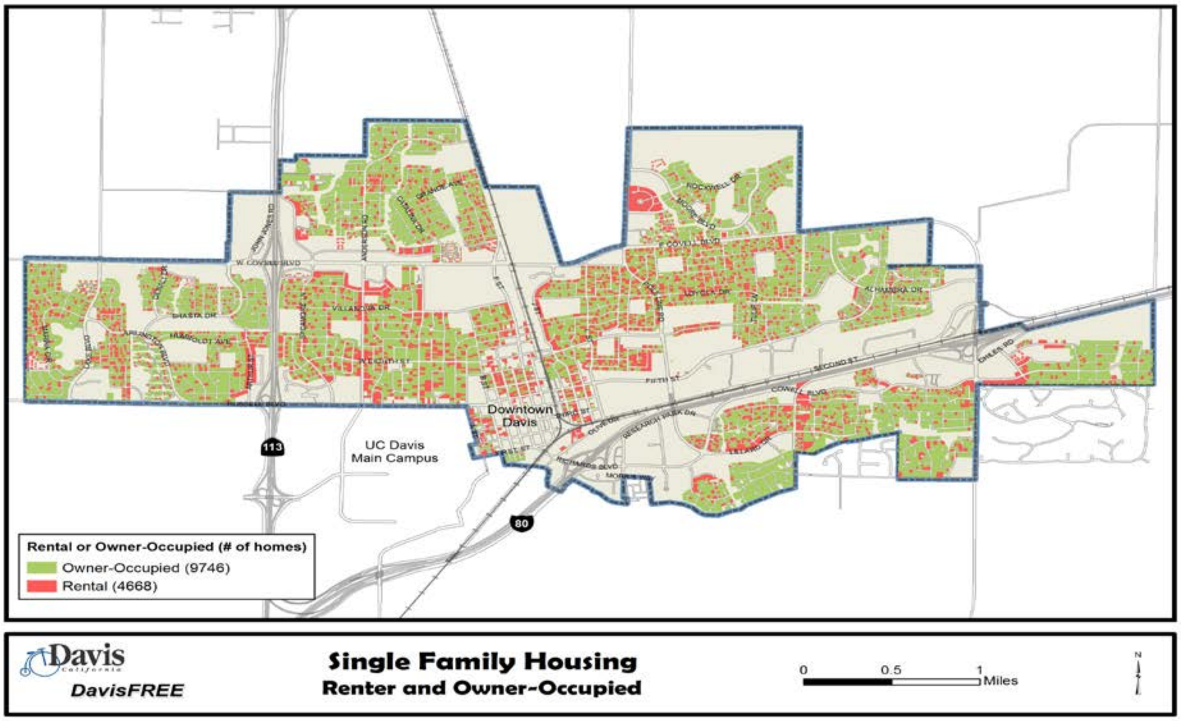

Photo Credit: City of Davis

2.2.2 PG&E "Green Communities" Database and Target Marketing Tools

When DavisFREE approached PG&E about obtaining community-wide energy usage data and other planning support, PG&E invited the City of Davis to be a "beta" test partner for development of the "Green Communities" program. Green Communities (GC) provides energy data services to help local governments perform strategic energy and climate action planning and implementation. GC is an on-line interactive tool that helps users to understand trends in electricity, natural gas, total energy usage, and energy-related GHG emissions. Its purpose is to help municipalities and PG&E customer representatives to develop local energy efficiency target-marketing programs. The GC includes annual energy usage data (natural gas and electricity) over the past eight years for:

- Community-wide and municipal operations greenhouse gas inventory reports.
- Municipal, residential, and non-residential energy usage reports.
- Photovoltaic interconnection reports (number of PV installations and total capacity).
- Utility customer participation in incentive programs—by market segment and by technology (building shell, appliances, lighting, and so forth)—and the energy savings and emissions reductions that resulted for the community.

Davis received the above data for 2005 – 2013 and will be able to receive updated data for 2014.

2.2.2.1 PG&E Proprietary and Confidential Data

The Green Communities program protects the business privacy of individual PG&E customers through multiple means:

a. No individual customer identification information can be accessed through the portal.

b. The energy usage data can only be used for research purposes.

c. DavisFREE and city representatives signed non-disclosure agreements before being allowed access to the restricted GC–Davis web portal.

d. The data was aggregated at the nine-digit ZIP code level into clusters of 20-50 homes.

e. The California Public Utilities Commission (CPUC) "15/15 Rule" applied to all aggregate data; no centroid could have fewer than 15 customers or any one customer with more than 15 percent of usage in that grouping. If either of these cases occurred, merging of centroids would be required (up to the "ZIP+2" level, for example).

2.2.2.2 Data Aggregation at "ZIP+4" Level

The Green Communities energy data for Davis was aggregated at the nine-digit ZIP code level ("ZIP+4") to protect individual business customer privacy; this is equivalent to clusters of 20-50 homes. PG&E would not reveal the actual geographic boundaries encompassing the clusters; they were masked as "centroids." This level of aggregation was still considered good for the purposes of DavisFREE and should also adequately serve the future energy improvement customer marketing needs of the City of Davis.

In contrast to the centroid model, DavisFREE proposed development of a "polygon" approach that followed the CPUC rules on customer data privacy but had designated geographical boundaries (street intersections and so forth) that would be much more effective in representing neighborhoods and similar homes. This approach greatly simplify neighborhood marketing approaches. PG&E was requested to experiment with the approach by reassigning aggregated customer data into the polygon structure, but they unable to comply with this request.

Figure 5: Proposed Neighborhood Polygon Map for Green Communities

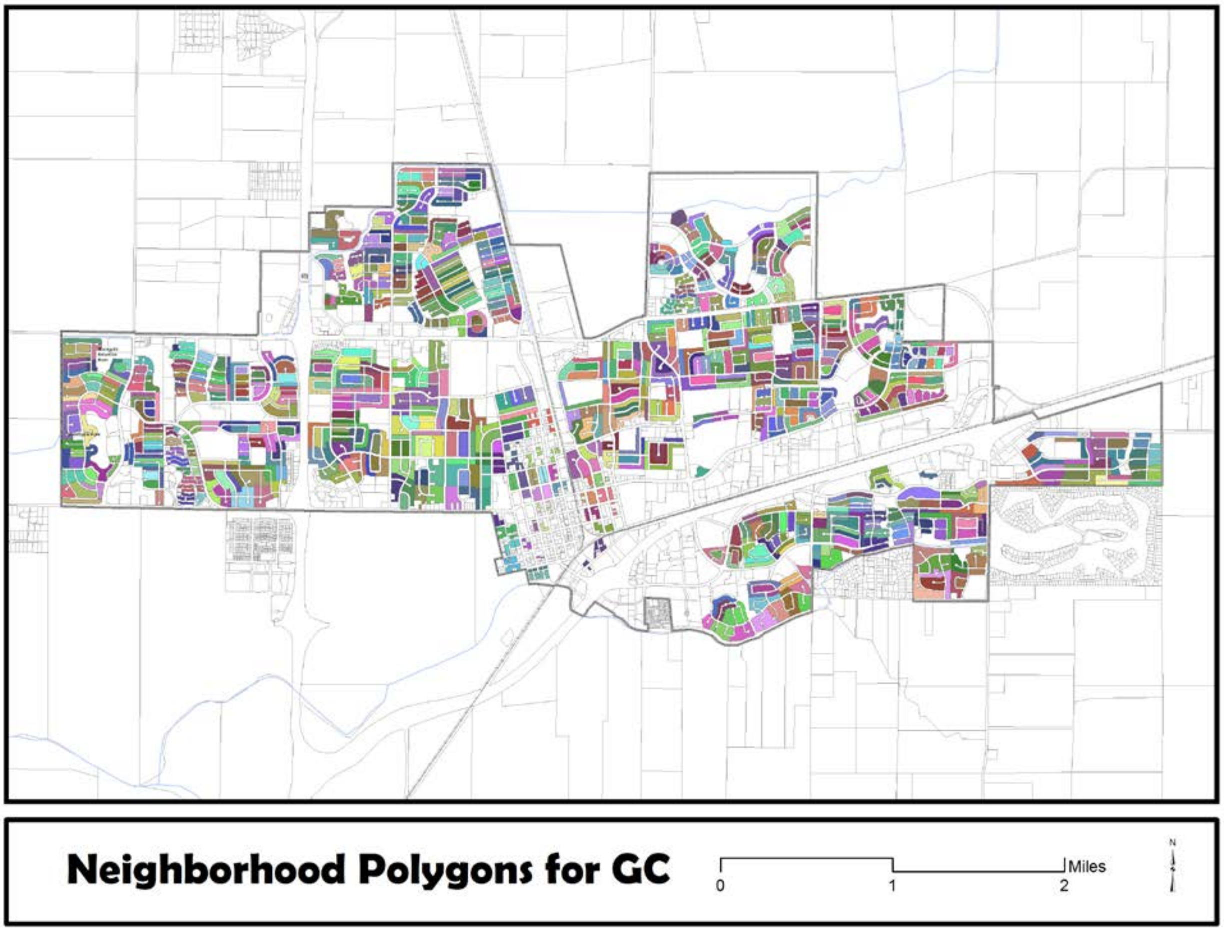

Photo Credit: City of Davis

2.2.2.3 Green Communities "Dashboards"

Green Communities provided a number of graphic reports, three of which are displayed in Figures 6, 7, and 8 below. On the web portal, these reports become interactive tools; sliding the cursor to certain locations will bring up additional information about the trends being demonstrated.

Figure 6 displays overall energy usage in Davis. The upper left quadrant shows the percentage breakdown of non-residential and residential energy usage and a line graph and bar graph of the year-over-year changes; total energy usage has increased 1.2 percent since 2005. The upper right quadrant has similar representations for natural gas and electricity use. The lower left quadrant has two charts, one comparing CO_2 emissions from building energy usage by market sector and fuel type, and another that shows emissions avoided as a result of Davis residents' participation in PG&E incentive programs. The lower right quadrant illustrates PG&E's electricity generation from renewable and non-renewable resource technologies.

Figure 6: PG&E Energy Usage Summary for Davis 2005 to 2013

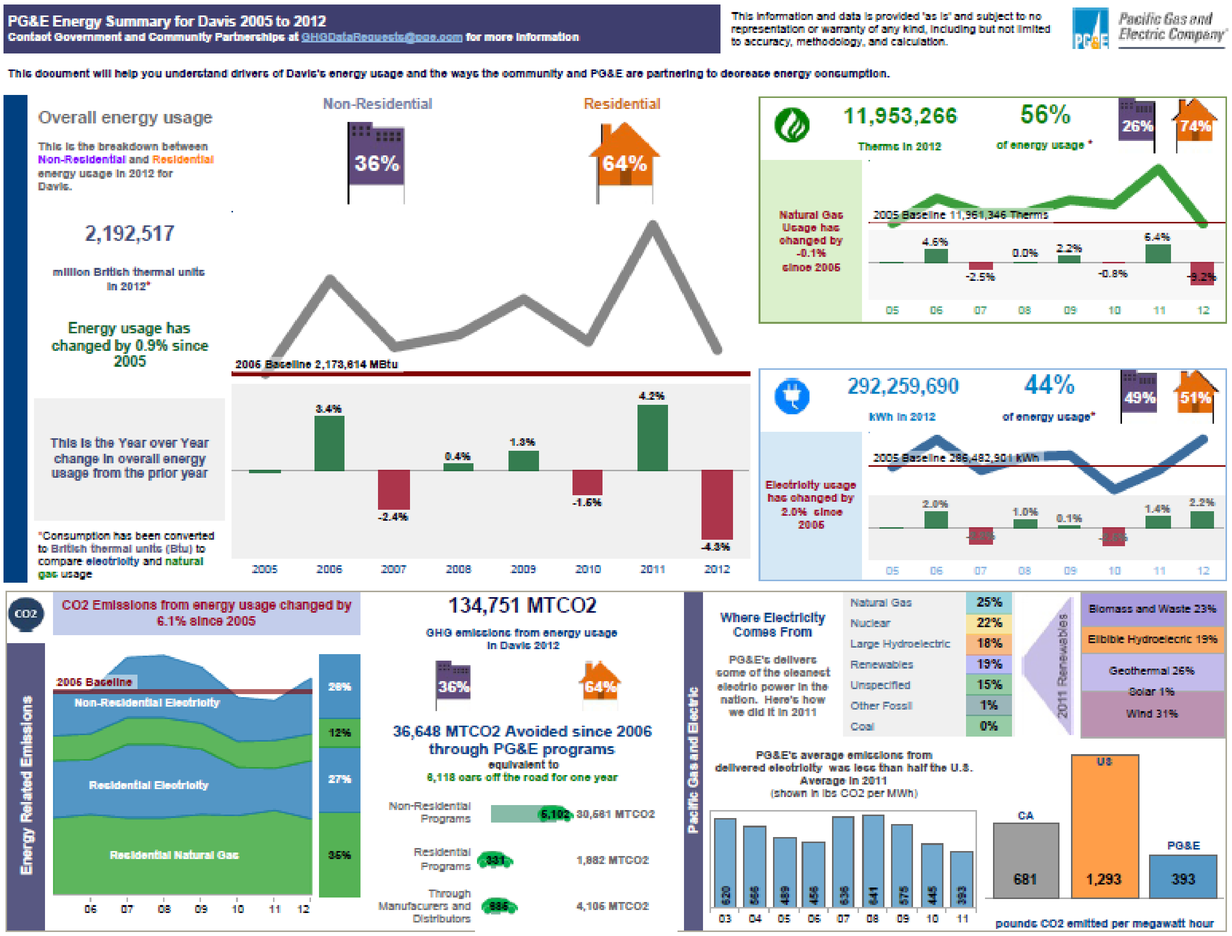

Photo Credit: Pacific Gas & Electric Co

Figure 7 breaks down energy usage and PV interconnections for the two market segments. The upper half page displays overall and monthly energy use trends since 2005 for both single- and multi-family households, including breakdowns for electricity and natural gas usage. It also shows the number of residential sites and alternating current (AC) capacity of photovoltaic installations since 1999. It also provides information on the kWh and therms savings as a result of Davis resident participation on PG&E incentive programs, by energy efficiency improvement type, and a statement of the avoided emissions associated with this participation.

The lower half page of Figure 7 shows similar energy use trends, PV installs, and avoided emissions for non-residential customers. It also includes a graph of the market segments that are most responsible for energy usage in 2013, which can help guide the City of Davis in energy improvement target marketing activities.

Figure 7: PG&E Residential and Non-Residential Energy Usage Summary for Davis

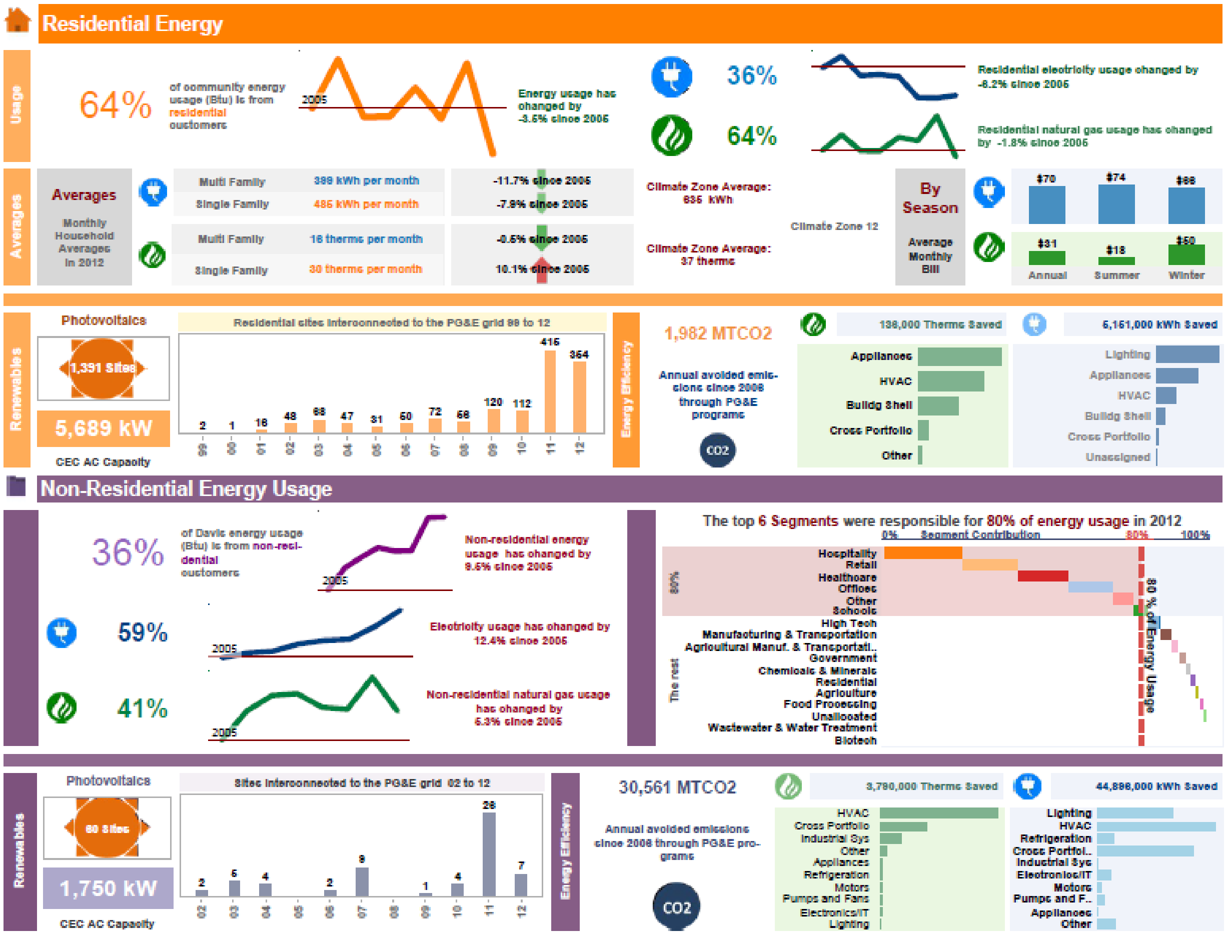

Photo Credit: Pacific Gas & Electric Co

Figure 8 graphically represents the installed capacity and number of installation sites by year since 1999 for both the residential and non-residential market segments.

Figure 8: PG&E Photovoltaic Interconnection Report

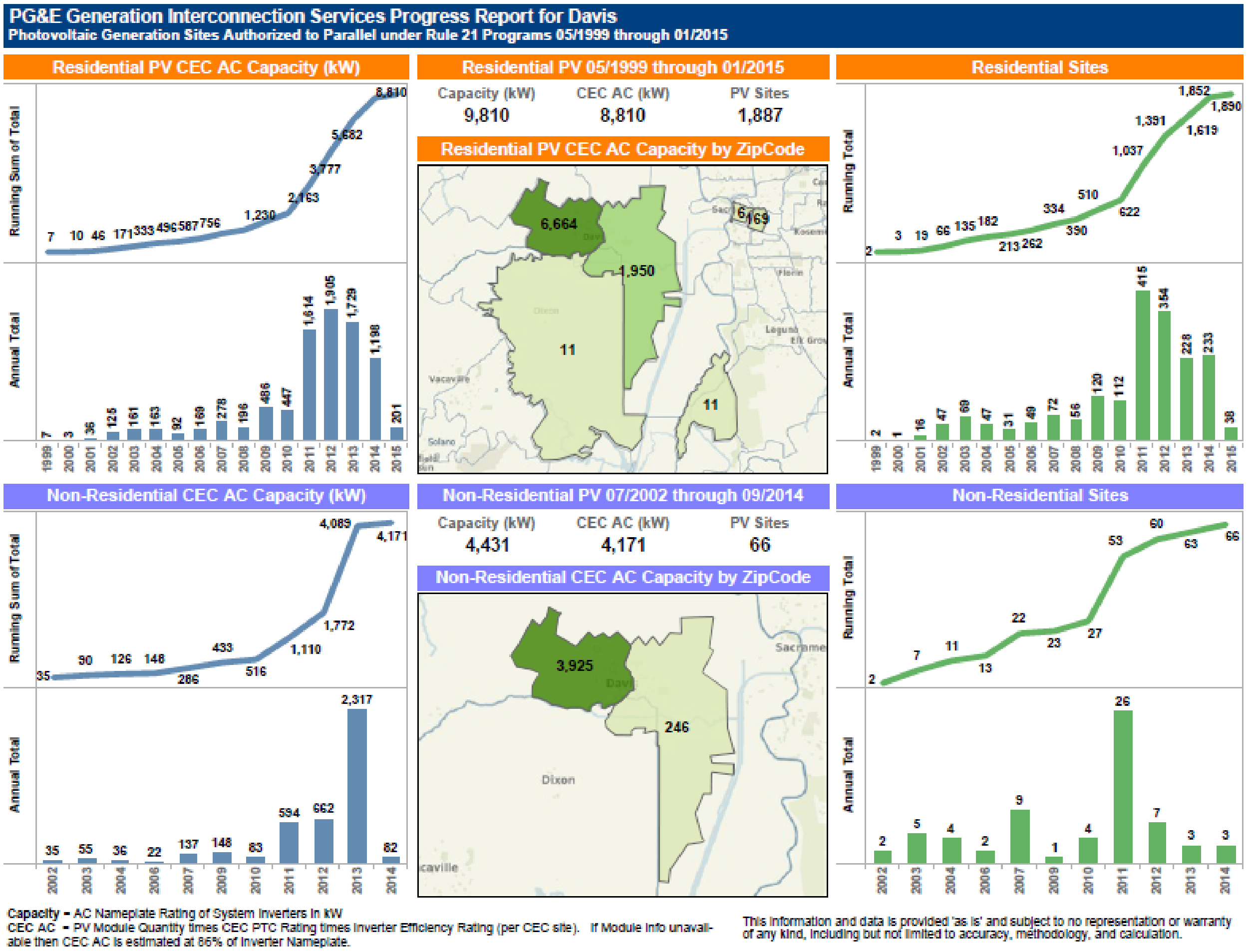

Photo Credit: Pacific Gas & Electric Co

2.2.2.4 CPUC Changes to Customer Data Privacy

Subsequent to the DavisFREE planning involvement with Green Communities, in January 2015 the CPUC issued new rules on utility customer data privacy and expanded the data aggregation requirement to the standard 5-digit ZIP level. Since Davis has just two ZIP codes, the value of Green Communities will become much diminished. PG&E has decided to transition the Green Communities program into a simpler program design. Green Communities agreed to support DavisFREE through the end of the California Energy Commission contract period, and update historic energy usage data for 2014. The City of Davis can continue to work with the new PG&E community energy usage program.

2.2.2.5 Value of GIS Data to Green Communities

Although there was insufficient time for further development, it seemed clear to PG&E that finding methods of incorporating municipality GIS information with Green Communities could potentially create a more robust tool to support target marketing activities. This could also be useful for developing "solar garden" distribution grid neighborhood groupings.

DavisFREE requested several other sets of data that are of high importance to municipalities in planning for advanced energy efficiency, community-scale PV, and target marketing efforts, but the Green Communities representatives were not able to evolve these opportunities:

a. 5- to 15-minute interval data -- sampling rate of electricity demand from ZIP+4 groups.

b. Average peak demand from ZIP+4 groupings during summer peak and critical peak billing periods.

c. Energy consumption and demand projections for time increments up to 2050, and the assumptions therein.

d. Cost escalation projections (electricity and natural gas).

e. Heating and cooling load data for average homes or typical models of homes.

f. Customers with installed home energy management systems.

g. Customers having signed up for demand response rate programs. There are indications that customers that sign up for demand response programs subsequently invest in energy efficiency or renewables, but the reverse case does not show the same correlation.

h. Residential customers who have logged on to the PG&E "My Energy" website or received "Home Energy Reports" are probably looking for additional assistance.

Chapter 3:
Zero Net Energy Retrofits for Existing Residential Buildings - Best Practices Guide (Task 5)

The Zero Net Energy (ZNE) Retrofit Guide report was intended as a stand-alone document which the City of Davis can use when evaluating energy service options to determine which can be expected to most effectively meet its energy efficiency, renewable energy, and greenhouse gas emission reduction goals. The Guide is designed specifically for implementation in and by Davis, but can easily be modified to be broadly applicable to many other California communities.

Task 5 was led and authored by Rob Hammon, President of BIRAenergy, with database development support from Kat Donnelly.

The following is a summary of the ZNE Retrofit Guide report, which appears in entirety as a .doc file in Appendix B.

3.1 Goal and Purpose of Task 5

The goal of this Task was to develop guidelines for retrofit of existing residential buildings in Davis to drive them toward achieving ZNE usage, where the annual energy consumed is less than or equal to the energy produced by the building. This can be achieved by whole-house "deep" energy efficiency improvements and the integration of renewable energy systems. The guidelines were to include both design approaches and a community-wide social marketing program delivery approach. Research and development led to a retrofit design approach with multiple energy efficiency packages that range from moderate, more affordable improvements to full ZNE retrofits for the variety of primary home design types built in Davis. The ZNE program delivery approach is a neighborhood-scale, volume–marketing approach using community-based social marketing techniques that are based on a previous pilot project tested in Sacramento.

As a low-growth community bound by prime agricultural lands, Davis cannot expect to achieve its energy usage and greenhouse gas reduction goals through construction of new high-efficiency buildings. Rather, it must rely on energy efficiency improvements to existing building stock in its largest market segment, residential. The purpose of Task 5 was to provide the essential tools for achieving this goal.

3.1.1 ZNE Guide Deliverable

The original California Energy Commission contract deliverable for Task 5 was the development of two complete narrative chapters, and detailed outlines of six additional chapters. As this task evolved, the internal scope was expanded and the contract deliverable was exceeded. Six narrative chapters were fully completed and five more were fully outlined. Additionally, a chapter on retrofit financing was included that had been developed by BIRAenergy for a project funded by the California Solar Initiative. This is a recent study on financing opportunities, but needs to be revised specifically for the City of Davis by other entities to make it applicable to the energy industry companies and organizations active in the Davis area including PV integrators, PACE programs, utility representatives, commercial lenders, non-profits, and others. The authors anticipate that the outlined chapters will ultimately be completed by others and the guide will provide the basis for development and deployment of a residential retrofit program in, and likely by, the City of Davis. It is intended that the guide will remain in the public domain for potential use and guidance by other entities to assist them in designing and deploying similar programs.

3.1.2 Importance of the Research

According to the California Energy Commission, the residential sector produced 7 percent of the total GHG emissions in California in 2012. That year the transportation, industrial, and electricity generation sectors were responsible for 80 percent of GHG emissions. The remaining 20 percent was produced by agriculture (8 percent), residential (7 percent), and commercial (5 percent) market sectors.

The primary opportunities for the City of Davis to effect GHG reductions are in residential and commercial buildings, which account for 12 percent of the total California GHG emissions. Over the following 35 years, a ZNE program in the residential sector could not only reduce GHG production to zero, assuming 100 percent participation by 2050, but also produce clean energy for use in other sectors with the application of solar generation (both photovoltaics and solar thermal) on residential rooftops. The most approachable and predictable market segment is residential. This guide is the first step toward a ZNE residential market in Davis.

Figure 9: California GHG Inventory for 2012 – by Economic Sector[1]

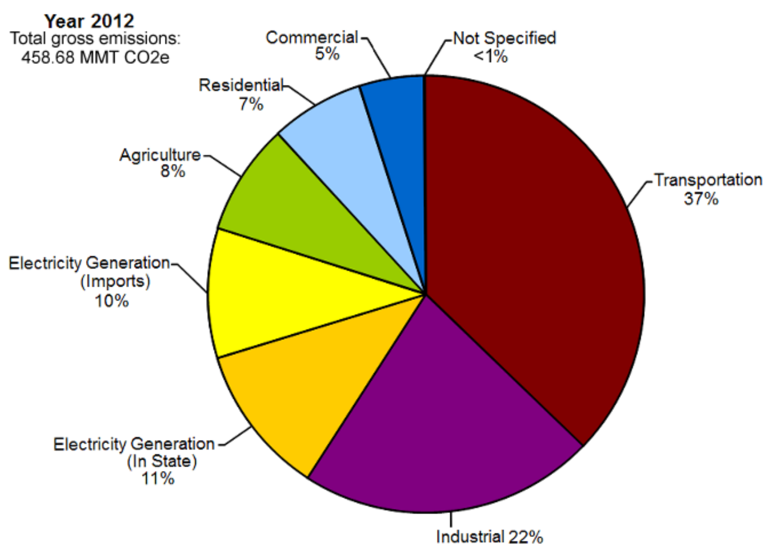

Photo Credit: California Air Resources Board.

3.1.3 General Approach to ZNE Retrofit Program Design

The guide includes the methods for and development of three sets of "deep" energy efficiency and renewable energy retrofit packages for decade-based illustrative homes that are representative of existing building stock in the City of Davis. Three sets of integrated ("whole house") energy-efficiency measures ("packages") were developed for each of the three illustrative home types for each decade (pre-1970s, 1980s 1990s, and so forth) in which they were constructed, as well as calculation of the PV capacity required to take each illustrative home, with each level of efficiency package, toward ZNE[2]. The packages are good, better, and best general designs that can help homeowners strive "toward" ZNE while considering affordability. The "decade of construction" approach characterizes the home size, number of stories and rooms, construction materials and practices, major energy-using equipment, and other conditions typical of each time period.

The guide also provides the main elements and the steps necessary to set up a volume residential retrofit program based on previous successful pilot work by BIRAenergy, which was

[1]California Air Resources Board: http://www.arb.ca.gov/cc/inventory/data/data.htm

[2] ZNE is defined herein as a home in which the (time-dependent variable) TDV-energy consumed annually is less than or equal to the TDV-energy generated by clean- and/or renewable energy sources on-site or in Davis. This definition is based on that from the New Residential ZNE Action Plan (draft 14 Oct 2013) in support of the California Energy Efficiency Strategic Plan.

performed in the Sacramento Municipal Utility District territory under funding from the U.S. Department of Energy (DOE) "Building America" program.

These packages were developed illustrate the different retrofit options and ZNE opportunities for use by the City of Davis, should they decide to develop and implement a city-wide volume-retrofit program to reduce carbon emissions from the residential sector. Such a program would be the key element to Davis reaching its carbon neutrality goals by 2050.

3.1.4 ZNE Residential Best Practices Guide Table of Contents

The following is a summary of the chapters of the ZNE Retrofit Guide report. The first six narrative chapters were completed and five more were fully outlined (to be completed by future funding). A chapter on retrofit financing conducted by BIRAenergy under a California Solar Initiative grant is also included. The guide appears in entirety in Appendix B.

- Chapter 1: Defining a ZNE Retrofit Program and General Approach to the Retrofit Market for the City of Davis
  The chapter contains definitions of misperceptions regarding ZNE, ZNE program messaging, and the proposed general approach for a volume retrofit program in Davis.
- Chapter 2: Approaches to Market
  The chapter describes the neighborhood approach to energy efficiency and solar retrofits using social marketing approaches rather than "one-home-at-a-time" marketing. It defines the key elements and major steps to implementing a retrofit program using the neighborhood approach.
- Chapter 3: Model Retrofit Packages for Neighborhood Marketing
  This chapter explains the process used for characterizations of homes in Davis, and the design and construction of energy efficiency retrofit packages for demonstrating the good, better, and best efficiency levels, including definitions and descriptions of efficiency measures used in the packages.
- Chapter 4: Photovoltaic Systems
  The chapter describes and defines PV systems and the importance of integrating efficiency and PV generation to achieve an optimal ZNE program design and delivery. It provides definitions and descriptions of different PV systems and their components, how they are installed, and different financing mechanisms available for residential retrofit PV.
- Chapter 5: Marketing to Neighborhoods
  This chapter describes the steps needed to develop and provide initial marketing for a neighborhood approach ZNE program. It provides approaches and messaging for both the initial pilot program launch and for subsequent expansion to other neighborhoods. It describes steps in homeowner participation in the neighborhood marketing program process, and sets realistic market penetration expectations for the Davis ZNE Retrofit program. The chapter discusses contractor rebates, marketing strategies, and lessons learned from prior neighborhood approach program experience.

- Chapter 6: Initial Meeting with Homeowner
  The chapter describes how, subsequent to neighborhood group informational meetings, the retrofit contractor needs to meet with individual homeowners to collect necessary information regarding retrofitting each specific home; and how to couple program marketing, data collection, and closing the sale all in the same meeting.

- Chapter 7: Energy Efficiency Retrofit Packages Specific to Client Home
  The chapter describes permitting and documentation requirements, estimates of energy savings and energy-costs savings. It describes the importance of good energy modeling and the key steps in modeling, such as how and when to apply (or not apply) the concept of loading order. It also provides information regarding measure costs estimations.

- Chapter 8: Quality Installations
  The chapter stresses the importance of quality control and quality assurance, and discusses commissioning, inspections, diagnostics, and both the importance of and suggestions for keeping close track of the quality of program delivery.

- Chapter 9: Contractor Selection and Training
  This chapter describes processes for selecting contractors, establishing minimum contractor qualification requirements, and guidance for selecting the better and best contractors. It sets requirements for training and certification of contractors, and the value of on-going training programs to maintaining program quality. The chapter also provides information regarding existing training programs.

- Chapter 10: Miscellaneous Electric Loads (MELs) and Occupant Behavior
  MELs represent a very large segment of electric energy use, which can be 50 percent or more of total home energy usage. This chapter describes what they are, the importance of managing these loads, how reductions can be achieved through simple control systems and behavior changes, and the amounts of energy and energy cost that can be saved.

- Chapter 11: Retrofit Financing
  This is a document prepared for another project, funded by the California Solar Initiative. It is submitted as an adjunct to the DavisFREE report but needs to be updated and revised specifically for the evident Davis financing opportunities.

- Chapter 12: Program Monitoring
  The chapter describes the importance of retrofit program monitoring and evaluation to maintain good program quality. It provides key components to monitoring and evaluation and discusses different market channels and their importance to this program and to maintaining program quality. It also discusses the importance of contractor performance quality, methods for monitoring contractor performance, and what to do with under-performing contractors.

3.1.5 Characterizing Housing in Davis

Data were needed to develop characteristic homes ("illustrative homes") for use in developing energy-efficiency packages and estimating PV systems sizes for the DavisFREE project, ultimately for use in developing a residential ZNE retrofit program. To assist in that effort, the City of Davis provided BIRAenergy with an Excel database of basic characteristics for all single-family homes in Davis. These characteristics include the year the home was built, conditioned floor area, and the numbers of stories, rooms, bedrooms, baths, and half-baths. BIRAenergy sorted these data, first by separating records with complete data from those with data missing. The entire database consists of about 13,000 useful records.

The database was evaluated in a number of ways to find key delineating factors that could be used to develop a set of approximately six "illustrative" homes types with characteristics of large portions of the Davis residential market. This analysis determined that the most prominent delineating factor for differentiating homes was the decade in which they were originally constructed. Thus the database was sorted by decade and for each decade. Other key characteristics were then determined to represent/characterize homes built within each decade. These factors included the number of stories, foundation type, amount of windows (percentage of glazed area of the home exterior), number of bedrooms and baths, and so forth. Illustrative homes were developed for each "decade": those built prior to 1970, from 1970-1980, 1980-1990, 1990 – 2000, and beyond 2000. Both one-story and two-story models were developed for the decades 1980-1990 and 1990-2000.

3.1.6 Model Retrofit Packages for Neighborhood Marketing

The housing data, sorted and analyzed by decade, was then used to produce sets of "illustrative homes" that characterized cross-sections of existing homes in Davis. These illustrative homes were used to develop the basis for computer modeling of retrofit packages for initial marketing of the ZNE retrofit program. The modeling included:

- Estimating an energy baseline for the different home types characterized.
- Producing sample good, better, and best retrofit packages for each decade of home for developing a residential retrofit program.
- Providing a basis for estimating costs and energy savings potential for participants in this prototypical residential retrofit program.

The resultant good, better, and best packages, designed for housing representative of those built in the decades up to 1970, during the 1980s, 1990s, and since 2000 provide a basis for approaching homeowners with ready retrofit packages for which costs are relatively well known and understood. These packages form the basis of the program and the initial offerings to homeowners who are potential participants.

CHAPTER 4:
Local Renewable Resource and Technology Supply Curve Development (Task 4) and Technology Selection (Task 6)

The City of Davis has committed to reaching community-wide carbon neutrality by 2050. As described in the Davis Climate Action and Adaptation Plan (CAAP), development of renewable energy from on-site and other local generation facilities is one of the key strategies to achieving its carbon reduction goal. This chapter combines Tasks 4 and 6 descriptions, research activities, and results regarding the potential development of community-scale (for example, "solar gardens") and utility-scale applications in the Davis area.

4.1 Goal and Purpose of Tasks 4 and 6

The goal of these tasks was to identify locally-available renewable energy resources such as direct solar, wind, and biomass; develop a supply curve and levelized cost of generation modeling tool; run the tool for technologies that can take advantage of the resources available; and examine the cost of renewable energy electricity generation and natural gas offset for building-scale and community-scale technology applications specific to each of those local renewable resources.

The purpose was to provide information to the City of Davis regarding the best options for the various renewable energy resources expected to be available in sufficient quantities and that could be cost-effectively developed for community-scale (for example, "solar gardens") and utility-scale applications, and develop levelized cost of energy and renewable resource supply curves for the most promising renewable energy resources that are available locally.

DavisFree selected the University of California, Davis (UC Davis) Energy Institute and DNV-GL (doing business as KEMA, Inc.) as subcontractors and were tasked with identifying cost-effective community-scale and utility-scale renewable energy resources in the Davis area. Elise Brown managed the UC Davis work and Nellie Tong led the supply curve development activities for DNV-GL. The following sub-sections describe the team's methodology, research, and results.

4.1.1 Utility-Scale Renewable Energy Analysis in the Davis Planning Area

After preliminary decision-making meetings between DavisFREE team members and city staff, UC Davis was directed to conduct resource evaluations for direct solar, wind, geothermal, agricultural waste biomass, and small hydro. Guided by the prime contractor, Valley Climate Action Center, and the City of Davis, the definition of "locally available" renewable resources gradually expanded as resource data was obtained. Initially the resource reviews were conducted within the Davis city limits, but it soon expanded to the Davis Planning Area. Later, resource reviews expanded to the Yolo County and eventually it included wind resources in counties to the south of Yolo.

The city's current area is about 10 square miles. The Davis "sphere of influence" is about 15 square miles, including lands where near-term growth may be allowed over the next approximately 20 years, the water treatment plant, and some other city infrastructure. The Davis "Planning Area" is about 100 square miles, extending into both Yolo and Solano counties; Davis pays user fees to the counties for easements for agricultural and wildlife habitat protection, and keeps growth in check. Decisions regarding these defined areas constrained the available resources to Davis for certain renewable energy resources. Section 3.1.1.2 of this report describes how each resource was evaluated and in some cases excluded.

