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Renewable-Based Energy Secure Community Sonoma County

Task 5 Analysis and Modeling

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CLIMATE PROTECTION CAMPAIGN

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PREFACE

The Public Interest Energy Research (PIER) Program 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 PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

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Transportation

This report, *Renewable-Based Energy Secure Community Sonoma County Task 5 Analysis and Modeling Draft Report,* by the Climate Protection Campaign, is part of the PIR-08-038 project whose lead is the Sonoma County Water Agency. Information from this report contributes to PIER's Renewable Energy Technologies Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/researcg or contact the Energy Commission at 916-654-4878.

ABSTRACT

This report describes data analysis and modeling performed to establish renewable energy (RE) portfolios for the Sonoma County Renewable-Based Energy Secure Community (RESCO) project. In previous tasks, data regarding electricity use and energy supply alternatives were collected and integrated into database format and preliminary analysis identified energy use patterns and potential resource applications in Sonoma County. This report describes alternative renewable energy portfolios focusing on local resources including energy efficiency, combined heat and power, biomass, *solar photovoltaics*, and wind. The Sonoma RESCO Research Team developed these portfolios using various models, including a computer simulation tool called CLimate-Energy Assessment for Resiliency (CLEAR) created by Los Alamos National Laboratory. Another important product presented in this report is a refined "prototype," here defined as a systematic arrangement of design elements used to produce a cost-effective local renewable energy portfolio. This prototype draws upon concepts from *systems ecology* such as natural and artificial endowment of resources (for example, the sun and solar panels that capture the sun's energy), energy production and consumption, financial tools and transactions, analysis of flow rates of energy and money, energy service switching actions, community program goals, and systems of energy demand and production. This report also includes an analysis of site-specific opportunities for several local renewable resources, with special focus on expanding development of local combined heat and power to reduce energy system waste and thereby optimize *exergy*, the portion of usable energy in the system. The Sonoma RESCO Research Team developed methodologies for identifying "hot spots," areas of high electrical demand coinciding with favorable distribution grid characteristics and probable renewable energy deployment. A best-case portfolio of renewable resources is selected for a Sonoma County program including financial strategies that can support cost-effective development of the resources. The report also identifies barriers to implementation and opportunities for technology improvements and policy changes to surmount these barriers.

Keywords: renewable energy portfolio, data collection, energy data analysis, energy data maps, renewable generation site survey, local government, GIS, database, community choice aggregation, local renewable energy financing, systems ecology, combined heat and power, "hot spot", Sonoma County renewable energy resources, Renewable-Based Energy Secure Community, Sonoma County, RESCO

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EXECUTIVE SUMMARY

Introduction

This report presents local electricity resource options that can move Sonoma County toward the vision of a Renewable-Based Energy Secure Community (RESCO) program. Performance objectives for Sonoma County's RESCO are to:

- Investigate the use of local energy resources, including *energy efficiency* and *renewable energy*,[1] to meet community energy needs.
- Help Sonoma County to achieve state and local energy and climate policy goals.
- Provide the community with cost effective energy service options and local economic opportunities.

Three scenarios are developed in which eight local clean energy resources are combined in varying amounts to form *portfolios* that meet smaller and larger fractions of Sonoma County's electricity needs. One of these is selected as the best case, cost effective portfolio, which would meet 50 percent of the county's projected electricity demand in 2020 with local renewable energy, energy efficiency, and energy storage. Some of these resources have specific state policy goals, which are either met or exceeded by the best case portfolio.

A number data sources have been compiled to evaluate the possibilities for developing the RESCO resources, including:

- Local resource potential for solar, wind, biomass, and geothermal energy
- Electricity demand for the county, neighborhoods, and customers
- Data regarding existing and planned local renewable facilities
- Cost of energy sources and projected electricity rates

These various types of data are analyzed through the framework of a renewable energy *prototype*, which is a conceptual model used to support development of local renewable energy portfolios. The elements of the prototype model include evaluation of local resources, policy goals, electrical demand needs, financing tools, program alternatives, and cost analysis.

This report presents Task 5 of the Sonoma County RESCO project. It further develops the line of research that began in the Sonoma County Community Climate Action Plan (CCAP) in 2008. While the CCAP looked at energy supply to meet the entire county's electricity demand in the target year of 2015, RESCO focuses specifically on local resource, which only meet a portion of

[1] Technical terms appear in italics at first use and are defined in the Glossary.

the county's electricity demand. The Task 5 portfolios are based upon information that is more detailed and up to date than what was available for the CCAP. The RESCO portfolios are shown as unfolding over a decade, and have the target year moved out to 2020. The Task 5 report presents the updated RESCO portfolios in Chapter 3.

Additional data was provided through RESCO Tasks 3 and 4, such as an updated demand projection for Sonoma County, demand profiles for both the entire county as well as market sectors and substations. Most of this data has been provided by PG&E through a data request by the county, using its authority under state law to investigate developing a local community choice aggregation. The data collection and analysis in Task 4 was much wider ranging than just the demand profiles. A large part of the Task 4 report delved into using GIS tools to map potential target neighborhoods for concentrated development of RESCO projects, as well a discussion of potential modifications to the CCAP.

The Task 4 report also identified areas where data collection, analysis, and presentation, was not complete, and further work was needed. A significant portion of this activity was carried over into, and overlapped the scope of, Task 5, such as collecting information about how much local renewable energy has been installed in the county, quantifying the local renewable resources, quantification of relevant state and local goals for developing specific resources, and updated cost information.

The Task 5 work continued to use mapping tools, focusing on geographic information about local renewable resources and localized demand analysis. Certain resources, such as wind, geothermal power, and biomass, are highly specific to certain locations. The maps and quantification of these resources is presented in Chapter 4. Use of local demand profile data is explored in Chapter 5, which focuses on combined heat and power applications using micro distribution networks for the excess heat, in order to improve the efficiency of generating electricity.

These distribution networks, while they present significant technical and financial challenges to develop, also expand the potential for using waste heat from electric generation, improve efficiency of the use of fuel, and are an important tool for reducing greenhouse gas emissions. Furthermore, such distribution networks may be an important option for meeting the state policy target for combined heat and power, while also focusing development within Sonoma County.

Chapter 6 looks at programs to improve efficiency on the consumer side. While current efficiency programs focus primarily on single measures, such as rebates for efficient light bulbs or appliances, the RESCO team proposes moving to deeper savings that are possible through whole building retrofits.

Chapter 7 lays out a range of financing tools that can help support development of the RESCO resources. These tools are structured into an analytic model that includes four categories of financial support: upfront capital, ownership structures, revenue sources, and program design.

Chapter 8 presents conclusions, potential barriers and opportunities to developing large amounts of local and distributed renewable resources. The major opportunities to develop larger amounts of local resources assume the existence of local programs that support this development. In particular, a Community Choice program opens up the potential of having a locally controlled planning agency that has legal authority, revenue sources, and financing capability to implement the proposed RESCO portfolios and make use of the prototype tools.

Supporting analysis for the Task 5 report is provided in the report's appendices:

- Appendix A: Sonoma County RESCO Portfolio Resource Spreadsheets Description
- Appendix B: Cost of Electrical Generation in Sonoma County RESCO Portfolio

In all, the structure of the report itself, and the content of the chapters and appendices, map out a set of prototype elements that support development of local RESCO portfolios.

A glossary of terms and acronyms is included at the back of the report. The first time glossary terms appear in the report are noted in *italics*.

Purpose and Scope

The primary purpose of Task 5 is to determine how Sonoma County can move toward the vision of a Renewable-based Energy Secure Community (RESCO) through the following tasks:

- Create local renewable energy portfolio scenarios based upon a variety of collected data
- Test portfolios with a System Dynamics model called CLEAR, developed by Sandia National Laboratory
- Select a preferred portfolio
- Identify site-specific opportunities for local renewable energy development, based upon energy use patterns and/or resource availability in different areas of Sonoma County
- Develop a refined local renewable energy prototype structure for the select portfolio.

The prototype is a conceptual model of how community energy portfolios can be supported by the various tools that are described in this report. The analytic framework includes examining the availability of local resource, local energy demand profiles, and metrics for the cost effectiveness of using energy resources within the portfolios.

The purpose of the prototype framework is not to "determine" the quantitative amounts of each resource in the specific portfolios that are presented, but rather to evaluate, to the extent that relevant data could be found by the researchers, whether the selected amounts of local energy resources might be available and cost effective to develop within this decade. In this sense, the

three specific portfolios are "test points" using a low, middle and high case as a kind of stress test for local renewable energy development.

Another purpose of a prototype is to provide a "thought space" and set of tools to explore assumptions about goals and possibilities for local RESCO resources. The evaluation and quantification are not intended to be definitive, but rather exploratory. This is the fundamental concept of the prototype, that it maps out the areas of exploration that may be beneficial in order to develop local RESCO resources. This process is only carried to a certain point within this report, and there is much left for further investigation in the future.

In this regard, there are limits with respect to what the authors intended to be accomplished by the Task 5 report. It is not intended to be a feasibility study. Many aspects affecting feasibility are outside this report's scope, for example, evaluating difficulties in securing *interconnection* agreements. However, the report addresses certain elements of feasibility, such as making a provisional attempt to quantify local resources, and presents strategies to overcome feasibility challenges such as the lack of financing tools and portfolio options. Similarly, this report is not an engineering study for local renewable energy projects, although much of the report deals with topics that are relevant to engineering. Nor is this report an implementation plan for a local energy program such as a Community Choice Aggregation,[2] although the authors hope it may help to inform such a plan.

Policy Goals

The RESCO program includes a set of *qualitative goals* that are presented in Chapter 1, along with *quantitative goals* that have been researched, analyzed and presented in this report by the Sonoma RESCO Research Team. In addition to general goals regarding greenhouse gas reduction and renewable energy, some of the specific local resources also have quantitative goals that are based on Sonoma County's pro-rata share (about 1 percent) of existing state energy policy goals.

Three electricity supply portfolios each contain different amounts of eight types of local resources that are developed over the course of a decade, with a target year of 2020. Only one of these portfolios, Portfolio 3, which has the highest amount of local renewable resources, includes three select resources that reach exact adopted state policy goals: energy efficiency, combined heat and power, and biomass. A fourth resource, energy storage, reaches the proposed goal of Governor Brown's Clean Energy Jobs Plan, but this target has not been adopted by the state.

[2] Community Choice Aggregation (CCA) is a local government program that buys, and may generate and finance, electrical power for residents, businesses and other electrical utility customers of the entire community within their jurisdiction.

The state also has a policy goal for the California Solar Initiative, but Sonoma County has already far exceeded its pro-rata share of that program goal, a fact which is reflected in all the resource portfolios. In fact, discovery of the relatively large amount of already installed and planned local solar energy (40 to 50 megawatts) has important implications for deciding what amount of solar energy is reasonable for a future community development target, as well as how solar energy in local energy portfolios should be implemented (Table 1).

Table 1: Role of Quantitative Policy Goals in Portfolio 3

	Resource	Portfolio 3 Capacity	Pro-Rata Policy Goal	Match State Goals?
		MW	MW	
1	Efficiency	142.0	142.0	Yes
2	Solar PV (GoSolar/CSI)	85.0	31.0	Exceed
3	NG CHP	40.0	40.0	Yes
4	Geothermal	70.0	N/A	N/A
5	Biomass	30.0	30.0	Yes
6	Wind	25.0	N/A	N/A
7	Hydro	2.8	N/A	N/A
8	Storage	30.0	30.0	Not Adopted
	Total	424.8	273.0	

Quantitative policy goals for individual resources are only one factor in the development of the portfolios. Half of the eight resources in Portfolio 3 are not correlated to any specific quantitative policy goal, while Portfolio 1 and Portfolio 2 do not contain any resources that match state policy goals.

There are several reasons why these goals are incorporated into Portfolio 3. One of the overarching purposes of RESCO is to support achievement of these specific state policy goals. Furthermore, the division of state goals into pro-rata shares of smaller entities is general state policy. For example, utilities are required to meet their pro-rata share of the 33 percent renewable energy mandate and the GoSolar program goals.

The pro-rata share of state goals also is brought to into account when customers of a community choice program are required to cover their share of costs of state policy programs. These costs are included in a customer's bill, in the form of *non-bypassable distribution charges*, meaning all customers are required to pay. The state's quantitative goals can have direct relevance for calculating what amount of local development might be cost effective, since the local customers may have to pay for that amount of resource in any case. But Sonoma County may not derive the same economic benefits of a general utility program as would be the case if these resources are planned and developed locally, which a local community energy program could support.

For all of the above reasons, and because goals are a defining element of any functional system, quantifying existing policy goals is within the scope of the broad ranging data collection, analysis, and the prototype exploration space, relevant to designing local RESCO portfolios.

Methodology and Approach

There are several stages within the prototype space in which the local portfolio resources are embedded, of which policy goals is just one element.

1. Climate Plan: The original County Climate Action Plan (CCAP) portfolio is the starting point from which the eight resources are extracted. Conventional remote resources, meaning large hydropower, natural gas generation, and solar thermal power, have been excluded since they are not local to Sonoma County (Table 2).

Table 2: Climate Plan Portfolio Overview

Resource	Capacity MW	Capacity Factor	Annual Generation GWh	Percent of Supply
Hydro	113	49.9%	494	16%
Natural Gas	189	7.5%	124	4%
Natural Gas Cogeneration	58	85.0%	432	14%
Geothermal	125	90.2%	988	32%
Wind	71	34.8%	216	7%
Biofuel Cogeneration	58	85.0%	432	14%
Solar Photovoltaic	16	15.5%	22	1%
Solar Thermal	59	24.0%	124	4%
Energy Storage*	109	26.8%	256	8%
Total	798	44.2%	3,088	100%
Renewable Energy	438	53.1%	2,038	66%
* assumes supply energy from other renewable energy sources				

Source: Sonoma County Community Climate Action Plan

2. Practicality Screen: the quantities of each resource in the CCAP were modified according evaluation of other factors discovered or considered during the RESCO investigation. The discovery of 41 megawatts of already installed local solar photovoltaic power in early 2012 made the proposal for 16 megawatts of photovoltaics obsolete, but the general guidance of reaching for near 75 megawatts of total solar power was retained, but with the modification that all of it could be local. Development of 109 megawatts of storage, including a pump storage facility inside the county, was deemed infeasible within the 2020 timeframe.[3] Furthermore, the primary need for storage in RESCO is focused only on balancing power generation within the proposed local energy portfolios, which does not require 109 megawatts of storage. Thus, the storage goal was greatly reduced, and limited to batteries which could be placed at the same locations as small scale local generation projects. Another pragmatic consideration is that 71 megawatts of wind may be

[3] The feasibility of developing local pump hydropower as well as significant amounts of local wind generation was a concern expressed by and discussed with Sonoma County Water Agency staff, and these resource quantities were scaled back in response to the concern.

reasonable for Sonoma County's renewable energy mix, but may not feasible to develop locally by 2020. Thus, the local wind component was reduced to a fraction of the CCAP total quantity for wind.

3. Cost Screen: the resource blends were tested with cost screens, and in order to reduce the upside risk to higher rates, particularly due to the potential expiration or reduction of various tax subsidies in the 2014 to 2020 timeframe, some of the portfolio elements were scaled down. This was a factor in limiting the amount of geothermal, wind, biofuel, and energy storage that would be included in the local portfolios. Some of these factors were redundant to considerations in the other evaluation steps which lead to similar conclusions.
4. Resource Availability Screen: Data collected on Sonoma County's renewable resources revealed that the local solar, wind, geothermal technical resources are much larger than any amount of these resources that was proposed in the CCAP or considered for the RESCO portfolios. Thus, the resource potential did not play any further role in the portfolio design other than establishing physical feasibility. However, local hydropower resource is very small, which resulted in not considering expansion beyond what already exists. Investigation of the local biomass potential found a base case resource estimate sufficient to support up to 32 megawatts of power generation. Battery storage is not known to have any meaningful physical limit relative to plausible local amounts that are proposed in the CCAP or RESCO portfolios, although there may be other kinds of limitation such as cost, performance characteristics, and global manufacturing capacity, that affect specific storage technologies. The RESCO researchers did not find data to allow an estimate of total resource potential for combined heat and power (CHP), and local energy efficiency. Partly because of this data gap, the proposed local CHP development in the RESCO portfolios is significantly smaller than the 58 megawatts proposed in the CCAP.
5. Resource Policy Goals: As described above, policy goals for four of the eight resources were used to produce the 2020 target values in Portfolio 3, specifically for biomass, CHP, energy storage, and efficiency. Establishing a target of 30 megawatts for biomass represented a clear intersection between a policy goal and the base case resource potential. Data was also collected to determine the progress toward meeting these goals, to provide a reference point for feasibility in meeting the goals. This established that the CCAP proposal for 31 megawatts of local solar PV was far too modest.
6. Load Data: The overall RESCO portfolios required only limited evaluation relative to the load data, since the portfolio resources only meet a fraction of the demand. Portfolio 3 provides the largest amount of local resources, providing over 50 percent of forecast Sonoma County demand in 2020. The researchers created a spreadsheet model using substation data to test various amounts of local CHP and solar photovoltaics, the two generation resources that might be constrained by demand limitations on the distribution circuits. This screen was not used to determine the

specific amounts of local resources in the total portfolios, but rather as a test of whether distribution grid limits might be exceeded by the proposed *distributed generation (DG)*[4] resource mix. On the other hand, the load data was also used on a smaller scale to develop a methodology for identifying "hot spots" for concentrated local renewable energy development, and several such hot spots were identified by the RESCO team. This work was carried into Task 5 through a specific look at how to model demand a combined heat and power neighborhood heat distribution network, which is presented in Chapter 5. The reason this is important for the portfolios is that a) it may significantly expand the potential amount of CHP that can be developed in Sonoma County, which might be necessary to meeting the quantities of CHP envisioned in the portfolios, b) increasing CHP provides critical baseload to create a stable local energy supply as a balance to the intermittency of solar and wind, and c) CHP is an important strategy for reducing carbon emissions while providing a hedge against the downside price risk with natural gas.