The general approach to collecting data was by literature search for publicly-available and publicly-funded data from entities such as UC Davis, California Energy Commission, and California Public Utilities Commission, and consulting with other local energy experts, the City of Davis, and PG&E. No primary research was to be conducted for this project.

The following sections describe the renewable resource availability and estimated capacity of each of the locally-available renewable energy resources considered by DavisFREE.

4.1.1.1 Direct Solar Resource Availability for PV

The direct solar resource in the Davis planning area is substantial. In consultation with the California Solar Energy Collaborative at UC Davis and UC San Diego, and tools from the U.S. DOE National Renewable Energy Laboratory, it was determined that a solar direct normal irradiance (DNI) of 6.0, and a solar global horizontal irradiance of 5.5 are prevalent in Davis (see Sec. 4.1.1.1.1-B of this report for definitions).

These data were delivered to the City of Davis as data layers to be used with overlay mapping in ArcGIS. UC Davis worked with the city staff to identify city-owned areas that have the most potential to be developed for community-scale PV. A list of preferred brownfield and greenfield land parcels, and public parking lots were reviewed for technical potential for community-scale PV to serve Davis. One example is displayed in Figure 10 below, with the analytical process narrative following. The map outlines the boundaries of each property, not the specific areas that could potentially be used for PV.

Figure 10: Map of City-Owned Properties with Community Scale PV Potential

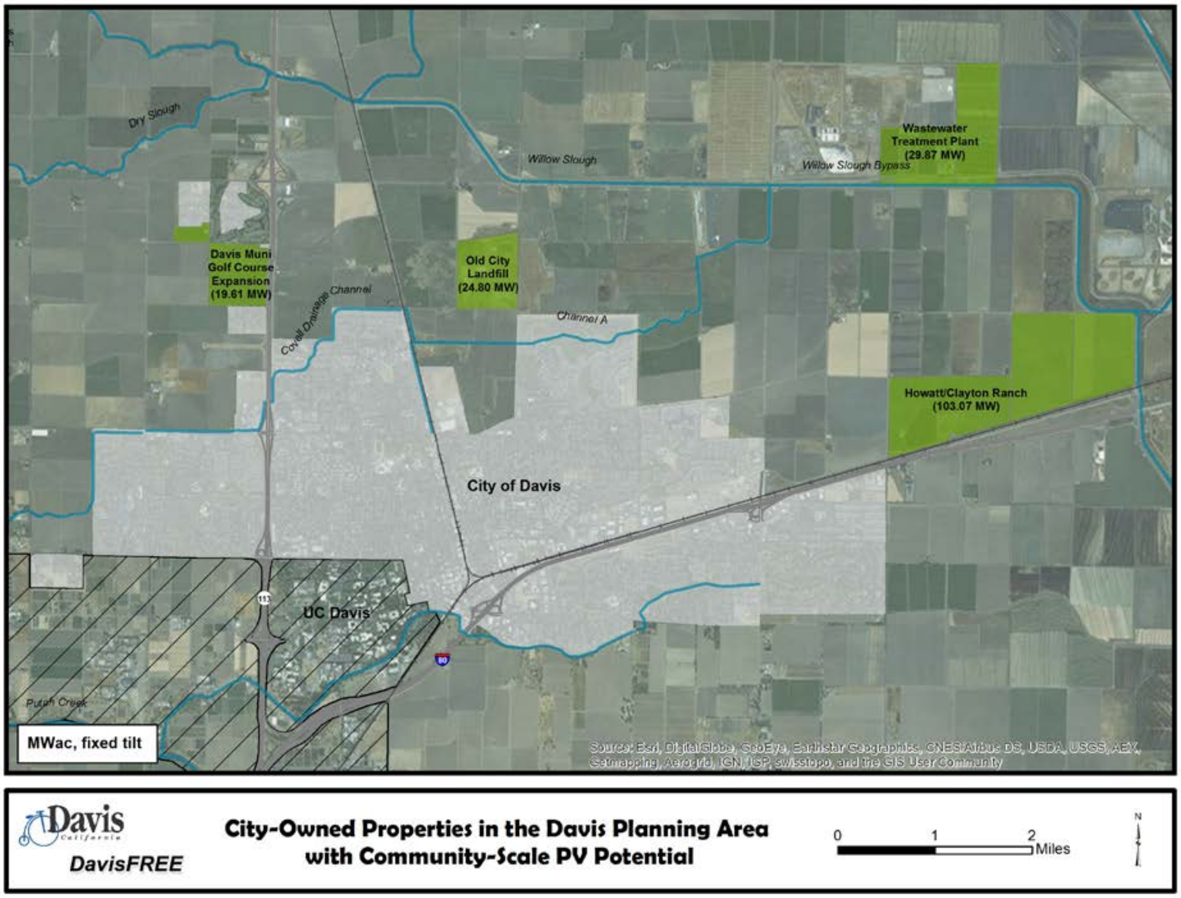

Photo Source: City of Davis

Once the preferred land areas were identified, a literature review was undertaken to identify the best metrics to identify how much solar PV capacity could be installed on an acre (or fraction thereof) based on three racking types: fixed tilt, single-axis, and dual-axis. The latter two of these are systems that rotate the PV array to more closely track the position of the sun during the day, increasing DNI exposure.

The most recent and comprehensive data found was from the National Renewable Energy Laboratory's report, "Land-Use Requirements for Solar Power Plants in the United States", published in June 2013[3]. Using metrics found in this paper, the UC Davis team identified the potential installed solar PV capacity for each of the potential Davis sites. The installed capacity for each site was calculated in megawatts (MW) for both direct current (DC) and alternating current (AC), which can have different purposes for researchers / engineers, and for customers

[3]http://www.nrel.gov/docs/fy13osti/56290.pdf

who are more used to understanding AC as the United States standard. Solar cells, modules, and arrays are rated according to international standards in terms of peak watts, which is the DC output produced by the device under standard test conditions specified to be broadly equivalent to full direct sunshine. The capacity of a solar generating system, after allowing for losses in the inverter and transformer, is generally expressed as the AC output capacity. Capacity is generally referred to as AC throughout this report.

With the capacity established, the next step was to figure the potential production for each site and potential racking technology (fixed tilt, single axis tracking, and dual axis tracking). Because the capacity by land area metrics in the national renewable energy laboratory report was derated to MWac, the team had to evaluate the best way to figure production potential using a conversion to MWdc factor. After consulting with the California Solar Energy Collaborative at UC San Diego, they recommended the conversion factors of 1.1 for fixed tilt and 1.05 for single and dual axis; and conducting further research, it was determined that the best way to go about converting the capacities for each site to MWac would be to use their recommended factors. After converting all potential installation capacities to MWac the team developed the data for each installation and each racking type through the national renewable energy laboratory *PV Watts*[4] calculator tool. PV Watts was selected because it is widely recognized as one of the best publicly available tools, and because it uses the same conversion factors the team applied in converting MWac to MWdc. By using this tool, the team ensured that the integrity of these data was maintained. The results were then used in the cost of generation calculator (see sec. 4.1.2).

The main advantages of tracking systems are that, since they "follow" the sun during a day and season, they can have higher daily and annual electricity production and can produce more power during peak demand hours as compared to fixed systems. This can be impacted by geographic location, sun/cloud conditions, and other factors of course. The additional tracking system equipment cost and maintenance costs may offset their generation enhancement value. Also, as demonstrated in Table 1 below, the amount of flat-plate PV that can be installed on a given land area declines because the tracking systems must be placed further apart than fixed systems because at lower sun angles, the trackers will self-shade each other as the arrays move through vertical positions.

Table 1 displays the gross capacity available by PV system racking type in the preferred land parcels identified by the City of Davis.

[4] http://pvwatts.nrel.gov/

Table 1: Potential PV Installed Capacity and Production in City-preferred Sites within the Davis Planning Area

Fixed Tilt		Single-Axis		Dual-Axis	
MWac Installed	GWh/Year	MWac Installed	GWh/Year	MWac Installed	GWh/Year
178.83	299.88	154.41	308.86	103.34	229.64

DavisFREE also mapped 34 parking areas at city-owned facilities and public parking lots where PV covered parking structures could potentially be installed. These data were delivered to the City of Davis as data layers to be mapped in ArcGIS.

Accurate calculation of PV technical potential will require analysis of aerial photographs to evaluate solar orientation options and shading from trees and adjacent buildings. It will also require on-site reviews to consider support structure designs, estimate the number of parking spaces that may be lost due to the support structure, pedestrian and vehicle movement, system security, and other factors that will determine the suitability of PV covered parking at each location.

ArcGIS shape area analysis identified the total area of all city-owned parking lots as 1,178,432 square feet, or about 27 acres. A few of these already have some PV and others are unlikely to be included for various reasons. However, for gross potential consideration, all sites were included in the initial analysis. Assuming five acres of area is required for installation of 1 MW of PV, about 4.9 MWac (5.4 MWdc) is the gross potential for all sites. The city assumes that about 25 percent of this amount could viably be built; the total is about <u>1.225</u> MWac.

A map of the parking lots is displayed in Figure 11 below.

Figure 11: Map of City-Owned Properties for Potential PV Covered Parking Structures

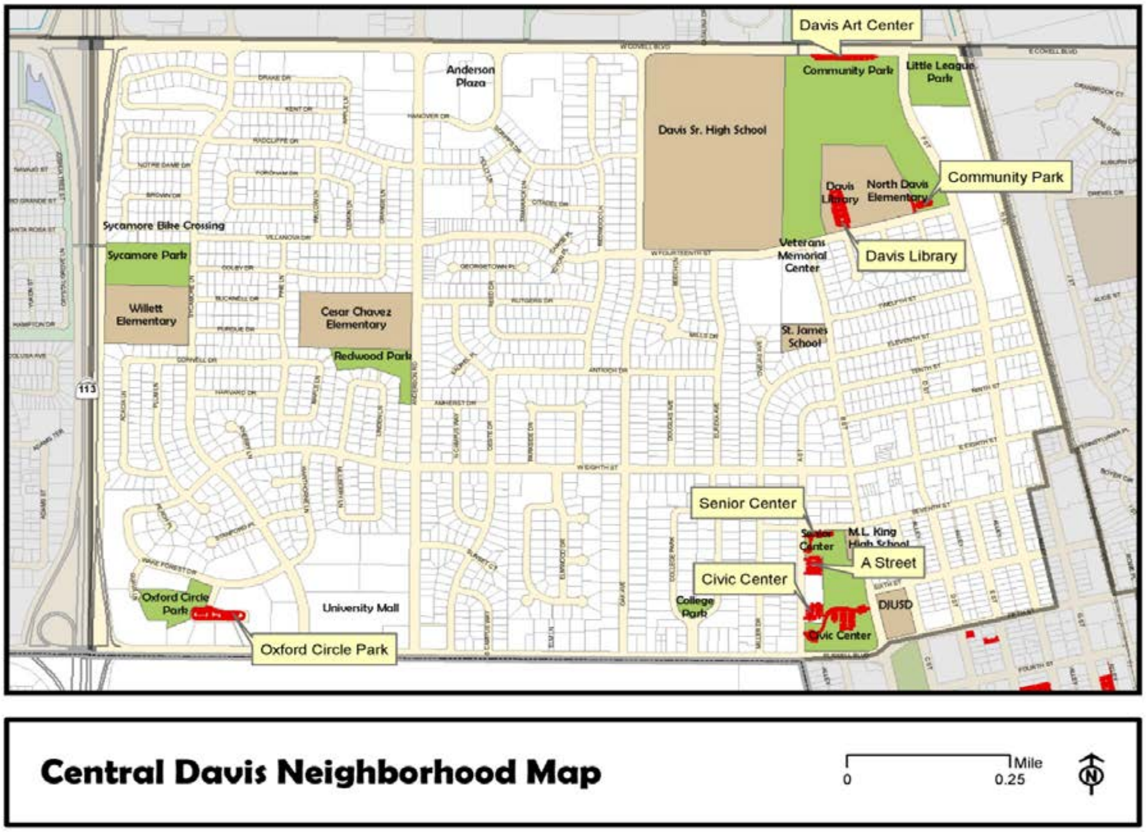

Photo Source: City of Davis

Initially, DavisFREE was also considering concentrating PV systems (CPV), which use dual-axis tracking systems to follow the sun and use Fresnel lenses, or curved mirrors, to concentrate sunlight onto small, but highly efficient multi-junction solar cells (unlike the silicon PV cells of flat-plate collectors) to produce electricity. CPV typically requires DNI above 6.0, so Davis is just at the edge of this requirement. When the proposal was being written, there were three CPV manufacturers in California, but only one of them has remained in business and that company's near-term production output has been 100 percent committed; it is not clear if this technology will remain economically viable for most applications since the cost of the tracking systems is high. Still, Davis may want to revisit this technology in the future, especially becase the CPV tracking can start generating electricity about one-half hour after sunup and stops at about one-half hour before sundown. Flat plate, fixed tilt collectors do not have the ability to generate as much electricity until the sun is more directly overhead.

It is important to note that this evaluation is for community-scale systems and does not include the potential for additional rooftop residential-scale solar installations; the latter evaluation was conducted by BIRAenergy under this same contract (see section 5.4) and greatly adds to the Davis PV production potential.

Benefits of Photovoltaics

Photovoltaics (PV) is a well-established technology that has been installed in increasingly large quantities since the late 1970s for utility scale generation, and since the late 1990s for on-site rooftop generation. This technology is often looked at as a primary solution for reducing greenhouse gas emissions for several reasons:

- Solar PV is Modular and Scalable
  The solar panels that one might put on a residential rooftop are the same panels that would be installed at a utility-scale solar power plant. This allows for home-owners, business-owners, and developers to easily size their systems as needed. Davis is interested in expanding rooftop PV for residential and commercial customers, as well as community-scale utility PV systems that can offer the benefits of PV to groups of people whose homes may not have adequate roof space to accommodate PV, have trees shading their roofs and blocking the sun, roof angles that cause incompatible solar orientation, or other reasons why rooftop PV is not viable.

- The Solar Resource Potential is Relatively Easy to Identify
  The solar energy resource hitting any ground area, measured by direct normal irradiance (DNI) or global horizontal irradiance (GHI), is well defined for locales throughout the United States. Based on decades of satellite data, the DNI for any one region has already been characterized. Because of this, the upfront cost of calculating potential production and savings from PV is minimal.

  - DNI is the direct beam radiation that comes in a direct line from the sun, excluding solar radiation that is absorbed or scattered by the atmosphere, and reflected or diffused by clouds, ground, or objects. GHI is total solar radiation and the sum of direct normal irradiance, any diffuse atmospheric irradiance, and ground-reflected irradiance. However, because ground reflected radiation is usually insignificant compared to direct and diffuse, for all practical purposes, GHI is said to be the sum of direct and diffuse radiation only.

  - Photovoltaic electricity generation is most effective and consistent with high DNI; therefore, PV panels need to be oriented to the direction likely to deliver the most direct sunlight during a day. Other solar energy technologies, such as solar thermal water heating, can function well even with more diffuse GHI levels.

- PV Prices Have Declined
  Due largely to direct financial incentives from CPUC/utility programs, federal tax credits for installing renewable energy systems, and state and federal research and development funding, the PV industry has become very competitive and robust. The resulting market forces continued to improve PV products and installation methods to further drive prices down. The cost of PV has come down over 50 percent in the last decade. As such, it is one of the most attractive options for those trying to achieve net-zero energy.

- Financing Opportunities are Available
  Although direct financial incentives are no longer available in California and the federal tax credit will begin to decline in 2017, PV installation firms have developed many innovative approaches for financing PV, including leasing, lease-purchase, power purchase agreements, property assessment loan repayment methods, and others. Many of these have no up-front costs to the building owner and have good payback opportunities.

- Drawbacks to Photovoltaics
  There are, however, some drawbacks to photovoltaics which relate to electricity grid reliability, regulatory policies as to how PV can be deployed, and what credit is given in net energy metering arrangements. As the City of Davis makes decisions about its renewable energy future, and what sort of utility structure they would like to move toward, these factors will need to be taken into account.

4.1.1.2 Solar Thermal Electricity

There are different types of concentrated solar power (CSP) technologies, including parabolic trough and power towers. CSP utilizes a thermal energy collector where sunlight is concentrated by mirrors onto an absorber system that heats water into steam that drives an electricity-generating turbine. One of the principle advantages of CSP is that it can be coupled with thermal storage. It is a unique renewable resource that can provide firm, dispatchable energy as well as ancillary services to mitigate ramping and intermittency issues, as well as lower the burden on conventional generation to provide ramping and reserves. Since CSP requires a large area for solar radiation collection, and the sizes of the lots preferred by the city for solar installations, it was determined that solar PV would be the better and more cost-effective option over CSP. The team did not calculate the production potential for CSP. If the city is interested in exploring the CSP potential, the team at UC Davis recommends consulting the previously-referenced "Land-Use Requirements for Solar Power Plants in the United States" for conversion and land intensity factors.

4.1.1.3 Wind Turbine Energy

Production of electricity from wind energy has greatly increased in the United States in the last decade. However the wind resource in the immediate Davis vicinity has been considered to not be viable for such development due to the low consistent wind speeds of this geographic area. There have, however, been recent developments in utility-scale wind turbine technologies that may soon allow for lower quality wind resources to become economically viable.

The research team at UC Davis consulted with the California Wind Energy Collaborative to obtain ArcGIS layers for regional wind potential that were delivered to the city and mapped. It was determined that there is limited wind potential in the Davis Planning area, especially as compared to photovoltaics. A confidential wind energy analysis report for Davis conducted by a wind turbine firm in 2012 was consulted, as well as a recent master's student thesis.

However, wind resource maps developed for a previous California Energy Commission project indicate that there is higher potential for wind energy generation in a region to the south of

Davis, including Solano and Contra Costa counties. It is not clear how Davis might negotiate the development of wind energy systems unless it were it become a publicly-owned utility or a community choice energy aggregator.

Figure 12: Wind Energy Potential South of Davis

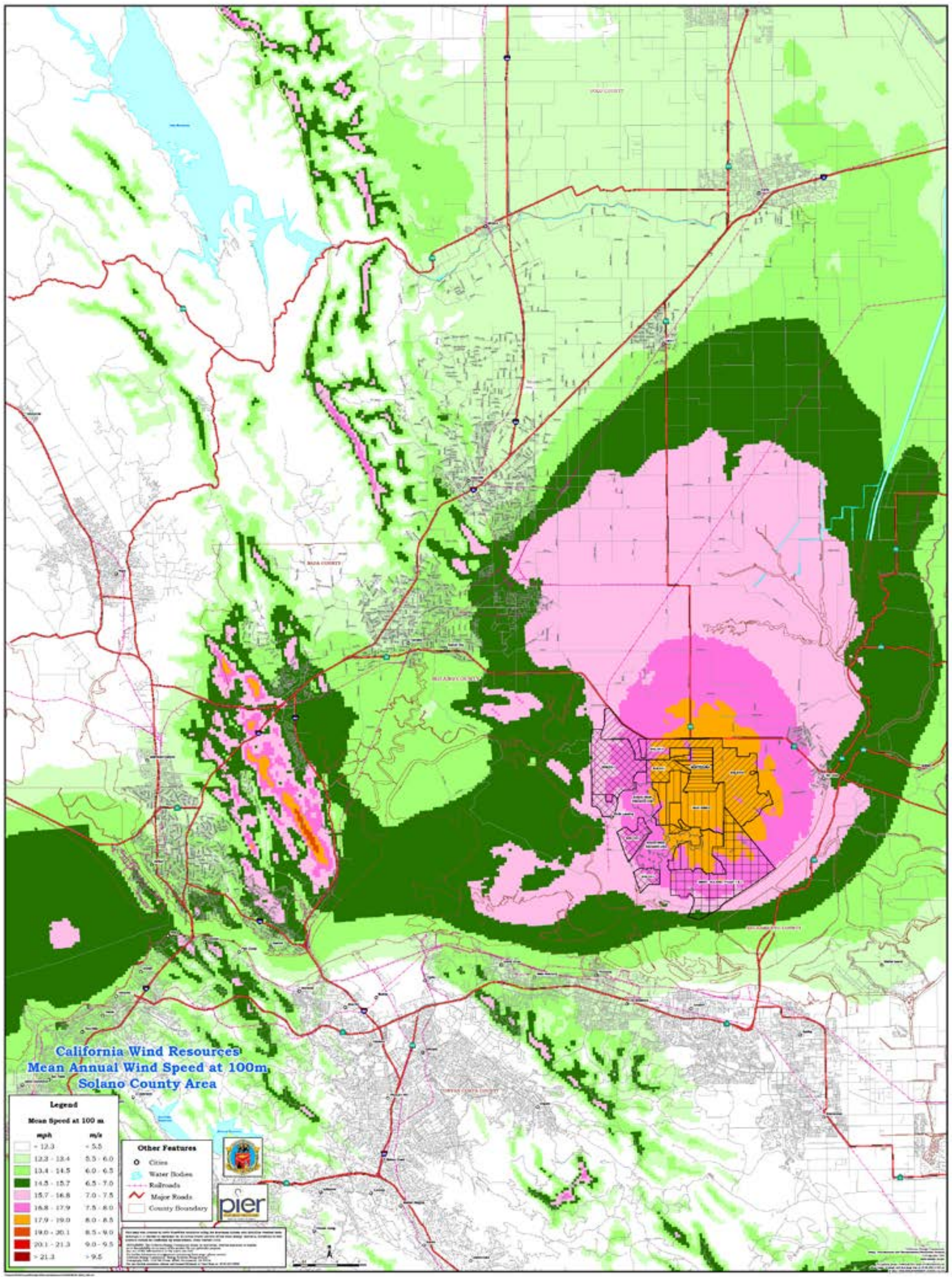

Photo Source: California Energy Commission

4.1.1.4 Agricultural Biomass

Because the biomass resources are not easily identified as a single source, as is the case with wind and solar, the potential for biomass energy production in the Davis area is complicated. Due to time and budgetary restrictions, DavisFREE and the city decided to look only at agricultural waste biomass at this time. Although, future consideration should be given to studies on urban waste, including compostable products for biodigestors, "clean" construction materials, tree trimmings, and so forth for gasification systems. A new biodigestor project[5] at UC Davis may provide operational research data to advise Davis; or possibly, a joint City-UC project could be developed at the existing biodigestor site.

The research team consulted with the UC Davis Biomass Collaborative on what resources may be available in the Davis Planning area and Yolo County as a whole. The California Biomass Collaborative was able to provide a spreadsheet that identified the acreage and gross tonnage of crop residues for almonds, citrus, corn grain, cotton, grapes, pistachios, rice, walnuts and wheat. The California Biomass Collaborative was working on another report for the California Energy Commission at the same time as this research, which found that Yolo County could potentially produce 42MW of biopower (315,897 MWh/year) if the total available biomass were to be employed.

One of the difficulties with biomass/biopower however is figuring out what residues already have dedicated uses. The California Biomass Collaborative advised that some are already fully subscribed as fuel for existing privately-owned combustion electricity generation systems, and others are sold as feedstocks for other plants or other secondary applications. It will be difficult to ascertain if the economics for a biomass power facility are better than using the residues for competing uses, if there are long-term contractual agreements, and what the economical range of transport of residues (from farm to energy center) will be. Further investigation into each may be warranted should the city decide to move forward with providing local energy; but for now, DavisFREE has dropped this resource from consideration.

In addition to the spreadsheet delivered, an ArcGIS layer was delivered and a map developed that outlines where the potentially available residues reside. It should also be noted that this information is for Yolo County as a whole and the majority of the available feedstock resides outside the Davis planning area.

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[5] http://www.cleanworld.com/news/uc-davis-biodigester-to-power-campus-in-january/

Figure 13: Yolo Crop Residue by Energy
Val

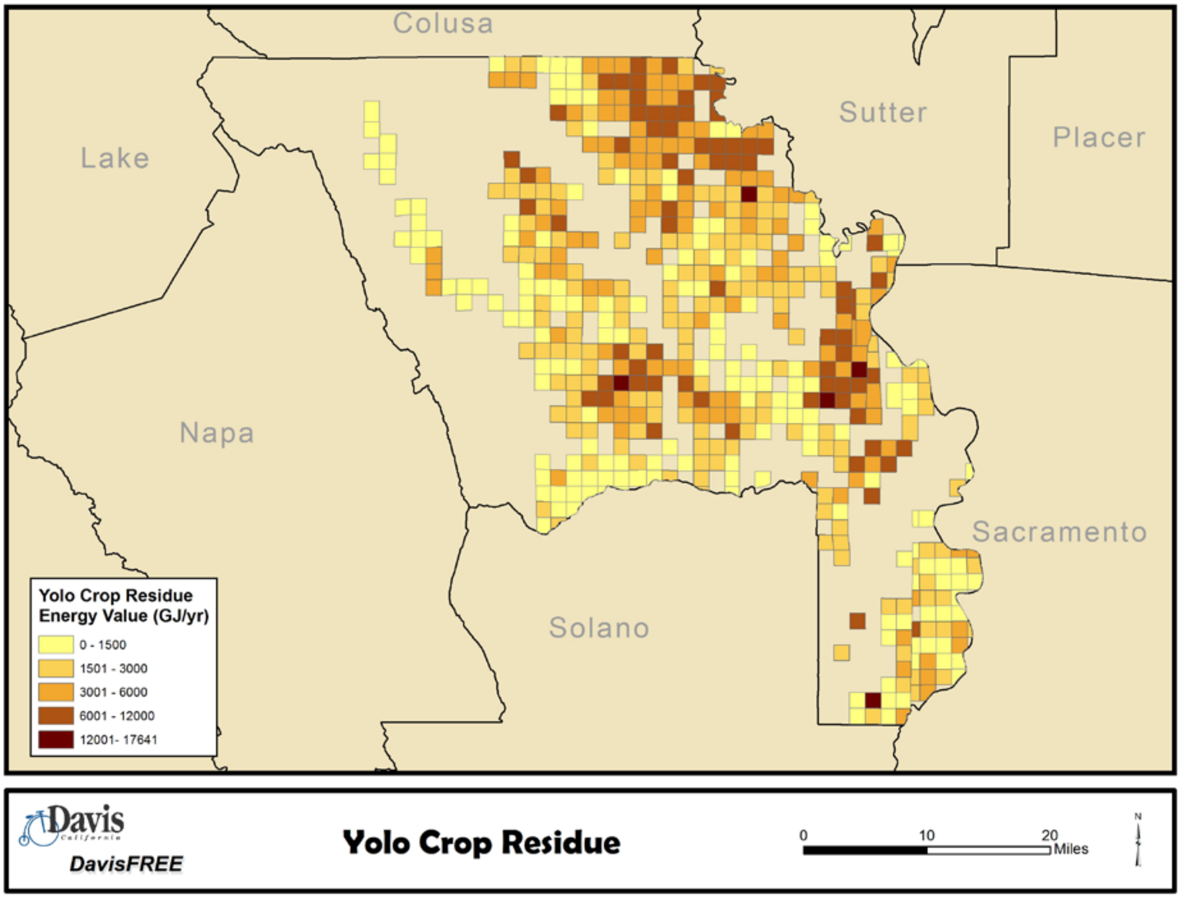

Photo Source: City of Davis

4.1.1.5 Geothermal Energy

Geothermal energy has three primary applications: electricity generation, direct-use, and space heating and cooling.

California has some excellent geothermal resources, including the largest developed field in the world: the Geysers, which are just outside of Calistoga. Geothermal energy can be used for electricity generation where there are naturally-occurring reservoirs at depth with enough pressure, permeability, and temperature to flash to steam when drilled. Similar to opening a soda can, when there is a release in pressure, the gases too are released. The resulting steam in these fields surges up the well to power a steam turbine. In many geothermal power plants, a binary approach is taken where the steam passes through a heat exchanger to heat a working fluid that runs the turbine and is then condensed and re-injected into the reservoir to be reheated and re-circulated repeatedly.

Geothermal Generation

Geothermal generation is attractive for communities desiring local power generation because the plants can not only provide baseload power, but can also be designed to ramp up and down quickly to backfill for variable resources, such as wind and solar, resulting in better reliability. The UC Davis research showed that the closest feasible geothermal field is well outside of the Davis area and is located in Sonoma and Lake counties which is far beyond the identified boundary for this study. Again, Davis would require a different utility structure to be able to utilize this resource. Cost of generation and delivery were not developed as geothermal is currently not considered viable for Davis.

Geothermal Direct-Use

This application of geothermal uses ground water that is not hot enough for electricity production, but still useful for a variety of applications such as reducing heating demands at processing plants, melting ice on sidewalks, heating indoor spaces or greenhouses, fish farms, and so forth.

After consulting with the California Geothermal Energy Collaborative at UC Davis, there are no identified local resources available for direct use geothermal.

Geothermal Heat Pump Systems

Geothermal ground-source heat pump systems are fundamentally different from the two previously described geothermal technologies. Instead of using a naturally occurring hot water source, geothermal heat pumps take advantage of the stable temperatures of the shallow subsurface earth.

Geothermal heat pumps are used to heat and cool buildings by way of a heat exchanger that pulls heat or sinks heat from the relatively constant ambient temperature of the ground. The science is similar to a refrigerator, where a heat pump is used to remove heat from the interior air of the refrigerator (heat source) and pump it into the air of the room in which the refrigerator is located (the heat sink).

In regions where summer cooling is required, exterior daytime temperatures generally are above 80°F (26.67°C). Where winter heating is required, exterior temperatures generally are below 50°F (10°C). At shallow depths in the Earth (about 6-10 feet), a consistent temperature of about 50°F (10°C) -55°F (12.78°C) is maintained. This intermediate temperature between the summer highs and winter lows makes the Earth an excellent potential heat sink in the summer and a heat source in the winter.

Because these systems are not applied in utility-scale electric production, they are outside the scope of this research team. However, UC Davis did encourage BIRAenergy, the DavisFREE subcontractor for the "ZNE Guidelines" component of this study, to look at the potential. A study published by the California Geothermal Energy Center quantifies the average available savings for a newly constructed single family home in the Davis Area as 53.7 percent.[6]

[6] http://www.energy.ca.gov/2014publications/CEC-500-2014-060/CEC-500-2014-060.pdf

4.1.1.6 In-Conduit Small-Hydro

When DavisFREE was preparing its proposal to the California Energy Commission, there was conjecture that the Davis Woodland Water Supply project might provide an opportunity for low-head hydro electricity generation using water turbines inserted into the conduit for water being pumped from the Sacramento River. Currently the water supply for Davis is from ground water pumping, which is depleting. The new water supply project will be completed by 2016, and will provide 12 million gallons per day of surface water pumped from the Sacramento River to Davis customers. A low-head hydro project generally describes an installation with a fall of water less than 16 feet, but the UC Davis Small-Hydro Collaborative review of the plans for the project revealed that the conduit will be laid too flat to accommodate hydroelectricity.

4.1.2 Cost of Generation Model

DNV-GL developed a cost of generation model to analyze the levelized cost for energy (LCOE) for the next five years (up to 2020). The base model inputs are those that were recently produced for the California Public Utilities Commission—by companies E3 and Black and Veatch—as an update to the Renewable Energy Transmission Initiative database. Concurrently with this study, UC Davis was working to optimize this model to include emerging technologies. DNV-GL used this as it is the most accurate publicly available model, and modified it as needed to fit the needs of this study. The spreadsheet model is fully functional and will be made available to Davis energy planners at a hosted website yet to be determined.

The model is simplified to focus mainly on the locational differences of renewable energy generation costs. This will help the City of Davis understand costs differences if resources are located within the city or in the surrounding areas. The simplified LCOE model accepts input data (described in sections below) and calculates LCOE based on resource type, interconnection type (Table 2 and Table 3), and location.

Table 2: Renewable Resource Types for LCOE Model

Solar PV	Fixed - 1 MW
	Fixed - 5 MW
	Fixed - 10 MW
	Fixed - 20 MW+
	Tracking - 1 MW
	Tracking - 5 MW
	Tracking - 10 MW
	Tracking - 20 MW+
	Distributed
Solar Thermal	Solar Thermal
Wind	Class 1
	Class 2
	Class 3
	Distributed Class 1
	Distributed Class 2
	Distributed Class 3
Biomass	Distributed
	Large
Biogas	Biogas
Geothermal	Geothermal

Table 3: Photovoltaic Interconnection Points

Distribution	City (preferred)*
	City
	PG&E (preferred)*
	PG&E
Transmission	CAISO
	BANC
	Other

*Does not require significant upgrades

Special attention was paid to deriving Davis-specific input data to capture the locational differences of renewable resources. Regional cost of generation inputs were drawn from the Renewable Energy Transmission Initiative cost of generation database as well as internal DNV GL databases. The costs data include:

- Interconnection
- Transmission
- Permitting
- Financing

The LCOE model was developed to compare the cost of energy (lifetime costs over lifetime generation in dollars per MWh). Since it is not known when Davis would acquire the generation and what the financing mechanism would be, there are two user inputs in the model:

- Planned installation year (currently assumed at 20 percent per year from 2016-2010)
- Financing mechanism (currently assumed at 100 percent municipal-financed at 3 percent)

The LCOE has various inputs relating to lifetime costs, including:

- Capital cost
- Fixed operations and management
- Variable operations and management
- Fuel cost
- Equipment life
- Degradation
- Incentives availability

- General financial data

It also has various inputs relating to lifetime generation, including:

- Capacity factor
- Degradation factor

In order for the model to forecast out to 2020, technology cost curves can be derived to capture expected decreases in equipment cost. DNV-GL contemplated deriving cost curves for other cost factors such as labor, fuel, and operations and management, but deemed the inclusion of these details would not significantly affect the ultimate outcome.

The Excel-based LCOE model is included as separate Appendix C to this report.

Chapter 5: Deployment Plan (Task 7)

5.1 Goal and Purpose of Task 7

The DavisFREE proposal to the California Energy Commission had two stated program objectives: (1) develop databases, supply curves, and net zero energy building guidelines for use in determining which initiatives recommended in the analyses should receive priority attention in the next phase of CAAP implementation, and (2) to develop methodologies and community energy flow models that can be used in planning subsequent community renewable energy technology deployment phases. The former objective is addressed in Chapters 2, 3, 4, and 5 of this report. The latter is addressed in this section. Task 7 initially identified the Solar Thermal Deployment plan as a primary component, but other components were less well defined. During the course of the overall research and as Davis needs were more clearly identified, supplemental subcontractor tasks were assigned and the following research activities were completed:

- "Integrated Energy for Davis California," a preliminary analysis of the energy service options potentially available to the city.
- The Georgetown University Energy Prize, a 2015-16 competition for energy efficiency and renewable energy deployment; DavisFREE was a member of the planning Task Force, and components of the DavisFREE research and recommendations will be delivered to Davis residents through the combined efforts of the city and local energy project implementers.
- The Solar Water Heating Deployment plan, now also including a set of training and workshop materials.
- Rooftop PV Technical Potential study, a new component that can supplement the city-owned stand-alone PV opportunities developed under Task 4.
- Draft Proposal for a pilot program for Zero Net-Energy for existing buildings, which the city can use to seek funding to test the ZNE volume-marketing approach proposed in Task 5.
- Near-Term Implementation plan for Davis, which prioritizes DavisFREE recommendations for the next phase of CAAP implementation

5.2 Integrated Energy for Davis, California

The following is a summary of the Integrated Energy for Davis report, which appears in entirety as a separate .pdf file as Appendix D. Gerald Braun of the Integrated Renewable Energy Systems Network authored the report and it was intended as a stand-alone document, which the City of Davis can use when evaluating energy service options to determine which can be expected to most effectively meet its energy efficiency, renewable energy, and greenhouse gas emission reduction goals.

5.2.1 Introduction

Davis is in the process of evaluating its energy service options. In general, they include for-profit utility service (current), establishing a municipal utility, or joining/creating a community choice energy agency. Davis also has a long term carbon neutrality goal. Accordingly, energy costs and energy related emissions are of particular concern. Approximately 72 percent of the city's direct energy costs and carbon emissions are attributable to building energy use, and approximately 28 percent to light vehicle fuel use. (Indirect costs and fuel use attributable to heavy vehicles are not included in the analysis).

5.2.2 Approach

The work was intended to inform further evaluation of energy service options. The city's population and housing statistics, energy profile, and electricity statistics were collected and interpreted. Energy usage, energy supply and the supply/usage balance were modeled for three scenarios corresponding to the three service options. Scenario-specific models were developed to account for building energy usage, transportation energy usage, and local solar, wind, and clean vehicle deployment over a 20 year period from 2015 to 2035. Strategies to address monthly and daily usage and supply variability were evaluated quantitatively to determine electricity imports and/or exports in the three scenarios.

5.2.3 Building Energy Trends

The integrated analysis approach starts with the best available information on building usage. Analysis of usage data for Davis creates a baseline or reference case. It also reveals long term trends that will continue unless the city decides to take a more active role in energy service. For example, Davis' energy use continues to inch upward in spite of intentionally slow population growth. Upward trends are more pronounced in the non-residential sector, while the residential sector trends slightly downward.

5.2.4 Economic Benchmarks

Building energy usage information can also be used to identify strategic priorities the cost-effectiveness of strategic choices. For example, Davis's energy usage per capita and its electricity load profile are significantly lower than those of comparable cities in northern California currently being served by municipal utilities. These two metrics have implications for both costs of electricity service and revenues captured by service providers. Along with other metrics, their implications must be evaluated in any serious economic feasibility work going forward.

5.2.5 Transportation Energy

Vehicle energy use accounts for only 20 percent of Davis's current energy use, but 28 percent of Davis's direct carbon footprint and 50 percent of its carbon footprint when heavy vehicle use is included. Clean energy vehicle energy use is expected to increase rapidly, so a twenty year integrated energy analysis must account for it.

5.2.6 Local Climate Strategy: Substitution

California's long term energy strategy hinges on efficiency and renewable energy. For purposes of near term local climate strategy, these elements are necessary but not sufficient. One missing element is the substitution of low carbon sources for high carbon sources. A major portion of Davis's building energy is used to generate heat using natural gas. In the building sector, substitution would mean heating water with solar energy and buildings with low carbon electricity and heat pumps. These steps can take a very large bite out of Davis's carbon emissions. In the transportation sector, substituting electricity and natural gas for currently dominant higher carbon transportation fuels can take an equally big bite out of Davis's carbon emissions.

5.2.7 Local Renewable Electricity – Energy Dollars Staying Home

A decision most businesses routinely face is whether to make what is needed or buy it. Davis' electricity is currently almost all imported, not locally produced. So, the next step in integrated local energy analysis was similar to the step related to usage, that is, to specifically identify current local area renewable energy usage, resources, and trends, plus opportunities to expand renewable electricity production locally.

Davis has abundant cost-effective opportunities to generate solar electricity locally. There are also large siting areas for cost-effective wind generation within 10 to 20 miles of the city limits.