7. Cost and Financial Support: The other important screen for resources is that they be cost-effective. This is achieved in part through deployment strategies, such as placing more expensive resources as on-site generation where they have the highest value because they are valued at the retail rather than the wholesale electricity rate. Cost is also used as a balancing factor in designing blended resource mixes in the whole portfolios. As mentioned above, cost is a major factor in why the portfolios have smaller targets for wind, storage, biomass, and geothermal than in the original CCAP, and why an earlier strategy for "maximizing" local renewable development were scaled back to a more modest preferred alternative of meeting 50 percent of Sonoma County's forecast demand by 2020. This goal is still very ambitious, but also greatly reduces a number of potential risks and technical challenges associated with even higher levels of reliance on local resources within this decade.

Local Renewable Energy Supply Portfolios

Task 5 presents in Chapter 3 a set of three energy portfolios that would deploy local resources over several years, reaching their targeted amount of local resources in 2020:

- Portfolio 1: Business as Usual, where historical development of resources continues; 15 percent of projected demand met by local resources (Figure 1).

Portfolio 2: Mid-case, Local Development augments historical programs. This Portfolio is assumed to be enabled by a Community Choice program; 30 percent local resources meet projected demand (

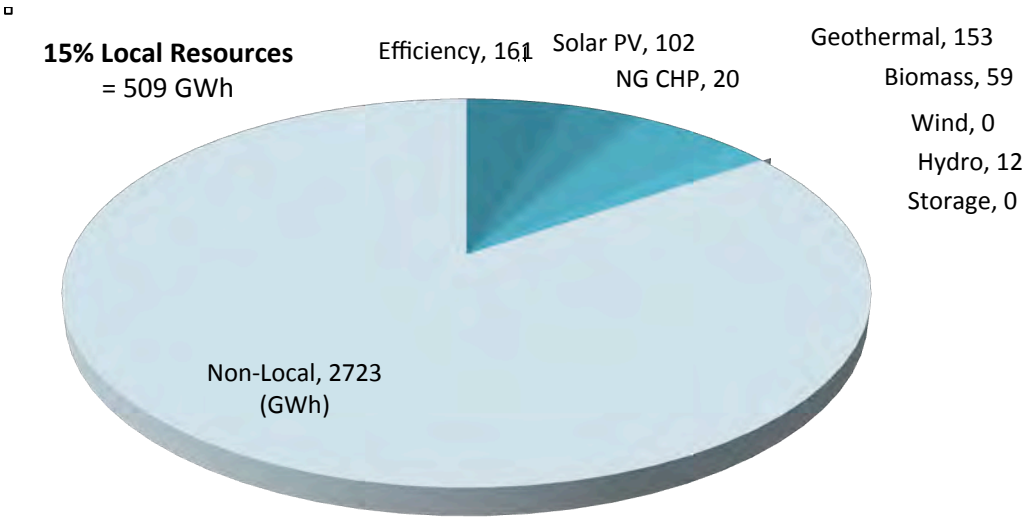
[4] *Distributed Generation (DG)* is defined as electrical generators, smaller than 20 megawatts, connected to electrical distribution circuits (rather than high voltage transmission), and that is intended to serve primarily local energy demand.

- Figure 2).
- Portfolio 3: High case, Community Energy Service Portfolio and Deployment, the preferred portfolio, where state and local policy goals are attained. This Portfolio is assumed to be enabled by a Community Choice program; 50 percent local resources (Figure 3).

The three portfolios focus on local resources including, energy efficiency, solar photovoltaics, geothermal-electric, combined heat and power, biomass, wind, and energy storage. Two other abundant local resources, offshore wind and wave energy, are evaluated, but are not in the local portfolios. These technologies are in early stages of development, with low probability that they can be deployed at significant scale by 2020.

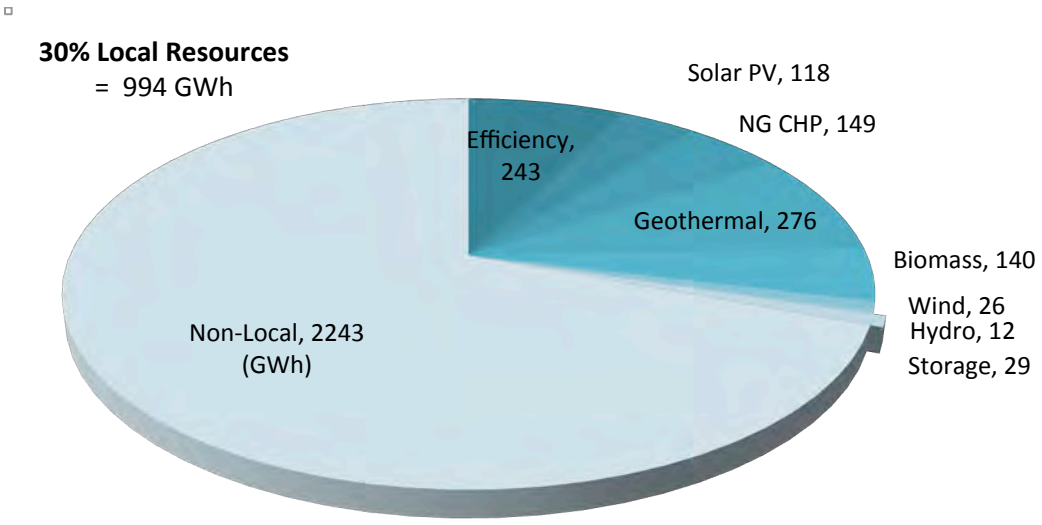
The proposed local resource portfolios supply only a part of Sonoma County's electricity demand. Therefore, remote, large-scale renewable generation and wholesale energy procurement are still needed in the near- to mid-term to support the attainment of Sonoma County's goals for renewable energy development and emission reductions, and to meet the county's electricity demand. The darker shaded areas in the pie charts are Sonoma County's local resources in each portfolio, and the lighter area is the balance of resources from outside the county. All quantities are in gigawatt-hours.

Figure 1: Sonoma RESCO 2020 Local Portfolio 1.
Low-Case Scenario — Business as Usual



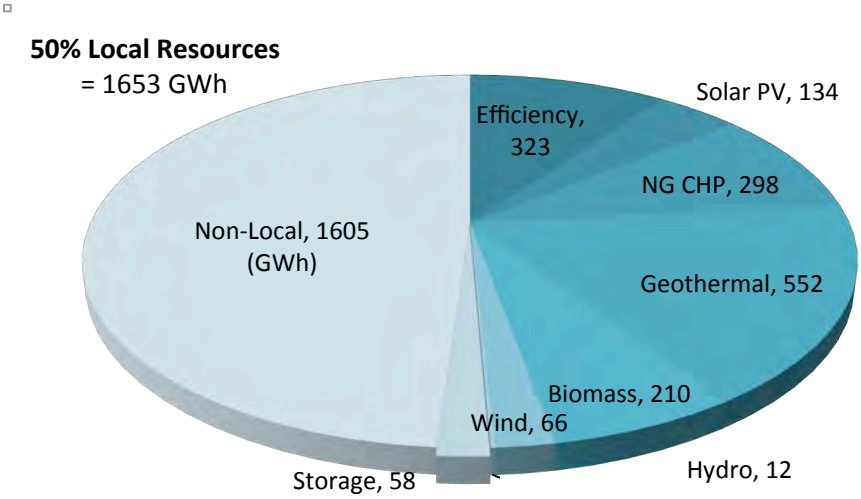
Units in gigawatt-hours (GWh)

Figure 2: Sonoma RESCO 2020 Local Portfolio 2.
Mid-Case — Community Program



Units in gigawatt-hours (GWh)

Figure 3: Sonoma RESCO 2020 Local Portfolio 3.
High-Case — Community Program



Units in gigawatt-hours (GWh)

In a year, Sonoma County consumes about 3,000 gigawatt-hours of electricity, which is approximately one percent of the demand for electricity in the entire state of California. By 2020, local electricity demand is projected to grow to about 3,200 gigawatt-hours if there were no utility or community energy efficiency programs. However, even in the business-as-usual case existing energy efficiency programs are expected to offset what would otherwise be an increase

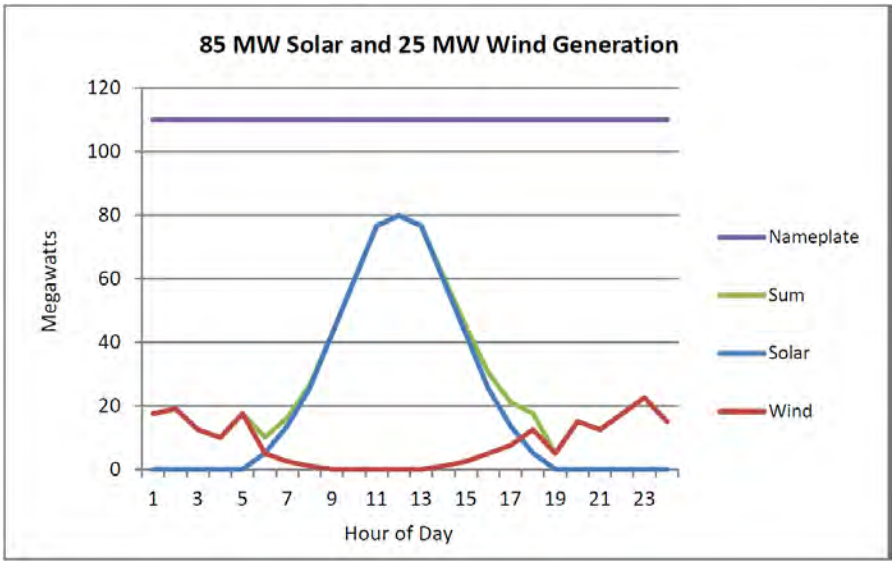
in demand. With more aggressive local efficiency programs, Sonoma County's electricity demand is projected to decrease in the RESCO model.

Another way to quantify these local electricity resources is in terms of power capacity, measured in megawatts. This is an instantaneous measure of the peak amount of power that each resource could produce, but in practice each resource varies considerably in the significance of this capacity measurement. For example, solar photovoltaics only produces its peak power for a brief period in the middle of the day, produces less power during other daytime hours, and generates nothing at night. On the other hand, biomass, combined heat and power, and geothermal generators produce relatively steady power round the clock that tends to be a high percentage—although generally less than 100 percent— of its rated peak power capacity.

Because generators, especially using solar and wind energy, rarely produce at full power, an energy supply for a community or utility may need significantly more peak generating capacity in renewables than the actual demand for that service area. Furthermore, the power capacity is not strictly additive between the various resource types. This can be the case when different resources produce power at different times of the day. For example, solar photovoltaics peaks at mid-day, while wind in California peaks in the evening and often produces very little in the middle of the day. Thus, at any given hour, the sum of solar and wind power production will normally be much less than the sum of the combined rated capacity of the generators.

The following chart illustrates this point showing 85 megawatts of solar photovoltaics and 25 megawatts of wind power, which is the mix of these two resources in portfolio 3, the high local renewable energy scenario. The combined nameplate capacity is 110 megawatts, but since the wind generators usually produces little or no power during the few hours of solar peak production, the solar peak alone represents the highest production of combined solar plus wind power during the entire day (Figure 4).

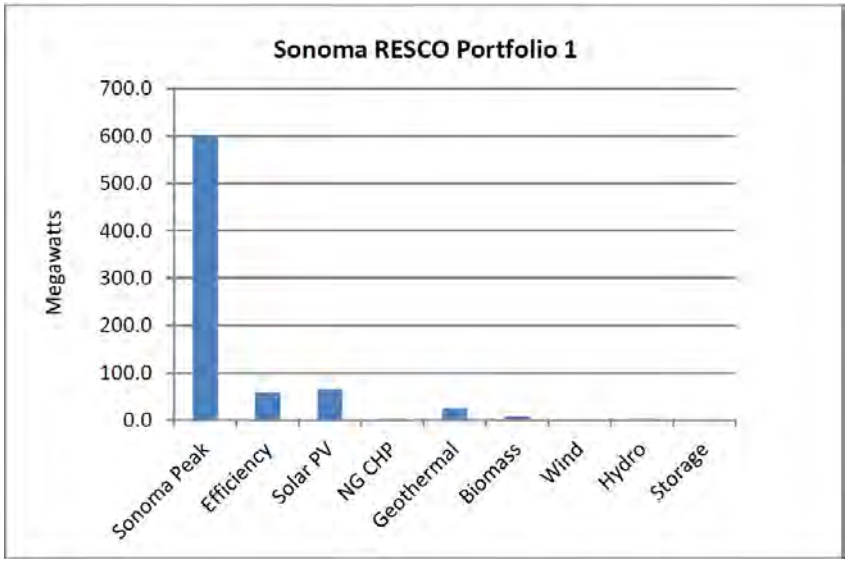
Figure 4: Illustrative Combination of Solar and Wind for Portfolio 3



Energy storage can act in a completely different manner by absorbing generation that is in excess of what may be needed at a particular time, and shifting the power to another time of day when there is more demand and less renewable power. An alternative, and sometimes less costly, way to compensate for excess intermittent renewable generation is either to curtail (reduce) the output for brief periods of time, or create increased demand for power at customer sites, using electrical controls.

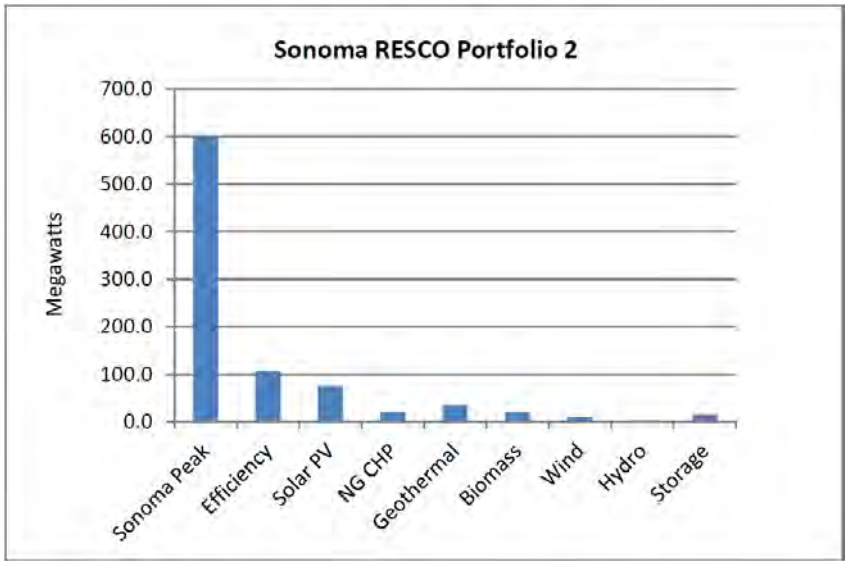
The following figures (5, 6, and 7) show the three portfolios in terms of peak capacity of each resource in 2020, with the approximate annual peak demand of Sonoma County provided for scale. While renewable capacity may exceed peak demand for the reasons given above, the actual portfolios of local resources are by design well short of the peak annual demand. This significantly limits potential technical problems from having a lot of local and intermittent electricity supply, while Portfolio 3, which is the preferred alternative, supplies an ambitious 50 percent of forecast energy demand in 2020.

Figure 5: **Sonoma RESCO 2020 Local Portfolio 1. Low-Case Scenario — Business as Usual**



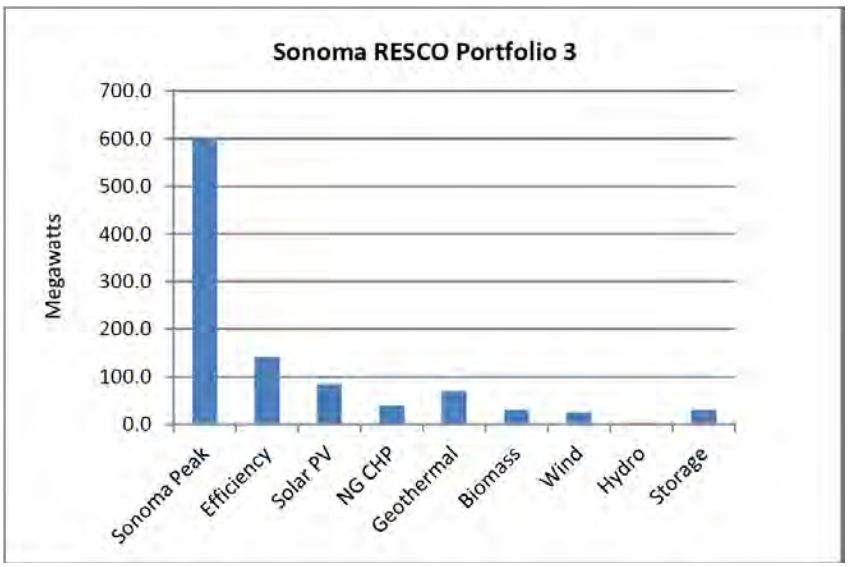
Meets 15 percent of Sonoma County Projected Electrical Energy Demand)

Figure 6: **Sonoma RESCO 2020 Local Portfolio 2. Mid-Case — Community Program**



Meets 30 percent of Sonoma County Projected Electrical Energy Demand

Figure 7: Sonoma RESCO 2020 Local Portfolio 3. High-Case — Community Program



Meets 50 percent of Sonoma County Projected Electrical Energy Demand

Local and Site-Specific Resources

To estimate the potential for development of certain types of local renewable electric power generation, (for example, solar, wind, *geothermal*, and biomass) the Sonoma RESCO research

team inventoried and analyzed available data. Some resources, especially wind, are concentrated in specific locations, while others such as energy efficiency and solar power are much more broadly distributed throughout the county. The intent was to determine the quantity of resources sufficiently to design an overall portfolio. Therefore, this renewable resource inventory is not exhaustive, nor did it include performing site-specific measurements, both of which are beyond the scope of this report.