Solar water heating and bio-fuels are potential complements to solar and wind electricity, as is vehicle-to-grid electricity storage. Also, as fuel cell electric vehicles gain a foothold, solar electricity will be used to produce hydrogen for vehicle fuel cells. In the longer term, additional hydrogen can be produced and used locally for heating purposes, displacing natural gas and reducing the city's carbon footprint.

On-site solar electricity installations, preferably matching or exceeding on-site use, will be the simplest and easiest pathway for increased dependence on local renewable resources. At current rates of deployment on-site solar electricity can be expected to supply 20 percent of the city's electricity need without any further action by the city.

5.2.8 Locally Accountable Energy Service – Key to Climate Action

In the dominant energy services paradigm, efforts to reduce energy usage or shift usage to less carbon intensive energy sources are not coordinated or adapted locally. Alternate frameworks that empower locally accountable energy service can have a greater and timelier effect. For example, in local power scenarios, on-site systems could come on line faster and some could generate net positive electricity. Likewise, development of larger but still local projects to serve users lacking suitable space for on-site generation would be possible.

Such "community" solar and wind projects are currently impeded by regulations and market rules that result in excessive costs to energy users. Locally accountable energy service providers can capture direct benefits of on-site and community-based projects and also indirect economic and resiliency benefits to local economies. To roughly assess the difference locally accountable electricity supply would make, renewable energy deployment and carbon footprint reduction trajectories were computed and compared.

The analysis assumed build-out of local renewable electricity generation in three scenarios, corresponding to the energy service options the City of Davis evaluated in 2013-14: Investor Owned Utility, Community Choice Energy, and Publicly Owned Utility. The study illustrates the combined effect of local renewable electricity build-out, substitution of electricity for fossil fuels in the building heating and transportation sectors, and more locally effective energy conservation programs in the Community Choice Energy and Publicly Owned Utility scenarios.

5.2.9 Variability – The Once and Future Challenge

Electric grid operators have been managing variability since the first electricity grid commenced operation. As then, electricity usage varies, but usage diversity makes the variability manageable. Strategies for managing variable and intermittent supply also preceded the advent of cost-effective solar and wind generators. As then, as supply variability increases, the need for flexibility increases.

In the big grid, some generators are flexible, some are not. Baseload plants are typically not designed for flexibility but for low marginal production costs. Solar and wind generators have even lower marginal production costs. So, instead of providing flexibility to complement inflexible baseload generation, the emerging need is to provide flexibility to accommodate solar and wind. It is easier to manage less flexibility than more, but the numbers of tools in the grid management toolkit are increasing. Small grids need smaller, more precise tools, but basically the same principles apply.

A local integrated energy analysis requires attention to variability and the use of tools available to manage it locally. Such analysis is necessary if local resources are to be fully and economically exploited. A first step was to develop monthly, daily, and hourly usage and renewable electricity supply profiles for Davis using available information. Then, the analysis roughly determined the amounts of flexible distributed generation and/or energy storage that would be required in a full local renewable build-out scenario, that is, one calling for all local electricity usage to be served by local renewable electricity generation.

Analysis of local residential and non-residential usage and solar and wind generation patterns pointed to a generation mix balanced approximately evenly between solar and wind. Hourly solar production profiles better match non-residential usage profiles than residential profiles, while hourly wind production profiles better match residential usage.

As expected the match is far from perfect and it is also better on monthly rather than daily or hourly bases. So, for such maximum reliance on least cost local renewable resources, Davis would be well advised to encourage residential and commercial combined heat and power installations (currently there are none) and/or to deploy flexible distributed natural gas generation for use in balancing variable demand and variable supply.

Analysis of production to balance monthly demand indicates that in summer months, some renewable electricity would be available for export or sale, while in winter months local natural gas generation would be needed to round out monthly supply. Model results show that Davis could achieve the necessary balance with proportionately much less local natural gas electricity generation than current levels of statewide and centralized natural gas generation.

Analysis of production to match hourly variations in daily usage indicated that significant amounts of distributed electricity storage would be required to distribute daily renewable production according to demand over 24 hours of usage. A couple of basic related questions were asked and answered:

First, would the likely amount of storage embedded in electric and plug-in vehicles suffice as a demand response tool; for example, encouraging charging during hours when renewable supply exceeds building usage? The analysis showed that it would not, per se. So other load management strategies would be needed as well.

Second, would the projected cumulative vehicular storage capacity suffice to store excess generation during some hours and return it to the local grid when needed each day? The analysis showed that it would in some but not all months. So, some additional stationary storage might be required.

5.2.10 Conclusions

It will be feasible for Davis, California to use a mix of local solar and wind resources to make major strides toward carbon neutrality in the next two decades, essentially eliminating its direct carbon footprint by 2035 in the Publicly Owned Utility scenario.

A combination of factors are creating a need for locally specific, detailed and integrated renewable deployment analysis and planning. The required analyses will need to consider expected patterns of end use energy substitution, for example, electricity for natural gas and for other fossil fuels. This will be tough and unnecessarily imprecise work unless better information, now held as proprietary by regional utilities, is shared with local jurisdictions.

Development of local renewable resources is likely to be slow, except in cases where energy service is accountable to local citizens and their representatives. It must be planned and managed to account for surprisingly large local variations in energy usage metrics and local supply resources. Locally accountable energy service may actually prove to be a necessary condition for locally integrated energy planning and deployment, especially where local economic and environmental improvements are targeted.

Some other similarly sized northern California cities are positioned to take the biggest climate action strides because they are already served by municipal utilities. Still others that receive community choice energy service can also make significant strides, but the increasing need for integration of regional utility and local planning will be more of a limiting factor in these cases.

Integrated energy analysis for a specific small city should be based on realistic assumptions and pragmatic scenarios. If this approach is taken, it confirms, calibrates, and in some cases challenges intuitively generated expectations.

5.3 The Georgetown University Energy Prize

Midway through the DavisFREE project activities, the City of Davis was notified that it was a semi-finalist for the Georgetown University Energy Prize. This was a significant development for both the City of Davis and DavisFREE, as it meant that the research results and proposed marketing activities in the Task 7 Deployment Plan would now have a defined route for delivery into the community my means of coordinated "existing community engagement partners" as envisioned in the original DavisFREE proposal to the California Energy Commission. The DavisFREE technical tasks and funding did not include an "implementation" component, just research and recommendations. The Davis GUEP effort will be the primary energy efficiency and renewable energy market delivery mechanism for 2015-2016.

5.3.1 Introduction

The City of Davis has been selected as one of 48 semi-finalists in the Georgetown University Energy Prize[7] , a nationwide competition that challenges medium-size municipalities (with populations between 5,000 and 250,000) to rethink their energy use and implement creative strategies to improve energy efficiency. The semifinalists are competing for a "winner take all" prize of $5 million that will be awarded to the community that demonstrates the most success (in accordance with its plan) in reducing utility-supplied electricity and natural gas energy consumption over a two-year period. The competition began January 1, 2015, at which time baseline community-wide energy usage was documented. The prize funds will be used for implementing community energy projects, in accordance with the winning community's Program Plan.

The final award judging will be based on (a) per capita reduction of energy consumption in a manner that is likely to yield continuing improvements within the community, and (b) replicability and scalability in other communities.

Davis is one of nine cities in California in this competition, also including Berkeley, Danville, Palo Alto, Claremont, Fremont, Sunnyvale, Redlands, and Chula Vista.

5.3.2 Approach

The City of Davis, Davis Joint Unified School District, and Cool Davis[8] are the primary partners leading the local effort. A thorough strategy and action plan was developed and submitted to GUEP as the final portion of the semi-finalist competition, and will serve as the implementation guide for 2015-2016. A GUEP Task Force has been established that includes representatives from DavisFREE, Yolo Energy Watch, Yolo County Housing, and other local energy experts and entities that will support the research, planning, and implementation tasks. Cool Davis intends that 75 percent of Davis households engage in a household-based carbon reduction program in 2015. These efforts will support the existing Davis goals for reducing the community's greenhouse gas emissions.

5.3.3 Strategy

For purposes of the competition, Cool Davis has identified three primary areas for energy and greenhouse gas emissions reduction efforts within the community:

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[7] More information: www.guep.org

[8] More information: www.cooldavis.org

- Buildings – energy efficiency, conservation, and renewable energy production for residences and commercial buildings.
- Transportation – helping the community shift to non-fossil fuel vehicles and modes.
- Consumption – reducing consumption and waste of food, water, and goods and services.

The strategy combines:

- Deep data mining – analyzing property data histories and building characteristics, comparing building permit information, and GIS data to develop analytics and coding to identify properties that would benefit from energy upgrades.
- Identifying new financing and rebate incentives for single family and multi-family units.
- Focusing efforts primarily on energy-intensive low-income neighborhoods.
- Utilizing neighborhood-based outreach and social marketing engagement approaches.
- Conducting workshops on how residents can reduce energy usage through "do-it-yourself" and contractor-based incentive programs.
- Trying new approaches to behavior change, using gamification or the latest methods in social science research.

5.3.4 DavisFREE Importance

The importance of DavisFREE to the GUEP two-year competition is that many components of the research and planning completed by DavisFREE can be used almost immediately, and will save a significant amount of time for the marketing and implementation teams. The DavisFREE research contributions (as described throughout this report) to the Davis GUEP competition include:

- Davis GIS and PG&E Green Communities database development, energy data extraction and sorting, mapping, incentive program participation data, PV interconnection data, and energy usage and GHG emissions trend analysis.
- ZNE existing residential building energy use modeling and retrofit energy reduction strategies / technologies.
- The neighborhood-based "volume marketing" approach for ZNE retrofits.
- Established collaboration with the PG&E Advanced Energy Upgrade technical assistance program, which supports "bundled" residential energy system retrofits, a calculated savings approach to incentives, contractor outreach and training, and unified market outreach approaches; supportive of the ZNE marketing approach.
- Rooftop PV Technical Potential Analysis.
- Solar Water Heating Deployment Plan.

- Established collaboration with the PG&E California Solar Initiative (CSI)-Thermal technical assistance and incentives program, including coordination on customer outreach.
- Financing opportunities descriptions and guidance.
- DavisFREE Task 8 Community Engagement activity plans that will be coordinated with the Georgetown Prize Task Force and completed in March and April 2015.
- Community Engagement activities will include webinars for other municipalities throughout California, contributing to the "replicability and scalability" interests of GUEP.

The research conducted by DavisFREE on Locally-Available Renewable Energy Resource Development (Tasks 4 and 6) is currently considered to be outside the planning horizon of the two-year GUEP competition.

5.4. Solar Water Heating Deployment Plan

This research and planning for this Task was managed by Jonathan Gemma of Aztec Solar, Inc.

While most of the focus of the DavisFREE research was on electricity use reduction and local generation using renewable energy resources, the DavisFREE planners also proposed development of a "fast-track" path for reducing GHG from natural gas combustion. The primary purpose of this initiative is to decrease natural gas use at the specific sources of combustion, thereby reducing direct natural gas carbon emissions in Davis. DavisFREE intends to make the solar water heating (SWH) program a rapid-deployment method for Davis residents to directly observe, through personal carbon footprint changes as well as extrapolated community-wide impacts, the near-term (2015-16) reductions in natural ags greenhouse emissions that can also stimulate enthusiasm for other energy fuel and emissions reductions. The program also supports State of California goals to install 200,000 solar water heating systems on buildings by 2017 (both natural gas and electricity-displacing systems), or the equivalent capacity to avoid 585 million therms of natural gas consumption over the 25 years of the systems' operation.

The Davis area has abundant and consistent solar insolation that is conducive to photovoltaic and solar water heating systems that can be mounted on existing buildings to help achieve the goals of the Davis Climate Action and Adaptation Plan.

5.4.1 Introduction

The deployment planning task (Task 7) of the DavisFREE program included the development of a Solar Thermal Deployment Plan. Davis residential and commercial buildings currently use approximately 268 million kilowatt hours of electricity and 12.5 million therms of natural gas per year. Solar water heating technology is a cost effective way to displace electricity or natural gas used for heating water. Most importantly, since the CAAP is an emissions reduction directive, solar thermal technologies can eliminate or significantly reduce greenhouse gas emissions from natural gas combustion directly at the end-use source.

The average household uses 64 gallons of hot water per day for activities like cleaning dishes, washing clothes, and taking showers or baths. On average, a residential solar water heater can reduce the portion of the utility bill that is for heating water by 50–80 percent. The primary factors that influence SWH savings include the amount of hot water the household uses (affected by the number of people in the household), the type and size of the solar water heating system, geographic location and ability of the site to directly capture sunshine, and the price of natural gas.

Prior to the DavisFREE study the city did not know how many SWH systems had been installed locally, the market segments in which they had been adopted, their applications (domestic water heating, pools, and so forth), their effectiveness, or their current functional condition. Prior to 2015 the PG&E California Solar Incentive-Thermal (CSI-T) program delivery design relied on a statewide mass media marketing approach which was ineffective in delivering information at the local level in communities such as Davis.

The plan includes single-and multi-family buildings including low-income housing. Although process heat, solar cooling, and combination water/space heating are now acceptable solar thermal technology applications under the CSI-T incentive program, it was generally conceded by DavisFREE and the city that there were few potential applications for these technologies in Davis or they were currently too expensive for most customers. A simpler, more cost effective and more expeditious approach was needed to help accelerate the general market adoption of solar thermal systems.

5.4.2 Approach

Aztec Solar participated in data collection and analysis from the PG&E Green Communities energy usage database and market targeting tool and the City of Davis Geographical Information System (GIS) databases. They researched market issues around the slow adoption of SWH for residential and small commercial customers, identified the locations of all existing SWH and photovoltaic (PV) installations in Davis, analyzed financial incentives and financing opportunities, developed cost-benefit models for various market segments using the new statewide CSI-T incentive program, and proposed methods for accelerating the installations of domestic SWH systems in Davis beginning in 2015 under GUEP.

The scope of work was limited to residential and commercial domestic water heating and commercial swimming pools solar water heating (SWH) as the fastest way to achieve market acceptance and natural gas greenhouse gas reductions. Domestic water is defined as potable water heated for personal uses such as drinking, food preparation, sanitation and personal hygiene, but not including space heating, swimming pool heating, commercial process food preparation, or clothes washing.

In the conduct of its research, Aztec Solar performed the following:

1. Developed a research plan for approval by the California Energy Commission.
2. Reviewed CPUC Energy Division reports, legislative actions, and California Soalar Energy Industries Association studies.

3. Participated in the statewide CSI-T working group to help propose changes to the CSI-T incentives structure, market definitions, acceptable technologies and applications, and customer delivery programs.

4. Collaborated closely with the PG&E CSI-T program manager to ensure understanding of that utility's roll-out plan, and to discuss resources and pilot project ideas that can be brought immediately to Davis.

5. Identified and mapped all existing SWH and PV systems in Davis.

6. Conducted interviews with over 60 apartment facility managers in Davis who know their facilities' thermal-mechanical systems well, as well as swimming pool construction and maintenance professionals with extensive knowledge of existing pool heating systems and electrical equipment in Davis.

7. Conducted secondary source research to identify active community-scale solar thermal projects in other U.S. locales.

8. Considered its own professional experiences and collegial interviews in the development of the research.

5.4.3 Significance of the Investigation

Solar water heating systems can significantly reduce natural gas use and greenhouse gas emissions. Examples of the average annual therm savings and associated CO_2 reductions by solar water heating systems for selected market segments are shown in Table 4.

Table 4: Market Segment Natural Gas and CO_2 Reductions with Solar Water Heating

Application	Annual Natural Gas Reduction (Therms)	Annual CO_2 Reduction (Metric Tons)
Single Family Residential	166	0.615
Multi-Family Apartments	2,000	10.6
Coin-op Laundries	700	3.7
Hotels	2,015	10.7
Full Meal Restaurants	2,535	10.8
Quick Service Restaurants	455	2.4
Commercial Pools	3,200	17.0

The therm reductions and CO_2 emission reductions are based on average size solar thermal systems and maximum size load profiles from the ASHRAE Handbook and the CSI-Thermal Handbook[9] (pg. 123).

5.4.4 Addressing Market Barriers to Solar Water Heating

Although solar water heating has been around since ancient Greek times and is in broad modern technology application in Europe, China, Hawaii, and other parts of the world, the

[9] http://www.gosolarcalifornia.ca.gov/documents/csi/CSI-Thermal_Handbook.pdf

California industry has been slow to develop due to several key market barriers Some methods that address this issue are described in the following sections.

5.4.4.1 Low Natural Gas Prices and Incentives

Natural gas prices have not increased significantly in the last five to seven years as had been anticipated, making the economics difficult for customers to justify. But natural gas prices are expected to begin to rise in the near future[10], but perhaps not for a long period.

According to the January 2015 CPUC decision on revisions to the CSI-T incentive program, the single biggest factor that has limited expansion of solar water heating installations has been the low price of natural gas. Natural gas pricing is a complex estimation process based on weather, economics, demand, storage, and production. When the CSI-T Program was first designed, natural gas prices exceeded $17 per thousand cubic feet and were expected to rise. Instead, natural gas prices dropped and have remained between $8 and $11 per thousand cubic feet. Although gas prices are expected to rise, the industry remains volatile and therefore the market is not very predictable. But with the 2015 CSI-T incentives, Federal Tax Credits, and gas cost offsets, investments in solar water heating may now represent a prudent hedge against future gas market volatility. The 2015 CSI-T program significantly increases incentives for residential and commercial buildings.

5.4.4.2 Up-Front Costs for SWH Installation

The up-front costs of the SWH systems have often limited customer participation, and innovative financing schemes have not followed the trends seen with the photovoltaic (PV) industry. The CSI incentive program for PV helped to create market competition by providing direct cash and annual tax incentive levels which drove manufacturing and installation prices down and, therefore, customer demand up; but, the CSI-T program has not yet seen the cost offset or adoption levels needed to cause something similar for the solar water heating industry. By comparison, the market for rooftop solar PV took nearly ten years to gain traction, but costs then were driven down precipitously through competition, improved equipment, research funding, reduced soft costs, innovative financing approaches, concern over GHG emissions, legislated options to large utility control of electricity generation and distribution, and widespread acceptance by the populace.

To become effective rooftop PV projects received 28 percent to 44 percent of system costs through monetary incentives. By contrast, the CSI-T program rebates have so far covered only 15 percent to 19 percent of the costs of single-family residential installations. The multifamily and commercial sub-program has had rebates of 29 percent to 41 percent of project costs, far closer to incentive levels for the CSI-PV Program. The same factors that made PV affordable will hopefully have similar influence on driving costs down for the solar thermal industry.

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[10] U.S. Energy Information Administration: http://www.eia.gov/dnav/ng/hist/n3010us3A.htm

5.4.4.3 2015 CSI-T Rebate Levels

The CSI-T program has previously not provided high enough incentive levels to encourage potential SWH customers. The 2015 CSI-T incentive program payment levels are expected to create significantly better cost-benefit results for customers in all market categories.

The CSI-T program is probably the major driving force behind SWH adoption, if the incentives are high enough and the program delivery methods are improved. The CSI-T incentive program was introduced in 2010 in response to Assembly Bill 1470 (Blumenfield, Chapter 24, Statutes of 2012) which directed the CPUC to design and implement an incentive program which would install the equivalent of 200,000 solar water heating systems on buildings by 2017, or enough capacity to avoid 585 million therms of natural gas consumption over the 25 years of the systems' operation. It also included a component for electricity-displacing solar water heating. It originally contained two sub-programs, single-family residential and multifamily/commercial. Similar to the CSI program for rooftop PV, it established four incentive step levels for the gas-displacing part of the program, with levels dropping as customer participation milestones were passed.

Because the initial programs were not showing much acceptance in the marketplace, subsequent CPUC decisions increased incentive levels and caps on individual projects, changed step levels, and added process heat, solar cooling, and combination water/space heating as acceptable technology applications. The CPUC also introduced a performance-based incentive structure for larger solar water heating systems and for the new technologies. Assembly Bill 2249 (Buchanan, Chapter 607, Statutes of 2012), expanded the definition of solar water heating systems to include solar pool heating systems, although single-family residential solar pool heating systems were specifically excluded from the definition.

A recent review[11] by the CPUC shows that, since its inception in 2010, the CSI-T program administered by the investor-owned utilities has achieved just percent of the statewide goal for the single family residential sector, while the multifamily / commercial program "has had modest success."

The subsequent CPUC January 2014 report to the Legislature[12] on its review of incentive levels and progress of the CSI-T Pprogram, focusing on the gas-displacing part of the CSI-T found that:

1. At the 2014 installation rates, the CSI-T Program would not reach its target of 585 million therms displaced over the life of the systems installed.

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[11] CSI-Thermal Public Export Database, downloaded October 23, 2014, measured by Current Incentive Amount and Current Status Paid. http://www.gosolarcalifornia.ca.gov/solarwater/

[12] The Report can be found on the CPUC's CSI-Thermal webpage at: http://www.cpuc.ca.gov/NR/rdonlyres/B7D3D1AC-5C9A-49C9-81E1-8E03E471AA73/0/CSIThermalAB2249ReportFinalWebVersionJanuary292014.pdf

2. Natural gas prices declined by roughly 20 percent from 2007-08 wholesale prices, which significantly diminished the cost effectiveness of solar heating technologies.
3. The general market single-family sub-program had only achieved 0.64 percent (58,377 therms displaced) of its cumulative program goal through 2013.
4. The multifamily/commercial general market sub-program had only achieved 7.23 percent (981,977 therms displaced) of its cumulative program goal through 2013.
5. The higher incentive offered by the low income multifamily/commercial sub-program was credited with helping that market segment achieve greater success than the general market sub-program, though still inadequate to achieve program goals.
6. Because solar pool heating is more cost effective (the solar pool heating system rebates are set at a lower level than the other technologies that the CSI-T funds), the introduction of swimming pool heating systems may spur significant program participation.

As a result of further CPUC market research and recommendations from the industry owned utilities, industry representatives serving on the Solar Thermal Working Group, California Soalr Energy Industries Association , and others, on January 29, 2015 the CPUC granted modifications to the CSI-T program[13] for 2015. The industry owned utilities subsequently replied on February 28, 2015 with proposed revisions to the CSI-T program Handbook and market plan for customers[14]. More detailed information and essential components such as a revised on-line cost- benefit calculator, installer's lists, application forms, and other items are in development by the industry owned utilities but are not expected to be complete until late April 2015. The PG&E CSI-T website is still in development[15] but is functional.

In addition to insufficient financial CSI-T incentives, there is little evidence to show that the CSI-T program was effectively marketed in municipal or county jurisdictional areas, and public awareness of the technology and the financial incentives appears to be extremely low. The previous CSI-T marketing approach relied on statewide media mass marketing rather than more direct customer interaction and local community outreach. The 2015 CSI-T allows the individual industry owned utilities to conduct local-market outreach activities.

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[13] Decision Granting Petition for Modification of D.12-08-008 and D.13-08-004 Regarding Changes to the California Solar Initiative Thermal Program. Rulemaking 12-11-005. Issued 1/30/15 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M145/K938/145938942.PDF

[14] Proposed Revisions to the California Solar Initiative (CSI) Thermal Program Handbook in Compliance with Decision 15-01-035. PG&E Advice Letter 3570-G/4579-E, et al.. http://www.gosolarcalifornia.ca.gov/documents/CSI-Thermal_Handbook.pdf

[15] http://www.csithermal.com

5.4.4.4 Key CSI-T Modifications for 2015[16]

Modifications to the 2015 CSI-T Program include the following:

- Higher incentive levels for the single-family and multifamily/commercial sub-programs.
- A separate budget for the solar pool heating system sub-program.
- Reallocation of the sub-program budgets as 10 percent single-family, 60 percent multifamily/commercial, and 30 percent solar pool heating.
- A higher individual project cap for multifamily/commercial of $800,000.
- An individual project rebate cap for solar pool heating systems at 50 percent of total system cost.
- Authorization for the industry owned utilities to request future changes to the program through Tier 2 advice letter filings.

Table 5: CSI-T Incentive Increases (Step 1) for 2015

Market Segment	**$ Incentive Per Therm of Annual Natural Gas Savings**		**% Increase**
	2014 Amount	2015 Amount	
Single Family Homes	$18.59	$29.85	61%
Low Income Single Family Homes	$25.64	$36.90	44%
Multi-Family / Commercial	$14.53	$20.19	39%
Low Income Multi-Family / Commercial	$19.23	$24.89	29%

Examples of business cases for SWH for selected applications are displayed in section 5.3.6 of this report.

5.4.4.5 Investment TaxCredit Uncertainty

Uncertainty over the past few years about whether the 30 percent Federal Investment tax credit incentive would be continued also had effect on investment decisions. The Energy Policy Act of 2005 created a 30 percent investment tax credit (ITC) for the installed cost (minus rebate amounts) of commercial and residential solar energy systems, including solar-electric systems, solar water heating systems, and fuel cells. Subsequent amendments extended the tax credit to small wind turbines, geothermal heat pumps, microturbines, and combined heat and power systems.

Under the residential ITC, the credit is applied to the homeowner's income taxes. This credit is used when the homeowner purchases the solar system outright and has it installed on the

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[16] http://www.cpuc.ca.gov/NR/rdonlyres/902D32D2-0D83-427E-953C-EDEF9F5E4206/0/FinalCSIProgramForum_CSIThermal20150325.pdf

residence. A taxpayer may claim a credit of 30 percent of qualified expenditures (on-site preparation, labor costs, equipment costs, interconnection costs, and so forth) for a system that serves a dwelling unit. The commercial ITC is used for utility-scale, commercial, and residential sized projects. The company that installs, develops, or finances the project uses the credit.

The ITC for renewable energy systems for commercial properties will remain in place through December 31, 2016, but is expected to decrease on January 1, 2017 from 30 percent to 10 percent. The residential ITC is currently expected to drop to zero at the end of 2016. However, legislation has been proposed to extend and expand both ITC programs, so Davis community engagement teams need to remain informed of changes.[17]

DavisFREE recommends aggressive SWH marketing activities so Davis residents and businesses can take advantage of tax and/or accelerated depreciation opportunities during 2015-2016 while ITC is available at the higher level. High adoption rates may help to drive down marketing and installation costs so that the market can better sustain itself after the ITC drops. The city should also support initiatives to encourage Congress to continue the ITC beyond 2016.

5.4.4.6 Lack of Affordable Commercial Financing

Solar thermal lacks widespread financing. With such a low adoption level of SWH installations, the cost of capital needed to finance such projects has been very high. Along with weak customer acceptance, the financial community has not fully considered solar thermal as an investment. The lack of physical performance data, of installation quantity, and of cheap natural gas prices have kept financiers away.

According to a Solar Energy Power association report[18] titled, "Heating Up: The Impact of Third Party Business Models on the US Market for Solar Water and Space Heating," 16 percent of the 110 million United States households are suitable for solar domestic hot water systems. The report states that at given market conditions, the technology is not attractive for natural gas customers but is favorable in 72 utility areas around the country at an installed cost of $7,000 before incentives. This represents a $123 billion dollar market.

Combining the CSI-T incentives, ITC federal tax credits, and the natural gas cost offsets can now create a very strong case for saving money and reducing GHG emissions. There are a number of ways to finance solar thermal heating systems for residential and commercial building owners, including the ones in the following sub-sections.

Self-Financing

After CSI-T and ITC incentives, residential SWH systems can now be installed in California for between $1,000-$2,000, which should be affordable by many Davis homeowners without incurring loan interest payments. For a typical single-family residence, the PG&E SWH calculator tool (see example results in section 5.3.6) estimates an installed net cost of $1,100 and simple payback of 4.9 years.

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[17] http://energy.gov/savings/residential-renewable-energy-tax-credit

[18] https://www.solarelectricpower.org/discover-resources/publications-and-media.aspx?s=Heating+Up

Traditional Commercial Lending
For commercial customers, traditional banks can offer terms of six to seven years with a competitive market interest rate. These programs will allow for 100 percent financing and will work with owners' needs depending on credit ratings.

For single family homeowners, credit unions and banks can offer low interest loans for terms up to 20 years depending on customer credit. These loans can be 100 percent and allow for a one-time reamortization if used in conjunction with the Federal Tax Credit to pay down the loan amount. Many banks also extending lines of credit based on the equity in the home.

Property Assessed Clean Energy Programs
A relatively new way to finance energy efficiency improvements and renewable energy systems is through a Property Assessed Clean Energy (PACE) program. Yolo County and its cities have recently authorized three PACE providers to serve the area. PACE provides financing for energy upgrades and clean energy projects through a voluntary supplemental property tax assessment to the premises. The loan is considered a priority lien on the property and is repaid through property tax payments over a term of up to 20 years. PACE is tied to the property itself, so if the property is sold the loan remains with the property and is transferred to the new owner. Projects can generally be 100 percent financed, loans can be for up to 10 percent of the value of the property, and qualification is not based on credit score. Information on the Davis area PACE programs will become available to residents in mid-2015.

Other Third-Party Financing Options
The photovoltaics industry has developed a variety of PV system leasing, shared savings, and power purchase agreements. A few firms in other states use a program model that has no upfront cost and will deliver domestic solar hot water at a fixed percentage discount to its utility rate. Most SWH installers cannot participate in these programs because the need for a lower installed cost prices them out of the work. In order for the Solar Thermal industry to grow, third-party financing needs to be available for all contractors. It is anticipated that with higher SWH adoption rates and customer demand, innovative new financing options will be developed.

PG&E Incentives and On-Bill Financing for Energy Efficiency
Customers installing SWH systems may want to consider other energy efficiency improvements and the PG&E 0 percent interest loan program, which allows principal repayment through the monthly utility bill. The PG&E website provides "Additional Resources" for residential[19] and commercial[20] energy efficiency financing.

5.4.4.7 Lack of Customer Knowledge about SWH

It is apparent that most residents do not know much about solar thermal technology, and many don't know to differentiate it from solar electric photovoltaics. Market confusion can be reduced

[19] http://www.pge.com/en/myhome/saveenergymoney/rebates/index.page
[20] http://www.pge.com/en/mybusiness/save/rebates/onbill/index.page

by improving community outreach and localizing information campaigns as can be initiated by Davis-area community engagement teams in conjunction with PG&E's 2015 revised CSI-T marketing approaches, and using DavisFREE data and recommendations.

DavisFREE has been coordinating with the PG&E CSI-T program manager on providing focused attention for outreach to Davis residents. This approach is summarized in section 5.4.5.6 of this report.

5.4.4.8 High Soft Costs

There has been a slight rise in soft costs due to lack of knowledge or experience about SWH at the city construction permitting and inspection level. This can be alleviated through direct educational support to city staff.

DavisFREE will recommend minor changes to construction permit data gathering to allow capture of more complete and concise information about the types of renewable energy systems to be installed and estimated energy capacities at each site. Periodic update training for construction inspectors on SWH equipment and installation methods should also be helpful. Davis may also want to consider its own financial or other incentives, such as lowered or waived permit and inspection fees, expedited permit processing, ordinances, or even a city-financed SWH leasing program (see Section 5.3.5.5.3 for the Lakeland, Florida example) to encourage SWH.

DavisFREE has developed Powerpoint presentations that can be excerpted for city staff training, as well as for broader community engagement activities (see Appendix E).

5.4.4.9 Identification of Qualified Solar Thermal Contractors

There are a limited number of expert SWH installers in California. There are also a relatively limited number of competitive domestic SWH systems available, and innovative technologies for higher temperature applications are struggling to gain a foothold for building space heating and cooling, and industrial process heat. Future state initiatives and expansions to the incentive programs are in consideration to support expanded solar thermal applications and encourage technology research and development and market introduction.

DavisFREE compiled a list from the Davis construction permits database of contractors that installed rooftop or pool SWH systems over the past 12, and more, years, and has proposed a contractor workshop to inform them of the DavisFREE initiative and how it will be rolled out to the community through GUEP. This effort should only support contractors having (or able to obtain) the necessary credentials, certified products, stability, and experience in the industry. The PG&E website also has a contractor search tool to help customers locate local SWH and energy efficiency contractors[21].

The team is also working with the PG&E CSI-T program manager to participate in additional contractor identification and to provide incentives program information and direct support to

[21] http://www.pge.com/en/mybusiness/save/energyefficiencycontractors/index.page

Davis area contractors as an informal "pilot program" for PG&E to test its local-market outreach activities and materials. The Davis program will also provide information on financing opportunities, such as PACE, commercial loans, on-bill financing, and others.

CSI-T requires customers to use contractors with active A, B, C-10 or C-46 licenses from the Contractors' State License Board, but of course customers should get two to three estimates from different contractors to compare costs, system types, and savings; as well as check each firm's experience and references before signing contracts.

5.4.4.10 Lack of Investment Capital

Many innovative new solar thermal prototype products have been developed in recent years but most are struggling to find production investment capital and pilot project installations to test and demonstrate their products. Since 2013 CSI-T has included incentives for process heat, solar cooling, and combination water/space heating systems. But even solar thermal water heating remains relatively invisible, so the other applications may not begin to catch on until the general technology is proven.

5.4.5 Market Facilitation

All tasks of the DavisFREE research work encourage neighborhood-based approaches to customer outreach and marketing. DavisFREE collaborated with the PG&E "Green Communities" program in the development of energy usage databases aggregated to groups of about 20-30 homes. It also developed methods of sorting energy-related data from the various City of Davis GIS databases that resulted in much premise-specific data and detailed mapping of renewable energy installations that can support SWH customer target marketing.

The previous CSI-T marketing approach relied on statewide media mass marketing rather than more direct customer interaction and local community outreach. The 2015 CSI-T program will be converted to allow "local market facilitation" plans by each investor owned utility for marketing, education, promotional materials, and outreach tactics and activities. This model is much better allied with the ambitions of the City of Davis for community engagement.

PG&E developed a consumer guide to "What You Need to Know About Solar Water Heating"[22] that can be distributed through Davis community engagement partners.

The Davis / GUEP community engagement programs should endeavor to:

- Increase customer understanding of SWH technologies, applications, and benefits (natural gas usage reduction, cost benefits, and GHG reduction).
- Leverage PG&E and GIS data to target the best prospects for SWH.
- Develop and deliver tools and materials that support investment decisions.
- Integrate messaging and outreach planning with incentive programs.

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[22] http://www.pge.com/en/myhome/saveenergymoney/solar/waterheating/faq.page

- Simplify the procurement and installation process by providing referrals to qualified installers.
- Support the local contractor network to strengthen and grow its capacities.

5.4.5.1 Possible Customer Resistance Due to Earlier SWH Incentive Programs

This category is anecdotal, but the SWH incentive programs of approximately 20 years ago were not very well administered and may continue to be a factor in the slow growth of the industry. SWH incentive programs were first introduced in California in the 1980's. However, there were few standards or regulations that policed what types of systems were installed, or the qualifications of the installers. There were some unqualified or unscrupulous installers who did not provide quality products, installations, maintenance or service, creating many unhappy customers. SWH systems were not required to have freeze damage control protection systems, and damage occurred on SWH in several climate zones, instilling a false sense that SWH technologies simply didn't work.

As a result of this industry calamity, third-party certification groups have been formed to independently test solar thermal collectors for performance. The current CSI-T Rebate Program requires SWH equipment to be performance-certified by the Solar Rating & Certification Corporation or International Association of Plumbing and Mechanical Officials. The program requires only proven freeze protection techniques. Incentives will only be paid on projects using contractors who have attended CSI-T approved training sessions to learn best installation practices. The industry has learned from past difficulties how to demonstrate to customers that solar thermal systems do in fact work and is the most efficient solar system on the market.

Assuming the lifespan of a residential SWH system as 20-25 years, any remaining systems in Davis from this previous incentive period are likely to no longer be functioning, or are functioning at significantly reduced efficiencies. Residents, particularly those who purchased the homes with SWH already installed by previous owners, may not know if or how the systems work.

DavisFREE has identified all of the existing SWH systems installed on Davis rooftops and pools through low-level aerial photography and other means. The Davis construction permit records have been electronic since 2000, and the city can now compare the site data developed from the photo analysis against permit records to determine which systems are more than 15 years old. This potentially opens a niche market for repair or replacement of systems for customers who apparently like the notion of having SWH. The new CSI-T incentives can be applied for replacement of old systems that are no longer functioning adequately. Since much of the plumbing and perhaps other components may still be in place, lower (re-)installation costs and payback should be quite appealing.

5.4.5.2 Solar Water Heating Retrofit Targets for Davis

Solar thermal technology can be broadly applied in the residential and commercial market segments in Davis.

Residential Segment
The average household uses 64 gallons of hot water per day for activities like cleaning dishes, washing clothes, and taking showers or baths. A standard single-family residential water heating system can use up to 30 percent of the total energy load of the house, and up to 50 percent of the natural gas usage. On average, a domestic solar water heating system will save 116 therms of natural gas per year. This amounts to a reduction 0.615 metric tons of CO_2 emissions per household.

Single family homes can utilize solar heating systems to pre-heat water in their existing gas-fired or electric water heaters, and to heat their pools. There are some solar water heating technologies that include space heating and cooling for the home, but these are not considered to currently be cost effective due to the upfront costs, and are not incented through CSI-T, and were not included in this study.

Low-income single-family residences, although few in number in Davis, are particularly good targets because the high CSI-T incentives for this category allow very low up-front costs ($63 after rebate and ITC) and rapid payback (0.5 years).

Commercial Segment
The best commercial applications for solar thermal systems are those that use a great amount of hot water consistently in a day. For Davis, these include multi-family apartments, coin-op laundries, hotels, full-meal and quick-meal restaurants, and commercial pools.

Because Davis has a large university, there is a large and continuing need for off-campus student housing. There are many multi-family apartments that use large gas-fired central boilers to heat their water. Solar water heating applications can pre-heat water before it reaches the boiler and significantly lower the gas usage.

Larger heating loads create a potential for higher therm savings per system. Each commercial building, business type, and energy load is different. The potential savings can vary, depending the size of the property, types of hot water applications, and how much hot water is used on a consistent basis.

Community and commercial pools need to be heated to a comfortable temperature to attract swimmers. It costs an extraordinary amount to heat large pools on a yearly basis or even partial year. SWH can dramatically decrease the amount of fossil fuel therms used to heat swimming pools, thereby also saving money and reducing greenhouse gas emissions.

5.4.5.3 Davis Solar Thermal Potential for 2015-16 and through 2020

Aztec Solar obtained data from multiple sources and mapped all existing SWH and PV sites within the City of Davis. Aztec conducted a visual analysis of low-level aerial photographs (periodically obtained from commercial sources by the City of Davis) and Google maps that accurately located the SWH and PV systems. This is considered highly accurate through at least 2012 (the most recent photosets available), although comparison with city construction permit records through that year indicate some minor discrepancies (perhaps the systems are not visible from the angle of the aerial photo, permits were obtained but the systems were not installed, or a single home resident installed PV in two different years, and so forth). [There are also discrepancies when comparing with PG&E PV installation data because the Green Communities reports for the number of PV systems and capacity include installations at premises outside the Davis city limits, but using the same interconnection points.

Figure 14: Map of Locations of all PV and Solar Thermal Systems in Davis

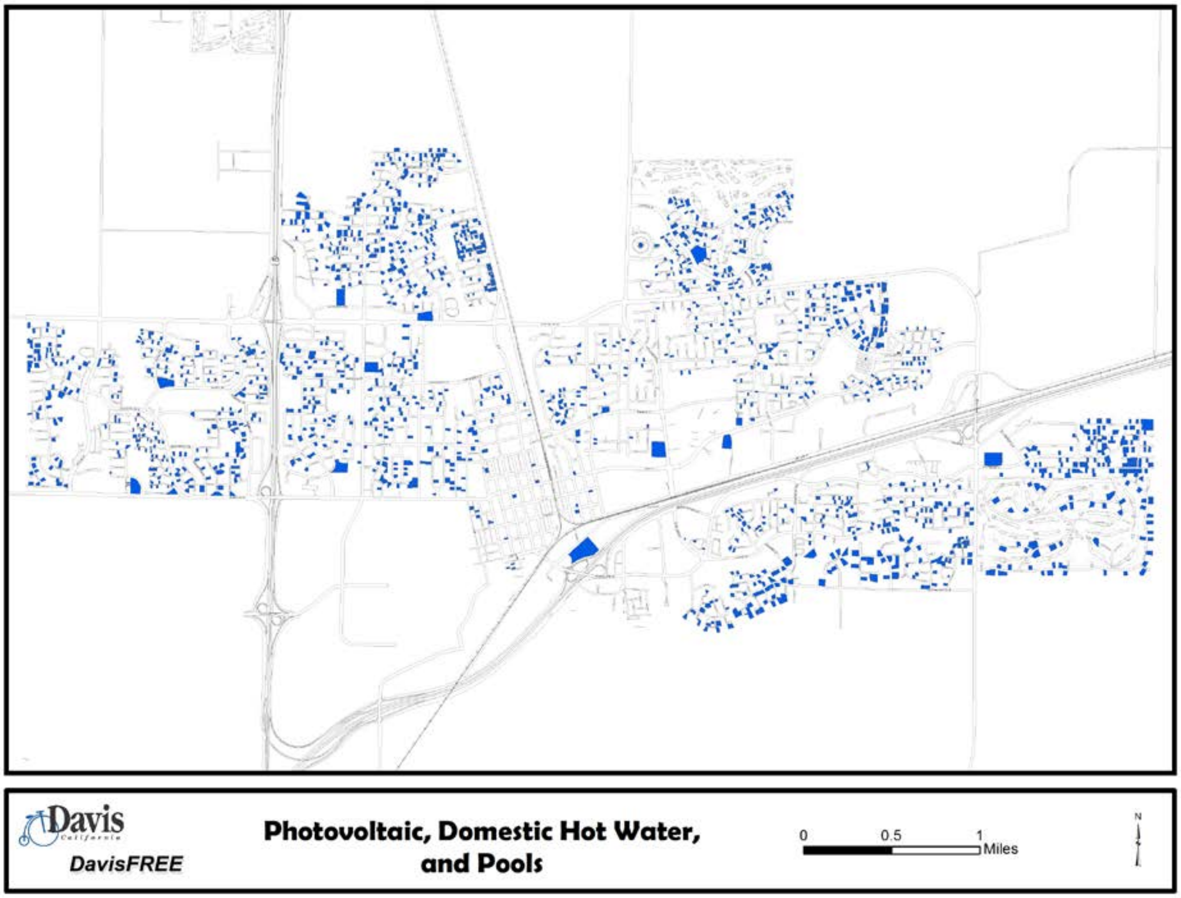

Photo Source: City of Davis

Figure 15: Example Map of all PV and Solar Thermal Systems in a Neighborhood

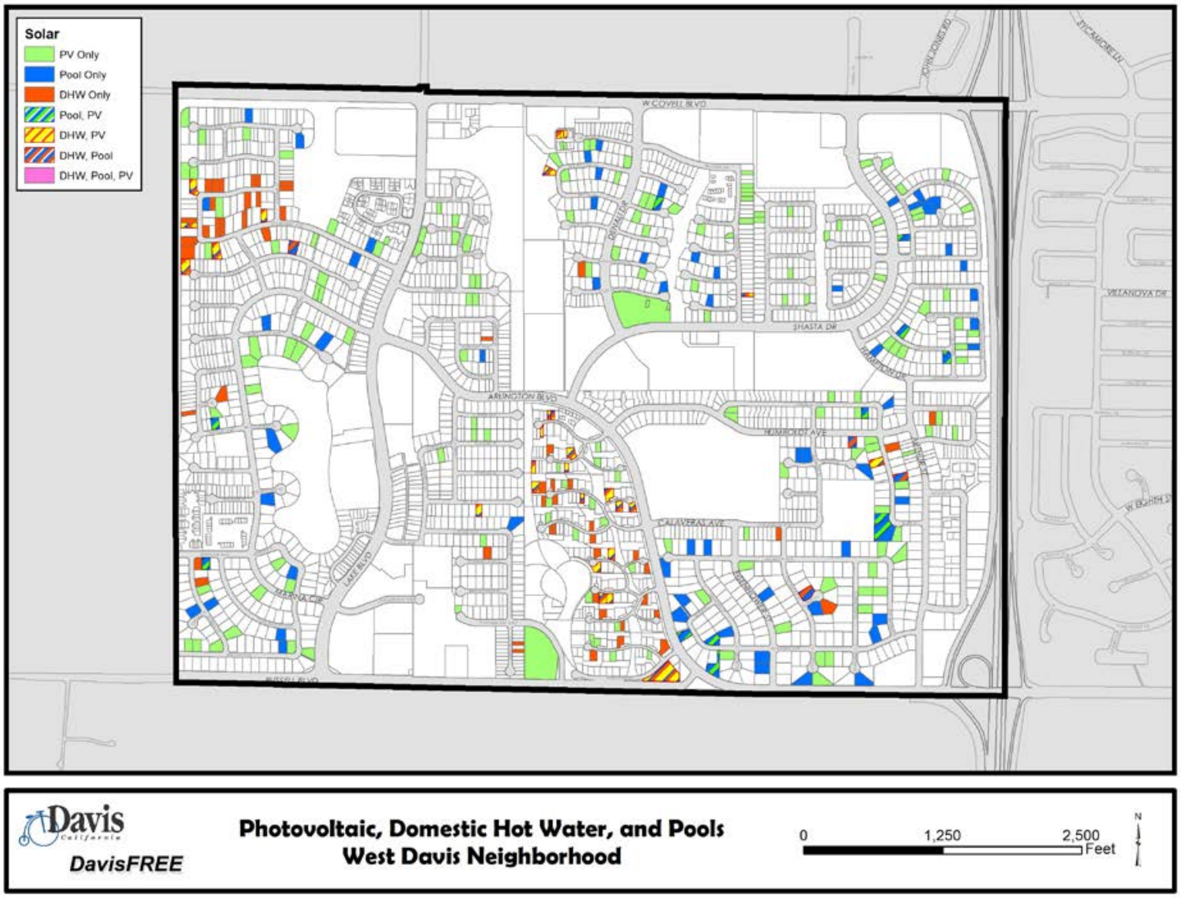

Photo Source: City of Davis

Since city construction permit applications were not converted from manual entry form to a semi-electronic form until 2000, the aerial mapping approach was necessary to locate as many existing SWH and PV systems as possible, which will serve future target marketing activities. For continued future updating, permit applications for SWH and PV installations may be sufficient.

To capture SWH/PV sites from 2012 through late 2014, city SWH and PV construction permit application records and the PG&E “Green Communities” database aggregated data (number of incentives paid through CSI-T and the number of Davis “Net Energy Metering” (NEM) tariff change records for PV sites) provided supplemental recent data. The city data and aerial mapping reveal only the locations of SWH and PV systems, but not their energy capacity (solar thermal output potential or PV electricity generation capacity). However, SWH industry assumptions (rules-of-thumb for the type of system and number of panels needed for a building or business type) and aggregated data from PG&E about incentive program participation, net energy metering program participation, and capacity interconnected at substations can help with extrapolation. DavisFREE will also recommend some refinements to data collection on the city's construction permits and inspection processes to make future tracking more easy and accurate.

BIRAenergy also used the aerial photo analysis approach in its analysis of rooftop PV technical and market potential to identify physical barriers to further installation of SWH and PV at specific locations due to such issues as solar orientation, roof segment design, roof perimeter setbacks and fire code restrictions, and shading by trees or nearby structures.

Single Family Homes – SWH and PV
The largest numbers of solar thermal systems in Davis are installed on single family homes. Through November 2014, of the 14,400 single-family home addresses provided by the City of Davis, there were 282 domestic water heating systems and 650 pool heating systems. The SWH systems range from 20-plus year-old systems installed in the 1980s and 1990s when the original utility rebates were available, to the recently installed systems under CSI-T. Since 2010, and as of October 28, 2014, CSI-T rebates were issued to 17 single family home domestic solar water heating systems one small commercial pool[23]. There are 1,026 PV systems installed on single-family homes in Davis.

The average Davis single family home uses around 348 therms per year for water and space heating. This amounts to about $30-$40 per month on each gas bill. With the 2015 CSI-T rebate increase and ITC, DavisFREE estimates that 40-50 domestic water heating systems will be installed per year for the next two years. 15 solar water heating systems for single family homes are estimated to save a total of 9.2 metric tons of CO_2. Fifty solar water heating systems for single family homes are estimated to save a total of 30.75 metric tons of CO_2.

Apartment Buildings – Domestic Water Heating
Davis (excluding the university) has 242 multi-family apartment complexes ranging in size from three units up to 240 living units. Apartments typically either use individual water heaters for each living unit or a large central boiler to distribute hot water to multiple units. The former are generally not good candidates for SWH as it is expensive to install a lot of smaller systems for each unit. An apartment complex that has a central boiler that heats water for 75 or more units is generally considered to be an economically viable candidate for a large SWH installation. Apartment buildings that have fewer than 75 units typically don't see a great return on investment with solar water heating systems. The City of Davis has 22 apartment buildings with central boilers that have 75 or more living units, and thus are good target candidates. Of the 242 apartment complexes in Davis, six have installed solar water heating systems, four have installed solar pool heating systems, and five have installed PV systems.

Based on interviews with apartment managers at the 22 apartment complexes that have central boilers, it is estimated that at least five, and perhaps as many as twelve, will consider installing domestic solar water heating systems now that the CSI-T rebates have been increased. Five solar

[23] CSI-Thermal Public Export Database, downloaded October 28, 2014: http://www.csithermal.com/public_export/

water heating systems are estimated to save a total of 53 metric tons of CO_2; twelve would save 128 metric tons of CO_2.

Apartment Buildings – Swimming Pool Water Heating
Due to Davis' moderate-to-high ambient temperatures throughout the year, few pools are heated at any time during the year. About 90 (about 38 percent) of the Davis apartment buildings have swimming pools, and these facilities have 16 living units or more. There are currently only four apartment pools that have solar heating systems. Based on the interviews of apartment owners, there was only one pool that was heated every year by a natural gas system. Installation of a solar heating system at a pool that is not currently heated will not have any financial savings or emissions reductions because there is no heating fuel expense to be offset. In such cases, installing solar pool heating could only be used as a marketing technique for apartment owners to attract tenants with a heated pool as an amenity. The installation and maintenance costs would be recovered only through increased rents.

One of the swimming pool maintenance specialists interviewed proffered his opinion that all pools should have adequate PV installed to offset the high electricity usage and demand of the pool electro-mechanical systems – pumps, filtration systems, ionizers, lighting, controls, and other devices. This could be an interesting niche market for PV installers. PG&E's 2015 energy efficiency incentive catalogs include variable-speed and variable-flow pool filtration systems, which should also be encouraged in conjunction with CSI-T marketing activities.

Commercial Swimming Pool Water Heating
The CSI-T rebate program includes commercial pools because a large amount of natural gas is being used to heat the pools year-round. The majority of the large commercial pools in Davis are either owned by the city or by UC Davis. The other commercial pools are owned by country clubs (1), homeowner associations (2), hotels (5), fitness centers (2), and a small school (1). Most of these pools are heated during the year by natural gas systems.

A solar pool heating system can save an average of 3,200 therms per year and reduce gas bills by 20-30 percent per year. The city can affordably install SWH at three to four large pools that are currently gas-heated by 2016. Four solar pool heating systems on the larger pools are estimated to save a total of 68 metric tons of CO_2.

Pool owners should also consider variable-speed and variable-flow pool filtration systems that are supported by PGE rebates.

5.4.5.4 Marketing and Outreach

The City of Davis has a number of outreach program opportunities to help educate potential solar thermal customers.

- The city can coordinate with existing local organizations (Cool Davis, Yolo Energv Watch, Yolo County Housing, and the others) to provide customer and contractor outreach, especially in coordination with planning for energy improvement market implementation services proposed under the GUEP competition.

- Solar water heating can also be included under the "bundled solutions" volume marketing approach as developed under the "Zero Net Energy for Existing Residential Buildings" component of DavisFREE, to help lower overall energy load. Support for this approach should come from GUEP, PACE programs, and the PG&E "Advanced Energy Upgrade" incentives program.
- Solar water heating can also be marketed as a stand-alone technology by qualified SWH installation firms, with the encouragement and support of the PG&E CSI-T incentive program and GUEP.

5.4.5.5 Innovative Marketing Program Opportunities

Davis Woodland Water Supply Project

Currently the water supply for Davis is from ground water pumping, which is depleting. The Davis Woodland Water Supply Project[24] will be completed by 2016, and will provide 12 million gallons per day of surface water pumped from the Sacramento River to Davis customers. Ground water can have high amounts of calcium and magnesium[25], which can cause formation of scale in water heaters, reducing their efficiency and the life spans. The City of Davis can take this opportunity to create a water heater replacement program (to take scale-ridden and less efficient hot water tanks out of commission) to coincide with the changeover from ground water to surface water, and simultaneously promote the advantages of solar water heating to complement the new water heater. SWH pre-heating can prolong the life of the traditional water heater.

SWH Repair and Replacement Program

As previously described, there may still be a number of old inefficient or non-operational SWH systems that were installed in the 1980s-90s. There may be benefit to offering an inspection service for these systems; and since existing piping should still be usable, the customer would be able to install a new SWH system at a discounted cost. These systems represent an interesting potential niche market for repair, upgrade, or replacement as it is likely that current owners or residents do not know if the systems are operating efficiently or at all. CSI-T offers full incentives for replacement of non-operational SWH systems.

SWH System Leasing

Lakeland Electric has partnered the City of Lakeland, Florida and Regenesis Power to create a Solar Hot Water Service[26]. Regenesis Power establishes exclusive partnerships with utilities and municipalities to offer SWH systems to customers with no upfront costs. This model accelerates customer adoption by removing barriers to entry with a no upfront cost solution. A customer can sign up for the 20 year program commitment by being a Lakeland customer, by owning their own home, and by having a south facing unobstructed roof space available. The

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[24] http://water.cityofdavis.org/the-davis-woodland-water-supply-project

[25] http://www.ngwa.org/Fundamentals/studying/Pages/Dissolved-mineral-sources-and-significance.aspx

[26] www.solarlakeland.com

advantages for the customer are (a) immediately reducing their natural gas energy usage, (b) locking in a fixed monthly fee of $34.95, and (c) eliminating any hot water tank maintenance expenses. This program works well in areas where Renewable Energy Credits are obtainable. With AB32, the California Global Warming Act of 2006, the City of Davis could utilize a program like the Solar Hot Water Service to capitalize on carbon credits.

5.4.5.6 Proposed Coordination with PG&E CSI-T Program Delivery

DavisFREE has had discussions with the PG&E CSI-T program manager regarding development of near-term market engagement activities to facilitate early adoption of SWH on a local level. DavisFREE will facilitate further discussion between PG&E and the GUEP planning team. The discussions considered:

- A concentrated and targeted approach to SWH outreach in Davis beginning mid-2015.
- Using Davis as a test market for integrating CSI-T creative assets developed in 2014, such as digital message marketing, paid media, direct mail and email, and outbound calling.
- Combined education and training workshops and webinars for several different audiences and skill/knowledge levels.
- Leveraging customer data for target marketing to SWH prospects using:
    1. DavisFREE: Davis GIS data on premise-specific energy improvements
    2. SWH and PV installations database and maps
    3. The ZNE for Existing Buildings Guide volume marketing approach
    4. Knowledge of multi-family facilities acquired through interviews
    5. PG&E Green Communities energy usage database and trend analysis system
- GUEP Planning Team: neighborhood target marketing approaches and outreach teams.
- PG&E: Identification of customers with high gas bills, integrated marketing with Advanced Energy Upgrade, and other energy partners and efficiency programs.

5.4.5.7 Benchmarks for Measuring Goal Achievements

The City of Davis should adopt a benchmark on reductions of CO_2 emissions by the end of 2016 and by 2020. Below are proposed benchmarks for both single family homes and for commercial applications.

Table 6: Single Family Home Solar Thermal Potential

	Total Capacity	Total Potential with Higher Rebates (through 2016)	Total Potential with Outreach Efforts (through 2020)
Number of Systems	16,601	40	350
Therms Saved per Year	1,925,716	4,640	40,600
Metric Tons of CO_2 Saved per Year	10,210	24.60	215,25

Table 7: Commercial Solar Thermal Potential

		Total Capacity	Total Potential with Higher Rebates (through 2016)	Total Potential with Outreach Efforts (through 2020)
Number of Systems	Apartments	18	10	15
	Hotels	12	4	8
	Pools	10	3	8
Therms Saved per Year	Apartments	36,000	20,000	30,000
	Hotels	10,500	3,500	7,000
	Pools	32,000	9,600	25,600
Metric Tons of CO_2 Saved per Year	Apartments	190.80	106.00	159.00
	Hotels	55.20	18.40	36.80
	Pools	170.00	51.00	136.00
Totals	# of Systems	40	17	31
	Therms Saved / Yr	78,500	33,100	62,600
	$MTCO_2$ Saved/Yr	416	175.40	331.80

5.4.5.8 SWH Training Materials: Supplemental Task Assignment for Aztec Solar

Aztec was assigned a supplemental task to develop PowerPoint presentations on SWH that can be excerpted for instructional and marketing purposes for the energy target marketing teams partnering with the City (Cool Davis, Yolo Energy Watch, and the other), groups of potential customers, installation contractors, city staff, and others. DavisFREE received approval to use portions of training presentations of the North Carolina Clean Energy Technology Center and SunEarth, Inc., which have been coupled with training materials Aztec has used for previous presentations. The North Carolina Clean Energy Technology Center training materials are used for solar installer professional accreditation by the North American Board of Certified Energy Practitioners (NABCEP, http://www.nabcep.org/).

One slide deck is for installer technical training and another for customer marketing and financing. The technical training slides include descriptions of solar water heating system types and how each functions, system components and schematics, design parameters, installation practices, and key target markets. The customer slides cover basic SWH technical principles, system types and applications, energy and environmental benefits, cost-benefit examples, incentives and financing, and photographic examples of installed systems.

The training materials are included in entirety as a separate PowerPoint (.ppt) presentation as Appendix E.

BIRAenergy was assigned a supplement task to digitize the rooftops of residential and commercial buildings in Davis (see Section 5.4). The study resulted in concise information about the roof sizes, roof segment angles, solar orientation, shading, and other information that can help determine the best locations for both SWH and PV systems. This data and mapping can also be used for siting of SWH systems.

5.4.6 Example SWH Business Cases

The following estimates are based on the PG&E CSI-T Incentive Calculator on March 15, 2015. System performance and rebate calculations may change due to tilt, azimuth, shade, and other factors. System costs will vary somewhat for each specific site installation.

Table 8: Single-Family Homes SWH Business Case

Installation	(2) 4' x 8' panels and 80 gallon storage tank	22° tilt, south facing, 100% sun
Installation Cost	$7,800	
30% Federal Tax Credit	($2,340)	
CSI Thermal Rebate	($4,366)	Step 1 incentive $29.85 per annual therm displaced
Net Cost	$1,094	
First Year Savings	$194	
Payback	4.9 years	$1.25 per therm and 155 therms saved per year, 5% escalation
Annual Reduction CO_2	0.615 metric tons	

Table 9: Low-Income Single Family Home SWH Business Case

Installation	(2) 4' x 8' panels and 80 gallon storage tank	22° tilt, south facing, 100% sun
Installation Cost	$7,800	
30% Federal Tax Credit	($2,340)	If a low-income homeowner does not pay taxes they may not be eligible to receive the 30% Federal Tax Credit.
CSI Thermal Rebate*	($5,397)	Step 1 incentive $36.90 per annual therm displaced
Net Cost	$ 63	
First Year Savings	$194	
Payback	0.5 years	$1.25 per therm and 155 therms saved per year, 5% escalation
Annual Reduction CO_2	0.615 metric tons	

Table 10: Low-Income Apartment Building Domestic Hot Water SWH Business Case

Installation	(26) 4' x 10' collectors	22° tilt, south facing, 100% sun
Installation Cost	$182,725	
30% Federal Tax Credit	($0)	
CSI Thermal Rebate*	($106,479)	Step 1 incentive $24.89 per annual therm displaced
Net Cost	$76,246	
First Year Savings	$4,674	
Payback	12.2 years	$1.04 per therm and 4,278 therms saved per year, 5% escalation
Annual Reduction CO_2	1,102 metric tons	

97 apartment units

Table 11: Apartment Pool SWH Business Case

Installation	(10) 4' x 12.5' collectors	22° tilt, south facing, 100% sun
Installation Cost	$11,350	
30% Federal Tax Credit	($0)	
CSI Thermal Rebate	($5,850)	Step 1 incentive $5.00 per annual therm displaced
Tax on rebate	$2,565	
Depreciation Tax Savings	($4,982)	5 Yr MACRS Fed, 12 Yr Straight Line State
Net Cost	$3,083	
First Year Savings	$1,535	
Payback	3.1 years	$1.25 per therm and 1,170 therms saved per year, 5% escalation
Annual Reduction CO_2	121 tons of CO^2	

Pool size 400-450 sq.ft.

Table 12: Hotel Domestic Hot Water SWH Business Case

Installation	(21) 4' x 10' collectors	22° tilt, south facing, 100% sun
Installation Cost	$162,245	
30% Federal Tax Credit	($48,674)	
CSI Thermal Rebate*	($67,717)	Step 1 incentive $20.19 per annual therm displaced
Tax on rebate	$29,687	
Depreciation Tax Savings	($60,972)	
Net Cost	$14,569	
First Year Savings	$3,394	
Payback	4.8 years	0.95 per therm and 3,354 therms saved per year, 6.5% escalation
Annual Reduction CO_2	864 metric tons	

200 rooms; estimate 15 gallons hot water per day per room

5.4.6.1 PG&E Energy Efficiency Rebates for Water-Using Appliances

In addition to the CSI-T program incentives, Davis residents should be encouraged to take advantage of, and preferably integrate with solar water heating systems and CSI-T incentives, the statewide rebates for higher energy efficient appliances including:

Single-Family Residential[27]

- Clothes washers
- Gas storage water heaters
- Electric heat pump water heaters

[27]http://www.pge.com/includes/docs/pdfs/shared/saveenergymoney/rebates/ee_residential_rebate_catalog.pdf

- Variable speed pool filtration pump (requires programmable multi-speed controller)

Multi-Family Residential[28]

- Clothes washers (including coin-operated)
- Central system natural gas water heaters
- Natural gas boilers for water and space heating
- Natural gas storage water heaters
- Electric heat pump water heaters
- Low flow showerheads
- Commercial pool heaters
- Variable-speed and variable-flow pool filtration systems

Commercial[29]

- Clothes washers (including coin-operated)
- Process water heating equipment
- Electric heat pump water heaters
- Gas water heaters
- Ozone laundry systems
- Commercial pool and spa heaters
- Pipe and storage tank insulation

5.5 Rooftop PV Technical Potential Study

The purpose was to analyze the technical and market potential for residential rooftop PV in Davis, in addition to the nearly 1,100 PV systems already in place.

5.5.1 Research Methodology

High-resolution digital aerial photographic imagery was used to create a database of rooftops on Davis homes that could be suitable for PV installation by accurately digitizing rooftop-

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[28]http://www.pge.com/includes/docs/pdfs/myhome/saveenergymoney/rebates/property/multifamily_catalog.pdf

[29]http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/Business_Rebates_List.pdf

segments and their corresponding orientation. A roof segment is a portion of a roof with a particular cardinal orientation and tilt, and large enough (greater than 150 sq.ft.) to hold at least a few PV panels. The number of segments per roof ranged from one (flat-roof) or two (simple gable roof) to many (complicated "hipped" roofs). Digitization was performed using the GIS program ArcMap 10.2, which can designate a segment by pointing to each corner of the roof using a digitizing pad. This particular project used the North American Datum 1983 for California State Plane Zone 2 coordinate system (NAD 1983 SP California II FIPS 0402 Feet).

Digitizing created digital outlines of the shape of each rooftop segment over the digital imagery, creating a new layer over the original photograph to which attributes could be added and automatically attached to an area. The digital footprint is stored in a layer upon which spatial analysis can be conducted. Due to time constraints, homes in some neighborhoods were completely digitized (63 percent of all roofs in Davis) while houses in other neighborhoods were sampled at a minimum 25 percent rate. Rooftop-segment data was collected for the following attributes that were used to estimate the maximum installable PV on Davis rooftops:

- Orientation – N, S, E, W, NW, NE, SW, SE, Flat.
- Type – Single Family, Multi Family, or Commercial.
- Shade Obstruction from trees or objects – 0-25 percent, 25-50 percent, 50-75 percent, 75-100 percent.
- House Number – A log of how many houses and angled segments on each roof (1-10 roof segments; an average house has three or four).
- Solar Status – A yes/no field to determine how many houses already have PV installed.
- Roof Area – Automatically collected on each roof segment polygon digitized, in square feet.
- Length – Perimeter around each roof angle segment, in linear feet.
- Fire Code Accessibility – Adjustments were made to the data to accommodate safety regulations, typically three feet from the edges of the roof and three feet on top.

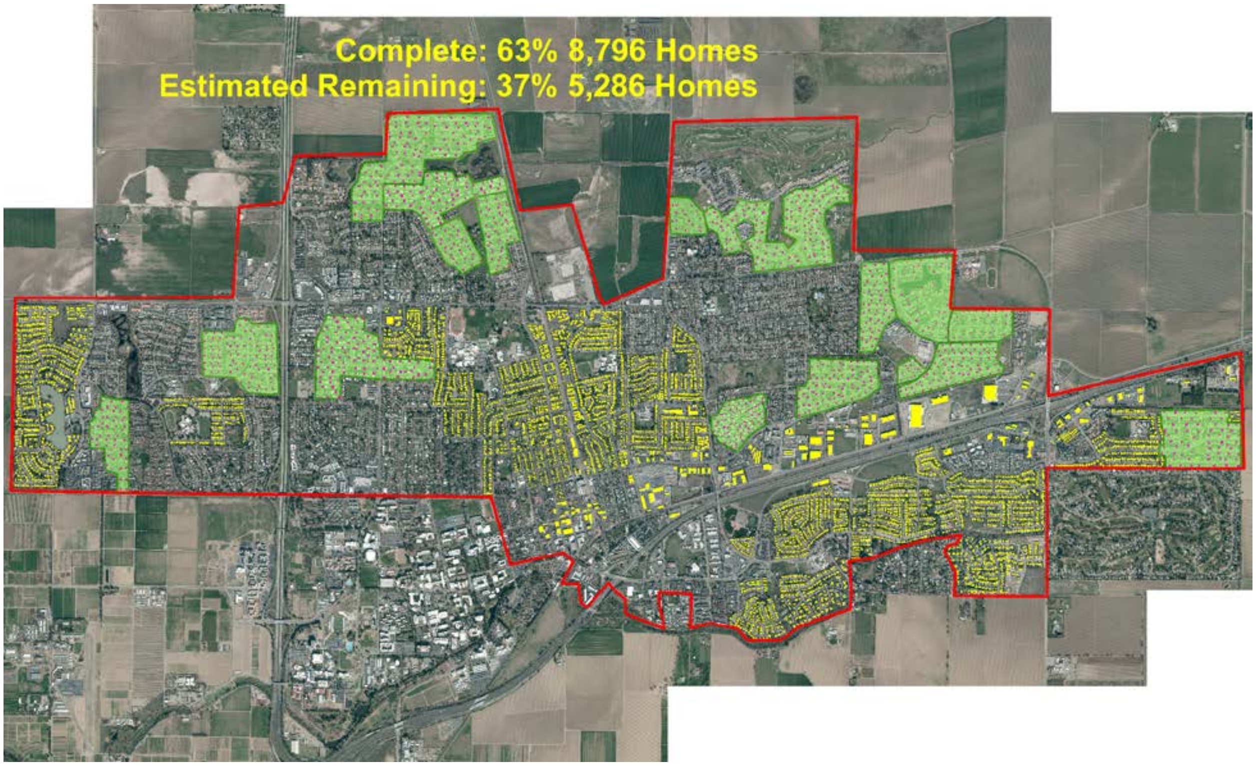
In total, 5,814 single-family homes were digitized, with another 2,986 in sampled groups associated with similar roofs but without hard data which brought the total to 8,976. Davis has approximately 14,000 single-family home, so the data represents nearly 65 percent of all the homes.

The research focus was on single-family homes, but when commercial buildings or multi-family apartment buildings were encountered within a residential area, they were digitized and put into the database, but labeled as either multi-family or commercial. The data from such buildings is very limited in this study and further research should be conducted for these market segments.

Assumptions:

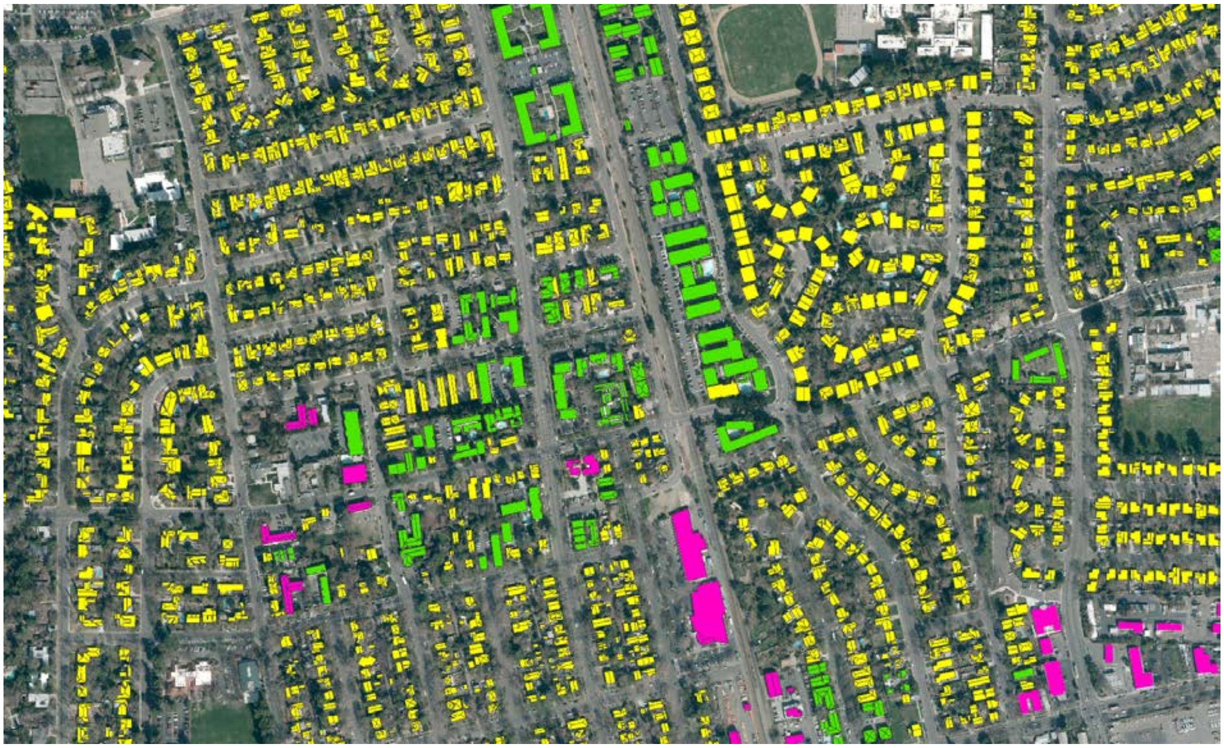
- Rooftop segments that were smaller than 150 square feet were not considered suitable for installing PV, and were therefore not digitized unless they already had PV installed.
- The shade rating was based on the winter satellite imagery that was provided with sun at morning sun angle. Therefore shade on rooftops with a southern or eastern origin were exaggerated and intentionally underestimated because during solar maximum (12-4 p.m.) and during the summer, the shade obstructions are much less.
- Some parts of houses were virtually surrounded by trees and rooftops were hard to locate from aerial views, so these houses were either left out of the databases or conservatively digitized with a shade rating classified as 75-100 percent.
- Visual identification home groups that appeared to have similar rooftop types based on what could be visualized in the imagery determined sampling zones. Most sampled areas had three to four different rooftop patterns, and all roofs in each grouped area fit into the same three to four rooftop segment patterns. Each sampled area was noted and classified in advance of digitizing by identifying the borders of each sampled area and drawing polygons around them. The sampled data is also filed separately from the single-home data in the database.
- In the sampling zones, at least every fourth house was digitized to maintain a minimum of 25 percent sampled in the group-area. Where streets and segments of houses ended, more houses were digitized in order to preserve the 25 percent minimum. Of the 4,100 and more homes that were sampled, hard data was collected on 27 percent of them.
- Roof segments from all orientations were used in this calculation, using the orientation of each segment to provide a multiplier for the reduction in annual generation compared to a roof-mounted array facing due south. This included use of the north-facing arrays, which were estimated to produce about 40 percent less annual energy than a south facing array. North orientation was included because, if PV prices continue to decline and on-site PV generation needs increase (for example, with electric vehicle recharging), even this orientation will become economically viable.
- To estimate the total number of single-family homes in Davis estimated, a value was calculated for the density ratio of houses already digitized divided by the square footage area around them. That fraction was multiplied by the square footage area of land with single-family homes that was not digitized. This process was performed at different times throughout the project with a lower and more accurate number each time, ultimately landing at +/- 150 of the 14,000 homes in Davis.

Figure 16: Davis PV Rooftop Usable Area Digital Photo



Yellow roofs were digitized, green areas were sampled groups. Red dots are existing PV.
Photo Source: BIRAenergy

Figure 17: Davis PV Rooftop Usable Area Digital Photo – Closer View



Yellow roofs are Single-Family, Green are Multi-Family, Pink are Non-Residential.

Photo Source: BIRAenergy

5.5.2 PV Technical Potential Results

The combined rooftop PV potential for the 8,352 home-rooftops analyzed by aerial photography was calculated to be 143 MW, including all roof segment orientations. PV on these rooftops could potentially produce over 203,000 MWh of electricity annually. North-facing roof segment orientations were included because the cost of PV continues to drop and this orientation may soon become economically viable.

This data can be used to extrapolate to the entire existing home stock in Davis. The assumptions were made that there are 14,000 homes in Davis but that 10% of these homes would not get PV installed for various reasons, including sufficient obstacles to make such installations not worthwhile, or excessive shading from large, mature trees or adjacent taller buildings, or difficulties with access. The remaining 12,600 homes would have PV, the size of which would vary, as they did in this research project. Thus, the average array size and annual estimated production were multiplied by the 12,600 homes. It was determined that the technical potential for this market segment is over 250 MW, or over 350,000 MWh potential annual electricity production. This is sufficient electricity to supply the annual needs for nearly 60,000 homes—or about four times as many homes as now exist in Davis. These results are for all roof segments, including the significantly decreased annual output from north-facing arrays. The results of this analysis can be limited to roofs facing from due east (90^0 azimuth), through south to due west (270^0 azimuth), and setting the generation from any roofs north of these limits to zero, replicating the current rules for being eligible for incentives for installing PV.

Interestingly, the existing rooftop PV distribution across the city is relatively uniform, not clustered by neighborhood as originally expected. The southern and eastern parts of the City of Davis, which have some of the newest housing developments, have the best potential for solar energy systems due to less shading than is evident in older neighborhoods where the trees are more plentiful and mature. The central portions of the city are less productive for PV, due to the smaller size of homes and more shading. The newer, western portions of the City of Davis should be very viable for additional PV.

There is a small area of Davis that comprised of mobile / manufactured homes. These were placed in a sample group during data collection, and excluded from the rooftop technical potential estimate.

5.5.3 PV Market Potential Assumptions

The market potential for additional PV in Davis was not assigned to or conducted by BIRAenergy in the supplemental task. The City of Davis may desire to have such a study conducted under separate funding. This section provides some guidance for a market potential study. Market actors continue to drive the PV industry and Davis should coordinate with PACE providers (CaliforniaFIRST, Home Energy Renovation Opportunity, and Ygrene Energy Fund) and PV aggregator firms already active in the area to further facilitate and accelerate PV installations. "RepowerYolo"[30] is an organization currently marketing to the community to install 100 residential PV systems in Davis, and may be able to provide information on customer interest and perceived local market barriers. The GUEP team will, of course, also become a good source of market information. Installation distribution across the city is surprisingly even, indicating broad customer acceptance of PV.

BIRAenergy's recent technical potential PV cost and generation estimates show that after a few cost-effective energy efficiency features (duct sealing and high-R duct insulation, as well as envelope sealing) are installed, and including current incentives and tax credits, photovoltaics are likely to be more cost-effective than the majority of remaining efficiency options. At present, the cost would be higher for supplemental energy efficiency improvements to achieve a significant utility-energy offset than for PV to produce the same offset. This is under current market conditions with incentives, tax-credits, and equal value net-metering. These market conditions are likely to change in the near future with the possible market changes of reduced or zero incentives, federal tax credits reduced to 10 percent from the current 30 percent, and equivalent valuation of electricity used from the utility grid and that are sent back from on-site PV generation for electricity generated beyond net-zero.

[30] http://www.repoweryolo.com/

Tariff and net-metering rule changes are being discussed at the CPUC, and both are likely to change by 2016. These decisions may impact both the cost-benefit of PV and the capacity of PV that can be installed at any one residence.

PG&E has not provided DavisFREE with information about the amount of additional capacity the local grid feeders can accommodate, which is an essential item for future investigation as it may place limits on the City-wide PV opportunity.

In addition to consumer studies, refinement of the data from the technical potential study (not including existing PV installations) should be conducted to provide a more accurate assessment of market potential:

- Remove North-facing roofs / roof segments from the database.
- Select a target size for each PV system, somewhere between 3.5 to 4.5kW.
- Determine what roof area (sq.ft.) is necessary to accommodate a PV system of that size.
- Locate all single roof segments large enough to accommodate that PV system size, without having to split the PV system.
- Total number of homes and PV capacity that meet these criteria.
- Assemble the target market addresses and conduct outreach.