The available data indicates that the local renewable energy resource potential is quite large, exceeds the total Sonoma County demand for electricity. More significant for the purposes of the RESCO project is that the technical potentials, particularly for solar photovoltaics, wind, and geothermal power, far exceeds the proposed development of these resources even in Portfolio 3 ("P3 Capacity" in Table 3 below).

Table 3: Estimate of Technical Potential for Select Local Resources

Resource	Location	Technical Capacity	Capacity Factor	Annual Energy	Share of County	P3 Capacity
		MW	%	MWh	% of MWh	MW
Solar Photovoltaics	Residential Rooftops	508	16%	712,013	22%	35
Solar Photovoltaics	Commercial Rooftops	308	16%	431,693	13%	50
Wind	Onshore	579	30%	1,522,663	47%	25
Wind	Offshore	307	30%	805,745	25%	0
Biomass (Base Case)	Sonoma County	32	80%	224,256	7%	40
Geothermal Power (New)	Geysers	300	80%	2,102,400	65%	70
Total		2,034		5,798,770	180%	220
Sonoma County Demand (2020)				3,221,000		

There is one renewable resource for which there is a significant question regarding technical availability in sufficient quantity to meet the requirements of the proposed portfolios, which is biomass. The RESCO evaluation found a very large range of potential values for biomass resource and electric generation, ranging from a low of 22 megawatts to a high of 103 megawatts. The table shows the "base case" estimate of 32 megawatts. RESCO Portfolio 3 has 30 megawatts of biomass development, which fits within the base case estimate. However, there is some downside risk on the resource potential such that obtaining this amount of biomass may not be feasible if feedstocks are constrained to what currently exists inside Sonoma County.

No development of offshore resources is proposed in the RESCO portfolios for 2020, due to the high cost of this type of energy, the early state of technology development, and the formidable political barriers to permitting, especially in an area that may become part of an expanded marine sanctuary. However, the offshore wind and wave resource is quite large. Only considering the offshore wind resource at two selected sites revealed 282 megawatts of potential that could produce nearly a quarter of Sonoma County's electricity. While only a small portion of the offshore wave potential could be tapped by existing technology, the raw power in the 80-mile wavefront averages over 4000 megawatts. If only 10 percent of this power could be tapped, it would be sufficient to supply all the electricity demand of Sonoma County.

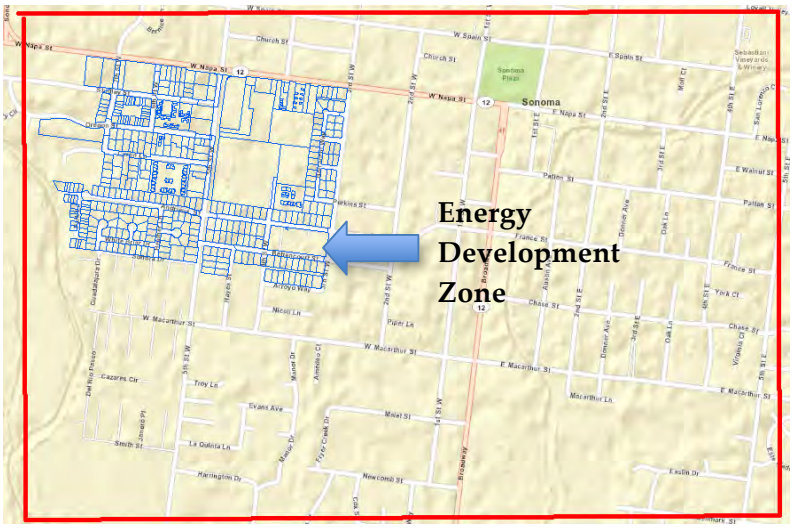
Community Scale Electric Demand Analysis

Initial modeling performed in Task 4 built upon the analysis of electricity load *profiles* or *shapes*, graphical representations of the variation in electrical load over time. Task 5 takes the analysis further by investigating the electrical load at the *substation* and more site-specific levels.

In this "*bottom up*" approach, the research team investigated energy demand in select neighborhoods. This analysis identified "*hot spot*" locations that had sufficient energy demand, favorable characteristics for local distribution infrastructure, and deployment potential for local energy resources based upon their demand profile. While the researchers originally hoped to have time to propose full distributed energy packages as initially examined in the Task 4 report, the local demand profile data analysis in task 5 focuses on the more limited scope of site-specific opportunities for combined heat and power to reduce energy system waste and thereby optimize *exergy*, the portion of usable energy in the system.

The design feature explored in this report involves combined heat and power generators that would be located at a customer site with high electricity and heat demand, and that serves as a core for extending a micro heat distribution network in neighborhoods that have high energy density in a relatively compact geographical area. While technically and financially more complex, a heat network system significantly increases the local potential for combined heat and power compared to the more typical "single building" approach. Furthermore, a blend of residential and commercial customers is carefully balanced to allow for more efficient use of electricity and heat than would be possible if the project only served a single customer (Figure 8).

Figure 8: Area of Interest 1 Energy Development Zone



The analysis of hot spots and potential energy development zones is one of the principle activities using the demand profile data collected in Task 3 and Task 4. The current conventional approach to local distributed generation is primarily market based, meaning projects are proposed by anyone who wants to build and pay for a facility. The planning simply

screens out projects that are considered to cause excessive problems for the distribution system, rather than engaging in a constructive way to figure out optimal configurations of distributed resources. Thus, the energy development zone is an innovative approach that may foreshadow and even become necessary in the future when much larger amounts of distributed generation are built. At that point the design, infrastructure and control mechanisms for distributed energy systems will need to be much closer to the present deployment of communications systems.

A second use of the local data was to take the substation demand profiles and test them against varying levels of local baseload from combined heat and power and solar photovoltaics. A year of hourly data for each substation was loaded into a spreadsheet, and structured to compare the load with hourly energy production data from a 500 kilowatt solar project owned by the Water Agency. A scale factor is applied to compare different amounts of hourly solar energy production against the substation demand profile to test for faults, which would be hours when more solar power is produced than there is demand on the substation distribution circuits. This test revealed that the total proposed 85 megawatts of solar photovoltaics plus 40 megawatts of distributed combined heat and power should not produce faults during the year. This test is limited by the fact that the data is only resolved down to a full hour, and that the demand data is for the full substation rather than each distribution circuit, but the results are nevertheless interesting.

Supporting the increased levels of local renewable resources presented in the Task 5 portfolios may also require resources that allow the electrical load to be modulated or "balanced," including energy efficiency, advanced demand response, and energy storage. For example, more efficient air conditioning and appliances can be targeted to address portions of peak load that are only partially met by solar energy, while storage can absorb excess power from distributed generation and fill in gaps created by intermittent renewables. While these features may prove important at high penetrations of local renewable energy, the researchers did not perform technical analysis of renewables integration, leaving this as a gap requiring further work in the future.

Finance Structures

Securing the necessary financial resources is essential for building local clean energy projects. The initial construction cost of energy infrastructure, including renewable energy systems, entails borrowing funds and finding suitable investors. The *upfront* investment usually carries an ongoing cost burden in the form of interest payments and profit payments to investors that, over the lifecycle of the project, might rival the initial construction cost. Thus, reducing financing costs can be a major tool for making renewable energy more affordable. Furthermore, certain financial and ownership structures can enhance the value of the energy resource, or reduce the cost to the general customer base of a community choice aggregation program.

Development of a cost-effective renewable energy portfolio depends on optimizing the use of finance structures; for example, project capital, ownership structures, cost-recovery methods. In the case of a Community Choice program, wholesale transactions should be evaluated against

their impacts on the wholesale cost of electricity, while customer self-generation projects should be measured against retail electricity rates. This bifurcated revenue stream, self-generation and wholesale community energy supply, is a crucial tool used to minimize financial burden and optimize value, as well as to evaluate cost-effectiveness.

Finance structures in the context of this report include four major system categories:

1. Obtaining initial funds to cover the up-front cost of projects; for example, equity investment, loans, bonds, and subsidies.
2. Ownership structures and options; for example, individual customer, public agency, public-private, third-party.
3. A financial value stream that can be used to recover the cost of upfront investment and pay for ongoing operations; for example, *net metering*, feed-in tariff, on-bill financing, community program revenues.
4. Program and commercial structures that create goals, engage in planning, and support the development of projects; for example, Community Choice, *Property Assessed Clean Energy (PACE)*, Energy Service Companies, Energy Service Providers.

Taken together, these four categories constitute a financing model for a community energy program, and this model is in turn embedded in the larger prototype system model. The four categories each include several different financing tools, some of which are listed above. These financing tools can be mapped to specific resources in the portfolios in various ways that often depend on current policy structure. For example, the state has policies to support solar photovoltaics through net metering and rebates, while the federal government provides tax subsidies for most renewable energy resources. The following table shows potential financing tools for each of the eight resources in the RESCO portfolios.

Table 4: Financing Tools for RESCO Portfolio Resources

	Capital		Ownership			Revenue				Program Structure			
Resource	Subsidies	Loan or Bond	Customer	Public or Hybrid	Third Party PPA	Net Metering	Feed-in Tariff	Ratebase	On-Bill Financing	CCA	State Program	PACE	ESCO
Efficiency	x	x	x					x	x	x	x	x	x
Solar PV	x	x	x		x	x	x	x	x	x	x	x	
NG CHP	x	x	x	x	x		x	x		x	x		
Geothermal	x	x		x	x			x		x			
Biomass	x	x		x	x		x	x		x			
Wind	x	x	x	x	x	x	x	x		x			
Hydro				x									
Storage	x	x	x	x	x			x		x	x		

Cost of RESCO Resources

One of the key scope requirements is to propose a cost-effective portfolio of local RESCO resources for Sonoma County. The evaluation of cost of energy for each of the major resources is presented in Appendix B. Cost input assumptions, for upfront capital cost, operations and

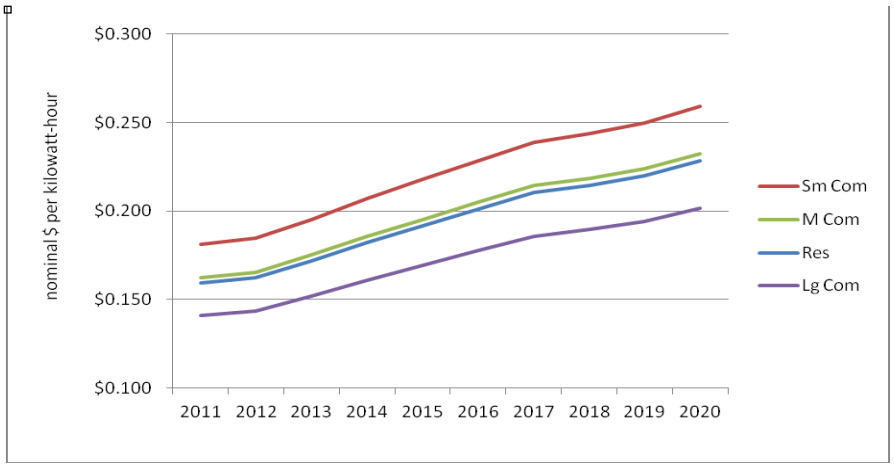
maintenance, fuel, and technology performance, were made based upon collection of data from a number of source, including several California programs and publicly available reports. The assumptions are input into a spreadsheet cost of energy model that is modified from an online tool produced by the National Renewable Energy Laboratory (Figure 9).

Figure 9: Sample Cost Model for Rooftop Solar Power

Residential Rooftop Solar Photovoltaics Cost of Electricity	
Financial	
Period (Years):	20
Discount Rate (%):	7.50%
Renewable Energy System Cost and Performance	
Capital Cost ($/kW)	$5,000
Capacity Factor (%)	17%
Fixed O&M Cost ($/kW-yr)	$60
Variable O&M Cost ($/kWh)	$0.000
Heat Rate (Btu/kWh)	3400
Efficiency	100%
Fuel Cost ($/MMBtu)	$0.00
Tax Benefits	
Investment Tax Credit (%)	30%
US Tax Rate	35.0%
State Tax Rate	9.0%
Utility Electricity Cost	
Initial Year Electricity Price (cents/kWh)	18.0
Cost Escalation Rate (%)	2.50%
Results	
Average Cost of Utility Electricity (cents/kWh)	23.0
Simple Levelized Cost of Renewable Energy (cents/kWh)	21.3
Net Balance (cents/kWh)	1.7

The resources are broadly divided into two groups. The first is small-scale generation that produces energy either partly or primarily for meeting a customers' own electricity demand. These include solar photovoltaics, and combined heat and power. In these cases, the baseline for measuring cost-effectiveness is the customer's retail electricity rate (Figure 10).

Figure 10: Projected Average PG&E Retail Electricity Rates by Customer Class, 2011 to 2020



By 2014 residential rooftop solar photovoltaics installed at $5.00 per watt of alternating current capacity will produce electricity at about 21 cents per kilowatt-hour. While this is significantly more than the average retail rate for residential customers in 2014, the average retail rate over 25 years of the photovoltaic project will be over 23 cents per kilowatt-hour, making the

investment cost effective. Electric rates for large commercial customers is lower, however, larger solar installations also cost less than residential projects.

On-site generation from combined heat and power generation, located at commercial buildings where there is large electricity demand, has an assumed average installed cost of $3.50 per watt, with scenarios assuming both high and low price for natural gas. Both cases were cost effective over the 20-year life of the project, but with a smaller margin when natural gas prices are high. The higher cost of on-site combined heat and power is partially balanced by the fact that utility rates are also increased by higher natural gas prices. Also, when natural gas prices are initially high, this makes it unlikely that the project will start off cost effective in the first year, and cost effectiveness must rely on a longer term benefit.

Another set of resources, including wind, geothermal, and biomass, are modeled as wholesale energy sources for a community choice program. In addition, half of the combined heat of power generation is purchased by the community program through a standard offer fixed price, called a feed-in tariff. This enables the generators to overbuild for their on-site needs which can significantly reduce the cost of energy. Alternatively, the project developers can leverage this benefit to add other features like energy storage and load balancing which can help a community energy program to support more local power generation.

Two scenarios are modeled, one assuming lower conventional wholesale electricity prices. In each case, the cost of renewable generation is shown both with and without currently available tax subsidies, to reveal the risk associated with depending on policies that may prove unreliable (Table 5). In the first scenario, the cost of renewable resources is 22 percent to 56 percent higher than conventional power. Although apparently expensive, customer rates only increase by 6 percent. This is because of two effects that dilute the high cost: the renewable energy is only one third of the electricity supply, and electricity supply is only half of the total utility bill.

Table 5: Cost of Resources and the Production Tax Credit
Low Avoided Cost Scenario

Resource	Rate	Share	Weight	Resource	Rate	Share	Weight
Baseline Wholesale Electricity Mix	$0.080	63.0%	$0.050	Baseline Wholesale Electricity Mix	$0.080	63.0%	$0.050
CHP Feed-in Tariff	$0.119	6.0%	$0.007	CHP Feed-in Tariff	$0.119	6.0%	$0.007
Geothermal	$0.098	20.0%	$0.020	Geothermal	$0.072	20.0%	$0.014
Biomass	$0.125	8.0%	$0.010	Biomass	$0.099	8.0%	$0.008
Wind	$0.116	3.0%	$0.003	Wind	$0.090	3.0%	$0.003
Total		100.0%	$0.091	Total		100.0%	$0.083
				PTC	($0.026)		
Retail Rate	$0.160			Retail Rate	$0.160		
Rate Effect	$0.011			Rate Effect	$0.003		
Rate Change	6.6%			Rate Change	1.6%		

The 6.6 percent rate effect assumes no tax subsidies, and can be mostly erased if the tax subsidies are utilized. In this case, the rate increase is reduced to 1.6 percent, which is supporting a conversion of one third of the electricity supply to local clean energy.

A second scenario assumes higher conventional wholesale electricity price of 10 cents per kilowatt-hour, close to what is projected by the Sonoma County CCA Feasibility Study by 2020. The net rate effect is reduced by half to 3.5 percent in the case where there are no tax subsidies, and in the case where current tax subsidies are utilized; the total cost of energy for the whole

portfolio is actually lower than purchasing the conventional electricity mix. By 2020, the large utilities assume that 33 percent of electricity is from renewable sources. Thus, the higher price scenario embeds includes these renewables, and implies a total resource mix of 66 percent renewables when both local and remote resources are included.

Conclusions

The Sonoma County RESCO Task 5 report presents a new, localized energy infrastructure paradigm that provides environmental and economic benefits for California's electric bill payers in the following ways:

- Protects against rising cost of electricity for utility customers on a long-term basis.
- Helps to stabilize rates in the midterm.
- Provides local economic development and jobs.
- Expands private enterprise opportunity in the energy sector.
- Improves grid system reliability and resilience.
- Enhances local energy security and independence.
- Increases local control and community participation.
- Offers a model to help achieve California's greenhouse gas emission reduction goals.

Sonoma County can meet a large portion of its forecasted electricity demand through development of local distributed and small scale renewables, combined heat and power, biomass, and demand resources such as energy efficiency, with substantial participation from the private sector and application of the right financing structures. The cost-effectiveness of meeting this demand is likely to improve over time as the cost of wholesale energy and corresponding retail electric rates increase.