5.6 Draft Proposal for a Pilot Program for Zero Net-Energy for Existing Residential Buildings

The ZNE Retrofit Guidelines for existing residential buildings recommends the use of a "neighborhood volume marketing" approach to produce high market penetration of deep energy efficiency and solar retrofits in Davis. BIRAenergy was assigned an additional task to develop a draft proposal outline for the City of Davis to use to seek supplemental funding for a pilot marketing and construction program. The model can be used for pilot programs of any scale (single or multiple neighborhoods, with the latter approach being preferable to obtain comparative information to refine the program design) or for a full city-wide initiative.

5.6.1 Basis for Program Design

The DavisFREE ZNE pilot program design for the City of Davis is based on BIRA's experience in designing and field-testing a similar program for the Sacramento Municipal Utility District (SMUD) and the U.S. Department of Energy "Building America" program in 2010-11. The SMUD program was determined to be substantially more effective in producing whole-building energy efficiency retrofits than the statewide investor-owned utility and SMUD programs of that time, particularly the PG&E deemed savings rebates and Energy Upgrade California program, which offered calculated savings incentives for a limited number of bundled technology retrofits, and the SMUD High Performance Retrofit program, which had more extensive options and incentives. None of these programs achieved the penetration levels originally anticipated by the respective utilities, perhaps due to inadequate marketing and construction delivery approaches. The SMUD ZNE retrofit program was conceived, designed, and implemented by BIRAenergy.

DavisFREE used the lessons learned from this program design and developed a new version specific to the City of Davis. The new version incorporated neighborhood and household data from the Davis GIS and energy usage data from PG&E Green Communities, as well as an upgraded approach with new ideas and better understandings of market barriers that Davis neighborhoods and households may face. These barriers include input from the implementers of the statewide Industry Owned Utility 2015 Advanced Energy Upgrade program. The new proposal outline can be used by the City of Davis to seek funding and collaborative support from state agencies, utilities, or other entities.

The program design utilizes "community-based social marketing" approaches to facilitate ZNE retrofit construction at the local neighborhood level. The pilot project is expected to provide proof of concept and create homeowner interest, education, and participation in ZNE retrofits. The purpose is to accelerate the adoption of "toward ZNE" bundled residential energy efficiency and renewable energy retrofits.

5.6.2 PG&E 2015 Whole Building Energy Incentive Program

The CPUC and industry owned utilities residential incentive programs have in recent years shifted from previous approaches, such as individual end-use technology "deemed savings" rebates and "calculated energy savings" incentives, to the current Advanced Energy Upgrade program which suits the needs of the ZNE Neighborhoods approach very well.

DavisFREE has established collaboration with the third-party administrator for the PG&E Advanced Energy Upgrade[31] technical assistance program which supports whole-house "bundled" residential energy system retrofits, a calculated savings approach to incentives, contractor outreach and training, contractor selection (by homeowner) assistance, unified media and social marketing outreach approaches, referrals to financing programs, and program monitoring services; all of which are supportive of the ZNE Neighborhoods marketing approach. PG&E desires collaboration with Davis to further test and refine its messaging, education, and technical services delivery systems. The program refers homeowners to participating contractors who have been trained in the whole-house approach to energy efficiency, which ensures a certain level of knowledge about ways to make a home more energy efficient. Only participating contractors can submit the paperwork necessary to reserve program incentives.

Energy Upgrade California is a statewide program that offers financial incentives to homeowners who take a whole-home approach to energy efficiency instead of focusing on individual energy equipment improvements. The basic Home Upgrade option focuses on

[31] http://www.pge.com/en/myhome/saveenergymoney/energysavingprograms/euca/faq/index.page#advanced

sealing up leaks and improving the building shell of a house. For example, instead of simply replacing an air conditioning unit, customers can upgrade attic, wall, and floor insulation; duct sealing; air conditioning and furnace replacements; window replacements, and other energy system improvements.

Homeowners must choose three or more measures from a flexible menu of options, including one "Basic" measure. Each measure has an assigned number of points based to its energy reduction potential, with bonus "kicker" points for adding more basic measures that provide interactive effects on whole-house energy reduction. "Flex" measures add to the points total that determines the amount of the incentive. The more points, the higher the incentive will be for the customer. Advanced Energy Upgrade typically offers incentives of up to $6,500 but this can be higher depending on the customized approach for any individual home.

Advanced Energy Upgrade offers a build your own approach for homeowners. Such projects include improvements and advanced efficiency levels beyond those in the Home Upgrade option, in addition to hardwire lighting, whole house fans, water heater systems, cool roof, and other customized upgrades. Solar water heating incentives can additionally be obtained through the CSI-T program.

Whole-house retrofit financing is also available from a variety of sources, such as PACE programs and others referenced on the Energy Upgrade website[32].

5.6.3 ZNE Neighborhood Volume Marketing Pilot Program Components

The following ZNE pilot project design should be refined by the GUEP Task Force in collaboration with the PG&E Advanced Energy Upgrade program, PACE providers, and other community engagement and marketing specialists the City may recommend. The components of the ZNE Neighborhood Volume Marketing program are discussed in the following sections.

5.6.3.1 Develop Program Marketing Materials

The City of Davis should assign or otherwise identify and procure marketing materials design assistance. Some hints are:

- Develop program marketing materials specific to this program.
- Core materials should appear to be for a specific neighborhood/area within the city, but easily modifiable to work with other neighborhoods.
- Test-market the core materials through participating Community Engagement team members.

5.6.3.2 Identify and Define the Initial Target Neighborhoods

Work with the City of Davis to:

[32] http://www.gsfahome.org/programs/energy/overview.shtml

- Define appropriate "neighborhood" size or sizes, based on the Davis GIS and PG&E Green Communities data and maps developed under DavisFREE.
- Develop methods and means for identifying initial pilot project neighborhoods and determining their boundaries.
- Prioritize roll-out to the selected pilot neighborhoods.

5.6.3.3 Identify and Develop Social Marketing Approaches and Activities

Work with the marketing firm to develop program logo, name, program description, and characteristic look of program marketing materials.

Develop the plan for rolling-out the marketing campaign for one or more pilot neighborhoods, including:

- Initial neighbor group meeting
- Follow-up marketing to the target neighborhoods
- Deliver social marketing approaches to target neighborhoods
- Follow-up meetings as deemed necessary

5.6.3.4 Conduct Energy Audits for Samples of Neighborhood Homes

- Develop ZNE retrofit design packages for each pilot neighborhood, based on the "illustrative homes" construction modeling conducted by DavisFREE.
- Determine the benefits to homeowners that will encourage them to volunteer their homes for energy audits, and to participate fully in the program.
- Canvas each target neighborhood (sequentially, prior to roll-out) to locate about three volunteers whose homes can provide the data needed to verify characteristic homes for that neighborhood.
- Audit the three homes to garner the data necessary to develop example retrofit packages for each neighborhood.
- Develop and establish methods for data collection and storage that should provide excellent data security.

5.6.3.5 Analyze Audit Data and Develop Packages

Analyze the energy audit data for each of the volunteer characteristic homes to develop good, better, and best packages for each target neighborhood.

5.6.3.6 Neighborhood and Social Marketing Campaigns

- Roll-out the neighborhood and social marketing campaigns.
- Hold a neighborhood meeting for each target neighborhood, sequentially, approximately three every three-months, starting three months into program roll-out.
- Implement other social marketing campaigns.

5.6.3.7 Direct Marketing to Home Owners in Target Neighborhood(s

- Follow-up with homeowners in target neighborhoods.
- Contact all homeowners who provided contact information.
- Implement city-wide marketing campaigns.

5.6.3.8 Develop and Implement Customer Support Activities

Based on previous experience, along with reviews of on-going programs, work with the City of Davis and a few contractors to:

- Determine likely and key customer support needs and activities.
- Determine best staff or others to best provide such support.
- Establish a structure for providing customer support.
- Establish methods for customers to contact program support personnel.

5.6.3.9 Determine Program Approach for Participating Contractors

- Develop a set of minimum requirements and/or certifications and training for participating contractors, focusing on general contractors who will oversee and be responsible for the retrofit work, and who will take on any and all liability for performing the work, including undesired consequences, foreseen or not.
- Work with Davis to develop the contractor model that the team believes will be most effective in Davis; that is, single contractor per neighborhood, or other such assignments of contractors and jobs, or an open-market approach.

5.6.3.10 Identify, Recruit, and Characterize Trade Contractors

- Using data provided by Davis and Energy Upgrade, develop a list of contractors who have performed energy retrofit work in Davis.
- Using information developed in Task 5.5.4.9, develop a contractor recruitment form that the contractors will use to provide their qualifications to the program team, and circulate the form to the list of potential contractors. Review the results of the contractor's submittals and develop the initial universe of potential contractors for the program.

5.6.3.11 Conference with Trade Contractors to Discuss Program

- Working with Davis, hold a meeting with the contractors identified and selected in Task 5.5.4. 10.
- This meeting will be arranged to provide program information, needs, goals and responsibilities to the contractors. The meeting simultaneously allows opportuinity to meet and evaluate the contractor in a group and side-bar 1:1 environments to gather additional data to qualify contractors for participating in the program launch. New/additional contractors may be added using similar, but improved procedures as in Tasks 5.5.4.9, -10, and -11.

5.6.3.12 Identify Qualified Trade Contractors, Develop and Finalize Contracts for Participation in ZNE Program

- Using data collected by the team from the contractors via Tasks 5.5.4.10 and -11, identify the contractors who will participate in the program launch and the initial neighborhoods.
- New/additional contractors may be added using similar, but improved procedures as in Tasks 9, 10, and 11.

5.6.3.13 Orientation and Training for Trade Contractors

- Develop training materials to be used to orient and train contractors in the program design, market approach, and roles and responsibilities.
- This training is not technical "how to do retrofits" training, but rather training to ensure that all interactions with potential and actual customers are essentially the same and consistent with program goals, objectives, and overall design. Ensure that program messaging is consistent and customer relations are optimized.

5.6.3.14 Qualify Homeowners, Gather Home Data, Meet with a Recommended and Qualified Contractor

- Marketing activities in earlier tasks will result in interested homeowners. Follow-up meetings will be held in the potential customers' homes, optimally by a program representative, the contractor, and a home energy rater.
- The program and contractor representatives will continue to work with each homeowner to close the sale, develop a scope of work and cost estimates, based on the characteristic home data collected in Tasks -4 and -5.
- A draft contract will be developed prior to the meeting for review by the homeowner. If financing is desired, homeowner financial data will be collected, or the homeowner may be referred directly to participating financing agencies
- The contractor or rater will gather actual dimensions, equipment, and test results (duct and envelope leakage, et al) for the home. The collected data will be used in Task 15 to develop the final scope of work and cost of the retrofit, assuming the homeowner moves forward with the retrofit.

5.6.3.15 Baseline Assessment, Confirm Existing Conditions

- The data collected in Task 14 will be used to develop a final contract and scope of work specific to the individual home and owner(s).
- The data collected from the home will also be used to tailor the simulation baseline and improved cases to the actual home and its condition.
- The updated contract, scope, costs and projected savings will be developed from the data collected in Task 14, and presented to the homeowner for review and signing of the contract.

5.6.3.16 Schedule Retrofit Work

After the customer has signed the final contract, the retrofit work can be scheduled with the construction contractor.

5.6.3.17 Implement Improvements;, Conduct Test-Out

To save costs, the retrofit work should be coordinated with other homes in the neighborhood with similar timing and needs. Costs savings will result mainly from quantity-of-scale discounts on equipment purchases, rentals of any equipment not owned by the contractors but needed to do installations (for example, a crane to remove/replace roof-top packaged HVAC units), and coordinating labor for multiple installs in a locale. Once the retrofits are complete, a third party will perform test-out to ensure that the work was professionally completed, the right equipment was installed and functions according to design specifications, and tests of duct and envelope leakage are performed.

5.6.3.18 Program Quality Assurance: Monitor, Track, Review, and Refine Program

Monitor and track program progress, results, contracts, service, and so forth, while performing continuous internal quality assurance review.

Throughout the program, collect and log any spontaneous program feedback

In addition, at all appropriate junctures, request program evaluations from participants. Such data should be requested from participants to provide feedback to the program management regarding the quality and courtesies of program representatives, services rendered, contractor representatives, contracted work, clean-up, and so forth, as well as of the overall program operation and processes.

These survey results should be reviewed by program management and city partners from Davis, with improvements determined and implemented accordingly.

5.7 Near-Term Implementation Plan for Davis

5.7.1 Overview

Section 5.7 is a brief summary of the areas that DavisFREE recommends for near-term implementation activities by the City of Davis and the GUEP Task Force. Details of these recommendations, the reasons for them, and the research backing them, can be found in the various technical task sections of this report.

5.7.2 Integrate Financing Programs into Planning and Implementation

5.7.2.1 PACE Programs

Beginning in 2010, the City has supported efforts to bring Property Assessed Clean Energy (PACE) financing programs to Davis. Davis property owners are now able to participate in any of three PACE programs: (1) CaliforniaFirst, (2)Ygrene, and (3) HERO. The PACE providers approached Yolo County and the cities that comprise the county about adding their financing programs to the available traditional energy financing options. Staff from the Yolo County jurisdictions conferred, and by consensus agreed to allow the PACE programs to provide additional choice for residents and businesses interested in financing energy and water conservation projects. The PACE providers should be encouraged to accelerate their programs, and GUEP should facilitate neighborhood and community meetings and outreach support.

5.7.2.2 PV Integrators

A number of photovoltaic manufacturing and/or installation firms provide financing for PV installations. The financing models are innovative and highly competitive because they have different structures for direct customer needs—including direct procurement, leasing, lease-purchasing, shared savings, and discounts—and financing in combination with other energy improvement opportunities, such as re-roofing and insulations. One local non-profit organization is working to install 100 PV systems in the county using a group buying program model to provide discounts. This component is already market driven and the integrators are already highly active throughout California. However, notifications to them about the GUEP initiative and implementation coordination plans and DavisFREE findings should encourage them to concentrate efforts in the Davis area. However, to avoid a "gold rush" competition among them, Davis and GUEP will want to consider means of more courteously introducing them to the community through community meetings, fairs, neighborhood meetings, and so forth.

5.7.2.3 Pacific Gas & Electric Co., Technical Support, and Incentive Programs

The primary technical and incentive support programs that will support this initiative in 2015-16 are the CSI-T program and the Energy Upgrade / Advanced Energy Upgrade programs, which are summarized and referenced in several other sections of this report. The revised Green Communities program will also be able to continue to provide community-wide aggregated energy usage data, but not at the level of detail previously provided. DavisFREE has developed the program manager relationships and participation enthusiasm needed to introduce the programs to Davis/GUEP, and will do so in May 2015.

5.7.2.4 Traditional Financing

Davis area real estate and lending institutions companies should be informed of the DavisFREE and GUEP through group or individual meetings, to inform them of the initiatives and assess their interest in participating in energy retrofit programs. This will need to include overview instruction on the technologies involved as well as the marketing activities intended.

5.7.3 Solar Water Heating

DavisFREE considers solar water heating to be the first priority technology that should be promoted in Davis. DavisFREE recommends that a solar water heating program be a rapid-deployment method for Davis residents to directly observe, through personal carbon footprint changes as well as extrapolated community-wide impacts, the near-term (2015-16) reductions in natural gas greenhouse emissions that can also stimulate enthusiasm for other energy fuel and emissions reductions. The market barriers are well known and are fully addressable, the utility incentives have been significantly increased and the tax incentives are fully in place through 2016, and the SWH technology is stable and readily available. This report delineates the market sectors and applications appropriate for Davis, and existing systems have been accurately located, which can be used as examples of technology growth in the community. Installers can be identified through GIS and the PG&E CSI-T program.

Enabled by the DavisFREE program, community-based social marketing is a deeper consumer engagement approach than has been undertaken in most energy efficiency and distributed renewable energy programs. It may be possible to use community-based social marketing in Davis to amplify the results over PG&E's existing outreach methods, as well as the direct advertising and promotion activities that PG&E and the SWH manufacturers / installers typically employ. DavisFREE has the potential to trigger deeper deployment of energy efficiency and solar technologies if needed funding flows into understanding not only what consumers should do, but more critically, why they make energy efficiency improvement and renewable energy choices and what can be done to actually address both the economic and non-economic barriers to action. SWH can be a stand-alone recommendation, as well as an integrated technology with ZNE and PACE energy efficiency projects. SWH may also be considered as an alternate or required technology in future iterations of the proposed City of Davis Renewable Energy Ordinance.

5.7.4 Residential Rooftop PV

The DavisFREE second priority recommendation is residential rooftop PV, as described in Section 5.4 . The analysis digitized rooftops of nearly 6,000 single-family homes and calculated the potential for rooftop PV at the roof segment level. The technology is well known and has gained wide acceptance in Davis, but more can be done. The technical potential is extremely high, which could be an encouragement to slower adopters, especially when promoted along with the array of financing options that now bring PV into an affordable range for many more people. The solar integrators are well established and PACE programs are coming on-line. The BIRAenergy PV Roof Segment Analysis should encourage many residents to install at least some PV, hopefully with the intent of installing more at future times. The proposed City of Davis Renewable Energy Ordinance would require minimum levels of PV be installed on all new single-family and duplex residences, depending on the house size. PV can be a stand-alone recommendation, as well as an integrated technology with ZNE and PACE energy efficiency projects.

5.7.5 Zero Net Energy Pilot Project

DavisFREE encourages the City of Davis to pursue funding opportunities to conduct a ZNE pilot project as outlined in Section 5.5 and more thoroughly detailed in Appendix B. The program design helps target potential neighborhoods for retrofit activities based on age of the structure and can utilize "community based social marketing" approaches to facilitate ZNE retrofit construction at the local neighborhood level.

The pilot project is expected to provide proof of concept and create homeowner interest, education, and participation in ZNE retrofits. The purpose is to accelerate the adoption of "toward ZNE" bundled residential energy efficiency and renewable energy retrofits.

Chapter 6:
Community Engagement (Task 8)

6.1 Goals of the Task

The goals of this task were to (a) develop ongoing communication and collaboration with local policy-makers, stakeholders, and partners to improve the DavisFREE program design and delivery; (b) communicate project results and recommendations of the project to other communities; and (c) establish confidence in the energy action plans developed for the CAAP.

6.1.1 Steering Committee

The Valley Climate Action Center (VCAC) Board of Directors served as a steering committee for project design and implementation, and members provided expert review of individual Task research reports. The VCAC Board has energy experts from Davis Energy Group, Integrated Renewable Energy Systems Network, California Environmental Protection Agency, M-Cubed, Cool Davis, UC Davis, business development firms, and energy policy consultants.

6.1.2 Local Collaboration

DavisFREE team members maintained regular collaborative contact with:

- Yolo Energy Watch – third party energy efficiency implementers
- Cool Davis – California Cool Communities implementer
- Georgetown University Energy Prize Task Force, including DavisFREE participation in the competitive bidding process and implementation planning
- Climate Change Compact of Yolo County
- Yolo County Housing, executive staff
- PG&E Green Communities program staff and web developers
- PG&E Sacramento Division, senior supervisory staff
- PG&E CSI-T program manager
- PG&E Energy Upgrade program managers

6.1.3 VCAC Website

VCAC redesigned its website and added content to support community access to, and implementation of DavisFREE recommendations. The website will be further developed to include more information about the services, offerings, qualifications, and financing of energy efficiency and renewable energy upgrades for residents and businesses in Davis. The website will be promoted locally through mass media and social media. VCAC will also archive the data developed under DavisFREE for access by the GUEP Task Force.

6.1.4 Presentations

- City of Davis Natural Resources Commission (1/26/15)
- Davis City Council / public attendance / televised (3/3/15)
- Davis local energy and policy experts, at various VCAC Board meetings
- Zero Net Energy Guidelines
- Solar Water Heating Deployment Plan

6.1.5 Webinars (hosted by Municipal Sustainability Forum[33])

- Davis Integrated Energy analysis - 1/13/15, targeted at California energy professionals interested in independent power generation. 70 registrants
- Near Zero Neighborhood Retrofit plan for Davis, California – 3/10/15, 110 registrants; 60 from California and 50 from other states. Cities, universities, utilities, and independent power entities were represented
- Davis Integrated Energy analysis – 3/10/15 (with ZNE Plan).30 registrants.
- GUEP Task Force. Closed session to begin implementation transition process. 4/27/15, 12 invitee participants.
- Solar Water Heating Deployment plan / CSI-T Incentives. 5/19/15, 35 participants from California, five from other states. State and metropolitan area energy planners, universities, utilities and community choice aggregations, energy consulting firms.
- Local government commission (in discussion)

6.1.6 Workshops

- Davis area construction contractors / Trade Allies – May, 2015. Invitees will be drawn from construction permit application records and PG&E participating contractors with the PG&E CSI-T and Advanced Energy Upgrade programs.
- City of Davis staff – May, 2015
  - Community Development and Sustainability
  - Permits and Inspections
  - Neighborhood Services

6.1.7 Transfer of Information to Cool Davis / GUEP

- In progress April-May 2015

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[33] Webinars archived at http://www.municipalsustainability.com/info

- Training of GUEP Task Force members
- Archiving of data, maps, reports, and recommendations
- Transition Support

GLOSSARY

Term	Definition
AC or ac	Alternating Current
ArcGIS	An analytic software package for compiling geographic data and creating maps; produced by the Environmental Systems Research Institute (esri.com)
CPUC	California Public Utilities Commission
CPV	Concentrating Photovoltaics
CSI	California Solar Initiative
CSI-T	California Solar Initiative – Thermal (solar thermal component)
DavisFREE	Davis Future Renewable Energy and Efficiency project
DC or dc	Direct Current
DNI	Direct Normal Irradiance
GC	PG&E Green Communities program
GHG	Greenhouse Gas emissions
GHI	Global Horizontal Irradiance
GIS	Geographical Information System
GUEP	Georgetown University Energy Prize
LCOE	Levelized Cost of Energy
PACE	Property Assessed Clean Energy financing
PV	Photovoltaics
SWH	Solar Water Heating
VCAC	Valley Climate Action Center
ZNE	Zero Net Energy, defined as the value of energy at different times of day and different seasons of the year, i.e. time dependent valuation

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APPENDIX A:
List of Tables and Maps Produced by Davis GIS

- Master List of all Davis addresses, property use (res, comm., etc), subdivision name, zoning, etc.
- Table including acreage and map of city-owned lands outside the city limits for potential community-scale PV.
- Table including acreage and map of public-owned parking lots within the city limits for potential community-scale PV.
- Table of building permits issued for single-family energy-related retrofit projects. Quite complete, for each individual premise, what was done, and when.
- Table of all permitted PV and SWH installations, including location and estimated output.
- Table and map of Yolo County Agricultural Residues (biomass) by location, plant type, energy production potential.
- Wind energy potential map – regional (CPUC)
- Samples of county "Zoning District" form that can be obtained for any address. Property characteristic data on single-family homes (square footage, lot size, age, rental, # rooms / bedrooms, what can and cannot be built at the site, etc.)
- Detailed aerial photo system sent to Aztec Solar for inventory and specific site locating of rooftop solar installations (PV and solar thermal).
- Shade trees planted / maintained by City. Can be used as an aid to determine rooftop PV siting issues.
- Business license table by license categories for 2014 – sorted version identifies all landlords for residential rental properties.
- List of top 10 contractors for each type of energy-related retrofit in Davis – HVAC, roofing, windows, insulation, solar. Taken from permit applications.
- Subdivision recording dates for general age information ("decade built")
- Polygon map of grouped single family housing to target 15-30 homes per group to extract/compile PG&E Green Comms energy data – we have asked if PG&E can convert its' current "centroid" data to the "polygon" maps defined by specific streets. Aggregated data can still protect PG&E customer data privacy requirements.
- PV and Renewable Auction Mechanism (RAM) map (from PG&E) – substation and feeder data

- Commercial swimming pools table. Address, location name, # units served.
- Map of single-family housing; renter and owner-occupied
- Map of single-family housing by year of construction (5 groupings)
- Map of single-family housing by lot size (3 gpgs)
- Map of single-family housing by subdivision recording date (5 gpgs)
- Map of single-family housing by census block
- Map of assessor parcel page polygons - # dwelling units by polygon (5 gpgs)
- Graph of single family housing by year built

APPENDIX B: Guidelines for Zero Net Energy for Existing Residential Buildings

[Begins on Next Page]

Zero Net-Energy Retrofits
Guide to a Volume Market Approach

Focusing on Very Efficient Packages, Rooftop Solar Generation, and a Market-Driven Delivery Method

December 2014

<u>For</u>
DavisFREE CEC Project
and
The City of Davis

<u>Research and Reporting by</u>
Rob Hammon, Ph.D., President
BIRAenergy
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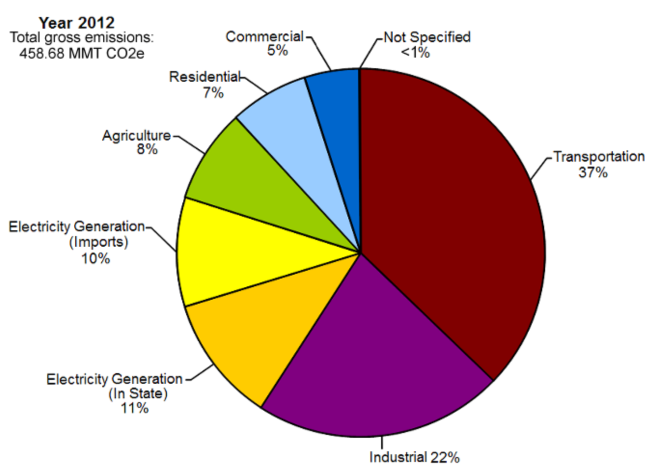
Contents

ZNE Retrofits Best Practices and Deployment Guide

City of Davis: Climate Action Plan Goal

A goal of the Davis Climate Change Action Plan is to reduce the carbon footprint of Davis to zero by 2050. According to the California Energy Commission, the residential sector produced 7% of the total Greenhouse Gas (GHG) Emissions in California in 2012. That year the transportation, industrial, and electricity generation sectors were responsible for 80% of GHG emissions. The remaining 20% was produced by Agriculture (8%), Residential (7%) and Commercial (5%) market sectors. The main opportunities for the City of Davis to effect GHG reductions is in residential and commercial buildings, which account for 12% of the total California GHG emissions. Over the intervening 35 years, a Zero Net Energy (ZNE) program in the residential sector could not only reduce GHG production to zero, assuming 100% participation by 2050, but also produce clean energy for use in other sectors with the application of solar generation (both photovoltaics and solar thermal) on residential rooftops. These are lofty goals, that can only be met by starting to work toward them today. The most approachable and predictable market segment is residential. This guide is the first step toward a ZNE residential market in Davis.

California GHG Inventory for 2012 — by Economic Sector[34]



[34] CA Air Resources Board: http://www.arb.ca.gov/cc/inventory/data/graph/pie/pie_by_sector_2012.htm

Problem Statement

The City of Davis, California, (Davis) is a low-growth community, bounded by prime agriculture lands that intentionally restrict new construction expansion potential, and by the University of California, Davis campus[35]. Davis cannot expect community-scale zero net carbon and energy goals to be strongly influenced through new high-performance building construction. Instead, existing buildings must be retrofit with renewable energy systems and significant energy efficiency improvements. Davis is the home of a major university and thus has a large number of single- and multi-unit rental buildings for student housing, creating disincentives and split incentives for potential investment in renewable energy generation and advanced energy efficiency. The history of building owner investment in utility energy reduction strategies is not fully understood, although Davis is considered a leader compared to other similar size and climate zone communities, as well as a leader in sustainable community design and management.

Zero Net Energy – Definitions

Zero net energy (ZNE) buildings are designed and constructed to produce as much energy over the course of a year as they consume over the same time period. The State of California has developed a Long Term Energy Efficiency Strategic Plan[36] that contains the "Big Bold Goal" for all new homes to be ZNE by 2020. For meeting that goal, the generic definition provided here has been refined by the California Energy Commission and Public Utilities Commissions to calculate energy use in units of Time Dependent Valuation[37]. ZNE calculations can also be done using source energy (including generation and transmission losses) or site energy (kWh and Therms, at the buildings' meters). At the time the illustrative packages were developed, there was not consensus on the energy metric for defining ZNE, and the energy metrics in this version of the guide assumes a site energy basis in the development of efficiency packages. From a consumer/homeowner perspective, the definition of Zero Net Energy should be in the units of energy on their bills – i.e., site energy in kWh and Therms.[38]

Development of the ZNE Best Practices Guide

The original CEC contract deliverable for Task 5 was the development of two (2) complete narrative chapters, and detailed outlines of six (6) additional chapters. As this Task evolved, the internal scope was expanded, and the contract deliverable was exceeded. Six (6) narrative chapters were completed, and six (6) more were fully outlined. The guide is designed specifically for implementation in and by Davis, with the anticipation by the authors that the guide will ultimately be completed to provide the basis for development and deployment of a residential retrofit program in and likely by the City of Davis. It is intended that the guide will

[35] The University buildings are not part of the City of Davis, nor part of this retrofit program at this time.
[36] California Long Term Energy Efficiency Strategic Plan, CPUC, 2008
[37] Time Dependent Valuation of Energy for Developing Building Standards, E3, 2011
[38] As part of the completion of this Guide, the packages and all energy metrics should be in site energy (kWh & Therms) to be understandable to the homeowner, end-customers.

remain in the public domain for potential use and guidance by other entities to assist them in designing and deploying residential retrofit programs

The Guidelines will ultimately include the following, the first two bullets having been developed for this draft, and the remainder requiring additional work to develop:

- A stepped, Good, Better, Best efficiency-and renewable generation (typically PV) Retrofit Market Approach
- Multiple energy efficiency packages that range from moderate, cost-effective efficiency improvements ("Good") to full, zero net-annual energy (ZNE) retrofits
- Integration of renewable energy systems into the core design principles
- Define the steps in the retrofit process, including market approach, sales, assessment, tailoring the packages to specific sites, qualifications of contractors, and best practice installation guides for contractors
- Design training programs for installation contractors and homeowner participants
- Define methods for certifying contractors and quality control mechanisms for installations, including challenge and loss of certification for inadequate service and work from contractors
- Address miscellaneous electric loads as well as primary end uses
- Address deployment strategies to develop program messaging and market approaches proven elsewhere that are likely applicable to Davis
- Develop a process for monitoring and evaluating program effectiveness.

Chapter 1. Defining a ZNE Retrofit Program and General Approach to the Retrofit Market for the City of Davis

Introduction

The City of Davis has developed an aggressive and comprehensive Climate Action and Adaptation Plan (CAAP) that requires community-wide carbon neutrality by 2050 and a 15% reduction below the city's 1990 carbon emissions level by 2015. The CAAP also adopted a 2015 goal of reducing the total energy use in Davis by 5% from 2010 levels. The CAAP includes many options for Davis to reach its goals, one of which is a residential energy-efficiency retrofit program. This document is designed to guide Davis in the development and implementation of a residential retrofit program tailored to Davis.

The Davis "Future Renewable Energy and Efficiency" (DavisFREE) project, supported by a grant from the California Energy Commission, as one of its tasks, supported the development of multi-level energy-efficiency retrofit packages tailored to Davis housing and weather, as well as this outline for development of a detailed and comprehensive best-practices guide to design and implementation of an integrated renewable-energy and enhanced energy-efficiency residential retrofit program.

Task 5 of the DavisFREE program is initial development of **Zero Net Energy (ZNE) Guidelines for Existing Residential Buildings** (as described in the preface of this document). In a settled, low-growth community such as Davis, applying ZNE only to new buildings will have very little impact on community-scale ZNE ambitions and carbon reduction goals. Increasing energy efficiency in existing buildings will reduce the need for energy generation from electricity and natural gas, and promote building-integrated renewable and clean energy systems to provide the energy needed to balance the annual, net energy used by the participating homes. This program aims to have significant uptake of energy-efficiency retrofits and rooftop PVS. The efficiency packages are designed to potentially include rooftop PV systems, showing the generation size-requirements of additional PV systems to make them ZNE Homes. Such homes, in addition to having annual net-zero energy use, also would have annual net-zero carbon emissions from energy used in the home, assuming the home is operated in a manner closely following the assumptions set out in the Davis residential retrofit program.

1.1 Zero Net Energy Defined by California

The current official California definition for ZNE is in terms of Time Dependent Valuation (TDV)[39]. In 2005, the California investor-owned (public regulated) utilities worked with the

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[39]CEC Integrated Energy Policy Report http://www.energy.ca.gov/2013_energypolicy/; www.energy.ca.gov/.../100.0-100.2_Scope_Definitions_TDV.pdf; www.energy.ca.gov/.../Title24_2013_TDV_Methodology_Report_ 23Feb2011.pdf

California Energy Commission (CEC) and HMG (now TRC) to develop this ZNE approach. The purpose of TDV is to emphasize the value of energy at different times of day and different seasons of the year. There are different multipliers for every hour of day of every year (total 8,760 hours per year and TDV values) for both electricity and natural gas. To determine ZNE, building models are simulated to produce hourly, whole-house energy use predictions; similarly, the on-site generation is estimated on an hourly basis. These hourly energy-use and energy-generation values (in kBtu) are multiplied by the appropriate TDV values to produce the TDV electricity use and generation, and gas use. The total TDV usage should be balanced by the total TDV generation for a TDV ZNE home. In equation form:

$$\text{TDV energy (TDV kBtu)} = \Sigma(\text{TDV}_{hour} \times \text{site energy}_{hour})$$ [40] **Equation 1**

TDV energy and TDV ZNE are energy-code based metrics, and are not known nor directly relevent to the general public, and therefore would be confusing as a program basis. Two other energy metrics are source energy and site energy. Source energy (in BTUs), is the amount of energy at the power plant used to generate (fore electricity) and deliver the energy that is used on-site, and includes both generation and transmission losses. Prior to the use of TDV multipliers, the Title 24 code used a factor of 3 to determine the amount of source or primary energy used to generate and deliver electricity to the site. Termed as the source-to-site multiplier for electricity (i.e., 2/3rd of the energy used to power electric generation is lost in the generation, transmission, and delivery systems). For natural gas, the source-site multiplier was 1.0

The simplest definition for homeowners to understand is site ZNE, which is that the annual on-site generation of electricity will balance the site energy use, or in the common vernacular: "the home will generate as much energy as it consumes over the course of a year". However, current net-metering rules do not allow trading excess electricity generation to offset natural gas use, so site ZNE forces one to all-electric homes. Because most Davis homes use gas, BIRAenergy used Source Energy as the basis for calculating ZNE.

To provide a relatively straightforward and transparent mechanism for interacting with stakeholders, source energy (rather than TDV) was used in the development of the packages for the Davis program to allow offsetting of both electricity and gas use in the homes. Ultimately more appropriate metrics such as zero carbon or zero greenhouse-gas production should be defined and adopted.

1.1.1 Zero Net Energy Misperceptions

The current official definition of ZNE, based on TDV is important to drive statewide policies, energy codes, and state-regulated utility programs in setting near-term goals and targets. The

[40] Hourly calculations for 8760 hours in a year. TDV factors are also by climate zone and fuel type.

current CEC definition of ZNE as well as the CEC-defined Home Energy Rating System (HERS) are based on TDV energy, and are not understandable or relevant to typical homeowners. Therefore these TDV-based metrics and tools are not employed in this guide. Reasons for that decision are provided in this subsection for those interested in this policy-based issue, others should skip this subsection.

Most existing homes in Davis and across California have a HERS score higher than 100 because they were built prior to 2008 and are less efficient than that code.

Households will always pay a utility bill as long as distribution systems need to be maintained, and those costs are spread across ratepayers. They will also be charged for energy use exceeding the amount generated in a zero-HERS home because TDV energy is generally less than source, which is less than site (assuming gas use in source and no gas in site). That is, source energy vs. site energy vs. zero TDV energy all equal different amounts, but in no case will the household get a zero dollar energy bill. This will be confusing to consumers and must be addressed in the program design and messaging.

Time of Use (TOU) and tiered rates further complicate the situation. For TOU, the utility bill depends on when energy is used, where it is more expensive to use energy during peak times; e.g., a savvy energy customer with PV can optimize their return by minimizing energy use in summer afternoons, when TOU electricity costs are the highest, so that they "sell" energy back to the grid (net meter) at the high rate during peak hours and control equipment to use energy at night or in the early morning when it is metered at a much lower rate (factor of 5 difference). This TOU customer can zero their electricity costs (exclusive of fees) while producing less electricity than they use, annually.

More commonly, consumers are on a residential tiered rate, and if they are significant energy consumers, energy generation will drop them down from the top tiers to a lower tier, greatly reducing their electricity costs, even if not zeroing annual usage by annual production.

One would expect TDV hourly valuation to look similar hour-by-hour and day-to-day, but it does not. The idea is very complicated and is not understandable for the implementers or the consumers. Due to the fixed costs of electric distribution (peak time, transmission, distribution, and "externalities") an electric bill will not be eliminated even with added solar PV. TDV disconnects the consumer and home energy ratings from their energy bill and from a clear understanding of how much energy they are really using.

1.1.2 Zero Net Energy Messaging

Due to multiple definitions, and that the official State of California definition is "zero TDV" (see section 1.1, above) rather than zero site energy, ZNE is not the best phrase for describing and messaging the program to homeowners in Davis. Driving program uptake for homeowners involves speaking to primary homeowner concerns, including costs of upgrades, savings, payback and/or cash-flow, home value, and comfort. The term "Zero Net Energy" leads one to think of zero energy bills, which are not going to occur, if for no other reason than utility fixed costs must be passed on to all ratepayers connected to the grid. More important, even the "Best" package is not designed to result in zero net energy, but rather zero TDV. This can and will result in disappointed homeowners, who may vocalizef their discontent. ZNE is not the correct marketing term and will cause future confusion; as a result the initiative will suffer. While the authors cannot provide a program moniker based on a generally accepted and defined metric that is as powerful as Zero Energy, methods to develop program messaging include the following:

- The Davis goal of zero net-carbon (metric definition likely required)
- Make the message simple, memorable, and fun
- In addition to the energy- and cost-savings benefits, include non-energy benefits for the program, including comfort and home value
- Communicate the "what's in if for me" message tailored to homeowners in the neighborhood

1.2 General Approach to Davis Single-Family Residential Retrofit Market

The prevalent approach to the residential retrofit market is to treat every home as unique; this approach is not compatible with the City of Davis' goal of, in the next few years, retrofitting a significant proportion of the existing homes to be considerably more energy efficient, targeting in the longer term, ZNE homes and neighborhoods. To achieve this goal, a mass market, volume approach is needed.