There are barriers to increasing the amount of local renewable energy that can be integrated into a community electric energy supply. These barriers include near term cost and other financial issues, challenges in matching the power generation profile of renewable energy to electricity demand, and other characteristics of specific technologies (for example, intermittent availability of solar and wind power), limits to the architecture of the local distribution grid (for example, capacity bottlenecks), lack of access to high resolution local demand profiles, limits of local resource availability, regulatory and institutional barriers, and political challenges, as well as risk-averse attitudes and limited knowledge about how to accomplish high levels of local renewable energy.

Opportunities for increasing the amount of local renewable energy include the following:

- Establishing a community choice aggregation program to provide planning and financial tools for implementing portfolios with high penetration of local resources.

- Streamlining the process for distribution-grid impact evaluation of small-scale projects to greatly facilitate local generation. Small scale projects have been restricted by California Public Utilities Commission's Electric *Rule 21*, however, a revision to the Rule made in September 2012 may help to address some of the problems.
- Implementing efficient computer software tools that provide rapid analysis of distributed generation and distribution grid architecture.
- Integrating *smart grid* features (real time monitoring of demand on local distribution circuits coordinated with demand response and controls for distributed generation).
- Increasing the ability of inverters to engage in two-way communication in real time, and enabling receipt of grid services such as voltage regulation and curtailment instructions from a grid operator or automated system.
- Developing a more robust distribution grid to improve local power quality while also allowing much higher penetration of distributed generation.
- Implementing financial tools, such as on-bill financing, low interest loans, feed-in tariffs, and community purchase programs to expand deployment of energy efficiency and on-site distributed generation *behind the meter*
- Removing restrictions that prevent biomethane in natural gas transmission pipelines to qualify as a renewable energy resource, which would improve the cost-effectiveness, flexibility, and efficiency of using this fuel.
- Integrating energy storage with distributed generation projects

CHAPTER 1:
Introduction, Scope, Goals, and Background

Introduction

This report presents local electricity resource options that can move Sonoma County toward the vision of a Renewable-Based Energy Secure Community (RESCO) program. Performance objectives for Sonoma County's RESCO are to:

- Investigate the use of local energy resources, including *energy efficiency* and *renewable energy*,[5] to meet community energy needs.
- Help Sonoma County to achieve state and local energy and climate policy goals.
- Provide the community with cost effective energy service options and local economic opportunities.

Three scenarios are developed in which local clean energy resources are combined in varying amounts to form portfolios that meet between 15 percent and 50 percent of Sonoma County's electricity need. The portfolio with 15 percent local resources assumes no local program is developed to promote community energy resources, and that current development trends continue. The 50 percent local resource scenario assumes an aggressive Sonoma County community energy program, developed by a Community Choice Aggregation agency that can plan, implement, and provide various forms of financial support for achieving this goal.

Financial support can come in many forms, including improved net metering programs, standard offer purchases of local generation through feed-in tariffs, assisting customers with competitive pricing and bulk purchase of solar energy and other projects to lower cost, wholesale power purchases from larger renewable energy facilities, and use of public bonds.

Financing and other features that support development of the local resources are integrated into a prototype. In the context of this report, this prototype is a model incorporating a systematic arrangement of design elements used to produce a cost-effective local renewable energy portfolio. Thus, the prototype is a tool used for developing a portfolio.

The prototype is a conceptual model of how community energy portfolios can be supported by the various tools that are described in this report. Within this prototype framework, several features of developing local energy portfolios are evaluated:

- Physical availability and geographic distribution of local energy resources
- Demand profiles that allow for development of local generation

[5] Technical terms appear in italics at first use and are defined in the Glossary.

- Analyze opportunities for improving energy efficiency of electrical generation by capturing and using waste heat (increasing exergy, the fraction of useful energy)
- Look at program designs to increase energy efficiency in the consumption of electricity
- Present financing options that can improve cost effectiveness of deploying local resources
- Evaluate cost of energy and develop metrics for cost effectiveness of using local energy resources

The purpose of the prototype framework is not to "determine" the quantitative amounts of each resource in the specific portfolios that are presented, but rather to evaluate, to the extent that relevant data could be found by the researchers, whether the selected amounts of local energy resources might be available and cost effective to develop within this decade. In this sense, the three specific portfolios are "test points" using a low, middle and high case as a kind of stress test for local renewable energy development.

Another purpose of a prototype is to provide a "thought space" and set of tools to explore assumptions about goals and possibilities for local RESCO resources. The evaluation and quantification are not intended to be definitive, but rather exploratory. This is the fundamental concept of the prototype, that it maps out the areas of exploration that may be beneficial in order to develop local RESCO resources. This process is only carried to a certain point within this report, and there is much left for further investigation in the future.

Scope

The scope of work for Task 5, mapped to the content of this report, is as follows:

- Develop refined local renewable energy-based portfolios building on RESCO Task 3 and Task 4 data and analysis, and on the portfolio developed in the Climate Plan which was discussed in the Task 4 report; local portfolios are presented in depth in Chapter 3 and Appendix A, with cost analysis in Appendix B, and load analysis in Chapter 5.
- Test local renewable energy-based portfolios with the Los Alamos National Lab's CLimate-Energy Assessment for Resiliency (CLEAR) system dynamics modeling (Los Alamos National Laboratory 2012, Web--CLEAR Model)
- Identify site-specific opportunities for distributed generation based on energy use patterns and potential volumes for resource development in different areas of Sonoma County; on the demand side this is presented in Chapter 5, while locational information about supply resources is presented in Chapter 4.
- Develop a refined renewable energy prototype (the methodological tool used to develop the portfolios); this is embedded in the structure of the overall report and summarized in different places, including the presentation of the prototype model in Chapter 2.

- Prepare analysis and a modeling report that includes but is not limited to the following:
  - Data interface report that describe data interfaces and data processing used in the analysis; included in various places in the report, particularly Appendix A, Appendix B, as well as Chapter 5.
  - Identification of a "best case," cost-effective renewable energy-based portfolio for Sonoma County; this is presented as Portfolio 3
  - Report on barriers to implementation, including necessary additional policies, regulatory changes or technology improvements; this is presented in Chapter 8

The data and analysis for Tasks 3 and 4 is in different categories, and includes:

8. Demand data and analysis tools that provided load shapes for the county. This data has been used in a general way to assess the scale of Task 5 portfolio elements, as well in more detailed ways to provide the framework for analysis of the combined heat and power networks in Chapter 5, and the substation data to test combinations of solar energy and baseload distributed generation.
9. Intermediate analysis of the CCAP portfolio and projected additional data needs; this was introduced in the Task 4 report. A large amount of further data and information was collected in the course of Task 5 to continue the investigation and follow certain recommendations in the Task 4 report, including — among other things — the amounts of local energy resources already developed, current prices and cost structures for energy projects, current program goals, updated rate projections, and quantifying and determining the geographic distribution of local resources.

There was initial hope by the RESCO team to investigate these load data in a manner that would maximize local renewable energy, a task that would require a high degree of renewables integration and design work. However, the actual work on this data in developing the prototype heat district element in Chapter 5 proved very time consuming, leaving the research into this granular level of detail partly as a general conceptual model, but also with moderate level of detail about select specific areas where local energy networks could be implemented. This meets the defined scope requirement, but leaves much more to further investigation in the future.

Much of the effort in Task 5 was focused on filling in other elements that were needed to fulfill the scope of work, particularly creating the prototype and its elements, development of financial data and cost models, finding data on local resource potential, adding discussion of energy efficiency as a local resource, consideration of financing tools, and evaluating barriers and opportunities for local resource development.

This Task 5 report is not intended to be a feasibility study. Many aspects affecting feasibility are outside this report's scope (for example, evaluating difficulties in securing interconnection

agreements). However, the report addresses certain elements of feasibility, such as making a provisional attempt to quantify local resources, and presents strategies to overcome feasibility challenges such as lack of financing tools and portfolio options.

Similarly, this report is not an engineering study for local renewable energy projects, although much of the report deals with engineering topics. Nor is this report an implementation plan for a Community Choice program, although it may help to inform such a plan.

Task 5 is a *research project* that develops energy supply options and a more refined prototype for analyzing a community choice aggregation program. It aims to provide the connections among multiple disciplines necessary for developing local renewable energy resources at significant scale, including policies, program design, renewable energy technologies, natural resources, electrical demand needs, and financing.

Goals

In the context of a system, such as a renewable energy network, or a community energy program, goals are among the most powerful control elements that help to determine the operation of that system (Meadows 1996-2013). Development of the portfolio scenarios, the portfolio prototype, and the analysis performed in this Task 5 report is guided and based in significant part upon various goals.

The California Energy Commission set overarching goals for the RESCO program, shown below (California Energy Commission 2008b).

- Support California's Integrated Energy Policy Report and climate leadership in reducing greenhouse gas emissions (GHGs) and other policy goals (for example, RPS, CSI, and Bioenergy Action plan, etc.)
- Support the general goal of PIER Electricity and PIER Natural Gas Programs to develop and help bring to market, energy technologies that provide increased environmental benefits, greater system reliability, and lower system costs
- Provide RD&D support to communities committed to a clean energy future and accrue public benefits
- Support local government efforts to address climate and energy in their master plan
- Bring full menu of mature, viable, distributed RE technologies, products and services and related California RE resources into play by accelerating their commercialization and use in and by California communities in conjunction with complementary energy technologies and integrated solutions that include:
    - Energy efficiency and demand response,
    - Smart grid technology,
    - Energy storage,
    - Combined cooling, heating and power, and

    - Co-production of value-added products such as bio-fuels thus, making California's electricity and transportation fuels more diverse, safe, cleaner, and affordable.
- Reduce congestion at transmission gateways
- Stabilize energy costs for families and local businesses
- Create local jobs and keep energy purchase dollars and related tax revenues inside the community
- Protect the environment and tap economically exploitable local energy resources
- Improve quality of life in communities
- Consolidated and streamlined permits

With the emphasis on CCA, there is also an underlying goal of achieving energy autonomy, regardless of GHG reductions and renewable goals.

Quantified Goals for Sonoma County

In 2005 all nine Sonoma County cities and the County of Sonoma in 2005 set the greenhouse gas reduction goal of 25 percent below 1990 levels by 2015. In 2008, the Climate Protection Campaign in conjunction with Sonoma County local governments issued the Sonoma County Community Climate Action Plan (CCAP 2008) which described a package of the local measures to achieve the 25 percent target. The Sonoma County RESCO project is a means to help refine the plan to reach the 25 percent goal for the electricity that Sonoma County consumes.

For energy resources that have statewide targets, a proportional share of each California goal to Sonoma County. For these resources, the local target is calculated by multiplying Sonoma County's approximately one percent share of the statewide total electricity demand by the total statewide target.

Of the eight resources in the portfolios, four have specific adopted state goals: energy efficiency, solar photovoltaics, combined heat and power, biomass. Governor Brown, in his Clean Energy Jobs proposal, has also recommended a goal for energy storage of five percent of each utility's peak demand, but this has not been officially adopted by the state.

In addition to state goals, Sonoma County has also adopted a Solar Implementation Plan that proposes local goals for solar photovoltaics and demand reduction that was significantly larger than the state goals for these resources.

The other three resources in the portfolios, wind, small hydro, and geothermal power, do not have any specific state goal, but are broadly supported by the state's renewable portfolio standard which requires load serving entities, including electrical corporations, publicly owned utilities, and community choice aggregators, to provide at least 33 percent of their retail sales from qualified renewable energy resources by 2020 and thereafter.

1. Energy Efficiency (Sonoma County Goal: 323 GWh by 2020)

California Air Resources Board has adopted the Climate Scoping Plan, pursuant to AB 32, the state's Global Warming Solutions Act, setting a target of saving 32,000 Gigawatt-hours of electricity by 2020; these savings are incremental to efficiency savings that are already assumed in the Energy Commission's 2007 official demand forecast. This goal represents a savings of approximately 10 percent of forecast statewide demand in 2020, and the 10 percent savings is scaled to Sonoma County's projected electricity demand for 2020 and estimated by the Sonoma RESCO Research Team to represent 323 gigawatt-hours of local energy efficiency savings in 2020.

Based upon projections from the Energy Commission, Public Utilities Commission, and PG&E's Long-Term Procurement Plan, the Sonoma RESCO Research Team estimates that PG&E would meet approximately half of its proportionate share of the state's Climate Scoping Plan; however, no data has been found regarding the specific amount of efficiency savings that might be attained in Sonoma County from existing programs.

2. Solar Photovoltaics (Sonoma County Goals: GoSolar Program 31 MW by 2017; various other specified programs and goals)

California's Million Solar Roofs (SB 1, Murray, 2006), renamed GoSolar, set a target of building 3000 MW of new on-site solar energy by 2017. This target is also incorporated as a policy goal in the state's AB 32 Climate Scoping Plan, representing a reduction of about 2 million tons of CO2 per year in 2020. The GoSolar target is implemented as self-generation that is net metered on customer sites; this generation is considered to be separate from, and has carbon reductions additional to, the state's 33 percent Renewable Portfolio Standard for 2020. Sonoma County's share of this statewide goal is approximately 31 MW.

California has several programs that implement construction of distributed solar photovoltaics. The SB 32 Feed-in Tariff, IOU Solar Program, and RAM program are all subsumed under the Renewable Portfolio Standard program, and the local proportionate share of these combined programs was initially estimated to be about 30 MW; however, this did not account for the fact that the IOU programs are not statewide. A corrected estimate is likely to be closer to 38 MW.

Only two of these programs, the CPUC's Investor-Owned Utility Solar PV program, and the GoSolar/CSI, are specific for solar, and thus contribute specifically to the overall policy target for solar. However, a majority of the generation capacity built in the other programs is also expected to be Solar PV. This table, from the RESCO report, summarizes these program targets and Sonoma County's proportionate share (Table 6).

Table 6: Pro-Rata Share of Existing and Proposed California Renewable DG Programs

RDG Goals		GoSolar	SB 32 Feed-in Tariff	IOU Solar Program	RAM	Legacy SGIP, ERP	Subtotal Existing Programs	Governor Brown's Target
State Goal	MW	3,000	750	850	1250	285	6,135	12,000
Sonoma County Share	MW	31	8	9	13	3	64	125

Source: GoSolar program data, California Public Utilities Commission, California Energy Commission, Gov. Brown's Clean Energy Jobs Program (California Office of Planning and Research 2011).

In the specific case of solar photovoltaics, the proportionate share of certain policy goals and/or program implementation have already been met in Sonoma County[6], and thus all three of the Portfolios assume that some of these specific targets will be exceeded. Through the GoSolar/California Solar Initiative, over 30 MW of solar PV have been installed in Sonoma County by early 2012, meeting Sonoma County's share of the state program goal years in advance of 2016. State data shows that Sonoma County has also installed an additional 11 MW of net metered solar PV through two other state solar rebate programs: the Self-Generation Incentive Program (SGIP) and the Emerging Renewables Program (ERP). This far exceeds Sonoma County's proportionate share of these programs which would be only about 3 MW.

For the RPS-eligible programs, PG&E data shows that the utility already has contracts in the feed-in tariff program for about 7 MW of solar PV capacity in Sonoma County.[7]

3. Combined Heat and Power or CHP (Sonoma County Goal: 40 MW by 2020)

California Air Resources Board's adopted AB 32 Climate Scoping Plan includes a target of adding 4000 MW of new combined heat and power by 2020, providing 30,000 gigawatt-hours of electrical generation. Sonoma County's proportional share of this goal would be 40 MW generating approximately 300 gigawatt-hours per year by 2020. The state's policy goal for combined heat and power is incremental to the renewable portfolio standard and the energy

[6] Goal described in *Sonoma County Solar Implementation Plan*, (Solar Sonoma County 2012)

[7] Some programs do not have policy goals (for example, SGIP and ERP), and most of these programs are not limited to solar (for example, SGIP, ERP, SB 32 FiT, RAM). The 31 MW GoSolar share is *not* the Sonoma RESCO goal, but it is derived from *a state policy goal* that is incorporated as a fraction of the solar in the portfolios, and the GoSolar program is specifically responsible for helping to fund most of the solar in Sonoma County. In fact, photovoltaics in the RESCO portfolios are not currently tied to the exact value of any specific policy goal or any combination of them. As the text explains, all the portfolios assume that the policy goals (other than the very high goal of the Sonoma Solar IP, which is presented separately to avoid confusion with the narrative in this section) will most likely be exceeded. Unfortunately, making solar in the portfolios conform with policy goals is a problem due to the outstanding local performance of the existing solar programs in Sonoma County, where performance is likely to overtake goals (exceeding solar goals is okay, especially if it results in achieving goals in another category, such as GHG reductions. So rather than analyzing solar goals to death, we should say that we exceeded those, because solar is the least offensive RE technology to develop and therefore is the cornerstone to achieving a strong RE portfolio for Sonoma county.).

efficiency target cited above. Therefore, we assumed for the portfolios that this combined heat and power is primarily fueled by natural gas.

State data shows Sonoma County with 2.7 MW of existing combined heat and power. Considerable uncertainty exists regarding the feasibility of building 40 MW of local combined heat and power by 2020. The Sonoma RESCO Research Team has not found a comprehensive public inventory for local resource potential. Further, PG&E did not comply with a data request for site-specific natural gas meter data, creating a significant data gap. Without this data, the uncertainty for implementing Portfolio 3 increases. This is one of the reasons the mid-case portfolio is presently considered to be more feasible for a CCA.

4. Biomass (Sonoma County Goal: 20 percent of Renewable Portfolio Standard)

Governor Schwarzenegger issued Executive Order S-06-06 establishing targets for biomass in California, with a specific target for electrical generation: "Regarding the use of biomass for electricity, the state meet a 20 percent target within the established state goals for renewable generation for 2010 and 2020." (G. A. Schwarzenegger 2006)

This same target is reiterated, and developed in much greater depth, in the state's 2011 Bioenergy Action Plan (Bioenergy Interagency Working Group 2011). The state's overall renewable generation target for 2020 is 33 percent; 20 percent of this target is therefore 6.6 percent of total electrical generation. For Sonoma County this would be supplied by 30 MW of biomass capacity producing 210 gigawatt-hours annually. Portfolio 3 in its current form meets this target in by 2020.