In 2011-2012 The BIRA team was supported by the U.S. Department of Energy and SMUD to develop, implement and evaluate a neighborhood approach to existing home energy efficiency retrofits, through the "Neighborhood Program."[41] This Neighborhood Program shares the same basic objectives and technical approach to retrofits as the SMUD single family home performance program and the CA Energy Upgrade CA program, with the addition of marketing and performing the home performance retrofits with a neighborhood focus. The unique objective of that project was to test the theory that a significantly higher level of home performance retrofit market penetration could be achieved by leveraging the social networks found in tight-knit neighborhoods. This theory was predicated on market research that home performance jobs are most effectively sold by word-of-mouth due to the high cost and the unfamiliarity most homeowners have with home performance retrofits. Additionally, a neighborhood approach provides the opportunity for economies of scale and efficiencies, when implementing numerous jobs in a neighborhood with near-uniform construction and vintage.

This SMUD pilot found that the neighborhoods were not "tight-knit", but that there were groupings of households that provided venues for presenting the program. These groups included neighborhood watch, homeowner associations, churches, and clubs – see the Building

[41] BIRAenergy website: BIRA Building America Report 6.4.2 Final Technical Report_SMUD Neighborhood Approach, 2012

America report[42] for additional details. The lack of tight-knit neighborhoods simply changed the foci for presenting the program from direct neighborhood meetings set-up by the team, to being permitted to present the program to homeowners as part of existing meetings of existing groups.

At the close of the SMUD pilot in February 2012, 24 homes were retrofitted within four neighborhoods, and overall, 30 homes were estimated to be retrofitted by the end of March 2012. The program met its objective of testing and documenting the results of various strategies that could enhance consumer acceptance of home performance retrofit services, evaluating the program's effectiveness, and determining how to improve the program to increase both participation and energy savings per retrofit. The program also achieved the goal of a higher market penetration rate (8 times higher) than the single family home performance program.

Chapter 2. Approaches to Market

2.1 Neighborhood Volume Marketing Approach: Not One Home at at Time

This guide recommends developing an energy-efficiency retrofit program that takes a mass-market approach to energy-efficiency upgrades. This is a different approach than that currently employed by The California IOUs, who currently support the Energy Upgrade California Program (EUCA) that treats homes as each being unique and is "sold" by the retrofit contractor, often referred to as an energy-performance contractor. They use several approaches to reach individual homeowners, including the utility website, bill stuffers, and public service announcements. All require the individual homeowner – the marketing target – to take action to participate. Further, the action that the consumer takes is to either (option 1) pick individual devices in the home to upgrade, e.g., an HVAC or water heater replacement, or (option 2) to have a performance contractor come to their home to do measurements, inspections and tests prior to providing the homeowner with any concrete information regarding the options and costs of improving the overall efficiency of the home.

The first EUCA option, individual device replacement, is usually used to replace equipment that is at or near the end of its useful life and likely quite inefficient. Once the individual device is replaced it is no longer part of a package to provide an overall improvement in the efficiency of the home. Prior to its replacement, it was likely a large contributor to the overall cost-effectiveness of an energy-efficiency upgrade package. After replacement, the benefits of an overall upgrade can be dramatically reduced, impeding the decision of a homeowner to implement a package of improvements rather than a single device.

The second EUCA option can lead to extensive efficiency upgrades once the performance contractor has all the information needed to make their presentation and sale. But it also involves huge inertia for the homeowner to overcome: to contact an EUCA performance

[42] IBID

contractor, to allow and wait for the contractor to gather all the information they need on the home, to wait for the data analysis and ensuing report with suggested upgrades, and to finally have the contractor present their findings to the homeowner and attempt close the sale.

An alternate approach, recommended by this Guide is referred to herein as the *Neighborhood Approach*, which uses multiple and different paths to gain access to the residential (existing home) market. This approach always promotes packages of measures to improve the overall efficiency of the home and does not support “cherry-picking” or “cream-skimming” of single, highly cost-effective upgrades. Rather, at its core are pre-determined packages, developed using a systems-approach to homes typical of those in the target region, city, and/or neighborhood. The program and the specific good, better, best packages, along with costs and benefits, are presented at neighborhood or social gatherings rather than in individual homes. These gatherings of people provide opportunities to sell to groups rather than individuals, and the type of group can sometimes facilitate the discussion of energy use, energy bills, and energy efficiency.

Neighborhood Approach paths or approaches into the market are chosen based on the likelihood that each can provide opportunities to sell energy-efficiency upgrades to *groups of people* who are attending a meeting due to their similar interests, not related to energy efficiency, but the team running the Neighborhood Approach asks to be invited to a group meeting to present the program and seed the initial sale. These market approaches can be meetings of neighborhood groups, such as Neighborhood Watch, church groups, athletic programs, and the like, where a representative of the neighborhood energy-efficiency program can explain the program and its benefits to the audience. Key to this approach is that this first encounter with the target homeowners uses concrete examples of the program, its costs and benefits that are direct and solid examples of what the target homeowners can expect from the program. Specifically, the Neighborhood Approach uses the good, better, best packages that were developed using typical (“illustrative”) homes in Davis to develop the packages, allowing the presenter to discuss known costs, savings, payback, cash-flow, and/or other metrics and messages that may resonate with the specific audience. Also important to this approach is that the presenter, where possible, ties the program to the purpose of the general meeting, and encourages discussion among the audience of energy costs, retrofit packages, construction issues, and any other benefits and/or barriers to improving the overall energy-efficiency of their homes.

2.2 Implementing the Neighborhood Approach: Key Elements

The Neighborhood Approach was initially developed and tested in several sections of the greater Sacramento area, all of which were within SMUD territory, working with SMUD. The key elements of that implementation, and recommended as the basis for a City of Davis Residential Retrofit Program include:

- **Program Marketing and Outreach Materials:** Develop materials based on community activities and activism relating to energy and/or climate, City of Davis goals, climate change, and other issues that could likely encourage Davis homeowners to participate in the program. Continually survey the effectiveness of these materials and refine them based on effectiveness.

- **Neighborhood selection:** Define and select neighborhoods based on criteria including active homeowners' associations, social groups, utility data, including high-energy use and/or high energy bills, defined income and energy use ratios, similar home construction/vintage characteristics, and city districts, such as proximity to UC Davis (core and outlying neighborhoods),. Determine active groups and associations for use/assistance in program roll-out.
- **Assessment of the selected neighborhood:** Construction and vintage characteristics through GIS, city database, and utility data. If needed, refine illustrative homes and packages as appropriate to reasonably represent homes in the selected neighborhood. Alternatively, find three to five volunteer homes in the neighborhood meeting the most common construction characteristics of the neighborhood in which to do energy assessments specific to the neighborhood.
- **Package Development**: Review and update as needed the performance-based "good", "better", and "best" packages. These serve as a visual marketing tool; being representative examples of the actual homes in the neighborhood, the homeowners can both relate to the home models, and be relatively trusting of the costs and benefits provided them. These packages will be used to educate and elicit homeowner interest.
- **Marketing and sales professionals**: Marketing and sales staff should have solid experience in front of groups and closing sales, as well as a thorough understanding of the program, the packages, and of the general neighborhood. They need only minimal technical experience – sufficient to just exceed that of the typical homeowner. The program should sell on merit – benefits to the homeowners, including comfort, reduced dust and allergens, reduced energy costs, personal contributions to reducing emissions, etc. The program should not be sold on technical bases, except for the rare individual driven strictly by numbers.
- **Marketing Outreach:** Using the marketing materials and partnering neighborhood groups/associations, deploy the program at several closely-timed public meetings. If possible, "seed" initial participation in each neighborhood with discounts for early adopters. As part of any discounts or other early-adopter benefit, require signage and other program visibility activities from those receiving any program marketing benefits.
- **Contractor Selection:** A minimum set of qualifications should be developed to qualify contractors , including that all contractors be properly licensed, in good standing with the California State Licensing Board, have proper and current insurance (types and levels of coverage), and provde some minimum references that should be checked. Beyond these minimum requirements. Davis will need to develop a strategy to avoid and reject contractors who are limited to or who attempt to promote single items for retrofit or singularly offering PVs. All contractors need to embrace the concept of optimal approaches to deep savings at the meter. This will likely require both efficiency retrofits and significant PV systems. Contractors who do not promote this program structure need to be removed from the program. All contractors should go through a program orientation and well-defined sales process as a condition to participate in the

program. Their customer care and selling skills should be evaluated as part of a hands-on training program. Speicific residential retrofit experience in Davis would be another likely aid in choosing the most appropriate contractors. The residential areas within Davis need to be separated into "neighborhoods" (see second bullet). A competitive process needs to be developed to try to match single contractors with neighborhoods – sign one contractor to each "neighborhood". A Key element of contractor selections should include guaranteed cost-reductions due to projected volume retrofits, sales skills, and demonstrated quality work and excellent customer service.

- **Retrofit Implementation:** Compile home performance retrofits. As the project proceeds, survey homeowner participants regarding the quality of service and workmanship, as well as the actual test-in, test-out results. Give more work to the better contractors, encourage the lesser, but average contractors to do better, including providing information regarding how they were rated and actual scores, and suggestions on how to improve. Drop any contractors whose level of service and/or workmanship fails to meet program expectations.
- **Continually Monitor and Tune Program:** Continually monitor all aspects of the program as it is rolled-out and as it is taken up by the homeowners. Take lessons learned, both positive and negative, from neighborhoods and apply those learnings to new neighborhoods as they are rolled-out.
- **Energy-Modeling:** Contractors who modify packages must use program-certified simulation software, such as BEoptE+, and should be required to produce a standardized simulation to ensure they are knowledgeable of and use whole-house systems-analyses performance evaluations, and do them properly. Otherwise, either program staff or qualified consultants should be available for evaluating changes to packages.

2.3 Lessons Learned from SMUD Pilot Neighborhood Approach

2.3.1 Optimize the Value of Packages: Program experience from the SMUD pilot demonstrated that the packages should not be considered static and should be utilized primarily as a tool to simplify the sales process for the contractor and homeowners. Therefore, the packages created for the neighborhood program, incorporated the most cost-effective improvements while providing each homeowner with the choice to customize the specific energy efficiency measures of their retrofit package, driven by various factors including homeowner's budget, and the needs of their home. These estimates were based on a 1,800 square foot home and assumed ideal conditions for package installation. The energy savings were calculated for the various packages against the baseline of a typical home in the selected neighborhood. The typical home pro-forma was developed based on a composite home reflecting the typical features/characteristics of the selected neighborhood.

2.3.2 Development of Marketing Collateral and Homeowner Outreach: The first neighborhood in the SMUD pilot was the Arden Park area of Sacramento. Initial outreach was via Arden Park's neighborhood HOA, using both traditional marketing channels (HOA newsletters and meetings, yard signs, door knob hangers, community events, meet the contractor and energy educational meetings) and new media (web based channels and third party websites) to connect with homeowners and promote the program.

At program launch, the Arden Park HOA board members were not the program advocates that the team had anticipated. However, after completion of an energy efficiency retrofit upgrade to a couple of their own homes, those owners provided positive program testimonials during the second marketing outreach. Word-of-mouth testimonials, from satisfied Arden Park participants (including HOA board members), increased other homeowner's willingness to inquire about the program during the second wave of marketing which included more traditional marketing (direct mail postcard, door to door sales by the contractor) and new media (HOA social media approach – for example, used "Yahoo Group" to post homeowner testimonials) to promote the program. Due to the low initial interest during the first wave of outreach, the selected contractor was motivated to support a second wave of Arden Park outreach to encourage additional homeowner interest. The combination of an initial market "softening" from the first outreach along with positive experiences and testimonials of the "Early Adopters" shows that adoption takes time, but with persistence and attention to what is working and what is not, adoption will occur and increase over time.

The second wave of Arden Park outreach included the following:

- Traditional Marketing
    - Door-to-Door sales were employed. The contractor walked the neighborhood for a day and a half discussing the program with interested homeowners.
    - A Direct Mail Postcard was devised to incentivize program participation by offering a free energy assessment to any homeowner who signed up within about a month
    - An interview testimonial of a satisfied homeowner was published as a lead article in the HOA's quarterly newsletter.
- New Media
    - Internet/Web-based Outreach was used in the form of a neighborhood-specific webpage, which was created to provide interested homeowners a means to sign-up for an energy assessment or speak directly with a contractor customer service representative.

Positive feedback from early adopters regarding their retrofit – both the retrofit itself and the positive impacts following – resulted in a spike in in program interest. Once social marketing was introduced, over 30 homeowners contacted the contractor and/or the program manager to schedule an energy efficiency assessment on their homes. This second outreach resulted in 10 additional energy efficiency retrofit upgrades (twice the contracts compared to the original 5 retrofit contracts signed during the first wave of outreach).

The pilot neighborhood provided experience and lessons learned in marketing outreach that were implemented in the Subsequent Neighborhoods. Some of the initial lessons from the pilot neighborhood included:

- Target Early Adopters and Employ Speed to Market
- Use Testimonials for Auxiliary Marketing Outreach
- Adoption Takes Time

It was found that an initial awareness campaign and sign-up period would attract the market innovators; to be successful, the program needs to attract well beyond that market segment, to encompass both early adopters and into the early majority market actors. A corollary finding in the SMUD study was that increased visibility of retrofit work and continued positive testimonials will produce a second wave of participants, often larger than the first wave. There will likely be at least six months delay until the second wave begins, and program visibility must be maintained during the lull period. The SMUD experience tells us that, given the program messaging is increased, a second wave will occur, mostly due to participation from early adopters. During that time it will be important to use surveys and other approaches to determine the relative effectiveness of various messages and marketing approaches, and to expand the most effective materials and avenues. At that point it would be wise to develop Davis-oriented program messaging, and to give it high visibility.

After the second-wave early-adopters, with the program extending well beyond the six-month and 1-year marks it will be entering relatively uncharted territory. Logic tells us to continue with the messaging that is working, to increase the visibility of the most effective program information, to increase dissemination into new and broader marketing channels and, probably most important, to garner testimonials from participants, encouraging participants to provide them, and encouraging participants to include praise for program benefits above and beyond the energy benefits, including comfort, potential health benefits (due to managing ventilation), and home values. These messages are going to resonate much more with the early majority than will messaging more limited to energy and even cost benefits.

2.3.3 Learning from Subsequent Neighborhoods – Additional Marketing Methods

The SMUD pilot consisted of a total of six neighborhoods with a single, first "pilot", followed by five additional neighborhoods. The entire pilot program lasted approximately 18 months. In neighborhoods subsequent to the initial, pilot neighborhood, marketing efforts were increased in frequency and more support was elicited and provided by SMUD and local community groups. Marketing outreach and materials used in the pilot were both continued and increased in the subsequent five neighborhoods. The frequency of outreach was also increased to ensure constant and regular customer contact, and to increase homeowner awareness and knowledge of the program. Over the last six months of the program, multiple marketing channels were employed including HOA meetings, door knob hangers, yard signs, community events, meet-the-contractor meetings, and third party websites to connect with homeowners and promote the program. The following activities were implemented in the five neighborhoods following the initial pilot neighborhood.

- Traditional Marketing
    - Neighborhood Meetings/Events – Over 34 meetings and events were held throughout the five selected neighborhoods, which included HOA monthly meetings, community events (i.e. historic/energy efficiency community building restoration event, neighborhood picnic, community informational event), historic preservation society meetings, PTA meetings, and meet-the-contractor meetings to promote the program and educate homeowners on energy efficiency.
    - Door Knob Hangers and Yard Signs were distributed following key neighborhood meetings or events to ensure constant and regular customer contact building homeowner knowledge and interest.
- New Media
    - Internet/Web-based Outreach – SMUD, on its program website created neighborhood specific webpages describing the program, components of each neighborhood and selected contractor information. The pages were created to provide interested homeowners an online research medium for information on energy efficiency and program information.

Based on lessons learned from the subsequent five neighborhoods, the team developed targeted marketing outreach strategies. Some of these follow-up marketing strategies include:

- Targeted outreach to homeowners who completed an energy assessment but did not complete an energy efficiency retrofit upgrade reminding them about the program, educating them on the benefits and encouraging their participation.
- Through utility [43]energy use data identify and target homeowners with highest energy use within the neighborhood, and create direct educational outreach towards those homeowners.

2.4 Major Steps in Neighborhood Approach to Energy Efficiency and Solar Retrofit

1. Identify target neighborhoods and social groups for group marketing;
2. Identify qualified contractors and train them on the program. Determine whether to assign single contractors for each neighborhood or allow free-market contracting. Determine best method to produce volume pricing for chosen contractor approach.
3. Characterize homes in the target neighborhoods and develop good, better, best packages for each neighborhood (for Davis: modify packages as appropriate for each neighborhood).
4. Hold Neighborhood / social group meetings to present the opportunity and benefits of energy-efficiency and solar retrofits

[43] This requires a cooperative utility partner

5. Contractor visit to interested homeowner to gather information needed to produce a correct cost estimate and get signed contract.
6. Schedule and perform the retrofit.
7. Continuously monitor and evaluate contractors regarding their customer relations and service, costs, and quality of work.
8. Continually monitor and evaluate program elements

Chapter 3. Model Retrofit Packages for Neighborhood Marketing

BIRAenergy has characterized the different housing types in Davis, resulting in a series of “illustrative homes” meant to characterize a cross-section of existing homes in Davis. These illustrative homes have several uses, as described in this (and following chapters) including:

1. Estimating an energy baseline for the different homes;
2. Producing sample Good, Better, Best packages for developing a residential retrofit program;
3. Providing a basis for estimating energy savings potential for participants in a residential retrofit program, as well as for setting residential retrofit program goals and objectives;
4. Providing tools for explaining the program and for initial sales presentations to homeowners (Chapter 5)
5. Estimating total available roof area that could support roof-top PV installations in Davis (See Chapter 4).

BIRAenergy developed Good, Better, Best packages for housing representative of those built in the decades up through 1970, during the 1980’s, 1990’s, and since 2000. These packages provide a basis for approaching homeowners with ready packages for which costs are relatively well known and understood. These packages form the basis of the program and the initial offerings to homeowners who are potential participants.

3.1 Characterizing Housing in Davis

Data were needed to develop characteristic homes (“illustrative homes”) for use in developing energy-efficiency packages and estimating PV systems sizes for the DavisFREE project, ultimately for use in developing a residential ZNE retrofit program. To assist in that effort, The City of Davis provided BIRAenergy with an Excel database of basic characteristics for all single-family homes in Davis – these characteristics include: year home built, conditioned floor area, and numbers of: stories, rooms, bedrooms, baths, and half-baths. BIRAenergy sorted these data, first by separating records with complete data from those with data missing. The entire database consists of over 14,400 records, and over 1,000 records were missing large amounts of data. Also some of the records were for duplexes, which were not included in this analysis because they would skew the results. During this analysis BIRAenergy also found that many of the records had Alpha-characters in numeric fields – these were converted to numbers with the integrity of the data unaffected; however, as noted below, not all these Alpha-characters were found in this data "cleaning" process.

During this process of "cleaning" the data, the BIRAenergy team became somewhat familiar with the nature of the data and decided that a good method to use the data to characterize the homes in Davis for a future energy-efficiency retrofit program would be to separate the data by decade built. The oldest home in the database was built in 1858, and between then and 1960 there are records of 337 homes. Thus the homes build prior to 1960 were treated as a single decade. The decade 2000 – 2010 was also increased to include data up through 2012, the latest data in the database.

Pivot tables were used to separate the data by decade (including prior to 1960, and post 2000), and provide average values for the living area, number of stories, number of rooms, bedrooms, baths, and a percentage of those with half-baths. The number of homes for each decade was also collected. **Table 1** provides a summary of this reduced data.

	#Bedrooms	#Bathrooms	th half-baths	#Rooms	Stories	Area	#SF Homes
Prior to 1950	2.9	1.7	0.2	6.2	1.3	1592.3	337
1960 - 1969	3.4	1.8	0.1	6.7	1.1	1571.4	1009
1970 - 1971	3.3	2.0	0.1	6.7	1.2	1735.7	3184
1980 - 1989	3.1	2.0	0.2	6.4	1.4	1823.0	1305
1990 - 1999	3.6	2.4	0.3	7.7	1.6	2161.0	3455
2000 - 2012	3.7	2.5	0.4	7.9	1.7	2623.0	1068
Averages of SF data	3.5	2.1	0.2	7.1	0.2	1911.3	10358

Table 1: Characteristics of homes in the City of Davis, with average values for typical home descriptors, sorted by decade that the home was built.

The reduced data in **Table 1** represents over 10,000 records. The discrepancy between the approximately 13,000 records with "complete" data and the over 10,000 reported is most likely due to the removal of non single-family records and additional Alpha-character data in numeric fields that were not found in the initial cleaning of the database. The Alpha-character data could not be sorted and averaged using the pivot tables, and were simply dropped by Excel in the pivot-table analysis process. Given the robust nature of the current findings, and the time required to regenerate the averages for the remaining fields, BIRAenergy decided to work with the 10,000-plus records in the decade-sorted averages. While these problems with database records resulted in not being able to use about 30% of the total number of records in the database, the results from analyzing the 10,000 usable records seem internally consistent in terms of general trends, such as size, numbers of bedrooms, bathrooms, stories, etc. In addition, based on the author's experience, the descriptive values for each decade's illustrative home(s) are generally consistent with California residential market trends. For these reasons, the author is confident that the results from the analyses of the 10,000 clean data-records provided a good representation of Davis housing.

Several fields in the decade-sorted data were plotted to see trends that, while clear from the values in **Table 1**, are interesting, and easier to see when plotted.

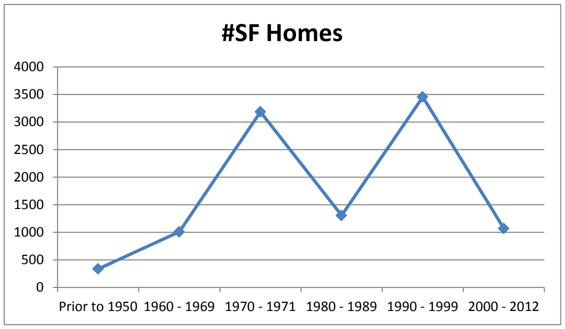

Figure 1: Numbers of SF homes by decade.

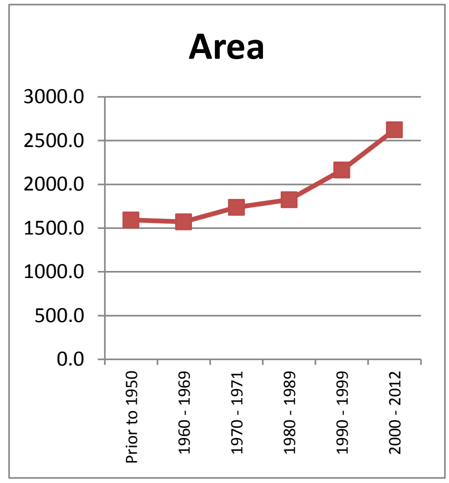

Figure 2: Living area of SF homes by decade.

Figure 1 clearly shows the two decades of the 1970s and 1990s as those with the largest numbers of homes built, and **Figure 2** demonstrates the unsurprising increase in living area of the homes over time, right up to the present.

Google Earth was used by BIRAenergy to view homes in different areas of Davis, as well as a limited amount of personal observation while driving around Davis, and the vast majority viewed were basically rectangular. Using the decade-averages data and treating the homes as basic rectangles, the graphic data-input function of BEopt[44] was used to generate simple images of the homes for the different decades. Three representative illustrations are provided in **Figures 3, 4 and 5.**

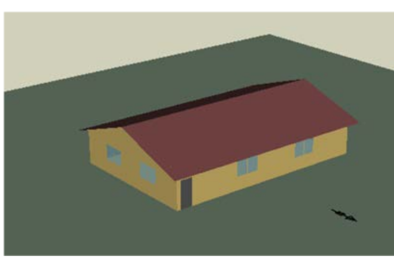
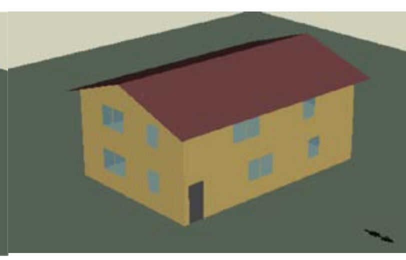


Figure 3: Single Story SF Home. **Figure 4**: Two Story SF Home. **Figure 5**: Two Story SF Home with Overhangs (size difference from figure 4 is an artifact of importing the figures into Word)

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[44] BEopt, developed by the National Renewable Energy Laboratory, is a shell for EnergyPlus, the current preeminent building energy simulation software; BEopt provides easy-to-use, and powerful data input and output facilities.

Note that **Figure 5** shows overhangs on the windows. Some of the newer homes viewed with Google Earth were found to have some shading features, particularly of the entry and, while not visible in Google Earth, frequently on the back, in the form of a covered or partly covered patio[45]. In addition, newer homes tend to have hipped roofs[46], which will be used in the simulations of the more recent homes built.

City of Davis GIS (Geographic Data System) Staff expert, Bruce Boyd, recommended that the figures (and models) include garages, which by the 1960's were attached to the main house. The figures will be updated to include garages, with some included in the main rectangle of the home and others with the garage added to the front of the home, producing an "L" shaped home (including garage). These decisions will be based on additional study of aerial and/or Google Earth data.

Using both the GIS data and aerial data, Bruce Boyd determined typical aspect ratios and typical home dimensions for each decade. These are provided in **Table 2**.

Decade	Width x Depth
1960-1970	30′ by 50′
1970-1980	35′ by 50′
1980-1990	38′ by 50′
1990-2000	40′ by 55′
2000-2012	50′ by 55′

Table 2: Typical home dimensions for Davis SF homes, by decade.

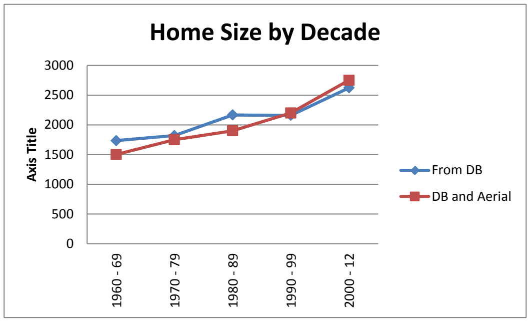

Figure 6: Comparison of home size from database averages and the combination of database values and aerial data.

Figure 6 is a plot of the average floor area from the decade averages derived from the database, compared with that from both the database and examination of aerial data. The data are quite similar and BIRAenergy staff recommends use of the combination data because houses tend to be built to more regular dimensions than those provided by the strict average values derived from the database.

The BEopt models in the simulations will be updated to show the garage, to match the revised home dimensions from **Table 2**, and to have hipped roofs for at least the last decade, and possibly more, to be determined by further examination of the aerial data.

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45 Based on experience of BIRAenergy staff with new homes over the past three decades.

46 Hipped roofs have no gables, rather, the roof extends down to eaves on all sides; hipped roofs tend to have more angles and less contiguous, open area that can be used to mount photovoltaics (PVs).

3.2 Building Packages

As part of its efforts for the DavisFREE project, BIRAenergy developed energy-efficiency (EE) packages for the six illustrative homes. As described in the last progress report, the six homes represent the five decades between 1960 and today. The six illustrative homes are representative of (1) 1970's and prior, (2) 1980's single-story, (3) 1980's two-story, (4) 1990's single-story, (5) 1990's two-story, and (6) 2000 through today. For each illustrative home, three EE packages were developed. The three packages, *Good*, *Better*, and *Best*, are intended to span levels of retrofit from cost-effective (*Good*) to ZNE-ready with the addition of a moderate-size PV system (*Best*). Statistics describing the energy savings and percent energy savings from the packages are provided in **Table 1**.

Decade	# Stories	Package Description	Source Mbtu/yr	% Saved vs Base Case
1970s	1	Good	110	34%
		Better	99	41%
		Best	83	50%
1980s	1	Good	92	33%
		Better	85	39%
		Best	75	45%
	2	Good	98	33%
		Better	85	42%
		Best	75	49%
1990s	1	Good	96	31%
		Better	91	34%
		Best	83	40%
	2	Good	106	34%
		Better	96	40%
		Best	88	45%
2000s	2	Good	115	19%
		Better	109	23%
		Best	93	34%

Table 1. Energy Efficiency packages by decade. Three packages are provided per decade, *Good* being cost-effective, Best being ZNE-Ready, meaning that the addition of a moderate-size PV system would make the home a Zero Net-Energy (TDV energy) home, and *Better* between the two. The Base Case for each was the appropriate illustrative Home with T24 package features.

Table 1 provides two different packages for each of the decades 1980's and 1990's: one each for a single story and for a two-story. Prior to the 1980's most homes were single-story. In the 1980's and 1990's both single-story and two-story homes were similarly common, by the 2000s, the majority of new homes were two-story to allow larger homes to be built on smaller lots. For details regarding the development of the illustrative homes, see the previous monthly activity report ("Home Characteristics Report, April 2014" by BIRAenergy).

Table 2 provides the features for the 1970's home that changed from the assumptions for the baseline, through the three packages, good, better and best, for the 1970's decade. The assumptions for the baseline were derived primarily from the California Energy Commission Vintage Tables. For simplicity in interpretation of **Table 2**, only the EE features that were changed to make the *Good*, *Better*, and *Best* retrofit packages are shown in the table.

3.2.1 Energy Efficiency Features

Descriptions and definitions of energy-efficiency features are provided in the next section of this chapter.

To help visualize in which features changed, and at which efficiency level, in **Table 2** each time a feature changes, it is highlighted a different color. The first time a feature changes (becomes a retrofitted improvement) it is highlighted in a light orange, if the feature increases efficiency a second time, it is highlighted pink, and a few of the features changed each time, from *Good*, to *Better*, then to *Best*; they are highlighted in violet. When a feature does not change, it is not highlighted.

Efficiency Measure	Baseline	Good	Better	Best
Ceiling Insulation	Vented Attic, R-13 flat on ceiling	Vented Attic, R-49 (new) flat on ceiling	Attic Sealed, R-38 under roof deck	Attic Sealed, R-38 under roof deck
Roof Characteristics	Asphalt Shingles, Dark	Asphalt Shingles, Dark	Cool Roof (Abs. = 0.2 / Emiss. = 0.5)	Cool Roof (Abs. = 0.2 / Emiss. = 0.5)
Windows (U-factor / SHGC)	U=0.76, SHGC=0.67	U=0.32, SHGC=0.25	U=0.32, SHGC=0.25	U=0.32, SHGC=0.25
Air Leakage (ACH_{50})	15 ACH_{50}	9 ACH_{50}	2.5 ACH_{50}	2.0 ACH_{50}
Refrigerator (25 cu.ft. side x side) EF	EF=15.7	EF=20.6	EF=20.6	EF=20.6
Lighting (% LED)	100% Incadescent	100% LED, both hardwired and plugin	100% LED, both hardwired and plugin	100% LED, both hardwired and plugin
HVAC Cooling A/C SEER	SEER 13	SEER 16	SEER 18	N/A
HVAC Gas Furnace HSPF	Gas, 78% AFUE	Gas, 92.5% AFUE	Gas, 92.5% AFUE	N/A
Heat Pump (SEER, HSPF)		N/A	N/A	SEER 18 & HSPF 9.5
Duct Verified Leakage (% Total Fan Flow)	15% leakage	7.5% Leakage	In finished space; $\le$ 7.5%	In finished space; $\le$ 7.5%
Duct Location and Insulation R-Value	R-2.1 ducts - vented attic	R-8 ducts - vented attic	R-8 ducts in sealed, semi-conditioned attic	R-8 ducts in sealed, semi-conditioned attic
Water Heating	Gas Standard	Gas Tankless, Condensing	Gas Tankless, Condensing	HPWH, 50 gal (4.0 COP)
Solar Water Heating	N/A	N/A	64ft Closed-Loop or equiv	64ft Closed-Loop or equiv
Whole House Energy Savings		33%	42%	Efficiency Only: 50% Add 4.6kW PV: 100%

Table 2. Energy Efficiency features improvements for the 1970's decade illustrative home. Each retrofit level, from Baseline to *Good*, then *Better*, and finally, *Best*. Only efficiency measures that change as one of the retrofits are listed. As described in the text, each time the efficiency of a feature is improved; it is highlighted; light orange for the first improvement, pink for the second, and violet for the third. As can be seen from the highlights, almost all features changed for *Good* (light orange), most for *Better* (pink), and a few for *Best* (viotet). The whole-house energy savings from the baseline to the retrofit package are provided at the bottom of this chart. PVs are only noted for "Best", but could be in any of the packages.

Figure 1 graphically shows the reduction in energy from the Baseline, through the three packages. The bottom row shows the reductions in energy use for each end-use, starting with the base case and going to the *Best* package at the far right. **Figure 1** also shows the impacts on the individual energy end uses. Each bar is made of the various energy end-uses stacked one-on-the-other, to produce a stacked bar for each simulated home, with the total height representing the total energy use.

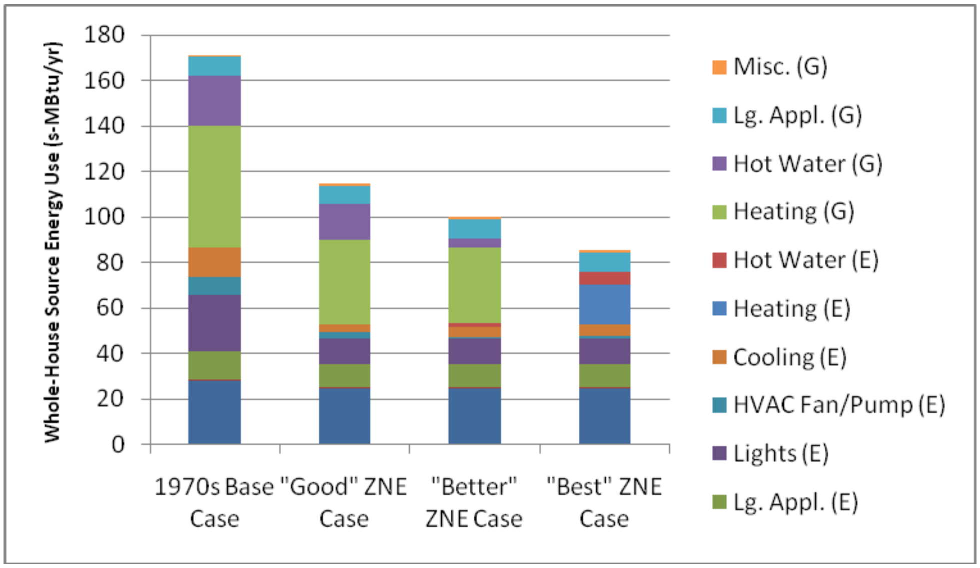

Figure 1. Total energy use and end-use energy reductions from the three 1970's-vintage retrofit packages, *Good*, *Better*, and *Best*, compared with the baseline ("base-case").

For the first two packages of efficiency improvements, the envelope and duct system both have considerable improvements – this results not only in reduced energy use, but also the potential to downsize the HVAC system, reducing its replacement cost. These sizing improvements are provided in **Table 3. Table 3** also shows the size PV system that would be required to offset all the energy use in the home (in source energy). These are provided for the home, as-is (baseline) and for each improvement. The purpose in showing these levels of PVs for each energy level are not to suggest that PVs be added at each level, but rather that the size of such a PV system is quite reasonable once the efficiency level of the *Best* package is achieved. The size of the PV system shown is that which would, over the course of a year, generate enough energy to offset the total annual energy use of the home. In the *Best* package the energy needed by the home has been reduced to half that required for the Baseline to offset all the energy, both gas and electricity, measured in source-energy.

It is important to point out that these PV system sizes are not based on net-metering economics – one cannot net-meter gas. So in the *Best* package, gas use has been minimized where appropriate to both save energy and optimize for net metering. In the *Best* package, the energy required to heat the home is reduced by an impressive 73%, and the heating is done via a heat-pump, so the energy used by the heat-pump to heat the home can be net-metered, making the *Best* package optimal for the installation and net-metering of solar generation in PV, as well as for energy reductions.

HVAC Size to Meet Loads	Baseline	Good	Better	Best
Cooling (Tons)	6.2	3.1	2.1	2.1
Heating (kBtu/hr)	47.8	27.1	17.7	13.1
% Reduction HVAC Size	-	47%	65%	69%
PV for ZNE (kW required for 100% source energy savings)	9.3	6.2	5.4	4.6

Table 3. The equipment sizing (capacity) requirements for the baseline and each of the retrofit packages is shown above (equipment size needed to condition the home is reduced by almost 70% from baseline to *Best*).

Costs for the 1970's packages were estimated using R.S. Means costs, from BEopt. These costs are based on national surveys and widely used as reference data. While the BIRAenergy staff do not necessarily trust every cost in the BEopt database, the totals for packages look reasonable. Using the BEopt and RS Means energy savings and costs, BIRAenergy estimated the cost-effectiveness of the 1970's package. The costs for the good, better, best efficiency packages were $4,224, $12,406, and $23,652, respectively. Adding 4.6kW of PV at an installed cost of $3/Watt, the Best/ZNE package cost was $37,560. The simple pay-back for the 1970's packages was 5 years for Good, 13 years for Better, and 26 years for Best without PV. The simple payback for Best/ZNE with 4.6kW PV was 17 years, very similar to the payback for the Better package (without PV). Should Davis go forward with designing and implementing a retrofit program, considerable time must be spent with the local contractors developing costs bases so that costs and paybacks are correct, but also so that the program can be designed with volume discounts. Local costs and planning are required to realize costs reductions; they did occur and were an important and real component of the SMUD Neighborhood Approach. They are also a point of differentiation of the best contractors – they will figure out how to maximize costs savings to increase their market-share and overall profit, even if their individual home profit is less.

The packages have been developed for the five decades 1960's (and prior), 1970's, 1980's, 1990's and 2000's (through today), as well as for both one and two-story homes for the 1980's and 1990's (a total of six illustrative homes, three packages each). The source energy savings are estimated in **Table 1**. The detailed analyses provided in **Table 2** and **Table 3** are currently in progress, and will be forwarded to the Program Manager as a section of the Task 5 Final Report. That section of the Task 5 Final Report will focus on the packages, with a separate and distinct section of the Task 5 Final Report covering the Residential ZNE Retrofit Best Practices and Deployment Guide. The ZNE Packages section of the Task 5 Final Report will provide all the features upgrades (as illustrated in **Table 2**) in Appendices, one for each illustrative home.

3.3 Descriptions and Definitions of Energy Efficiency Measures Used in Retrofit Packages

This is a descriptive list of individual energy-efficiency measures that will typically be considered for inclusion in both the illustrative retrofit packages developed for the DavisFREE program, as well as final retrofit packages chosen by the homeowner. These efficiency measures were used in the Good, Better, Best efficiency retrofit-packages that were developed to provide examples of retrofit packages that could be presented to homeowners as representative of retrofits for homes originally built just like their own.

The packages were designed to optimize efficiency and cost for the Good Package (between 20% - 25% savings, and positive cash flow); the Better package, that offers more efficiency than is cost-effective, and that illustrates some non-typical retrofit opportunities including efficiency measures such as heat-pumps, heat-pump water heaters, ground-source heat-pumps, and solar thermal water heating. The "Best" package optimizes energy-efficiency with rooftop photovoltaics (solar electric generation; PVs) providing the potential of being a zero net-energy home. When developing a retrofit package, PVs should always be considered as part of the package – it may be the least disruptive and most cost-effective option, especially when resale value is part of the equation.

The author strongly recommends that all retrofits include air sealing, duct sealing and insulating, communicating thermostats and home energy management systems that can communicate with the thermostat as well as other features in the home, low-flow faucet aerators, low-flow shower heads, and LED lamps in all lighting fixtures. Good retrofit program design would also ensure that homeowners are recommended to replace refrigerators, dishwashers, clothes washers and driers that are over ten years old[47] with new, ENERGY STAR models, and to remove and not replace any refrigerator and/or freezer in the garage.

The purpose of the "Good, Better, Best" packages developed for and discussed in this guide are not meant to be a set of optimal packages, but rather illustrative and informative, and provide a basis for a "sales package" useful for and sufficient to get the homeowner to commit to the retrofit work in the first meeting. Follow-up meetings are required to evaluate the specific home, tune the package to optimize savings based on the homeowner's needs and desires for his or her home, and to perform final negotiations on the retrofit.

3.3.1 List of Sample Energy Efficiency Measures

These energy-efficiency measure descriptions have been arranged in groups of like technology application measures. Each group has a description pertinent to that group, and each measure has its own description going beyond the descriptions pertinent to the group. Photovoltaics (PVs) are included at the end of this list simply because they are not an efficiency measure and are therefore independent from the group of efficiency measures. PV panels can be mounted on the roof of a home and connected through the electrical panel to produce on-site, clean-energy, and thereby reduce the amount of off-site generated grid-energy, supplied to the home via the electric meter. PVs can be an element of any retrofit package, ranging from being the only

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[47] National Association of Home Builders/

Bank of America Home Equity

Study of Life Expectancy of Housing Components retrofit feature, to being a key element of the "Best" package to generate the electricity needed to offset energy still needed and used in the home to achieve ZNE or near-ZNE results.

3.3.2 Building Envelope Efficiency Measures

The building envelope consists of walls, roof/ceiling, floor/foundation, windows and doors. An energy-efficient envelope will reduce energy gains and losses due to conduction, convection and radiation. Radiative gains are largely from direct sunlight onto the envelope structure; radiative losses are from the envelope radiating heat to cooler surrounds, such as a clear night sky. Conductive losses are reduced by insulating the envelope; the effectiveness of insulating materials is provided in an R-value, where R is the resistance to heat flow.

Windows are rated for their conductive losses in terms of their conductivity of heat ("U-factor"), which is the opposite of resistance to heat flow (1/R = U). Windows are also rated according to the amount of heat gained via radiation through the window. Radiative gains through windows are rated as Solar Heat Gain Coefficient (SHGC). A window with a low SHGC is more energy-efficient than with a high SHGC, except when the home is designed and sited to have passive solar heating in the winter, in which case the windows designed to collect winter solar radiation should have high SHGC ratings and should be shaded in the summer.

The main convective losses in a home are due to small openings in the envelope, typically at junctions (e.g., wall-roof interface) and penetrations (e.g., plumbing and electrical). All buildings have some amount of air leakage between the inside and outside. This leakage, or air infiltration, is quantified by measuring the house leakage when pressurized (or depressurized to 50 Pascals (0.2" water column).

House attics are typically vented to avoid trapping moisture that can damage building materials. In a home with a vented attic the insulation is typically on the "floor" of the attic which is also the top of the ceiling (see Ceiling Insulation). Vented attics tend to track outdoor temperatures: hot in the summer and cold in the winter. Another, less common attic construction is to seal the attic so that it is not vented. With this construction the insulation can be attached to the underside of the roof-deck, sometimes also with insulation on the attic floor. If the insulation is attached to the roof-deck, then the attic tends to track indoor temperature much more than outdoor temperature. California homes typically have the HVAC ducts in their attic spaces. Energy losses through ducts in an unvented attic with insulation at the roof-deck (implied in the description "insulated, unvented attic"), will be substantially lower than ducts in a vented attic.

- Cool Roof: A Cool Roof uses roofing material that has a high solar radiation reflectivity, reflecting most of the infrared light striking it, keeping the heat from being absorbed by the roof assembly components. A Cool Roof also has a low emissivity, meaning that it does not radiate heat away to a cooler surface.
- Ceiling Insulation (R-49): Insulating material is installed between the framing members of the walls and ceiling or joists to reduce conductive heat exchange. The most common approach to insulating the top surfaces of a home is to cover the ceiling of the home with insulation. R-49 insulation covering the ceiling is a high R-value, and therefore very resistant to heat flow.

- Insulated, unvented attic (R-38): This is a typical attic assembly and insulation retrofit technique for attics that are not vented to the outdoors. It involves installing insulation (or replacing lower R-value insulation) with relatively high R-value insulation that is consistent with new construction attic insulation levels.
- Radiant Barrier: A radiant barrier is a reflective material, typically part of the roof assembly, that, unlike most other surfaces in an attic, does not emit radiant heat from a hot roof downward toward the attic, keeping the attic cooler.
- High-R Wall (R-5 XPS Sheathing): The amount of insulation in the structural walls is limited by the thickness of the walls (typically 3.5 inches; 2x4 construction), the R-value of the insulating material and the amount of framing in the walls. Additional Wall R-value can be achieved by attaching rigid foam sheathing across the framing. Rigid board insulating sheathing is typically R-4/inch expanded polystyrene foam. An alternative is R-5/inch extruded polystyrene foam, providing a higher R-value, more energy-efficiency wall.
- Better Windows (U=0.35, SHGC=0.25): Dual pane, low-emissivity windows that reduce conductive and convective losses. Low U-factor and SHGC ratings (both below 0.40) signify an energy-efficient window.
- Reduced Air Infiltration (2.0 ACH_{50}): All buildings have some amount of air leakage between the inside and outside, which results in increased space conditioning, dust, and reduced comfort. The amount of this leakage, or air infiltration, is measured by pressurizing the house with a "blower-door" and measuring the leakage at a standard, fixed (low) pressure. While the house is pressurized (or depressurized), the leaks can be found and sealed. The current default air infiltration for new homes is 7 ACH_{50}. 2.0 ACH_{50} is a very air-tight envelope and will be more energy-efficient than one with a higher air-leakage rate. Homes with less than 2 ACH_{50} should have mechanical ventilation to maintain good indoor air quality (see ASHRAE 62.2 for details on ventilation).

3.3.3 Heating, Ventilating, and Air -Conditioning Measures

Homes are typically heated by a gas furnace and when cooled, it is via a compression-cycle air conditioner. Sometimes, rather than a furnace/air-conditioner, the home will have a heat pump. A heat pump is a vapor compression-cycle air conditioner that can move heat in either direction, taking heat out of the house in the summer and the opposite in the winter. Furnaces, air conditioners and heat-pumps all have well-defined tests to determine their efficiency rating. Gas furnaces are rated using their Annual Fuel Utilization Efficiency (AFUE), air conditioners by Seasonal Energy Efficiency Rating (SEER) and Energy Efficiency Ratio (EER), and heat-pumps by SEER and EER for cooling and Heating Season Performance Factor (HSPF) for heating efficiency.

HVAC systems typically have ducts to convey heated or cooled air from the furnace/air-handler to the spaces to be conditioned. California homes built since the early- to mid-1980's typically have ducts in the attic, which is typically vented and which tends to be hot in the summer and cold in the winter, resulting in significant energy losses from the ducts, both in terms of conductive losses and leakage (convective) losses. Another, less common attic construction is to seal the attic so that it is not vented to outdoors. With this construction the insulation can be attached to the underside of the roof-deck. A sealed attic with insulation under the roof deck tends to track indoor temperature much more than outdoor temperature. Energy losses through ducts in an unvented attic with insulation at the roof-deck (which, herein is implied in the description "insulated, unvented attic"), will be substantially lower than for ducts in a vented attic.

Typical air conditioners and heat-pumps move heat to/from the home to/from the air outside. In that situation, the outdoor air is a source or sink for heat being moved into or out of the home. A more efficient, but more expensive, source/sink for heat is the ground. Ground-source heat pumps take advantage of the improved conductivity and heat capacity of the ground compared with the air. Ground-source heat-pumps are rated by Coefficient of Performance (COP).

- High Efficiency Furnace (0.92 AFUE): 0.92 AFUE is an efficient condensing furnace; AFUE's can go as high as 0.96 AFUE. The national minimum is 0.78 AFUE.
- High Efficiency Air Conditioner (18 SEER, two-stage, 14 EER 2nd stage): 18 SEER (and 14 EER, 2nd stage) indicate high efficiency air conditioners (14 SEER will be the national minimum 1 Jan 2015; national ratings do not include EER).
- Heat-pump (18 SEER, 9.5 HSPF): These are high SEER and high HSPF ratings indicating a highly efficient air-to-air heat pump. The national minimum is 8.2 HSPF.
- Ground-Source HP (COP 4.6, EER 27): Although using a different rating method (COP), the ground-source heat pump can be significantly more energy efficient than air-source heat pumps; the extremely high efficiency of the ground-source heat-pump can be realized by comparing the 27 EER rating for the GSHP to the very respectable 14 EER of the two-stage 18 SEER air conditioner (see High Efficiency Air Conditioner, above). Although the rated efficiencies for this equipment is high, experienced design engineer and installers, working together are required to achieve these high efficiencies - pumping parasitic energy use, the sizing and performance of the ground loop, as well as the loads imposed on the system may significantly degrade actual field efficiencies.

3.3.4 Water Heating

Water heating equipment is typically a gas-fired, atmospheric storage water heater, holding 40 – 60 gallons, with an Energy Factor (EF) of 0.60±0.02, depending upon tank size. More efficient water heaters have higher EF's. Tankless gas water heaters have very large burners to heat the water as it passes through a heating coil in the water heater. Tankless water heaters efficiency ratings start at 0.80 – 0.82 EF and exceed 0.90 for condensing units.

- Highly Efficient Tankless Water Heater (EF=0.90+):
- Closed combustion, condensing water heaters are available as both tankless and storage types, with thermal efficiencies ranging from 90 to 96%EF.
- Heat pump water heaters have been available from major manufacturers over the past few years, with the more efficient models being on par with an 0.82 EF tankless water heater, considering source energy. Operating costs will typically be higher than a gas

water heater in much of California (including Davis) as electricity is relatively expensive relative to natural gas.

- Solar thermal collectors, as part of solar water heating systems, can be designed to either boost water temperature going into the tank, or to produce high grade heated water (over 140°F) and offset any fuel needed to heat the water, typically covering between half and three-quarters of the water heating load. A typical residential Solar Hot Water is a roof-mounted 64 sq. ft. flat-plate collector that is part of an active solar system. A well designed and installed solar water heating system can provide hot water to meet about 70% - 75% of the typical hot water load, depending upon location, usage, and storage tank size. The major barrier to solar thermal water heating is high first cost and the low current cost for natural gas.
- On-demand recirculating hot water pumps can be used with existing hot water systems to significantly reduce the water waste and waiting time in delivering hot water to use points. Water that would otherwise be wasted while waiting for hot water to arrive is now recirculated back to the water heater. At the push of a button a small electric pump pushes the cold water in the hot water line into the cold water line, simultaneously bringing hot water to the trunk, near most or all fixtures in the line, providing hot water much more quickly.. The system only pumps enough water to prime the hot water piping, then automatically shuts off. This can be installed on the return side of a hot water loop (at the storage tank), or if the plumbing is trunk-branch, the pump should be installed across the hot-to-cold at the most distant fixture or the closest to those with the highest needs (e.g., bathroom). Multiple pumps can be used where there are 2 – 3 trunks running to different parts of the home. The major benefit is improved hot water delivery and reduced water waste; home energy savings are minimal in most cases.

3.3.5 Other Systems

- HEMs with Programmable thermostat: A home energy management system (HEM) monitors electricity use throughout the house via the main electrical panel. Various user-interfaces are available depending upon consumer interest, with the basic system providing energy-use monitoring, and energy-cost tracking and forecasting. The systems have multiple layers of user interaction up-to and including active opening and closing of electrical circuits feeding equipment that does not need to be currently in use, but that draw power continuously in (at a minimum) a resting state that can immediately switch to full-on. These systems have been shown to reduce connected energy use from 7% to over 20%.

- Rooftop Solar Electric System (photovoltaics or PV): Roof-mounted array of solar panels generate electricity that can meet the major electricity needs of the home during daylight hours. Electricity generated that exceeds the immediate needs of the home are sent "backwards", through the meter from the home to the utility's distribution grid, to provide electricity for nearby homes or other electricity-using equipment. The annual electricity is "net metered" meaning that the electricity generated and the electricity used are balanced against each other, with the ultimate target of zero net-electricity

(ZNE)whereby on an annual basis the electricity used by the home is equal to or lower than the electricity generated on site.

Chapter 4. Photovoltaic Systems

4.1. Background

For this Retrofit Guide, a renewable energy resource as one that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal, wave power, and tidal energy). Not included as a renewable energy resource are energy resources derived from fossil fuels, waste products from use of fossil sources, waste products from inorganic sources, and nuclear power sources.

The two main renewable energy resources available at the residential level are solar thermal and solar electric. Solar thermal technologies capture solar radiation as heat which is used to heat water or other fluids, and can power solar cooling systems. Solar electric, or photovoltaic (PV) systems, generate electricity directly from PV panels when solar radiation hits a PV cell or panel. PV panels (a manufactured assembly of solar cells) are readily available for residential and commercial use, generally by installing arrays of PV panels on rooftops or parking structures. The City of Davis has some larger, community-scale PV systems installed on otherwise open land, independent of any buildings. This chapter is focused on residential rooftop solar thermal and photovoltaic (PV) systems.

4.1.1 Basic Description: Solar Thermal Systems

Typical residential solar thermal systems consist of a solar collector mounted on the roof, typically made of a dark metal heated by direct sunlight. When the collector is hot, a fluid passes through it and heat is transferred from the hot collector to the cooler incoming fluid. The fluid is circulated through a hot water storage tank, transferring heat to the water in the tank. The heat transfer fluid can be in a closed loop, using an alcohol, glycol or other liquid as the heat transfer medium, or in an open loop, directly heating the water from the water heater storage tank. There are several types of systems, including both passive and active. Details and logic for choosing the best solar water heater for Davis retrofits is beyond the scope of this document; that information can be provided by the appropriate contractors.

4.1.2 Basic Descriptions PV Systems

Photovoltaic cells convert sunlight directly into electricity through panels, the most important component of which is a photocell made of a semiconductor material (typically silicon). A portion of the sunlight shining on the panel is absorbed within the silicon breaking electrons loose and allowing them to flow freely. An electric field or fields causes the electrons to flow toward metal receptors at the top and bottom of the photovoltaic cells generating electricity. A PV panel is essentially a number of individual photocells in a framed-sandwich of glass cover and a bottom substrate; the cells are electrically connected in series and with positive and negative terminals for connecting to additional panels, and ultimately to an inverter.

4.1.3 Types of PV

Solar PV costs have dropped precipitously over the last decade due to advances in manufacturing and production, which have been strongly tied to GHG (reduction) policies, state and federal financial incentives, and local government policies. The National Renewable Energy Laboratory (NREL) reported in 2014 that PV system prices declined 6%–8% per year, on average, from 1998– 2013, and by 12%–15% from 2012–2013, depending on system size[48]. Individual system costs vary from state-to- state and within each state based on market size, sales taxes, labor costs, and the level of incentives.

In addition, the efficiency of solar PV panels has been increasing. Though solar cell technologies vary widely, most fall into three categories: thin film, polycrystalline, and monocrystalline.

Most residential systems installed today are panel systems containing crystalline solar cells. Crystalline solar cells are about the thickness of a human fingernail, and they use a relatively large amount of silicon. The silicon used to produce crystalline modules is derived from sand. Despite the broad availability of sand, it must be purified to an extremely high degree to be used to form semiconductor crystals that are sliced to make the photocells. The manufacturing facilities required to make crystalline photocells – purifying the substrate, and growing and slicing the crystals, requires a substantial investment – making them expensive to produce. However, these semi-conductor crystal substrates are also in high demand in the electronics industry because it is the base material for computer chips and other devices. The demand for these materials have driven the market to expand and find material and manufacturing advances, all of which have driven down the costs of crystalline PVs. Monocrystalline silicon boasts the highest efficiency rates, in the realm of ~18–20%, and the performance doesn't degrade as much as polycrystalline under warmer conditions, but it also costs the most.[49] This technology is the most popular for rooftops where available area is at a premium.

Polycrystalline silicon solar modules—familiar blue or black rectangular panels covered in glass—offer efficiency and costs between crystalline and thin-film. Their efficiency, in the realm of 15%, coupled with a mid-range price per module, makes them more attractive for larger applications.

In 2012,the market share for thin film was 11% compared to crystalline silicon (c-Si) at 89% (poly and mono combined), according to GTM Research. Thin film solar panels, which, until recently, tend to be lighter and cheaper than "traditional" solar panels made of silicon, can be composed of a variety of PV materials, including cadmium telluride, and have the lowest efficiency of the three categories, hovering around 12-percent for commercially produced modules. This lower efficiency requires larger areas of solar PV to achieve the same generation

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[48] Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections. National Renewable Energy Laboratory, September 2014. (http://www.nrel.gov/docs/fy14osti/62558.pdf)

[49] BIRAenergy, "Adding Photovoltaics (PV) to the 2016 Title 24 Energy Standards: An Economic Imperative, draft, August 2014.

capacity, and so thin film has gained the most traction for larger, land-based installations. However, recent advances, including improving efficiencies and decreasing module and balance of system costs—as well as some desirable properties, such as resistance to efficiency degradation under hotter conditions (e.g. on top of a house in Davis in summer)— made thin film attractive for certain rooftop applications as well, primarily large commercial rooftops.

4.2 PV and Energy-Efficiency

4.2.1 Loading Order – Efficiency and/or Generation

California entities that regulate efficiency and renewable energy programs have developed a "loading order" that prescribes a sequence for installation of technologies to reduce energy use in buildings. This loading order is: efficiency, demand-response, renewables, and distributed generation[50], based on an evaluation of the cost-effectiveness of these different technologies. This loading order was established to protect consumers and utility ratepayers by requiring state programs to follow this loading order.

As mentioned in the PV section of this document, the costs of PVs have dropped substantially since this loading order was first established. This program is designed to encourage homeowners to retrofit their homes with efficiency (including solar thermal) and/or PV (generation) systems. The impact of all these systems/technologies is to reduce the amount of energy used by the home, as measured at the gas or electricity meter (native energy), which results in reduced carbon footprint for Davis. This program is agnostic regarding the choices made by the homeowner to reduce the amount of native energy and resulting carbon footprint. It is important that the consumer be provided with accurate cost information so that they can made informed decisions regarding the incorporation of improved/increased efficiency measures and renewable generation (rooftop PVs). Beyond the program requirement that accurate cost estimates and best-estimates of energy and energy-cost savings be provided to homeowners, it is totally the decision of the homeowner which technologies, and the amounts and/or ratios of efficiency or generation to install as a retrofit. Thus this program does not inherently follow any loading order.

For maximum program effectiveness, PV should be combined with energy efficiency in every possible Davis home. New California 2013 Title 24 energy standards effective in July 2014 increased the energy efficiency of new homes built in California by an average of 27%.[51] This new update has dramatic consequences for builders throughout California. For most builders, squeezing out an extra 27-percent energy efficiency gain will require more innovation and highly scrutinized energy measures to ensure that these efficiency gains are achieved in the

[50]CEC Staff Report, 2005: IMPLEMENTING CALIFORNIA'S LOADING ORDER FOR ELECTRICITY RESOURCES http://www.energy.ca.gov/2005publications/CEC-400-2005-043/CEC-400-2005-043.PDF

[51] Goodrich Alan, Ted James, and Michael Woodhouse, "Residential, Commercial, and Utility-Scale Photovoltaic (PV) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities", NREL, 2010.

most economical combinations possible. As PV prices decrease, the increase in energy efficiency features required to get to and beyond California's Title 24 energy code (and to Zero Net Energy, or ZNE) will slow in exchange for PV, as it becomes more cost-effective than energy efficiency features. Other factors impact the ideal combination of energy efficiency and solar PV. For example, PV system size and roof availability (including the sectioning of roof areas, plumbing, chimneys and other penetrations that are obstacles to installing PVs, and shading of roof areas by mature landscaping) have huge impacts on the combination of technologies. Detailed cost/benefit analysis of whole house energy efficiency features should be weighed against the final installed price of the PV, which is directly dependent upon PV system size. System size is in turn influenced by the amount of roof available for the PV system, which is largely dependent on the orientation of the home, home design/architectural and related shading factors (please see the digitized solar maps that BIRAenergy did for the City of Davis (need reference). Due to the interplay of these numerous technical issues, energy modeling can be important to help the Davis builder/designer determine the right combination of EE and PV for them. The orderly addition and/or increase in efficiency measures is demonstrated for the Davis homeowners in the good, better, best packages that will be presented to them during the first group meetings. They can chose one of these packages, or work within the program to modify or design their own selections of efficiency and renewable energy technologies for achieving their goals in participating in this program. Computer modeling can be made available to assist the homeowners in these decisions, but simulating every home will increase program overhead, so use of the good, better, best packages, or modifications thereof is recommended. In addition, the simplest, least disruptive retrofit item would be to maximize the amount of PV on the roof.

4.2.2 Net Metering

Davis homeowners can benefit financially today from net-metering (aka net energy metering, or NEM) with their investor-owned utility, PG&E. Not only do they offset electricity consumption by generating their own electricity, but when their system generates more electricity than the home is consuming, excess electricity is transferred back on to the utility grid. That electricity is essentially sold to the utility which credits that back to the consumer. While the regulations and economics related to this metering can be complex, the bottom line is that residential solar PV system owners in Davis can reduce and sometimes eliminate their electric utility bills and generate electricity for the broader community. As described in Chapter 2, combining renewable energy generation on-site with more efficient use of energy pushes the home closer to the "Best" category, as well as toward zero net energy and zero carbon footprint.

4.2.3 Solar Homes: Higher Value, Sell Faster

A January 2015 study by Lawrence Berkeley National Laboratory (LBNL)[52] contains the most comprehensive analysis to date showing that consumers will pay a premium for homes

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[52] "Selling into the Sun: Price Premium Analysis of a Multi-State Dataset of Solar Homes", Lawrence Berkley Laboratory, January 2015 (http://emp.lbl.gov/publications/selling-sun-price-premium)

equipped with PV. They looked at sales data across eight states over a 10-year period that included other variables such as age, home condition, and local solar availability. After examining data from more than 22,000 home sales, LBL discovered that buyers are willing to pay $5,900.00 for each 1-kW increase in the size of the PV system.[53] Likewise, a National Bureau of Economic Research report[54] of home sales in San Diego and Sacramento Counties found PV systems added approximately a 3.5% increase in the sales price of an existing home, and the increases were even greater in more progressive areas of the counties due to the mere visibility of solar in the communities. This study also indicated that homeowners recover approximately 97% of their investment costs in solar *in addition to* the expected savings associated with reduced energy bills"[55]

4.3 PV Systems Components

4.3.1 PV Panels, DC, Inverter, Wiring

Different types of PV systems are discussed earlier in this chapter, noting that the predominant method of installing residential PVs are crystalline PV panels. PV cells and panels produce direct-current (DC) electricity that must be converted to alternating-current electricity to connect to the home's electrical panel and feed any excess electricity generated back through the electricity meter. The typical rooftop PV system consists of an array of panels mounted on the roof on rails or stanchions. The panels are connected in series and an electrical cable runs from the array of panels to an inverter typically located near the electrical box. The inverter converts the DC electricity to AC for integration into the electrical box. In its connection to the electrical box, the inverter is also connected to the electric meter; through this connection the inverter monitors the home's electrical system and if there is a break in the supply or availability of electricity at the meter, the inverter will electrically disconnect the PV array from the home (and meter). This is done to protect utility linemen who might be working on a portion of their electricity distribution system to restore power due to an outage – this automatic disconnect eliminates the possibility of electrocution of anyone working on the distribution system that they believe is not charged, and is not inadvertently charged by the residential system(s). There are special inverters that will both disconnect from the meter, but provide electricity to special circuits in the home, assuming the sun is shining. Battery systems can also be integrated into such systems to provide uninterrupted power to the home.

Some PV panels are manufactured with microinverters integrated into the panels. The output of these panels is AC electricity, and the electrical cable from an AC array can be connected

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[53] Need citation here for this 2015 report.

[54] "Understanding the Solar Home Price Premium: Electricity Generation and "Green" Social Status", National Bureau of Economic Research, July 2011 (http://www.nber.org/papers/w17200)

[55] "How much do Solar Panels Boost Home Sale Prices?", Ashlea Ebeling, Forbes, August 1, 2011. (http://www.forbes.com/sites/ashleaebeling/2011/08/01/how-much-do-solar-panels-boost-home-sale-prices/)

directly into the electrical panel.[56] Systems not connected to the grid will also require batteries and a stand-by generator in many cases.

4.3.2 When Electricity is Generated: Sunlight, Clouds, Orientation

Electricity is generated when the sun shines on the solar PV array. The orientation of the solar panels on a home is important. Davis is in the northern hemisphere and the sun rises in the east and sets in the west. Given this geography, and a roof tilt of 4:12 or greater, the south side of the building, and south-facing roof areas will have the greatest solar insolation. However, the differences between the insolation on south vs west or east facing roofs is less than 15%. So any roof orientation between 90^0 (east) through south (180^0) to west (270^0) are good for siting PVs. For homeowners considering time-of-use or some variety of real-time pricing for electricity, west facing roof areas might provide the best location for PVs because they will produce the most electricity in the mid- to late-afternoon, when electricity has the greatest demand, and is therefore the most valuable.

PV output will be reduced by clouds and anything that shades the panels. DC PV arrays are installed in series; if one panel is partially shaded, that reduction in electricity production is reflected in the outplut of the entire string. AC arrays are not so effected by shading – in an AC string, shading has only the direct effect of reduced output from the shaded panel. Other panels in the AC string are not effected by shading from neighboring panels.

4.3.3 What Happens When Electricity Goes Out?

When the primary source of electricity to the home is disrupted due to manmade or a natural disaster, or a brownout, most residential systems installed today will automatically and electronically disconnect at the inverter until external power returns and is sensed by the inverter (see section 4.3.1). There are special inverters that are designed to serve both the PV system and a battery system. During normal, sunny-day operation, the battery will be charged by the solar system and the battery system will discharge to supply electricity either when demanded by the home or at certain times programed into the battery system (e.g., to reduce electricity needed from the utility during peak afternoons). There are also some inverters that can provide a very limited amount of power to a single critical circuit in the home, should the utility power go down during daylight hours and there are no or minimal cloud cover.

4.4. Installations

4.4.1 Installed Over Roof – Type of Roof and Condition

Solar PV systems for residential use are installed almost exclusively on roofs because they provide convenient, available real estate for the panels. Roof-orientation is an issue, but not a large problem in the residential retrofit market. Of course, not every roof is built with their roof at the optimal orientation or pitch to produce the maximum amount of energy, but the PV systems are not terribly sensitive to either pitch or orientation (see 4.3.2). Each PV design and installation must consider the type of roof (flat, 12/2 pitch, or steeper), roofing material (asphalt

[56] http://energy.gov/energysaver/articles/small-solar-electric-systems

shingle or tile for example), and the design aspects of the home's construction which can affect the installation of wiring, the location of the inverter and other factors. Solar contractors will explain how they would install a system on a residence in Davis, considering home location, roof-type, shading, and any homeowner concerns about visibility of rooftop panels from the front of the home,

4.4.2 Orientation & Tilt – Effects on Generation

Orientation of the solar panels to the sun is important, but typically not a major issue in siting the solar array. Contiguous space and shading are likely to be larger issues. See Section 4.3.2.

4.4.3 Maintenance

PV systems require very little maintenance. The PV panels collect dirt, and can benefit from occasional rinsing; alternatively, they can be left alone and allow rain to rinse them. The most likely component to fail in a PV system is the inverter. A system inverter will typically last 10 – 15 years, and the homeowner should monitor generation as a method to monitor and verify normal operation of their PV system. Microinverters are warranted for 20+ years, but there is not sufficient field experience to know whether they will in fact last that long. Careful monitoring is required for microinverters because, unlike system inverters, which, when they fail will zero the production of the array they serve, each microinverter is part of a single panel, so for 10 or 20 panel AC arrays, a single failed microinverter will reduce the system output by only 10% or 5%, respectively. Electric breakers also fail over time, which can effectively disconnect the PV system from the electrical panel.

4.5 PV Ownership and Financing

4.5.1 Background

Third party financing has revolutionized solar purchasing over the past five years, further driving down the price of solar. When combined with state and federal incentives, third party models that allow consumers to defer long-standing upfront capital costs of solar PV and instead install a PV system with no money down have moved the market considerably. Solar City, a market leader in this approach and in market capture, actually offers incentive payments of $1,000 in many states to sign-up for a residential solar installation. Thanks to these third party arrangements, the financial community has taken notice, and solar PV enjoys new credibility—since the long-term power contracts that accompany these leases are securitized collateral and "bankable" well into the future—like home mortgages. As a result, the cost of capital has decreased for the solar industry as the perception of risk associated with solar projects has declined.

4.5.2 Owned

Most consumers new to the roof top solar market often assume that they must purchase and pay for the installation of their system. However, the California Solar Initiative found that in 2012 and 2013 more than two–thirds of residential installations in its program were owned by a third-party. Other studies have found this figure reflective of the industry in other states as well. The major benefit for the homeowner is that they can have a system installed without having to pay upfront costs, have operation and maintenance taken care of by the owner, and pay a fixed price amount not affected by fluctuating energy prices. The revamped California

PACE program is an excellent PV ownership model. PACE allows homeowners to purchase solar and energy efficiency equipment, by paying for 100% of a project's costs, which is repaid for up to 20-years via an assessment that is added to the property's tax bill. Therefore, the solar or energy efficiency improvement stays with the building, versus being transferred to someone else at sale.

4.5.3 Leased

Ninety-five (95) percent of new solar installations in many states, such as Colorado were made by third party leases recently, and other states, including California, are experiencing the same trend.[57] The two most common third-party financing approaches include leasing and power purchase agreements (PPA). In a leasing agreement the homeowner makes monthly payments to the leasing company based on what they calculate to be competitive electricity rates with the current electric utility provider, not the value of electricity generated by the system.

4.5.4 Power Purchase Agreement (PPA)

Under the PPA model, the homeowner buys all of the electricity produced by the solar PV system at an agreed-upon price over a set period of time, typically 20 years, which is typically sold to them by a third party (someone other than their traditional utility). In some PPAs, the cost of the power generated increases in steps over the life of the PPA.

4.5.5 Green Tariff Shared Renewables, Community Solar, and Virtual Net-Metering

With the potential advent of virtual net-metering, community solar programs, labeled "Green Tariff Shared Renewables" in California, can offer homeowners and residents of multi-family units and/or owned condominiums access to renewable energy, and specifically PV-generated electricity. Renters and homeowners typically cannot install a PV system on their roof and net meter the electricity produced because they do not have the authority to have a PV system mounted on the roof of the building, and/or have little to no space or solar access for a PV system. Virtual net-metering provides these households the opportunity to be credited on their electric bill for electricity generated and metered elsewhere by a large offsite PV array or "solar farm" PV system a portion of which they own or lease. Through the virtual net-metering, they are credited for the generation of their share of the PV system, even though that electricity is not associated with their home in any physical way. Community solar programs can be utility-owned systems or investor/developer owned systems. Community Solar programs are growing quickly in many portions of the country. California proponents of Community Solar are on hold as the industry awaits a final decision from the California Public Utilities Commission (CPUC) on how it will implement SB 43, which contains language pertinent to implementation of Green Tariff Shared Renewables (Community Solar systems) and virtual net metering.

[57] Regulatory Assistance Project presentation to the Colorado Energy Office as part of the "Cost of Solar" Collaborative, December 2013.

4.6 Additional Information and References

4.6.1 Interstate Renewable Energy Council

Best practice PV installation guides and related information is best found through the 32-year old organization, the Interstate Renewable Energy Council (IREC, http://irecusa.org), who accredits and credentials solar programs and instructors, and the North American Board of Certified Energy Practitioners (NABCEP, http://www.nabcep.org/) which credentials and certifies solar workers.

Chapter 5. Marketing to Neighborhoods

The prevalent approach to the residential retrofit market is to treat every home as unique; this approach is not compatible with the U.S. DOE goal of retrofitting over a million homes in the next few years, nor with The City of Davis's progressive 2050 zero-carbon goal. Rather, a mass market, volume approach is needed to increase homeowner participation in the retrofit program.

BIRAenergy principals conceived of this approach, and with support from the U.S. DOE and SMUD, they pioneered this approach to develop, implement and evaluate their neighborhood approach to existing home energy efficiency retrofits, through the Neighborhood Program. This residential retrofit program shares the same basic objectives and physical retrofit aspects of retrofits as typ1ical single family home performance programs, with the additions of:

1. Marketing the home performance retrofits to groups of homeowners with "neighborhood" connections;
2. Requiring contractors to implement procedures that result in volume purchases and thereby, lower costs; and
3. Utilizing and encouraging "neighborhood" (or any applicable social networking to increase program visibility, and recommendations of the program.

As compared with single-home retrofit programs, the neighborhood approach can produce a significantly higher level of market penetration of home performance retrofits by leveraging the social networks found in different neighborhood or other social groups. This theory was predicated on market research that home performance jobs are most effectively sold by word-of-mouth due to the high cost and the unfamiliarity most homeowners have with home performance retrofits. Additionally, a neighborhood approach provides the opportunity for economies of scale and efficiencies, when implementing numerous jobs in a neighborhood with near uniform construction and vintage.

5.1 Background

Supported by the U.S. DOE, the neighborhood approach was tested and evaluated in a few neighborhoods in the Sacramento area. This was done working with the Sacramento Utility District (SMUD) as the *Neighborhood Program* which was part of SMUD's larger *Home Performance Program* that focuses on one contractor, one retrofit at a time while the Neighborhood Program is intended to maximize the energy efficiency retrofit process through implementation at the neighborhood scale. The *Neighborhood Program* was first implemented as a single-neighborhood pilot, then expanded to six different geographic areas within SMUD service territory. A map with the geographic positioning of the pilot neighborhood and the five Subsequent Neighborhoods are shown in **Figure 1**.

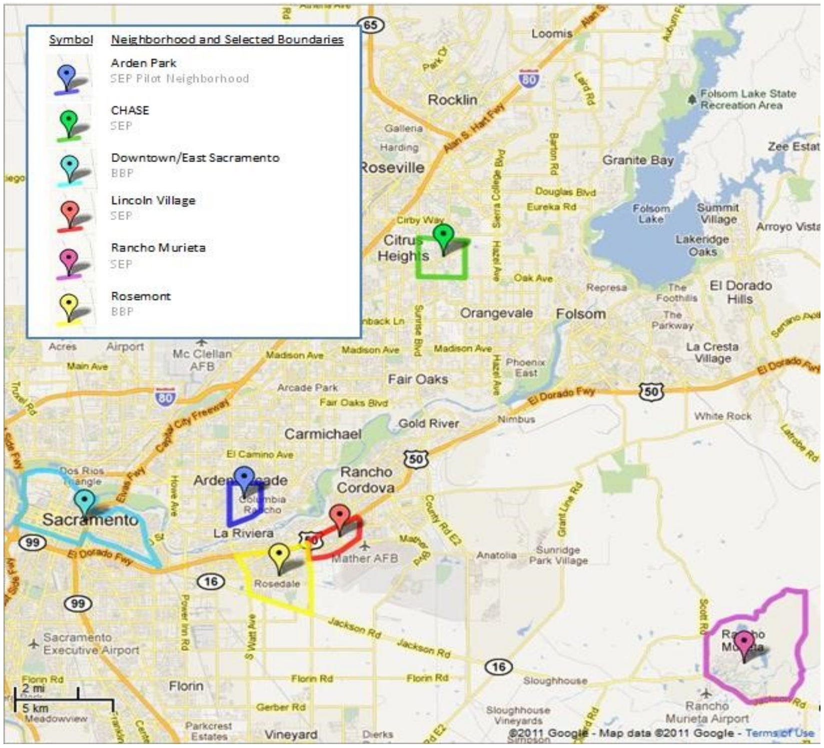

Figure 1: Program and Pilot/Subsequent Neighborhoods Geographic Locations

The Neighborhood Program development included the following steps:

- **Background Research:** Program development through research of other programs, compliance with state and utility requirements, and utility desired results. Research included review of program reports such as Better Buildings - Austin, Michigan and Seattle; 'LBNL Driving Demand' report; and 'NREL Review of Utility Retrofit Programs'. A full list of research documentation reviewed is provided under References section.
- **Neighborhood Selection:** Neighborhoods were selected for the study in concert with the utility, based on key criteria that included active social groups, utility defined income and energy use ratios, similar home construction/vintage characteristics, and utility district/ward coverage.
- **Assessment of the Selected Neighborhood:** Construction and vintage characteristics through online research and completion of up to five energy assessments of volunteer homes meeting the most common construction characteristics of the neighborhood.

- **Package Development**: Development of the performance-based "good", "better", and "best" packages. These also served as a visual marketing tool and representative examples to educate and elicit homeowner interest. (See Chapter 3)
- **Marketing Outreach:** Development and deployment of marketing collateral and neighborhood meetings to elicit homeowner participation.
- **Contractor Selection:** Competitive Request for Proposal (RFP) process for and choice of the contractor within each identified neighborhood; introduction of the contractor to interested homeowners through neighborhood meetings to educate and elicit program participation; and
- **Retrofit Implementation:** Completion of home performance retrofits. (See Chapter 6).

5.2 Program Development and Marketing Outreach Methods

Major Neighborhood Program activities included:

1. Defining target neighborhoods;
2. Researching target neighborhoods;
3. Assessment of the homes in the target neighborhoods;
4. Development of the performance-based 'good', 'better' and 'best' packages;
5. Development and deployment of marketing collateral;
6. Neighborhood meetings to elicit participation;
7. Competitive Request for Proposal (RFP) process for and choice of a single contractor for the neighborhood (Chapter 6);
8. Introduction of the contractor to participants; and
9. Performing the retrofits (Chapter 7).