Public data shows that current biomass generation capacity in Sonoma County is 6.4 MW, with an increase to a total of 8.4 MW planned by 2014.

5. Wind (Sonoma County Goal: None specified)

Currently no specific state or local policy goal exists that is specific to wind. It is subsumed under the general requirement of the renewable portfolio standard and its associated greenhouse gas emission target in the state's Climate Scoping Plan.

About 90 to 100 MW of local wind development was considered in early drafts of a RESCO portfolio. The current portfolios have a range of wind development of 200 KW (Portfolio 1), 15 MW (Portfolio 2), and 50 MW (Portfolio 3). The range was reduced partly in response to concerns about the feasibility of how much wind power could be developed in Sonoma County by 2020, but is not tied to any publicly adopted quantitative local or state wind policy goal. Rather, Portfolios 2 and 3 are tied more generally to the goals of supporting the renewables portfolio standard, the state and local climate goals, and the RESCO goal of utilizing a diverse range of local renewable-based energy resources.

6. Small Hydropower (Sonoma County Goal: Included in Carbon Free Water by 2015)

Currently no specific state or local policy goal exists that is specific to small hydropower. Hydropower plants must normally be smaller than 30 MW to qualify for the state renewable portfolio standard; however, large hydropower is generally considered not to emit carbon.

All three portfolios include 2.8 MW of local hydropower, which is the capacity that has already been developed. No further hydropower is included in any portfolio, and the Sonoma RESCO Research Team believes that there is very little additional local conventional hydro potential. Sonoma County does have significant offshore wave power resource; however, this is not presently considered economically viable for large-scale development.

While no quantitative goal exists specifically for local hydropower, the Sonoma County Water Agency does have a more general policy to achieve Carbon-Free Water by 2015. One of the proposed actions for achieving this policy goal is to take direct ownership of the hydropower electricity that historically has been sold to a public power authority that in turn serves a number of water agencies and irrigation districts in California.

7. Energy Storage (Sonoma County Goal: 30 MW by 2020)

Current state law (AB 2514) requires the California Public Utilities Commission to adopt energy storage procurement requirements for the investor-owned utilities (California Public Utilities Commission 2012f). Governor Brown, who was the original sponsor of this legislation when he was attorney general, has called for energy storage that would meet 5 percent of each utility's peak power demand. For the state as a whole the peak demand is about 60,000 MW, which would result in a storage target of 3000 MW. Sonoma County's proportional share of this goal would be about 30 MW, which is the amount of energy storage in Portfolio 3.

The Sonoma County Climate Action Plan proposed development of 91 MW of local *pump storage* and 18 MW of battery storage. Energy storage in current portfolios in the RESCO project has been modified in two ways: The amount of storage is reduced significantly; and the storage is considered in a more technology neutral manner, although the default assumption is that this would be battery storage. This modification is partly in response to concerns regarding the feasibility of developing pump storage within Sonoma County, particularly within the 2020 time frame. However, if intermittent generation is developed to meet a large portion of the county's electrical load, pump storage is an important option that would reduce reliance upon GHG-emitting natural gas power, as well as the potential need for curtailment or dumping of excess wind and solar power.

The Sonoma RESCO Research Team found no data for existing local energy storage in Sonoma County, and assumes that no significant amount of grid-connected storage is currently installed.

8. Solar Implementation Plan (Sonoma County Goal: 250 MW)

The Sonoma County's Solar Implementation Plan has an adopted goal of 250 MW of combined local solar photovoltaics and local demand reduction measures; however, this goal is not allocated between specific resources in the Implementation Plan. Incorporated into this larger goal is a prior goal of adding 25 megawatts of new solar generation in Sonoma County by May 2011, which has been met.

RESCO Portfolio 3 sketches out resource allocations that could contribute toward meeting the 250 MW local goal. Portfolio 3 includes 85 MW of local solar PV, and meets Sonoma County's proportionate share of the AB 32 Scoping Plan energy efficiency target, which is estimated by the Sonoma RESCO Research Team to reduce demand by approximately 142 MW in 2020. These

two portfolio elements provide a total of 227 MW of combined energy efficiency and local solar PV. The balance of 23 MW could be provided through a combination of demand response and energy storage. While demand response is not specifically included in the RESCO portfolio, the CPUC has adopted a policy goal that the investor-owned utilities meet 5 percent of peak demand with cost effective demand response, and demand response is considered a preferred resource in the *loading order* of the state's Energy Action Plan. Sonoma County's share of this target would be about 30 MW. A similar target of 5 percent of peak demand has been proposed for energy storage by Governor Brown, which Portfolio 3 exceeds with a deployment of 45 MW.[8]

Relation of Portfolios to Goals

Three portfolios include eight local resources, with each portfolio having different annual quantities of these resources from 2011 to 2020:

- Portfolio 1 shows "Business as Usual" which is based upon available public data of development of these local resources assuming continued service by PG&E. Portfolio 1 exceeds the state policy goal for solar photovoltaics in Sonoma County, but does not meet any other specific state energy resource policy goals.
- Portfolio 2 assumes local augmentation of PG&E's programs and represents an approximate mid-case between Portfolio 1 and Portfolio 3. Portfolio 2 exceeds the state policy goal for solar photovoltaics in Sonoma County, but does not meet any other specific state energy resource policy goals.
- Portfolio 3 shows Sonoma County exactly meeting three adopted state policy goals in 2020, for combined heat and power, energy efficiency and biomass, and exceeding the state goal for photovoltaics, assuming a CCA aggressively implements local programs that support achieving these goals (Table 7).

Table 7: Role of Policy Goals in Portfolio 3

	Resource	Portfolio 3 Capacity	Pro-Rata Policy Goal	Match State Goals?
		MW	MW	
1	Efficiency	142.0	142.0	Yes
2	Solar PV	85.0	31.0	Exceed
3	NG CHP	40.0	40.0	Yes
4	Geothermal	70.0		N/A
5	Biomass	30.0	30.0	Yes
6	Wind	25.0		N/A
7	Hydro	2.8		N/A
8	Storage	30.0	30.0	Not Adopted
	Total	424.8	273.0	

[8] The *Sonoma County Solar Implementation Plan* is presented separately because it represents a blend of undifferentiated resources. The 250 MW goal is not defined in terms of how much solar and how much or what kind of demand reduction is included. Therefore, it is not in the PV section because the 250 MW goal does not indicate how much solar should be built (Solar Sonoma County 2012).

Portfolio 3 best achieves the overall RESCO goals of maximizing cost effective deployment of local resources, while Portfolio 2 may be more feasible to implement by a community choice program in a 2020 timeframe.

Quantitative policy goals for individual resources are only one factor in the development of the portfolios. Half of the eight resources in Portfolio 3 are not correlated to any specific quantitative policy goal, while Portfolio 1 and Portfolio 2 do not contain any resources that match state policy goals.

There are several levels of reasoning why these goals are incorporated into Portfolio 3. One of the overarching purposes of RESCO is to support achievement of these specific state policy goals. Including these goals connects the Sonoma RESCO project to the purpose of RESCO established by the Energy Commission. Portfolio 3 illustrates, and provides a measuring reference frame for, what would be required in order for Sonoma County to achieve these state policy goals.

Furthermore, the division of state goals into the pro-rata shares of smaller entities is not arbitrary, but rather is general state policy. For example, load serving entities such as electrical corporations, local publicly-owned utilities, and community choice aggregators are generally required to meet their pro-rata share of the 33 percent renewable energy mandate by 2020. Other programs, such as the GoSolar program goals, are also divided in a manner according to a utility's proportional share of peak demand.

The pro-rata share of state goals also is brought to into account when customers of a community choice program are required to cover their share of costs of state policy programs. These costs are included in a customer's bill, in the form of *non-bypassable distribution charges*, meaning all customers are required to pay. For example, community choice customers in Sonoma County — even though they are not purchasing electricity from PG&E — would be required to pay PG&E so that the utility is compensated for each customer's fair share of the utility's cost to meet the state policy goal for purchasing electricity from combined heat and power generators. The charge can be imposed because the community choice customers still use, and therefore must pay for, PG&E's electrical distribution grid, as well as other services provided by PG&E.

The California Public Utilities Commission has stated in its decision on combined heat and power that the commission might evaluate relieving community choice program participants of this utility bill charge if the community choice program purchases its own equivalent amount of combined heat and power. In this case, developing local combined heat and power generation could have a financial incentive up to Sonoma County's pro-rata share of the state policy for this resource. In other words, the state's quantitative goal has direct relevance for calculating what amount of local development might be cost effective, since the local customers may have to pay for that amount of combined heat and power in any case. But Sonoma County may not derive the same economic benefits of a general utility program as would be the case if these resources are developed locally, which a local community choice program could help to support.

Background

This section summarizes previous work in developing models of a clean energy supply for Sonoma County, first in the County's Climate Action Plan (Climate Plan), and then through work in Tasks 3 and 4 in Sonoma County's Renewable-based Energy Secure Communities RESCO) project, and then finally in the Feasibility Study, sponsored by the Sonoma County Water Agency, for a Sonoma County Community Choice program (Sonoma County Water Agency 2011). The Sonoma RESCO Research Team collected data on local energy demand in Task 3, and presented an interpretation and overview of this data in Task 4. The results of these prior tasks inform the current Task 5, which reports on the RESCO methodology, analysis and modeling of local clean energy resources, with the aim of developing these local resources as a significant part of the energy supply for Sonoma County.

This background is provided to show how the Task 5 report fits into a series of analytic steps that begin first with the Climate Plan. RESCO takes a closer look at the local resources as they could be developed by a Community Choice program. Community Choice is a local program, established by a city, a county, or a group of cities and/or counties, that buys and, and potentially generates, electrical power for participating residents and businesses. All customers within the jurisdiction of the local government(s) are automatically enrolled in the Community Choice program, but have the right to opt out and must be informed of this right in advance of the program's formation.

To create a Community Choice program, an implementation plan must be developed. The RESCO work can inform the implementation plan by presenting a set of local resource options as well as discussion of program goals, financing and risk management strategies that may be incorporated into the implementation plan. However, this RESCO work is not the same as a Community Choice implementation plan. Elements of the implementation plan which are not considered here include the role of the energy service provider, program start-up plans, rate setting procedures, rate elements that are outside of the energy supply costs, customer rights and responsibilities, and the local governance and administration of the Community Choice program.

Prior Reports on Sonoma County Energy Supply

Four prior work products relate to the current RESCO Task 5 report:

- *Sonoma County Community Climate Action Plan*
  (Climate Protection Campaign 2008)
- *RESCO Task 3 Report — Data Collection*
  (Climate Protection Campaign, Local Power Inc., and Los Alamos National Laboratory 2012)

- *RESCO Task 4 Report — Data Integration*
  (Local Power Inc. 2010)
- *Report on the Feasibility of Community Choice Aggregation in Sonoma County*
  (Dalessi Management Consulting LLC; MRW & Associates 2011)

Community Climate Action Plan (2008)

This RESCO Task 5 report represents the most recent evolution of work that was begun in 2007 on the *Community Climate Action Plan* (Climate Plan) (Climate Protection Campaign 2008).

The Climate Plan was created in response to the adoption of a greenhouse gas emissions reduction target set by the nine cities and the County of Sonoma in 2005. The target, a 25 percent reduction below 1990 levels by 2015, applies to total Sonoma County greenhouse gas emissions in transportation, electricity, natural gas, water/wastewater, agriculture, and solid waste.

Although transportation represents the largest contributor to greenhouse gas emissions in the county overall, few good local solutions exist for significantly reducing emissions in the transportation sector. By contrast, Community Choice is a measure that allows local control over the sources of electrical generation. Therefore, the electricity sector was selected as a focus for Sonoma County's climate protection endeavors. The Climate Plan envisioned that a proportionally larger share of emission reductions could come from changing the electricity supply through a Community Choice program that has the authority to set policy goals, engage in planning for achieving those goals, create local programs, contract with suppliers that can implement the programs, and secure financing for construction of new renewable energy projects.

The Sonoma County greenhouse gas inventories revealed that electricity consumption in Sonoma County is responsible for about 23 percent of greenhouse gas emissions, and natural gas for an additional 17 percent, for a combined total of 40 percent. To achieve Sonoma County's reduction target in these two sectors, combined emissions resulting from electricity generation and direct natural gas use must be reduced by approximately 400,000 tons below the projected 2015 business as usual level (or nearly 500,000 tons below the actual 2005 level) (Climate Protection Campaign 2008, 21).

The Climate Plan found that with Pacific Gas & Electric (PG&E) as its energy supplier, Sonoma County's greenhouse gas emissions from electricity were projected to decrease by only 3 percent while emissions from natural gas would increase 18 percent. With PG&E, Sonoma County will exceed its target by over 40 percent in the combined electricity and natural gas sectors (Climate Protection Campaign 2008, 23).

Climate Action Plan Portfolio Overview

The Climate Plan included, among other elements, a proposed portfolio of electrical generation sources and energy efficiency demand reduction that could significantly reduce greenhouse gas emissions in the electricity supply for Sonoma County by 2015. The proposed electricity supply

for the Climate Plan relied primarily upon imported conventional and renewable energy, mixed with a modest portion of local resources: energy efficiency, rooftop solar photovoltaics (PV), energy storage, and biomass-based cogeneration.

The Climate Plan's overall portfolio was also designed to include a mix of resources that had different profiles of energy production over the course of the day. Geothermal, biomass, and combined heat and power generation supported the stable, underlying daily, weekly, monthly or annual demand, referred to as "base load" power, while other resources, such as solar PV and energy storage, were intended to help meet peak energy demands. Further work was needed to refine the analysis in the Climate Plan when it came time to implement an actual community energy supply.

The Climate Plan found that Sonoma County should develop its renewables using the following design criteria:

- Treat demand reduction (efficiency improvement and demand response) as a "virtual resource" in the electricity supply and develop it along with other resources in the supply portfolio
- Minimize transmission (and thereby minimize line loss inefficiency and the cost of new transmission lines) by building new supply as close to load as possible
- Use resources opportunistically by using what is available in the vicinity of the load based on surveys of conditions on the ground
- Tune the portfolio of renewable resources so that the characteristics of each type of renewable generation match the load profile
- Use the lowest cost financing available to make smaller scale projects cost effective (Climate Protection Campaign 2008, 28)

The original portfolio developed for the Climate Plan is shown in Table 8 to illustrate how baseload, dispatchable, peaking and intermittent resources are allocated to serve the load, and how costs were allocated. This portfolio, along with the analysis in the RESCO Task 4 report, is used as a basis for the refinements described in this Task 5 report.

Table 8: Climate Plan Portfolio Overview

Resource	Capacity MW	Capacity Factor	Annual Generation GWh	Percent of Supply
Hydro	113	49.9%	494	16%
Natural Gas	189	7.5%	124	4%
Natural Gas Cogeneration	58	85.0%	432	14%
Geothermal	125	90.2%	988	32%
Wind	71	34.8%	216	7%
Biofuel Cogeneration	58	85.0%	432	14%
Solar Photovoltaic	16	15.5%	22	1%
Solar Thermal	59	24.0%	124	4%
Energy Storage*	109	26.8%	256	8%
Total	798	44.2%	3,088	100%
Renewable Energy	438	53.1%	2,038	66%
* assumes supply energy from other renewable energy sources				

Source: *Sonoma County Community Climate Action Plan*

The RESCO project retains the Climate Plan's aim of reducing greenhouse gas emissions, but focuses particularly on the local elements of the energy supply. The RESCO project considers a similar range of local resources as were in the Climate Plan, and makes use of more careful characterization of local energy resources and demand patterns. Two prior RESCO Tasks, 3 and 4, examined these energy demand patterns as background preparation for this Task 5 Report.

Sonoma RESCO Tasks 3 and 4 Summaries

RESCO Task 3 Report — Data Collection (2010)

The renewable energy portfolio in the *Sonoma County Community Climate Action Plan* was based on publicly available aggregate energy data. A more accurate data set was needed to refine the portfolio, and to further evaluate the potential constraints, opportunities, cost effectiveness, and greenhouse gas impacts that would be associated with using the proposed energy resources.

The data collection methodology described in Task 3 was designed to provide an enhanced analysis of regional energy demand that in the future could be advanced further by a Community Choice program to plan replacement infrastructure and configure technologies, to choose locations, and to determine efficient and cost-effective applications (Climate Protection Campaign, Local Power Inc., and Los Alamos National Laboratory 2012).

Local governments investigating, pursuing or implementing Community Choice programs are legally entitled to receive from their incumbent electrical utilities detailed and complete databases of customer-specific as well as aggregate and climate-based energy use data. This data includes confidential customer information formerly limited to the power company and its consultants. The authority to access monthly and interval time-of-use power meter data provided Sonoma County with the ability to investigate through this RESCO project the use of local resources in a Community Choice program.

The Task 3 report includes a description of the data collection methodology, results, barriers and recommendations regarding data collection from local, state, and federal government agencies as well as from Sonoma County's investor-owned utility, PG&E. It also includes some samples of the analyses that will be possible with these data, including a number of maps and tables that illustrate the recent history of energy use, as well as the unique patterns of energy use throughout all sectors of Sonoma County's community and economy. The Sonoma County data collected from PG&E includes monthly energy use from approximately 230,000 meters, and more frequent reports from 20,000 interval meters.

The Task 3 report provides an explanation of the laws and regulations required for Sonoma County to be able to obtain the data, a history of the Sonoma County data collection process, a description and samples of the data received from PG&E, and makes recommendations for other communities undergoing similar analyses.