Key program marketing elements included:

- Implementation of multiple marketing outreach methods;
- Creation of predetermined performance-based, "good, better, and best" packages for use as a homeowner education and sales tools (see Chapter 3);
- Design and implementation of a contractor RFP process to evaluate and engage contractor(s) who were capable of servicing multiple homes concurrently, while maintaining schedules and quality;
- Contractor offering of discounted, volume pricing.

1) *Target neighborhood research and neighborhood assessment:* Neighborhoods were as much (or more) determined by having homes with similar physical properties and characteristics, as they were based on any social networks. The homes within a target neighborhood were identified based on several variables that included: average age of homes, average square footage, neighborhood size, average household income level and presence of active homeowners association.

The homes in the Pilot Neighborhood were generally built in the 1960s, prior to California's adoption of an energy code for residential buildings. These homes range from 1,300 to 3,000 square feet in area. Household income is classified as above the average of SMUD's customer base. The neighborhoods were selected by SMUD using the criteria listed below with an additional emphasis paid to income ratio ensuring each neighborhood covered one of the following income levels: upper-middle, middle and lower-middle:

- Active Homeowners Association (HOA) (community involvement and influence)
- Income ratio (SMUD internal data analysis of customer base by census block)
- Energy use ratio (SMUD internal data analysis of customer base by census block)
- Age of homes (10 year intervals)
- Homes with similar construction
- SMUD district/ward coverage

Each criterion was examined, but those that held the most importance in SMUD's final decision were the existence of an active HOA and high electricity use. SMUD territory research revealed that active HOAs (those with community involvement and influence) were prevalent in older neighborhoods (less homogeneous - early 1960s and older) and newer neighborhoods (1990s and newer - more homogeneous and energy efficient homes). While newer homes provide the homogenous characteristics desired, older less homogeneous homes have a larger capacity for energy savings gain, which in combination with the other criteria accounted for the targeting of neighborhoods with older less homogenous homes.

2) *Package development:* Program experience demonstrated that the packages should not be considered static and should be utilized primarily as a tool to simplify the sales process for the contractor and homeowners. Therefore, the packages (detailed in Chapter 3) created for the neighborhood program, incorporated the most cost-effective improvements while providing each homeowner with the choice to customize the specific energy efficiency measures of their retrofit package, driven by various factors including homeowner's budget, and the needs of their home. These estimates were based on a home commensurate in size and general architecture with those in the neighborhood. The energy savings were calculated for the various packages against the baseline of a home typical of those in the selected neighborhood. The typical home pro-forma was developed based on a composite home reflecting the typical features and characteristics of the selected neighborhood.
3) *Development of marketing collateral and homeowner outreach:* The initial outreach was via the neighborhood HOA, using both traditional marketing channels (HOA newsletters and meetings, yard signs, door knob hangers, community events, meet the contractor

and energy educational meetings) and new media (web based channels and third party websites) to connect with homeowners and promote the program.

The HOA board members did not act as advocates as had been desired for optimum success; but a couple of them, after completion of an energy efficiency retrofit upgrade to their own homes, provided positive program testimonials during the second marketing outreach. Word-of-mouth testimonials, from satisfied program participants (including HOA board members), increased other homeowner's willingness to inquire about the program during the second wave of marketing which included more traditional marketing (direct mail postcard, door to door sales by the contractor) and new media (HOA social media approach – for example, used "Yahoo Group" to post homeowner testimonials) to promote the program. Due to the low initial interest during the first wave of outreach, the selected contractor was motivated to support a second wave of outreach to encourage additional homeowner interest. The combination of an initial market "softening" from the first outreach along with positive experiences and testimonials of the "Early Adopters" shows how "adoption takes time".

It was found that an initial awareness campaign and sign-up period would attract the early adopters, but is not sufficient, and therefore needs to be coupled with a longer term strategy in order to attract the remaining homeowners.

5.3 Marketing Methods – Pilot Neighborhood

There were two waves of outreach in the Pilot Neighborhood. The first wave of marketing outreach was eight months long. The second wave of marketing immediately followed upon the first, and ran for another 3 months. Details regarding each wave are as follows:

5.3.1 First Wave of Marketing Outreach

The initial outreach was via the neighborhood HOA, using both traditional marketing channels (HOA newsletters and meetings, yard signs, door knob hangers, community events, meet the contractor and energy educational meetings) and new media (web based channels and third party websites) to connect with homeowners and promote the program.

5.3.2 Second Wave of Marketing

The second wave of marketing included more traditional marketing (direct mail postcard, door to door sales by the contractor) and new media (HOA social media approach – for example, homeowners used a community based "Yahoo Group" to post retrofit testimonials) promoting the program.

The second wave of Arden Park outreach included the following:

5.3.2.1 Traditional Marketing

- Door-to-Door sales were employed. The contractor walked the neighborhood for a day and a half discussing the program with interested homeowners.

- A Direct Mail Postcard was devised to incentivize program participation by offering a free energy assessment to any homeowner who signed up by a fixed, near-term date.
- An interview testimonial of a satisfied homeowner was published as a lead article in the HOA's quarterly newsletter.

5.3.2.2 *New Media*

- Internet/Web-based Outreach was used in the form of a neighborhood-specific webpage, which was created to provide interested homeowners a means to sign-up for an energy assessment or speak directly with a contractor customer service representative.

An immediate spike in program interest after homeowners heard the positive early adopters' feedback. Once social marketing was introduced, over 30 homeowners contacted the contractor and/or the program managers to schedule an energy efficiency assessment on their homes. This second outreach resulted in 10 additional energy efficiency retrofit upgrades (twice the contracts compared to the original 5 retrofit contracts signed during the first wave of outreach).

The pilot neighborhood provided experience and lessons learned in marketing outreach that were implemented in the Subsequent Neighborhoods. Some of the initial lessons from the pilot neighborhood included:

- Target Early Adopters and Employ Speed to Market
- Use Testimonials for Auxiliary Marketing Outreach
- Adoption Takes Time
- Marketing Collateral is Important and Should not be total Static.

5.4 Marketing Methods - Subsequent Neighborhoods

In the neighborhoods subsequent to the pilot, marketing efforts increased in frequency and more support from the utility and local community groups was elicited and received. Some of the same marketing outreach and materials used in the pilot neighborhood were used, incorporating increased outreach frequency to ensure constant and regular customer contact building homeowner knowledge. Over the last six months, multiple marketing channels were employed including HOA meetings, door knob hangers, yard signs, community events, meet-the-contractor meetings, and third party websites to connect with homeowners and promote the program.

5.4.1 Traditional Marketing:

- Neighborhood Meetings/Events – Over 34 meetings and events were held throughout the five selected neighborhoods, which included HOA monthly meetings, community events (i.e. historic/energy efficiency community building restoration event, neighborhood picnic, community informational event), historic preservation society meetings, PTA meetings, and meet-the contractor meetings to promote the program and educate homeowners on energy efficiency.

- Door Knob Hangers and Yard Signs were distributed following key neighborhood meetings or events to ensure constant and regular customer contact building homeowner knowledge and interest.

5.4.2 New Media

- Internet/Web-based Outreach – The utility on its program website created neighborhood specific webpages describing the program, components of each neighborhood and selected contractor information. The pages were created to provide interested homeowners an online research medium for information on energy efficiency and program information.

Follow-up marketing strategies include:

- Targeted outreach to homeowners who completed an energy assessment but did not complete an energy efficiency retrofit upgrade reminding them about the program, educating them on the benefits and encouraging their participation.
- Through utility energy use data identify and target homeowners with highest energy use within the neighborhood, and create direct educational outreach towards those homeowners.

Homeowner outreach should continue until market saturation is achieved, which will take a number of years – the SMUD implementation was two years, which was insufficient to achieve even significant market penetration of retrofits.

5.5 Realistic Program Expectations

The Neighborhood Program is a more effective retrofit delivery mechanism and marketing strategy than the single-approach; the Neighborhood approach improves awareness of the benefits and importance of energy efficiency and thereby produces homeowner participation in energy efficiency retrofit upgrades at a neighborhood scale. However, this occurs over a time-scale of years.

While the neighborhood program is more complex and costly due to the significant number of homeowner communications and education, the additional exposure is necessary, at least in the first few years of program implementation, to allow homeowners to get up to speed on the program, services being offered and impact to their homes. Concepts and strategies learned through the neighborhood program can be applied to other similar utilities programs, towards achieving a higher market penetration rate.

For reference, in the two-year period during which the neighborhood approach was implemented in six neighborhoods, with program launch in the different neighborhoods covering a six-month period, the overall results for the program are as follows:

1) Following the launch of the Pilot Neighborhood, the time needed to approach near-term market saturation was still unknown. Before additional neighborhoods could be launched, the program was put on hold due to administrative delays associated with a new contract. This resulted in the loss of six months during the prime sales season leaving only early fall and the holiday months to complete homeowner outreach and education.

2) Approximately 20 months into the program, 24 homes have been retrofitted within four neighborhoods with an estimated total of 30 homes by the end of the two-year program duration. This number was lower than expected because of the following:
   - Administrative delays in launching the program and putting a replacement program administration contract in place - see 1) above).
   - Insufficient time spent in the neighborhoods - the pilot neighborhood showed that interest was just beginning to spread at the one year mark, and we suspect that a minimum of two years or more may be required to near the full potential of perfusion of adoption in a neighborhood.

3) The program met its objective of testing and documenting the results of various strategies that could enhance consumer acceptance of home performance retrofit services, evaluating the program's effectiveness, and determining a way to improve the program to increase both participation and energy savings per retrofit. The results and the related learnings are discussed further in 'Lessons Learned'.

4) The program achieved the goal of a higher market penetration rate (8 times higher) than the single family home performance program. While the neighborhood program is more complex and costly due to the significant number of homeowner communications and education, the additional exposure was necessary to allow homeowners to get up to speed on the program, services being offered and impact to their homes. Homeowners began proactively contacting the utility and contractors just as the program was beginning the close-out procedures.

5.6 Results - Homeowner Participation

1) *Neighborhood Approach Increased Market Penetration*: In the Pilot Neighborhood, the neighborhood approach achieved significantly higher penetration than the single family program. Arden Park was the first and only neighborhood targeted that had 18 months for program word-of-mouth to spread from the early participants (the longest of the additional five neighborhoods had less than half that amount of time). The table below shows that, despite the very short time in the market, the market penetration rate for completed home performance retrofits in the SMUD pilot neighborhood is 8 times the rate achieved in the single family home performance program. In addition, the Arden Park resident's rate of completed assessments was 11 times higher than the single family program.

Table 3: Program Comparison Results as of Nov-2011 (after 18 months in market)

	Single Family Home Performance Program	Neighborhood Program Pilot
Number of Potential Homes	329,000[58]	1,900
Number of Energy Assessments	742	50
Penetration of assessments	0.23%	2.62%
Number of Completed Retrofits	327	15
Penetration of completed retrofits	0.10%	0.79%
Average $/Retrofit	11,132	$11,268
Average $/Retrofit	$2,492	2,946

2) *Geographic Clustering and Effectiveness of 'Word-of-mouth' Marketing:* Social networks within a targeted community such as homeowners associations are a key outreach mechanism for engaging early adopters. Early adopters are already knowledgeable and interested, requiring less information and education. Early adopters become valuable marketing outreach resources for the community, through 'word-of-mouth' and other testimonials which lead to increased assessments and retrofit conversions. As shown in the map of the SMUD pilot neighborhood in **Figure 2**, geographic clustering of energy assessments and home performance retrofits occurs around early adopters and shows the significance of geographical targeting.

[58] *Source: A Profile of Older Adults in Sacramento County: Focus on Housing, 2006, U.S. Census Bureau, 2005 American Community Survey*

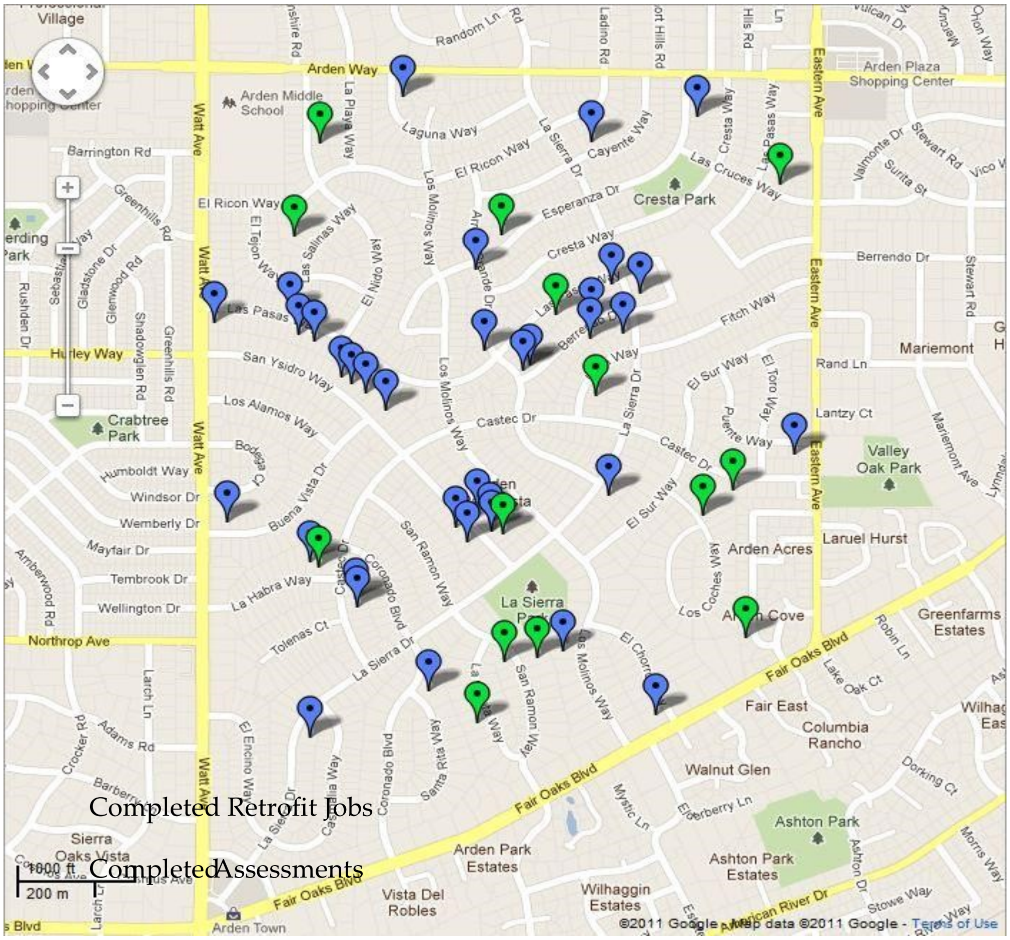

Figure 2: Map of Home Performance Activity in Arden Park (pilot neighborhood)

3) *Economies of Scale Advantage:* The neighborhood approach provided the opportunity to achieve the necessary economies of scale and efficiencies advantages (e.g. cost savings from cranes, bulk insulation, windows, etc.), when implementing many jobs in a neighborhood with somewhat uniform construction vintage and techniques. This could lower retrofit project costs further, with more experience with program coordination and providing contractors with a simple process to synchronize retrofit schedules to ensure timely and efficient use of resources.

4) *Selecting a Single Contractor Resulted in Reduced Job Costs and Eased Participation:* By competitively selecting a single contractor for each neighborhood in advance of marketing in the neighborhood, interested homeowners were relieved of the difficult task of identifying a suitable contractor from SMUD's list of over 40 qualified contractors. This further helped realize the benefits of economies of scale, since all jobs in a small geographic area were done by the same contractor. In addition, this approach provided a very clear trail to the responsible parties when there were any problems cited by homeowners, simplifying the differentiation between good, better, and best contractors.

5) *Neighborhood Incentives Catalyzed Retrofits:* Contractor efficiencies from higher job volumes in a neighborhood were passed along to homeowners in the form of neighborhood incentives or tier discounts of up to 11% in the form of cash-back incentives. The amount of discount was dependent on the contractor and number of participants within the neighborhood. While none of the contractor tiers (which would have provided additional cash incentives to homeowners) were met within the four neighborhoods, there was a perceived benefit to interested homeowners based on feedback received at neighborhood meetings.

Across the first four neighborhoods, 32 homeowners took advantage of the program rebates to complete their energy efficiency upgrades (i.e. signed contracts). The last two neighborhoods added to the program, and that benefited from lessons learned within the other four neighborhoods, had 30 signed contracts and 4 completed retrofits by the end of the 2-year run of the program. These two neighborhoods were provided an additional 18 months to meet their goal of 138 completed retrofits.

Table 4: Program Results as of January 31, 2012

Neighborhood	*Total Available Parcels GIS*	*Interested Homeowners*	*Energy Assessments Completed*	*Consultations Completed*	*Signed Contracts*	*Retrofits Completed*	*Dropped Out*
1 - Pilot	1906	55	50	30	16	15	6
2	3385	36	18	14	2	1	25
3	1771	30	15	6	3	1	5
4 (all-electric; no gas avail)	2171	71	39	32	11	7	31
5	7347	82	32	31	5	0	17
6	6573	104	83	75	25	4	28
Total	**23,153**	**378**	**237**	**188**	**62**	**28**	**112**

Only the initial pilot neighborhood had sufficient time for interest and participation to begin to propagate appreciably through the neighborhood. Out of the 55 homeowners who showed interest in the program, 91% (50 homeowners) took advantage of the home energy assessment and 27% (15 homeowners) completed energy efficiency retrofit upgrades to their homes. Overall participation rate (within the 2-year program duration) was approximately 1% of all homes, and higher considering only eligible candidates – an unknown number of homes in each neighborhood were vacant or rented. Based on current utility data, within the pilot neighborhood alone, the average Time Dependent Valuation (TDV)[59] energy savings was 32%, not including PVs.

5.6.1 Drop-Outs

Some homeowners who initially showed interest in the program did not complete the process. The main reasons homeowners dropped out of the program was related to economics. The highest drop-out rate of 52% occurred during the inquiry phase, while 26% dropped out after the contractor consultation. Even with the potential to receive significant rebates of up to $9,000 just over half of the homeowners dropped out during the program introduction phase. More time and effort should be put into educating homeowners on the short and long term benefits of retrofits.

Table 5: Drop Out Results as of January 31, 2012

	Drop Out Phase				
	Inquiry	**Assessment**	**Consultation**	**Retrofit**	***Total***
Arden Park	5	19	15	0	39
CHASE	15	3	7	0	25
Lincoln Village	15	3	1	1	20
Rancho Murieta	19	2	16	0	37
Rosemont	14	0	1	2	17
Downtown/East Sacramento	18	3	3	4	28
Total	86	30	43	7	166
	52%	**18%**	**26%**	**4%**	

5.6.2 Gaps and Barriers

The three most common gaps and/or barriers to participation communicated by homeowners to the selected contractors for both the Pilot and Subsequent Neighborhoods were lack of cash (homeowners claiming lack of discretionary cash and desire to hold onto existing savings due to economic uncertainties), bad timing (this program test period started in 2010, while the "great recession" was still an economic reality in the US, producing a very cautionary market and general avoidance of both taking on additional debt or spending available cash.

[59] Time-Dependent Valuation (TDV) is the new method for valuing energy in the performance approach in the '2005 Building Energy Efficiency Standards'. Under TDV the value of electricity differs depending on time-of-use (hourly, daily, seasonal), and the value of natural gas differs depending on season. TDV is based on the cost for utilities to provide the energy at different times.

URL: http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/tdv/index.html

5.7 Contractor Rebates

As part of the Neighborhood Program all contractors were required as part of the RFP submittal process to include a cash back incentive contingent on volume participation which was setup in the form of tiered discount percentages on a per package level. The idea was twofold: 1) Incentivize homeowner participation in the program by creating a system where as the number of participants increased so did the cash back incentive per homeowner; 2) Create a sustainable energy efficiency retrofit mechanism where homeowners receive non-government/utility funded cash incentives for completing retrofit work and contractors generate more work and jobs. The effective tier discounts by neighborhood (excluding the Pilot Neighborhood) are provided in the table below.

Table 7: Tier Discount Percentages for the Subsequent Neighborhoods

Tier & % Discount	Neighborhood	2	3	4	5	6
Good	1-9 retrofits	Base Price	Base Price	Base Price	Base Price	Base Price
	10-19 retrofits	1%	5%	4%	5%	2%
	20-29 retrofits	5%	10%	8%	8%	4%
	30+ retrofits	8%	14%	12%	11%	6%
Better	1-9 retrofits	Base Price	Base Price	Base Price	Base Price	Base Price
	10-19 retrofits	2%	5%	4%	2%	2%
	20-29 retrofits	3%	10%	8%	3%	4%
	30+ retrofits	4%	14%	12%	4%	6%
Best	1-9 retrofits	Base Price	Base Price	Base Price	Base Price	Base Price
	10-19 retrofits	2%	5%	4%	1%	2%
	20-29 retrofits	3%	10%	8%	1%	4%
	30+ retrofits	4%	14%	12%	2%	6%

5.8 Effective Marketing Strategy for Large Scale Retrofitting

The program design and implementation process provided valuable lessons in marketing outreach for retrofits that included:

1) *Target Customer Segments:* Utilization of a segmented marketing outreach approach enables various engagement messages reaching a broader homeowner pool and increasing homeowner education and commitment to energy efficiency retrofit upgrades. The segmented marketing encompassed a two phased targeted approach of early adopters and mass market.

2) *Mixed Marketing – Traditional and New Media:* The program benefited from frequent and detailed outreach through a combination of both traditional marketing (HOA newsletters and meetings, yard signs, door knob hangers, direct mailers, community events, meet the contractor and energy educational meetings) and new media marketing (web based channels and third party websites), and resulted in developing homeowner knowledge and interest.
3) *Homeowner Testimonials:* Testimonials proved to be an important and effective aspect of outreach. They provide interested homeowners with a valid proof of concept and encourage a sense of trust and legitimacy in the program and selected contractor.
4) *Utilize the 'Online Social Network':* Homeowners and community groups are well engaged with online technologies. The use of neighborhood social media including online newsletters, websites, 'Yahoo' groups and email groups was effective in transmitting testimonial information from early adopters/trusted community sources bringing legitimacy to the program.

5.9 Recommended Strategies and Lessons Learned

1) *Identify and Target Neighborhoods Strategically:* Spend time and effort identifying neighborhoods strategically and target these 'ideal' neighborhoods first. Some of the characteristics of these 'ideal' neighborhoods include:
    - Those with active neighborhood social networks, such as homeowners' associations with which a significant number of homeowners are actively engaged. It is important that the neighborhood organizations have an established and frequent formal communication channels such as monthly meetings, newsletters or email groups.
    - The emotional investment of homeowners in their neighborhood is also important. This can be identified by surveying homeowners regarding their satisfaction with their neighborhood, how long they plan to stay in it, and how active they are within their neighborhood.
    - Also identify trusted and credible community leaders to bring legitimacy to the program. Use existing neighborhood communication channels to reach homeowners and facilitate conversations about the program, supplementing other marketing strategies such as yard signs, door knob hangers, direct mailers, community events, meet the contractor meetings) and new media (web based channels and third party websites).
2) *Competitively Select One Contractor for Each Neighborhood:* Establish program qualification and/or certifications, ensuring multiple qualified contractors are available to homeowners at the time of homeowner outreach and interest. Bring the qualified contractors in early at the time of programmatic launch to ensure their readiness to begin educating homeowners and building credibility.

3) *Streamline Administrative Processes*: Policies and procedures for contracting processes, approvals, and checks and balances should be well outlined and streamlined to ensure that adequate time can be provided for the program to achieve its potential levels of

adoption. The ability to move fast is especially critical if total time is limited for a neighborhood home performance program. Higher levels of scrutiny present on this program and additional layers of documentation, approvals and requirements caused program set-up tasks to take up nearly half of the available time for the program, and also delayed approval of job scopes submitted by the home performance contractors. This was only a problem due to the hard-stop grant spending deadline and the finding that perfusion of adoption started to take off at about the one year mark.

4) *Adoption Takes Time*. Homeowners need time to absorb the information before committing, and all but the early adopters need significant time to be convinced by the experience of a peer that the service provides the promised benefits. It is important to understand that the adoption of any new product takes time to perfuse through a population, particularly if it is a complex and costly service such as home performance retrofits. As the Arden Park participation map shows, geographic clustering of energy assessments and home performance retrofits occurred around early adopters.
5) *Focus on Testimonials and Word-of-Mouth Outreach:* Traditional marketing channels are important, but home performance participation is most effectively fueled by 'word-of-mouth' outreach. Education and trust are key to homeowner participation. Homeowner testimonials in combination with brochures and referral bonuses offer other homeowners an important and effective form of outreach, bringing trust and legitimacy to the program, and serving as a valid proof of concept. For example - providing yard signs and brochures to satisfied participants will make it easier for them to share their success story with inquisitive neighbors.
6) *Tap into the Neighborhood Social Network Community Groups:* The strength of the neighborhood social network was the most important predictor of high participation in the neighborhood home performance program. It was critical to finding the early adopters, sustaining effective outreach efforts, and motivating the fence-sitters to commit to participate. Early adopters and trusted community sources brought legitimacy to the program.
7) *Utility Support and Involvement in Homeowner Outreach and Education is Key*: The utility provides existing community contacts, marketing outreach support and program validation. Utility presence positively impacts homeowner perception to see the program as a legitimate community service vs. a sales pitch. Direct marketing provided by the utility is critical to facilitate sustained outreach and education, but is secondary to word-of-mouth outreach.

Chapter 6: Meeting with Homeowner

The initial neighborhood / social group meeting should engender interest in retrofits from some individuals, typically the early adopters in the group. The presentation should employ the good, better best packages, on a home representative of those in this neighborhood/group. The presentation should explain the program, the interest from and benefits to the City of Davis, the costs and benefits of the program, possible financing vehicles, any utility or other incentives/rebates, and potential schedules for the retrofits. From the presentation of the good, better, best packages, the attendees should understand what work would be done under each package, and the approximate cost and benefits of each. They should understand the specifics of each package presented at the neighborhood meeting (discussed in the previous chapter), and that the estimates of energy and costs savings were derived using generalized information for that neighborhood and the sample packages (Chapter 3) tuned for the current neighborhood to market the program.

At the neighborhood meeting homeowners are encouraged to sign-up for a retrofit, and, if possible a specific package or performance level, based on the illustrative homes and the associated good, better, and best packages. At the close of the neighborhood meeting, homeowners are encouraged to sign-up to have the contractor visit the home to discuss the desired package (good, better or best), and/or to develop a different set of improvements specific to that home. Some attendees might be ready to sign a contract for the retrofit following this initial meeting, others will want more information. The next major step in the retrofit program is a follow-up visit to each interested-party by the Contractor. That meeting, which is scheduled to be at the convenience of the homeowner, in their home. It is important for the contractor to visit the home to inspect it for potential problems, to take measurements, verify equipment to replace, to measure performance of the heating and cooling system, and determine whether additional retrofits should be recommended.

As previously discussed, the neighborhood meeting uses specifications for a home characteristic of that neighborhood to develop the sample packages (Chapter3) tuned to generally represent the current neighborhood. At the neighborhood meeting, homeowners are encouraged to sign-up for a retrofit based on the illustrative homes and the associated good, better, and best packages. Following the neighborhood meeting, homeowners can sign-up to have the contractor visit the home to discuss the desired package (good, better or best), and/or to develop a different set of improvements specific to that home and that are desired by that homeowner. Regardless of whether the homeowner wants to go with a specific package or design their own, it is important for the contractor to visit the home to inspect it for potential problems, to take measurements, verify equipment to replace, to measure performance of the heating and cooling system, and determine whether additional retrofits should be recommended.

The focus of this Chapter is step 6 of the neighborhood approach: the contractor's visit to each interested homeowner. For reference, the major steps in the program are:

1. Identify target neighborhoods and social groups for group marketing;
2. Identify qualified contractors and train them on the program. Determine whether to assign single contractors for each neighborhood or allow free-market contracting. Determine best method to produce volume pricing for chosen contractor approach.
3. Characterize homes in the target neighborhoods and develop good, better, best packages for each neighborhood (for Davis: modify packages as appropriate for each neighborhood).
5. Hold Neighborhood / social group meetings to present the opportunity and benefits of energy-efficiency and solar retrofits

6. Contractor visit to interested homeowner to gather information needed to produce a correct cost estimate and get signed contract.
7. Schedule and perform the retrofit.
8. Continuously monitor and evaluate contractors regarding their customer relations and service, costs, and quality of work.
9. Continually monitor and evaluate program elements

6.1 Contractor-Homeowner Meeting – Finalize Package

The good, better, best packages presented at the initial homeowner meeting are excellent packages that are designed to be viable, and can be cost-effective (good and best, typically); however, they are not fixed packages that must be adopted by each participating homeowner. The homeowners can alter the packages as appropriate to their situations, but the minimum program participation should require that the efficiency features and/or solar systems desired as a custom package must meet or exceed the purchased-energy savings provided by the good package. It is an important outcome of this meeting with the homeowner for the contractor to encourage the homeowner to perform the maximum energy-efficiency and renewable energy package that they are willing to accept, because doing all the work at once minimizes costs and maximizes cost-effectiveness. When working with the homeowner to finalize their retrofit package, the contractor should develop a comfort-level for the homeowner with the final package and the specific upgrades in the package.

In summary, there are several purposes for and important outcomes from the contractor's visit to each homeowner interested in retrofits. They are:

1. Make homeowner comfortable with program, and comfortable and confident in the contractor
2. Collect measurements, equipment data, and performance data needed to refine energy and energy cost-savings for this home.
3. Discuss the desired retrofit package and any changes requested by the homeowner. Note that, to participate in this program, the homeowner must agree to retrofit the home to meet, at a minimum, the good package – the objective is to reduce non-renewable energy use in Davis residences as much as possible, based on encouraging homeowners to install as much energy-efficiency and solar as is practical and possible
4. Provide contract of services and changes to the home that will be done under the retrofit. This contract will include the costs of the retrofit, as well as a schedule of retrofit activities.
5. Contractor will advise homeowner regarding any repairs that should be considered (for health, safety, or home-value reasons) as part of the retrofit.
6. Contractor may explain to homeowner potential costs and benefits of additional efficiency and/or PV retrofit, if homeowner has interest; i.e., perform up-selling to interested homeowners.

6.2 Home Inspection and Tests

Prior to finalizing the retrofit package, it is important to perform certain home-performance diagnostics, and, if evaluating program effectiveness, to collect data needed to develop a baseline of home performance and things that affect the performance, prior to the retrofit, and again post-retrofit.

During the contractor meeting with the homeowner, a technician can collect the required data on the home, such as home exterior dimensions, equipment types, nameplate data, age and condition, as well as operational and maintenance practices, all of which are important to developing a solid baseline. If it is not desired to collect data and perform tests during the contractor-homeowner meeting, another visit can be scheduled to be performed later. If scheduled for later, it is recommended that the hiatus be short to minimize second thoughts regarding going forward with the retrofit.

Most of the features in the packages can be installed with only simple inspections prior to ordering materials and equipment – for instance water heater location, plumbing, and gas line size and location; furnace and air-conditioner location, orientation, access, and so forth. However, there are diagnostic evaluations that should be done on every home. These are: 1) the location, insulation and condition of the HVAC ducts, as well as the findings from a duct leakage test, 2) the location, depth, material and condition of the attic insulation, as well as attic venting; 3) envelope leakage, measured using a blower door or other similar device. These diagnostics will provide key insights into the need for improved attic insulation, duct replacement, sealing, and other potential air-distribution system repairs, and envelop sealing. These home systems have among the largest impacts on home energy use, comfort, and air quality, and should be evaluated as part of every retrofit.

Note that, when these detailed home evaluations are performed, it is imperative that proper safety practices be followed. This guide is not intended as a source of or guide to proper safety practices. The Contractor is responsible for properly training his staff and/or subcontractors to ensure that they follow all pertinent safety procedures. These include identifying by the age of the home whether asbestos is likely to be found in the home, and if so, how to identify it, how to avoid disturbing it, and determining whether its presence will need to be dealt with by a certified asbestos abatement professional. Other issues include safety practices around gas appliances, electrical panels and the like.

There are also home-safety issues that should be explored as part of the home inspection. These include back-drafting of gas appliances located in or around the home. Detailed diagnostics and test procedures are available for these energy-device-related tests from the California Energy Commission, the major energy-utilities, and Home Energy Rating systems providers.

Standard forms will be developed for all home evaluations, and contractors will be required to use the forms and provide copies to the City for audit and general program record-keeping. Such forms will be required for both the “test-in”, pre-retrofit evaluation, and the “test-out” post-retrofit evaluation.

Chapter 7. Energy Efficiency Retrofit Packages Specific to Client Home

1. Develop documentation for permit (Contractor)
2. For energy and bill savings estimates, use BEopt/EnergyPLUS or equivalent for modeling. Equivalency determined by documented calibrations of software against actual homes, using valid inputs, including MELs).
   a. This software has been validated by BIRAenergy and others and can provide accurate simulations. If possible, test model against bill data to ensure level of accuracy (set program requirement – need OH program element to spot-check models
   b. Do not use HERS2 or Code Compliance software -- not designed for retrofit – may not allow input of below national minimum efficiency equipment → cannot develop proper/accurate baseline, needed for cost/benefit calculations;
   c. Output can be inappropriate (other than for T24 documentation avoid TDV; need accurate site energy for bill estimation and savings).
   d. Do not allow simple tools (like RemRate - only use for national rating scale) – accuracy questionable; output inappropriate (normalized modified loads)
3. Experienced energy-modeler (trained and experienced in proper use of tool)
   a. Need to develop experience criteria for qualifying modelers. If not properly qualified, might as well not do detailed assessments.
   b. May require different companies to do modeling than those doing assessments.
4. Establish baseline values/calculations for certain variables, such as MELs (see chapter on MELs), MGLs (gas), rules regarding actual architecture vs simplifications, etc.. (Note: Software spec's, simulation rules, etc., need to be established as part of program development)
5. Establish local pricing for improvements – do not use NREL/BEopt default costs(for example)
6. Use data from assessments to model home(s)
7. With experience, develop recommended order of retrofit measures / improvements specific to this program
   a. Example order of improvements, from BIRAenergy experience: Air leakage; attic insulation; duct leakage; lighting; HVAC age, condition, efficiency; water heater age, condition, efficiency; faucet aerators, flow-restrictors (Skip any recently done, or not desired done by homeowner
   b. No sequence for addition of PVs – Homeowner wants or not – educated as needed to encourage; size as large as possible for situation (homeowner, costs, roof area)
   c. Review existing appliances' efficiency, age, and condition: Water heater; HVAC, ; duct location; roof/attic issues; windows; hot water plumbing (on-demand hot water pump system, e.g., D'mand)
   d. Take recently upgraded or replaced measures/equipment out of loading order and out of retrofit
   e. MELs: appliances, HEMs,

8. Adjust program ordering of measures choices based on experience, neighborhood, and program goals.
9. PVs can move up or down in "loading" order based on costs and consumer interest. See section on PVs.
   a. PV vendors can provide financing mechanism (leases likely; see chapter on financing options)
   b. Consumers may want visibility of PV system (early adopters; EE measures mostly not invisible)
   c. Costs widely variable depending on volume, type, installer, etc.
10. Other simulation issues to be determined by community research prior to program launch.
    a. Wall insulation when not known or visible, QII simulation practices, other envelope issues, solar hot water, recommendations, unless needed to reach top goals (e.g., ZNE)

11 Be prepared with a next-level upgrade package beyond initial choices; have simple up-sell readily available

Chapter 8. Quality Installations

1. Installation quality is paramount to achieve desired performance
2. ID Best Practices Guides for installations:
   a. Insulation, windows, air sealing, duct installation and/or sealing, etc.
   b. Often available from industry association, IOUs, industry training programs
   c. If possible, post on Program website or post links
   d. Use as basis for training and certifying installers, 3rd-party inspections and/or program QA professionals
3. Require commissioning of equipment by installers
4. Require inspections and/or testing of proper installations
5. Require on-going training of installers ("continuing education")
   a. based on Best Practices Installation guides and program experience
6. Use program website to collect information regarding installers / overall program
   a. Have short surveys sent to participants and on website
   b. Encourage post-participation evaluations
      1. Check literature for best methods
7. Quality Assurance mechanism is integral to program
   a. Third party raters or installers inspect and where appropriate, test all retrofit measures
   b. Program QA mandatory (significant percentage of installs inspected, declining over time?) by program staff or quality, independent contractor
   c. Have process built into program to suspend or decertify and disqualify inferior contractors and installers from participating in program

Chapter 9. Contractor Selection and Training Programs

1. Contractor Selection Process
   a. Use Quality Installation Guides for developing qualifications of contractors
      1) Licensing and Insurance requirements; good standing with CA State Licensing Board
      2) Required experience
      3) Required internal expertise
      4) Experience work with specific subs necessary to provide "best" package
      5) References – both from General and subs – check them out
2. Training and certification required for General Contractors and Installers
3. Research availability of existing training programs (PG&E, SMUD, CEC videos, other professional trainers
4. Provide training programs – need flexible methods and hours so that contractors can make time to attend
5. Choose existing, or develop new, training program for homeowners and their families
   a. Optional, but valuable
   b. Could opt-in program that encourages savings (avoid calling it conservation? YES!)

Chapter 10. Miscellaneous Electric Loads (MELS) and Occupant Behavior

1. What are MELS?
   a. Importance to ZNE
   b. Directly related to occupants' habits
   c. Lists of major electricity users—determined by audit?
   d. Standby mode vs. Off
2. Devices to reduce MELS
   a. Lighting
   b. Plug loads
1) Specific devices: e.g., power strips – different kinds
2) Programs to assist consumers
   c. Home Energy Management Systems

Chapter 11. Retrofit Financing Opportunities

This can be extracted from the BIRA-CSI Financing Report[60]

Chapter 12. Program Monitoring

1. Importance of monitoring and evaluating all key program elements
   a. Bad news broadcast more, further, stronger than praise

[60] www.biraenergy.com

2. Key elements to monitor:
   a. Message / messaging
      1) Main message and supporting marketing materials
      2) Interpretation and presentation of message and messaging
      3) Need updating and refreshing of messaging material to maintain interest and activity
   b. Market channels
      1) Where do homeowners go for information
      2) What websites; how direct homeowners to website?
      3) City of Davis promote program
         a) Information at public sites: building department, police, parking, etc.
         b) Signs on sides of local mass transit (buses)?
   c. Contractors: Quality
      1) Communication with homeowners
      2) Messaging consistent with program
      3) Following program processes, procedures, and rules
      4) Installations
      5) Follow-up

APPENDICES

APPENDIX C: Levelized Cost of Energy Calculator

APPENDIX D: Integrated Energy for Davis California

APPENDIX E: Solar Water Heating – Technical Training and Marketing Presentation Materials, E-1: Technical Training, E-2: Marketing and Financing Overview

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