Under the auspices of the Sonoma County RESCO project, the Sonoma RESCO Research Team has since imported the data into a single database, transferred files onto its secure server, run preliminary regional load analyses using non-confidential information, geo-coded confidential customer address information, and developed initial spreadsheets, graphs, and maps, samples of which are included as appendices in the Task 3 report.

The data collected in Task 3 showed that the peak loads for the residential and non-residential sectors, and the County overall for 2008 was 593.8 MW on September 5, 2008.

The baseload is just under 200 MW for the aggregate of residential and non-residential customers. For 90 percent of the hours of the year, the load is 400 MW or less. For 60 percent of the hours of the year, the load is 250-350 MW.

RESCO Task 4 Report — Data Integration (2010)

Task 4 organized and integrated data collected in Task 3 to provide a more detailed view of electricity demand patterns within Sonoma County. The analysis provided differentiated residential and non-residential power demand curves on peak days and weeks, as well as on an annual basis, including weather factors (Local Power Inc. 2010). The Task 4 analysis provides the basis for a reassessment of the renewable technologies as components of an integrated renewable energy portfolio. An approach to serving this regional load curve is proposed, based on the detailed aggregate load data provided by the work completed in Task 3.

Task 4 has four primary purposes:

1. Organization and integration of all geospatial and electricity consumption data obtained in Task 3
2. Allowing in Task 5 the spatial and temporal correlation of electricity consumption patterns with locally available renewable and/or low carbon electricity supply
3. Establish a basis for *system dynamics modeling* of baseline and development scenarios
4. Establish a basis for economic modeling of electricity supply, demand and market sectors

Further objectives include:

- Create and securely manage databases of geospatial and electricity consumption data for Sonoma County
- Perform preliminary analysis of data to prepare for refinement of the local renewable portfolio design proposed in the Sonoma County Community Climate Action Plan
- Develop methods for identifying load patterns and geospatial concentrations of energy use that are well suited for cost-effectively serving with a combination of local renewable resources and demand management
- Create protocols for data exchange to enable Los Alamos National Laboratory's Climate/Energy Assessment for Resiliency (CLEAR) system dynamics model to simulate the carbon and local employment impact of the local renewable energy portfolios developed under this Project

Several key questions regarding peak energy use guided the Task 4 preliminary analysis:

- What are the characteristics of peak energy use in the County, that is, how much, when and where?
- On a sectoral (residential, commercial, and industrial) basis, what are the temporal characteristics of electricity use in Sonoma County?
- How do these temporal patterns of energy use change geospatially in the county?
- What patterns emerge in the energy use patterns of different geospatial and temporal units — that is, from the aggregate county to the neighborhood level, and from the year to the day — that reveal how electric load can be cost effectively served?

Task 4 describes potential criteria that could be employed to develop a RESCO-type electricity supply, including:

- Onsite renewable power generation and storage
- Multi-user access to facilities
- *Interoperability* of generation, storage and demand management technologies

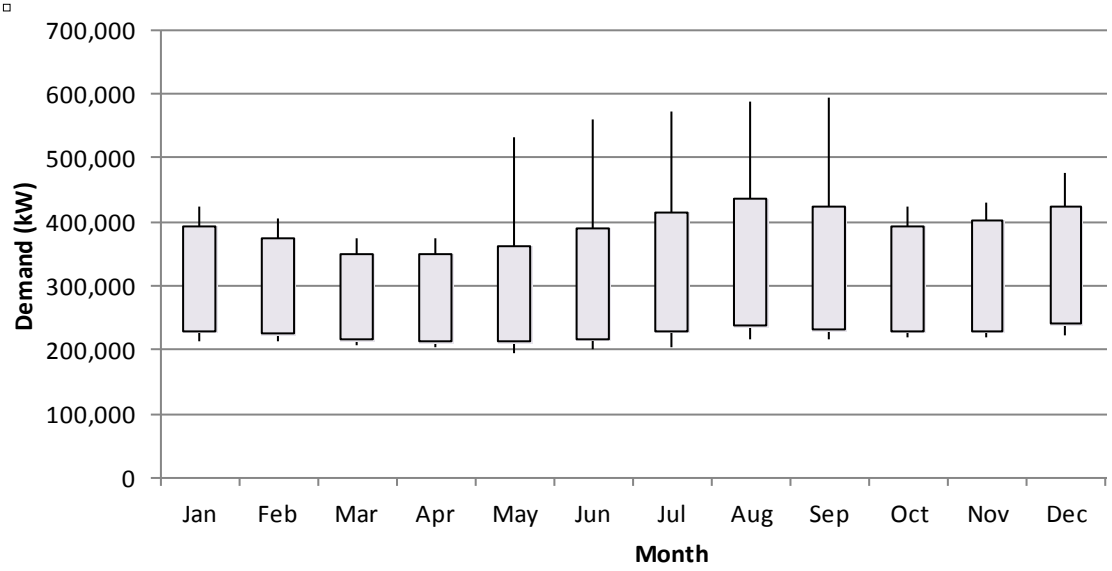
These criteria are applied in analysis of customer meter data. The Task 4 report provides samples of RESCO development opportunities that are assessed using aspects of the methodology that are to be further developed in Task 5 for site identification, and described the tools that were used to perform the analysis.

Task 4 outlines the Sonoma RESCO Research Team's proposed design approach, namely, to assign development volumes for various technologies at residential and nonresidential meter sites which:

1. Can provide time-specific, residential/nonresidential capacity that integrates into the regional load curve pattern, in a cost-effective manner
2. Identify residential and nonresidential sites with customer energy use characteristics that appear suitable for a RESCO portfolio resource and
3. Evaluate concentrations of suitable loads for proximity and potential interoperability with identified public or private energy security-enhancement opportunities

Figure 11 shows the monthly peaks and average demand in Sonoma County for 2008. The thick bars show the average *daily* high and low demand in kilowatts, and the vertical line shows the *monthly* maximum and minimum.

Figure 11: Monthly Averages, Peaks (2008)



The bars show the average daily range for each month, and the lines show the maximum and minimum for that month.

Report on the Feasibility of Community Choice Aggregation in Sonoma County (2011)

In October 2011, the Sonoma County Water Agency released a study on the feasibility of community choice aggregation (Community Choice or CCA) in Sonoma County (Study). Characterized as the first step in determining whether a CCA program was right for Sonoma County, the Study explored the estimated impacts of a CCA on costs, retail electric rates, greenhouse gas emissions, and the local economy. The Study found that CCA is feasible for the County.

The Study examined four energy supply scenarios and concluded that "implementation of a CCA program in Sonoma County could result in significant reductions in greenhouse gas emissions, provide substantial local economic benefits and additional local jobs, provide greater electric rate stability, and give local *ratepayers* a choice over power providers" (Dalessi Management Consulting LLC; MRW & Associates 2011).

Directly relevant to the RESCO perspective, the Study recommended "investigation of whether varying the mix of power resources could reduce CCA power costs, while still providing greenhouse gas reduction benefits." It also recommended "investigation of whether the addition of a significant energy efficiency component could result in a decrease in the estimated CCA program rates."

The four energy supply scenarios presented in the Study ranged from a baseline scenario that purchased all of its power on the wholesale market and only aimed to meet the minimum requirement for the state's renewable portfolio standard (RPS), to modeling a high renewable energy portfolio based on the *Sonoma County Community Climate Action Plan* portfolio.

Scenario 1: 33 Percent Renewable Energy Content by 2020

Scenario 1 is a base case that simply meets the minimum requirement for the state's Renewable Portfolio Standard, which starts at 20 percent renewable energy in early decade and reaches 33 percent in 2020. Although, according to the report, this energy supply mix offers the lowest rates for a local program, it does not offer significant environmental or economic benefits. Scenario 1 contains a mix of power purchases from non-renewable and renewable energy sources, including natural gas, solar photovoltaics, wind, and geothermal energy. It also includes generation from CCA-owned biomass and solar photovoltaic resources.

Scenario 2: 51 Percent Renewable Energy Content by 2020

Scenario 2 represents a more aggressive transition to renewable resources, starting out at 33 percent renewable energy and increasing to 51 percent by 2020. The mix of types of renewables is similar to those in Scenario 1, but they are scaled to achieve the higher renewable energy content.

Scenario 3: 75 Percent Renewable Energy Content by 2020, Local Emphasis

Scenario 3 represents an even more aggressive transition to renewable resources and emphasizes development of renewable within Sonoma County, both large and small-scale. The Scenario 3 renewable energy content starts at 51 percent and increases to 75 percent by 2020.

Scenario 3 contains a mix of non-renewable power purchases, purchases of small rooftop solar photovoltaic energy, small and mid-size ground-mounted solar photovoltaics, wind and geothermal energy, and generation from CCA-owned biomass and solar resources. The solar, geothermal and biomass energy would be generated locally while the other resources are assumed to be sourced from other parts of Northern and Central California.

Scenario 4: Climate Action Plan — Starts at 20 Percent and increases to 85 Percent by 2020

Scenario 4 includes a resource mix is based upon of the portfolio contained in the Climate Action Plan. Scenario 4 represents the most aggressive transition to renewable resources of the

four scenarios and strongly emphasizes development of renewable resources within Sonoma County, both large and small scale.

The Scenario 4 portfolio contains a mix of non-renewable system power purchases, purchases of wind and solar thermal energy, and CCA-owned geothermal, biomass cogeneration, wind, rooftop solar, pumped storage, and battery storage. With the exception of some wind and the solar thermal resources, all other energy would be generated locally. The aim of this portfolio is to "maximize the use of the tools afforded by CCA to achieve the greatest amount of local distributed renewable generation at the lowest possible cost" (Dalessi Management Consulting LLC; MRW & Associates 2011).

This projection was used as a baseline for comparison of the relative cost of PG&E's electricity to the four scenarios. The study summarized the average annual *incremental cost* of electricity from the four scenarios as follows (Figure 12):

Figure 12: CCA Feasibility Study Additional Annual Aggregate Customer Cost

	Share of Renewable Energy in 2020	Additional Annual Aggregate Customer Cost		
		Average	Highest Year	Lowest Year
		$ millions	$ millions	$ millions
Scenario 1	33%	$14.10	$18.60	$8.70
Scenario 2	51%	$16.10	$26.30	($4.70)
Scenario 3	75%	$34.30	$54.60	$4.60
Scenario 4	85%	$18.20	$29.30	($0.40)

Source: *Report on the Feasibility of Community Choice Aggregation in Sonoma County* (Dalessi Management Consulting LLC; MRW & Associates 2011)

The average incremental costs for the four scenarios range from a low of $14.1 million to a high of $34.3 million per year, with even wider variation for individual years. While additional renewable energy is responsible for some of the extra cost, the relationship is not linearly correlated to the percentage of renewable energy. The incremental cost of Scenarios 1, 2 and 4 are all within a relatively tight range of $14.1 million to $18.2 million annually. Scenario 3, the 75 percent renewable energy portfolio, is approximately double the incremental cost of the other three scenarios, and reaches a peak of $54.6 million in 2017. These extra costs are mitigated by the fact that the total of all retail bills is $350 million to $400 million. Thus, an extra cost of $14 million per year represents a rate effect of 4 percent or less. However, Scenario 3 reaches a peak range of 9 percent to 11 percent rate effect, which is likely to induce greater loss of customers who opt out of the program.

Although Scenario 4 reaches 85 percent renewable energy, even higher than Scenario 3, its incremental cost is much less than Scenario 3, and only adds $4.1 million per year compared to Scenario 1. The lower cost of the highest renewable energy scenario is in part due to the fact that Scenario 3 starts in the first year at 51 percent renewable energy before ramping up, while Scenario 4 starts at only 20 percent before ramping up over several years to 85 percent. This

illustrates the importance of planning the deployment of a high renewable energy portfolio over a period of several years, which increases the likelihood of getting projects on line in the specified time frame, and also greatly reduces the marginal effect on customer bills.

The Feasibility Study included a peer review that found that the "general approach, assumptions, and methods of analysis were reasonable and sound," but cautioned that there were several issues that could increase the cost or risk of a community choice program in Sonoma County. The concerns most relevant to RESCO were that the short-term future projected costs of wholesale electric power from PG&E could be overestimated, and they questioned whether the renewable energy projects could be built in the time frame proposed in the Feasibility Study. Scenario 4 appears designed to mitigate both of these factors; the more expensive resources are delayed until after the short term period of wholesale price risk and additional time is allowed to build the projects.

Intrinsic to the Feasibility Study is the need to make some assumptions, projections, and decisions about how resources will be financed and deployed. Not all of these assumptions, projections, and decisions in the Study are consistent with those made by the Sonoma RESCO Research Team. For example, while both this RESCO project and the Feasibility Study look at 2020 as the year for reaching the program's renewable energy goal, the Feasibility Study continues its cost analysis out to 2032, whereas the RESCO analysis only goes to 2020—the target year. The shorter times period simplifies the analysis, and also addresses the risk of long-term forecast error by only considering a forward period of about 8 years. Other differences include the Sonoma RESCO project carrying out deeper analysis of local vs. non-local resources, examination of load-balancing resources, site-specific resource analysis, and finance structures.

The Sonoma RESCO Research Team also finds that there are a few ways in which the excess cost of Scenario 4 can be reduced so that is more closely matches Scenario 1:

- Interest can accrue to the reserve account; for example, a rate of one percent annual interest [9] would provide $1 million per year in income by 2020 for Scenario 4, which has the highest reserve account of the different scenarios.
- The cost of solar photovoltaic electricity from local sources can be reduced, either by purchasing less of this particular resource, or by purchasing it at a lower cost. Purchasing at a lower cost may be made possible by aggregating projects within a Community Choice program thereby leveraging economy of scale.
- Some sources of local generation could be net metered and/or self-generated instead of purchased by the CCA.

[9] For example, current interest rates in 2012 on 2-year certificates of deposit earn an average of 0.9 percent annual interest, (Bloomberg.com 2012, Web--Key Rates)

CHAPTER 2:
Methodology and Approach

The primary purpose of Task 5 is to determine how a community, in this case Sonoma County, can move toward the vision of a Renewable-based Energy Secure Community (RESCO) by developing and analyzing renewable energy portfolios and developing a refined local renewable energy system prototype. The methodology of Task 5 on the most general level follows the strategic approach in the scope of work, and is as follows:

- Develop refined local renewable energy-based portfolios building on RESCO Task 3 and Task 4 data and analysis, and on the portfolio developed in the Climate Plan.
- Test local renewable energy-based portfolios with the Los Alamos National Lab's CLimate-Energy Assessment for Resiliency (CLEAR) system dynamics modeling (Los Alamos National Laboratory 2012, Web--CLEAR Model)
- Identify site-specific opportunities for distributed generation based on energy use patterns and potential volumes for resource development in different areas of Sonoma County
- Develop a refined renewable energy prototype (the methodological tool used to develop the portfolios)
- Prepare analysis and a modeling report that includes but is not limited to the following:
    - Data interface report that describe data interfaces and data processing used in the analysis
    - Identification of a "best case," cost-effective renewable energy-based portfolio for Sonoma County
    - Report on barriers to implementation, including necessary additional policies, regulatory changes or technology improvements

To provide flexibility to address issues that would be important for evaluating the potential use of local resources, the scope of work specified that the analysis and modeling would not be limited to the items listed above. The elements that the Sonoma RESCO Research Team selected for further analysis and modeling include:

- Evaluation of local renewable energy resource potential as well as local thermal loads for combined heat and power *hot spots*
- Description of financial tools that can be applied to make local renewable energy resources more cost-effective

These are not actually additional elements; they expand upon concepts contained in the scope of work, but are not fully defined there. While the scope specifies that the RESCO project is to

identify site-specific opportunities and volume for developing local resources, understanding these opportunities required evaluating the volume of local renewable energy resources, and creating a model for serving local thermal loads that uses the concept of "hot spots," or areas of both high energy use and high resource development potential. The scope also involves identifying a best-case cost-effective energy portfolio. The methodology in the Task 5 report develops the investigation into cost-effectiveness in at least two ways: 1) strategies for addressing cost-effectiveness are presented, and 2) a set of financing tools are described that can help to make developing local resources more cost effective.

In addition to the overall methodology of the report outlined above, there are further layers of methodology that relate to:

- The strategic approach to evaluating energy demand, resource potential, and program goals
- The principles by which the portfolios are designed
- How resources are characterized
- Evaluating the cost-effectiveness of resources
- Modeling energy demand and proposed local energy supplies

These features of the methodology are described in the following sections.

Task 5 Approach

Designing a renewable energy portfolio for a community with increased reliance on locally available resources is complex. The Sonoma RESCO Research Team approached the problem with both "top-down" and "bottom-up" methodologies. The top-down approach involves analyzing state and local policy goals and electric load characteristics at a county scale and developing alternative portfolios of resources that can be integrated into this load. The bottom-up approach involves working with meter-level and distribution system data, and "*chunking*," or partitioning the load according to various criteria.

The bottom-up approach is a very different paradigm that is focused on the penetration of localized and distributed resources. This local approach needs first to evaluate the potential for a specific set of various resources to be integrated in the form of "electric services," which includes both generation of electricity as well as demand reduction. A mix of electric services may be composed of energy efficiency, combined heat and power, distributed renewable generation, and elements that help balance the grid such as energy storage and demand response.

This approach acknowledges that there will be highly localized opportunities for renewable resource development, based on local energy use and geographic characteristics. This approach considers both the costs of small scale resources as well as the costs involved in locating the

generation resource far from the load: (1) the need for new transmission lines and (2) the need to compensate for energy lost in transmission by overbuilding the resource. Thus, using renewable resources available close to the load, elements of an electric supply can be constructed that take advantage of improved efficiency and site specific economic factors.

The current electric grid is profoundly inefficient; wasting near 70 percent of primary energy by the time electricity reaches the wall of a home or business. The use of distributed generation (DG) along with combined heat and power (CHP or cogeneration) reduces environmental, resource, and energy costs and inefficiencies associated with central remote generation, transmission, and frequently also distribution of electrical and thermal energy. A distributed energy supply improves utilization of the energy potential of renewable resources, which is called "exergy," and thus makes transition to a clean energy system much more feasible in a shorter time period. Expanding the deployment of DG and CHP involves working with meter-level data, for individual loads or small groups of load. The load characteristics of these individual or small groups of customer sites can then be used to specify an appropriate set of energy service resources.

Chunking the load allows a local approach to electric supply that treats the electricity demand of the local region as a set of quasi-independent "campuses." Part of the exercise is to determine how and to what extent campuses can be served in a cost-effective manner, based on analysis of demand patterns, with available renewable resources and site development opportunities.

The combination of the two approaches, top down and bottom up, transforms the electricity supply procurement process to one that can reduce the carbon impact of electricity generation by reducing the import of fossil-based grid electricity. When the overall load of the region is first served by a deployment of efficiency, and distributed, and frequently customer-side, renewable generation, based on analysis of localized load patterns and local renewable resources (bottom up), then the amount of *utility scale*, higher environmental impact electricity that is imported through the grid (top down) is reduced. Local "wholesale distributed generation" resources can be deployed that provide more conventional electricity products. The cost of these resources can be brought down by using financing and revenue mechanisms, such as tax-exempt municipal revenue bonds, net metering, *power purchase agreements*, and feed-in tariffs, to improve the cost-effectiveness of energy from those resources.

The Sonoma RESCO Research Team has designed three portfolios, ranging from approximately 15 percent to 50 percent local resources. This should test strategic elements of the deployment as well as show possible effects of increasing penetration of local RESCO resources.

In this report, there is significant difference in approach for each resource. For example, the evaluation of wind power looks primarily at the availability of local wind resource, which is strongly constrained due to the relatively small and highly specific regions in the county where wind resources are large enough to merit development. Wind resource locations are relatively independent of the availability of on-site load to assimilate the wind power, especially since most of the wind areas are in relatively sparsely populated parts of the county. Thus it does not make sense to analyze local wind as constrained by a narrowly local demand profile. Due to

this geographic constraint, if the local wind is developed to more than a minimal amount, the electrical power will need to be supplied to the grid as a wholesale energy supply for all of Sonoma County rather than only as self-generation for individual customers.

On the other hand, development of some other resources, such as combined heat and power, rooftop solar photovoltaics, and energy efficiency, are highly co-located with the location of energy demand. In the case of combined heat and power, the location-specific "bottom-up" approach is the dominant factor, and the Sonoma RESCO Research Team looked to identify both heat and electrical power demand loads that coincide at a large enough scale to pay particular attention to and identify as a "hot spot."

Solar photovoltaics and energy efficiency occupy a space in between, where top-down and bottom-up approaches are both used but each to a more limited extent. The top-down approach is used where the quantity of these specific resources in the portfolios is based upon general program goals and the projected level of implementation. These quantities, in a "best case" scenario, are based in part upon program goals established in the state as a whole, such as the efficiency targets in California's AB 32 Climate Scoping Plan, or local program goals for solar photovoltaics. Other scenarios tend to reflect historical data or forecasts on a state, utility, or countywide level that may fall short of the adopted goals. A more local bottom-up approach is used to consider the potential of local demand to assimilate solar photovoltaics on the distribution system. Energy efficiency also includes some bottom-up elements such as specific local program design options, a cost assessment, and a few location-specific case studies.

The analysis in this report includes the following procedures:

- Develop portfolio design scenarios based on an updated analysis of historical data, an updated demand forecast, more recent cost information for renewable and conventional energy supplies, and an updated PG&E rate forecast
- Determine program targets for local resources within the framework of the portfolio design; evaluate constraints from cost of energy, resource availability, and load profile
- Identify and provide a general quantitative estimate, sufficient to meet the needs of the portfolio design, of local renewable resources in terms of available power in each resource category.
- Evaluate the total electrical load in the county, and determine load profile characteristics for substations and identified hot spots.
- Determine and characterize select areas that may be suitable for distributed generation/combined heat and power deployment, including heat distribution based on energy consumption density.
- Describe program options and potential goals for local demand-side programs, focusing on energy efficiency
- Describe financing models and tools to reduce the cost burden of local energy resources on the participating customers of a Community Choice program

Task 5 Renewable Energy Portfolio Design Principles

The Task 5 portfolio design is based on a number of guiding principles. The following principles guide the design of new resources, and the strategy governing whether a local government energy agency should build specific electric generation facilities or purchase electric power from the market:

- Balance cost of electricity supply with program goals
- Manage resource and financial risk
- Set resource procurement targets and design program for implementing local energy resources
- Facilitate interoperability with other energy resources
- Ensure reliability
- Minimize environmental damage/footprint

The California Loading Order provides a general framework for the order in which energy resources are preferred in the electric power sector (California Energy Commission 2003) (California Energy Commission 2005) (California Energy Commission 2008a):

1. Maximum cost-effective energy efficiency
2. Maximum cost-effective automated demand management for all sectors
3. Renewable energy
4. Maximum deployment of distributed generation, including "high quality" combined heat and power
5. Low carbon natural gas generation for needs that cannot be met with the above resources

The portfolio design principles employed in this project augment the loading order with the priorities of RESCO, which are focused on developing local resources. The following modified priority order for electrical energy resources is used to emphasize local renewable-based portfolio development:

1. Local energy efficiency
2. Local demand response
3. Local renewable distributed generation
4. Local high efficiency combined heat and power using fossil fuel
5. Remote large scale renewables
6. Remote large hydro generation

7. Remote natural gas power

Application of these principles results in a prioritized set of electricity resource elements to serve localized demand within the geographic area of Sonoma County. This is an advantage that a Community Choice program potentially has over a large investor-owned-utility serving a territory with millions of customers. The tools and analyses presented in this report allow a level of detail to be considered for Sonoma County, geographic areas within the county, and even individual meters in the community. The portfolio design that results from this level of detail enables a level of service and utilization of resources that an investor-owned-utility would ordinarily be unable to provide.

While a Community Choice program must meet the entire electrical energy needs of its customers, the RESCO project focuses on development of local resources. Local is defined here as being within or adjacent to the boundary of Sonoma County. Thus it includes energy efficiency and other demand side resources located at local homes and businesses, as well nearby larger geothermal or wind generation projects at the Geysers. Outside resources supplying conventional natural gas power, large hydropower, or remote renewables are not described in these portfolios except occasionally in very general way.

The community energy portfolios are described according to the terms presented in the next section.

Energy Supply

RESCO Local Energy Portfolio Concept

The concept of a "portfolio" is taken from the field of managing financial investments, and is applied to the local energy supply that is available within Sonoma County. A portfolio is a planned mix of resources, though which various goals can be met, including mitigating risk, reducing carbon emissions, managing costs, providing a stable energy supply, and increasing use of renewable energy. A portfolio approach is contrasted with "putting all eggs in one basket" which tends to concentrate risk.

Several potential difficulties posed by renewable energy can be addressed through a portfolio approach. In a portfolio, one relatively expensive element of the portfolio can be balanced by other elements that are less expensive. Different resources in the portfolio can provide different services: the daytime production of solar energy, or variable character of wind power, can be balanced with biomass, geothermal, and combined heat and power that provide a stable supply of energy around the clock.

The portfolios in this report are focused on the RESCO goal of increasing the use of local energy resources. However, within the timeframe of this analysis — which is 2010 to 2020 — local resource portfolios supply only a part of the electricity demand. Therefore, remote resources located outside of Sonoma County are needed to support the larger environmental policy goals for renewable energy and reducing carbon emissions, and to help meet the full community electricity requirements. The full portfolios, which include both local and remote resources, are

examined using the CLEAR model as part of Task 6, and are schematically developed in this report as revisions of the electricity supply portfolio originally presented in the Sonoma County Climate Plan.

The three portfolios presented in this report are focused on the development of local resources, including energy efficiency, energy storage, renewable generation, and combined heat and power. These three scenarios supply between 15 percent and 50 percent of forecast energy demand in 2020 with these local resources, with the balance to be supplied by remote electric power sources. The total portfolio, including both local and remote resources, is structured to replace a large portion of fossil fuels and localize energy supply, pursuant to policy goals including climate protection and local economic benefits.

The local portfolio design seeks opportunities to deploy the following:

- Combined heat and power which provides both electrical and thermal energy to meet highly localized load.
- Local biomass, solar photovoltaics, wind and geothermal energy.
- Energy efficiency and energy storage are used as demand-side management and load balancing elements in the portfolio.

In this approach, cost-effectiveness is balanced against carbon reduction to reveal alternatives to fossil fuel use. At the present time, particularly because of the low cost of natural gas, these solutions may be more expensive than continued use of fossil fuels. However, the costs of utility electric power are likely to continue to increase in the future, which will make alternative, lower carbon resources more cost-effective over time. In addition, financing, program, and planning tools can help to make these alternatives cost effective sooner.

Cost-Effectiveness of New Resources

If a customer can be served with electricity from a community energy program with cost of service that is less than or equal to the customer's retail rate from the incumbent utility, then the alternative service from the community program is considered cost-effective. New utility-scale or wholesale resources in the portfolio of the community energy program are considered cost-effective if the cost of generation of the portfolio as a whole is less than or equal to the generation cost of energy supplied by the utility.

In general, it is much better if the initial bundled cost of energy for the community program is equal to or lower than the utility rate. However, while it may seem counterintuitive, there are cases where even a higher rate may nevertheless be cost effective. Higher priced energy resources for a community program may be cost effective for several possible reasons:

- A specific higher priced resource is offset by other concurrently lower priced resources
- The overall energy supply has a rate that only exceeds the utility cost by a de minimus amount that customers normally do not consider relevant
- An initial relatively higher rate will be offset by future rates that produce savings

- A higher rate is offset by reduced energy consumption through efficiency or conservation programs
- The benefit(s) of the new energy service offsets the higher rate due to features that have perceived value (such as higher carbon efficiency and local job generation)

Sometimes higher cost resources are dismissed as too expensive, even though they may provide important benefits for an energy supply mix. For example, solar energy may be more expensive than other energy sources, but it provides power during the day when demand for electricity peaks and purchasing electricity on the market from conventional sources is also more expensive. One important principle of building an energy supply portfolio is to have diversity of resources to reduce the risks of "putting all eggs in one basket." A diverse energy supply will balance performance as well as price risks, so that when the price of one source of energy goes up, or a particular generator produces less than anticipated, it does not unduly increase customer rates. A well managed portfolio will also balance more expensive resources with less expensive ones, such that the overall cost of the portfolio is made as affordable as possible while also achieving the overall policy goals of the program as nearly as possible.

In some cases a community energy supply may exceed the utility cost of energy by an amount that is not enough to cause customers to migrate away from the community energy program. This effect has been observed in Massachusetts with the Cape Light Compact community choice program which normally maintains energy costs very close to the utility energy supply. At particular times the community choice program's electric rate may exceed the utility rate, yet, even when rate difference is significant, this factor has evidently not caused significant migration of customers back to the default utility (Local Power Inc. 2009, 12-34) (U.S. Department of Energy EERE 2012a). Thus, there is a certain price band within which a community choice programs' rate may be considered equivalent to the utility's rate for marketing purposes, and therefore also be considered cost effective. This type of higher rate is not relied upon as a primary justification of cost effectiveness, but may do so in regard to higher rates that are ephemeral, or when it is higher by a de minimus amount, or in cases where the program benefit outweighs a marginal extra cost.

Some customers may be willing to pay a slightly higher initial cost of energy if they see that there will be long-term savings, or if there is a perceived "insurance value" in securing a more stable rate. In this case, the utility rate forecast is used as a baseline for determining cost-effectiveness, that is, a resource or a portfolio may exceed the current bundled retail rate at the present, but it may be lower than that rate in the future. This may happen if, for example, the portfolio cost is more stable than the utility rate, or there is a payoff of an owned asset in the portfolio. Additionally, the portfolio presented in this report seeks to minimize fossil fuel requirements and this tends to make the electricity cost more stable over time, particularly due to the volatility of natural gas prices.

Another way in which an energy portfolio can be cost effective is if the total amount of money that customers pay on their bills is the same or lower than for utility service, even if the rate for

generation is higher. This switches the defining metric from energy rates to customer bills. The volumetric portion of customer bills is a product of the retail rate multiplied by the amount of measured service, either in kilowatt-hours for energy charges or kilowatts of capacity for demand charges.[10]

One error that can be made in the analysis of electricity costs is to confuse rates with bills.[11] This error is particularly acute when applied to California, which has among the highest electric rates in the U.S. However, it would be a mistake to assume that this higher rate directly translates into a relatively higher economic burden for electricity expenses than in other states. In fact, residential electric total bills are *below average* compared to other states, even some states that are heavily reliant upon cheap coal power. California's moderate climate and efficiency programs are major reasons for this effect, such that reduced average consumption more than offsets the higher rates, resulting in lower total bills (Table 9).

[10] PG&E electric rates are generally volumetric, through energy and demand charges, although there are minimum daily meter charges and some rate categories have other charges (Pacific Gas and Electric Company 2012c, Web--Electric Schedules).

[11] An example is *Cost of State Regulations on California Small Businesses Study* (Varshney and Associates 2009, 25), which ranks California 45th near the bottom of the list of U.S. states for favorable electric utility costs. This report relies on the Small Business Survival Index 2007 (Keating 2007, 36) that provides an "Index of State Average Revenue Per Kilowatt-hour for Electricity Utilities Relative to the U.S. Average."

Table 9: High Rates and Low Bills —
Comparing California Residential Electric Rates and Bills
to Other U.S. States in 2009

Rank	State	Average Retail Price (c/kWh)
1	HI	24.20
2	CT	20.33
3	NY	17.50
4	AK	17.14
5	MA	16.87
6	NJ	16.31
7	NH	16.26
8	ME	15.65
9	RI	15.60
10	MD	14.98
11	VT	14.90
12	CA	14.74
13	DE	14.07
14	DC	13.76
15	NV	12.86
16	FL	12.39
17	TX	12.38
18	WI	11.94
19	PA	11.65
20	MI	11.60
21	IL	11.27
22	AZ	10.73
23	OH	10.67
24	AL	10.66
25	VA	10.61
26	SC	10.44
27	MS	10.22
28	GA	10.13
29	MN	10.04
30	NM	10.02
31	CO	10.00
32	NC	9.99
33	IA	9.99
34	KS	9.53
35	IN	9.50
36	TN	9.32
37	AR	9.14
38	MT	8.93
39	OR	8.68
40	WY	8.58
41	MO	8.54
42	NE	8.52
43	OK	8.49
44	SD	8.49
45	UT	8.48
46	KY	8.37
47	LA	8.10
48	WV	7.90
49	ID	7.80
50	WA	7.68
51	ND	7.58

Rank	State	Average Annual Bill per Customer
1	MD	$1,844.67
2	HI	$1,791.04
3	CT	$1,767.03
4	TX	$1,694.45
5	FL	$1,683.93
6	AL	$1,577.08
7	DE	$1,548.88
8	VA	$1,488.70
9	MS	$1,487.96
10	SC	$1,481.64
11	NV	$1,447.88
12	TN	$1,396.25
13	AZ	$1,385.04
14	GA	$1,375.70
15	NC	$1,347.55
16	AK	$1,345.58
17	NJ	$1,323.47
18	LA	$1,238.26
19	MA	$1,234.25
20	NY	$1,220.57
21	NH	$1,216.50
22	AR	$1,180.52
23	PA	$1,177.05
24	DC	$1,175.26
25	KY	$1,155.10
26	IN	$1,131.55
27	OH	$1,123.86
28	OK	$1,117.56
29	MO	$1,087.93
30	RI	$1,060.25
31	OR	$1,058.71
32	WV	$1,057.93
33	ND	$1,046.02
34	SD	$1,042.52
35	KS	$1,036.42
36	IA	$1,035.03
37	VT	$1,029.91
38	NE	$1,025.85
39	CA	$1,025.37
40	ID	$1,011.22
41	WA	$1,004.62
42	WI	$987.39
43	IL	$984.51
44	ME	$979.15
45	MN	$965.72
46	MT	$917.74
47	WY	$913.48
48	MI	$896.30
49	CO	$824.25
50	UT	$793.88
51	NM	$771.59

Source: U.S. Energy Information Administration (U.S. Energy Information Administration 2009)

Finally, a higher rate may be cost-effective if it provides a service or public benefit that offsets the higher rate. Many customers value renewable energy and are willing to pay a premium to ensure an environmentally superior product. A number of utilities offer "green energy" services

to which customers can voluntarily subscribe. For example, SMUD offers a few different programs that are paid for by voluntary surcharges:

- EnergyHELP, where customers pay $1 per month or more, and SMUD donates this money to charitable organizations that assist low income utility customers who are threatened with disconnection
- HomePower, where customers pay $5.95 per month to cover up to $500 per year of unforeseen electrical repairs
- Greenergy, where customers pay $3 or $6 per month to get 50 percent or 100 percent of their electricity from renewable sources; for $10 per month customers can offset their carbon emissions (Sacramento Municipal Utility District 2012a, Web--Greenergy)

The financial measure of cost effectiveness is thus two tiered: when the community program cost of energy is the same or lower than the utility rate it is de facto cost effective; and when the community program rate for energy is higher than the utility rate it may be cost effective in certain circumstances.

However, the establishment of cost-effectiveness is not simply a matter of comparing prices. The community energy portfolio is primarily designed to meet specified policy goals for carbon reduction, renewable energy, localization of energy resources, and energy security. Thus, the real question of cost effectiveness is the degree to which achieving the policy goals can be accomplished for the given energy cost. The fundamental measure for this feature is the ratio of benefit to cost, for example, by determining a value per ton for carbon reduction or the value to the community for a green energy supply. While much may be achievable within the framework of forecast utility rates, the utility rates are not considered the sole constraint in this analysis.

Modeling

The Sonoma RESCO Research Team used several different models and modeling tools for developing the concepts and analysis in the RESCO project. A few of these models are explained below. The most important models for the RESCO project are the CLEAR model, which is developed by Los Alamos National Laboratories, and the Prototype Model, developed by the Sonoma RESCO Research Team to show the relationships between different elements in Task 5 that are the framework for analyzing local RESCO resources and for designing the portfolios.

Resource Characterization Model

The following model was developed by the Sonoma RESCO Research Team to serve as a reference framework for localization of energy resources. The Task 5 Report does not include all or even most of these elements in its description of each resource; and different resources in the portfolios are described in different ways. However, the reference framework is a source for

how some of the portfolio elements were derived and conceptualized. Ideally, it also lays out elements of a roadmap for further development of local RESCO projects and planning for the future. As such, the following description can be considered as a facet of the prototype design model.

Each resource element of the portfolio can be characterized in terms of the following categories:

1. Location
2. Grid interconnection
3. Number of loads served (total capacity) and
4. Technology package

A resource also has a financial model associated with it that sets the *levelized cost of electricity* (LCOE) from that resource. The financial model includes cost data that is associated with the resource characterization.

Each of the resource characterizations can be further analyzed through the following categories:

- Location
- Onsite
  - The generator is physically co-located with the load. This is a typical configuration for a DG resource.
- Near Site — Shared
- The generator is located near the load, but not necessarily on the same physical site (land parcel) and may be shared by one or more nearby loads. An example of this may be a CHP installation that serves multiple meters at a business park.
- Substation
  - The generator is co-located and interconnected with a substation.
- Remote
- The generator is connected to the transmission or distribution grid at a location distant from the load.
- Interconnection
- Off grid
  - Self-contained energy supply for a particular location without a connection to the existing grid infrastructure. This would apply to remote locations where there is no transmission or distribution available, or possibly to new developments.
- Grid-Connected Wholesale: <60 kV
  - An electric generator that is connected to the distribution system according to the Small Generation Interconnection Procedure (SGIP) (California Independent System Operator 2012a, Web--Interconnection), that supplies electric power to the utility;

these generators are subject to rules about how much capacity can be connected to a distribution circuit.

- Grid-Connected Wholesale: >20 MW
- Grid-Connected: Net Metered
- Scale (measured here by the number of customers served)
- Single Meter
- "Neighborhood" (2-100)
- Campus (100-10,000)
- Metro (10,000-100,000)
- Region (100,000-1,000,000)
- Technology/Fuel Package

The technology package for an energy supply resource may consist of any or all of the following elements.

- Prime Mover/Energy Converters (generator)
- Biomass
- *Biogas/Biomethane*
- Thermal energy conversion (boiler, heat exchanger, chiller)
- Wind
- Onshore
- Offshore
- Solar
- Thermal (no electricity)
- Photovoltaic (electricity only)
- Solar Thermal Electric (CHP)
- Solar Thermal Electric (no CHP)
- Geothermal
- Direct Use
- Electrical Generation/Cogeneration
- Waste Heat Recovery
- Storage (electrical, thermal)
- Portfolio-integrated electric vehicle (EV) infrastructure is an element of the Sonoma RESCO that is reflected in the pilot project (Task 7). As part of the pilot, two EV charging stations have been constructed at the Sonoma County Water Agency's Administration Building. Two more charging stations will be included in the construction of the

Agency's new Fleet Center at the Airport-Larkfield-Wikiup Wastewater Treatment Plant. At these EV charging stations, charging times will be programmed to optimize and level out power drawn from on-site renewable sources and the electricity grid.

CLEAR Model

The CLEAR model (CLimate-Energy Assessment for Resiliency) is an integrated system dynamics model developed by Los Alamos National Laboratory designed to assess and simulate renewable energy mixes and other sustainability activities in Sonoma County that support reduction in electrical demand and low-carbon emission goals (Los Alamos National Laboratory 2012). The model analyzes the interdependencies of complex processes that involve water, energy, climate, social pressure, economics, regulations, and technical advances.

The CLEAR model enables assessment of these and other components with specific analysis of their coupling and *feedbacks* because, due to the complex nature of the problem, the interrelated sectors cannot be studied independently. Because the backbone of the CLEAR model is a general system dynamics platform, it is highly versatile, with potential application to many different energy development and utilization assessments.

The model quantifies the key factors involved in implementing a mixed renewable energy resource strategy. These factors include:

- Reduction of GHG emissions
- Implementation and integration of renewable sources to meet energy demand
- Increased efficiency to reduce demand for resources
- Sustained economic viability and quality of life in the County

Significant changes to Sonoma County's energy supply profile toward low carbon emissions pose a challenging problem due to feedbacks and potential impacts among interdependent County sectors (for example, energy, transportation, water, economy, agriculture, and solid waste). The interface, made available on a web portal, helps stakeholders and policy makers understand options for technology implementation.

The CLEAR model defines important systems and their interrelationships in order to understand feedbacks, emergent behavior, and the potential for unintended consequences. The nature of this model is not predictive but prognostic. External drivers that impact all modeled sectors include population growth, climate impacts, and policy.

Audience and Users

The CLEAR model users primarily will be County elected officials, staff, and County agency professionals. These stakeholders will utilize the CLEAR model, which can be exported as a web applet, to develop an understanding of the costs, benefits, tradeoffs, and potential unintended consequences of various scenarios for GHG reductions. Secondary users include the

general public and interest groups who may explore the model and communicate opinions or views to help inform decisions made by the primary stakeholder group.

Description of Complete CLEAR Model

CLEAR Modules

- Energy: Electricity and Natural Gas
- Water: Water supply, wastewater, and end-users
- Transportation: personal vehicles, mass transit, commercial fleets
- Agriculture: emissions, biomass and carbon cycling
- Solid Waste: emissions and energy potential

Emitting Sectors

- Residential
- CII (Commercial, Industrial, Institutional)
- Agriculture
- Water
- Transportation
- Solid Waste

Model Inputs

- Parameter values that define scenarios for energy sources (for example, Utility RPS, RESCO-RE Portfolio) and use patterns (efficiency, local generation)

Model Outputs

- CO2 emissions by sector and for the County as a whole
- Costs associated with efficiency and RE programs
- Jobs associated with efficiency and RE programs

User Interface

- Web-based applet
- Multiple scenarios
- Dynamic charts of variation in major parameters throughout the model run

Questions to Be Analyzed by CLEAR

- What is required for Sonoma County to meet its emissions reduction goals?
- What are the economic impacts of a given degree of RE deployment?
- What is an optimal renewable energy portfolio design given demand and varying generation options?
- What are the effects of the RESCO Pilot Project and what are the useful ways to assess those impacts in the County
- What are the impacts on CO2 emissions, costs, and jobs associated with various energy scenarios
- Baseline — PG&E RPS compliance
- Climate Action Plan (2008) and RESCO Task 4 refined RE portfolio (2010)
- Efficiency Programs: Water, Non-Water Related

A demonstration of the CLEAR model can be found at http://www.sonomaresco.org/

Specific modifications to the CLEAR model were made in response to design parameters for the Sonoma RESCO portfolio design:

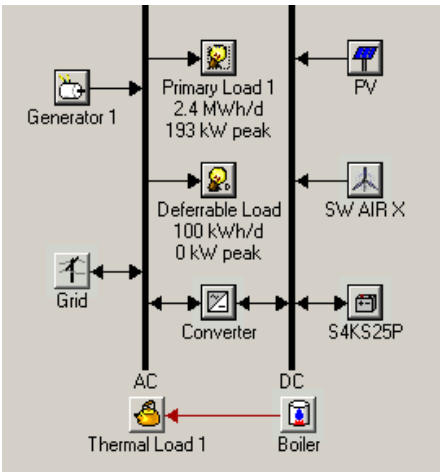
- The original model only assumed job creation for electric generation projects if they were financed and owned by the Community Choice program; this was changed to allow job benefits from projects constructed for the Community Choice program, but where the energy is procured through a power purchase agreement. Use of this element must be evaluated carefully to insure that the power purchase is in fact from a new facility in the county, and not from an existing facility
- The original model assumed that all electric generation supplied power for the entire Community Choice program; this was changed to allow customers to self-generate electricity. This is assumed not to affect general utility customer rates; this is a simplifying assumption which may result in errors due to cross subsidies of net metering. However, this effect is believed to be normally quite small, especially if only a small fraction of electricity is net metered.
- The model was adjusted to allow for combined heat and power systems which generate a portion of their electricity for on-site use and sell the balance of electricity to the Community Choice program; this arrangement follows the state policy adopting feed-in tariffs for excess generation from combined heat and power systems.
- A second feature of the combined heat and power inputs is to charge all CO2 emissions to the electric generator, and assume that all captured heat is zero carbon. This approach does not necessarily follow methodologies used by state agencies, but was adopted to simplify accounting for GHG emissions.

HOMER Micropower Modeling Software

HOMER software[12] allows the user to build models of a set of resources, interconnects, storage and auxiliary equipment, and simulates the operation of these resources to serve a particular annual hourly load profile. The researchers used this software to generate load curve data sets, and more broadly to draw from the model its conceptual framework of looking at a set of grid power elements in order to serve small distributed networks of energy loads, referred to as "campuses." However, HOMER was not otherwise used to model the actual operation of such a network, and this represents a potential further avenue for future investigation.

Figure 13 below shows the elements of the generation technology package and other elements that are represented in a HOMER model. In addition to fossil generation, renewable generation technologies can be represented, as well as storage and thermal loads. Many operational parameters of the generation elements can be modeled in order to minimize costs.

Figure 13: Elements of a Technology Package Model



Source: HOMER Energy LLC (HOMER Energy LLC n.d.).

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[12] HOMER is developed and supported by HOMER Energy LLC, Boulder, Colorado; http://homerenergy.com/software.html

Prototype Model

One of the activities of Task 5 is to develop a renewable energy prototype. A "prototype" in this context is a *model* incorporating design elements useful for producing a cost-effective local renewable energy portfolio. Thus, a prototype is a tool used for developing a portfolio — and is distinguished from the portfolio itself. A prototype is a tool, while the portfolio is a product.

The prototype developed in this report makes use of concepts from systems ecology, which considers local renewable energy development within a system of interrelated elements. This systems approach looks at natural and artificial endowment of resources, energy production and consumption, financial tools and transactions, flow of energy and money, switching actions between energy options, policy and program goals, and nested systems of energy supply and demand. Much of the content of Task 5 is concerned with developing various facets of the prototype and modeling analysis which are considered important for implementing local renewable energy portfolios.

There are several categories of elements in the prototype model, which are illustrated here using H. T. Odum's Systems Language Symbols.

Source

A "Source" is where energy, materials, money, or other raw elements of a system are derived. In the RESCO analysis this could be a source of renewable energy such as the sun or wind, or it can be a source of money for financing projects.

Store

A "Store" is a limited supply of energy, materials, money or other potentially processed elements of the system, where the elements can be placed for a time and later withdrawn. A store allows for control and transfer of the flow of process elements over time, and can be depleted or refilled at certain rates. Electricity can be stored in a battery, carbon dioxide is stored in the atmosphere, and the supply of fossil fuels is stored in the earth.

Generic Flow

A generic flow shows the movement of energy, materials or services through a system.

Self-Limiter

A self-limiter limits the flow of energy, money or materials through a system. Examples of self-limiters include constraints that limit the availability of renewable resources; the demand of customers for electricity limits the amount that can be generated or supplied; and efficiency measures such as LED lighting limit the amount of wasted energy.

Consumption

Just as generation is a source of electricity, consumption by retail electricity customers is where the energy is depleted; for a system consumption represents a sink.

Production

Production takes multiple inputs and produces an output that is the function of the nature and flow rate of the inputs. Electrical generators produce electricity using inputs, which depending on the type of generator includes fuel, air, water, sunlight, labor and money.

Switch

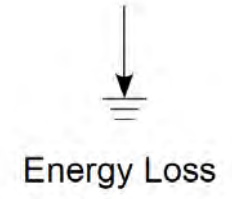
A switch allows for the change of flow of money, materials, or services. A switch can either control flow by being turned "on" or "off", or it can change the direction of flow to another channel. While physical switches can control the flow of electricity, the type of switch of concern for this RESCO report is a functional switch between different types of energy services.

Interaction

A customer may choose to switch between electric service providers, between a community choice program and the default utility, which also embody two different interactions.

Transaction

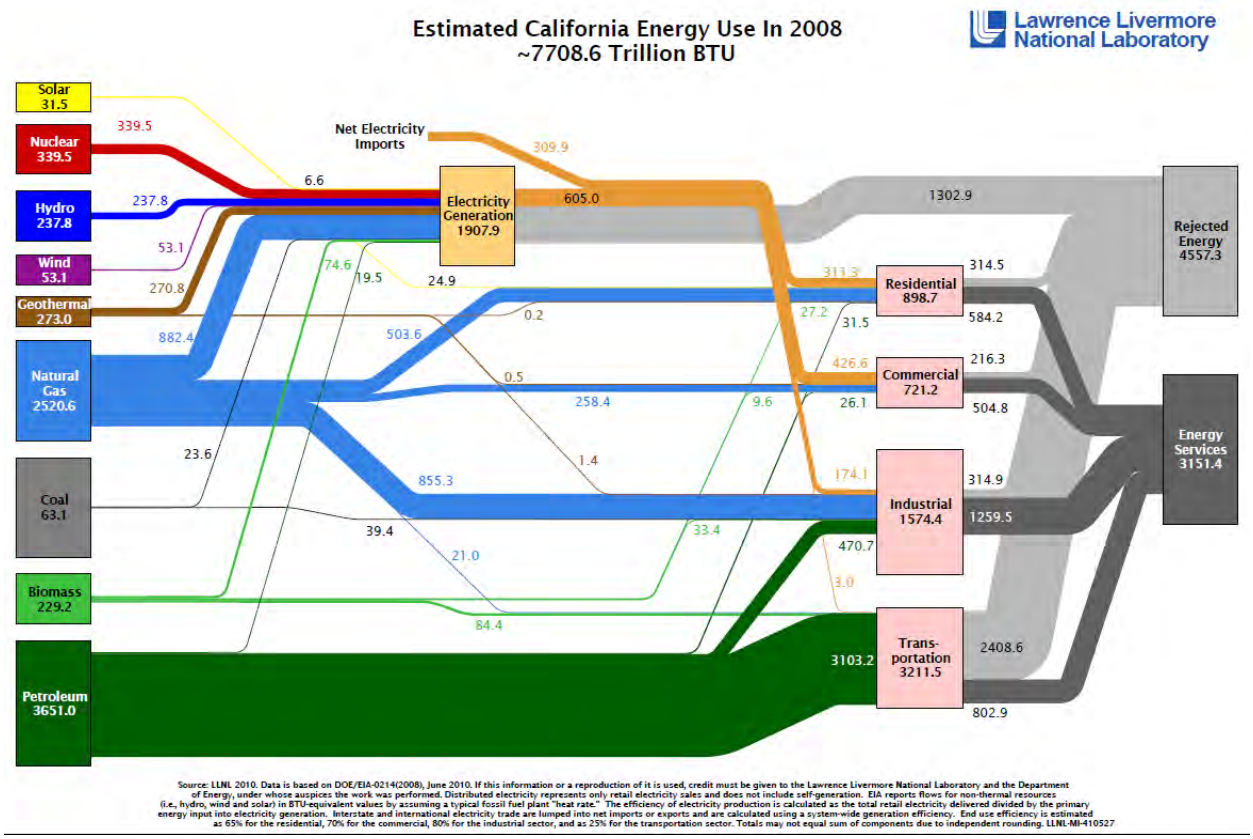
A transaction represents and exchange of services or materials for money or other form of value that compensates the cost of the good supplied.



Energy loss is the energy that leaves the system without producing any valuable service. It can therefore be construed as waste. No system is perfectly efficient, but the production and consumption of electricity is particularly inefficient. A typical central station coal, natural gas, or nuclear power plant only converts about one third of the thermal energy from fuel into electricity. The rest escapes as heat into the atmosphere. Additional energy is lost in the transmission and distribution of electricity through resistance in the grid circuitry.

The ratio of useful energy to energy consumption, which is the sum of useful plus wasted energy, is called *exergy*. Increasing exergy of the energy system for human technology is one of the fundamental design concepts for reducing anthropogenic greenhouse gas emissions, and also for making it much more feasible to meet large energy needs with renewable energy.

Figure 14: California Energy Use in 2008



Source: LLNL 2010. Data is based on DOE/EIA-0214(2008), June 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. Interstate and international electricity trade are lumped into net imports or exports and are calculated using a system-wide generation efficiency. End use efficiency is estimated as 65% for the residential, 70% for the commercial, 80% for the industrial sector, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Source: LLNL, 2010; Lawrence Livermore National Laboratory and the U.S. Department of Energy (Simon 2011).

Figure 14 shows that in 2008, California consumed 1907.9 trillion Btu of energy input to generate 605 trillion Btu of electricity, a net efficiency of 31.7 percent, meaning that over 68 percent of the fuel energy was lost as waste heat into the atmosphere. From a systems perspective, inefficiency in the production and use of electricity is *the primary cause* of greenhouse gas emissions in the electric sector.

After electrical generation and distribution energy losses, consumers waste most of the rest of the original energy either by using inefficient appliances, or by having appliances deliver services where or when they are not needed. For example, the most efficient fluorescent light bulb produce about 100 lumens per watt of electricity input, representing a light producing efficiency of about 38 percent; plug that into a 31.7 percent efficient electric generator and the net result is a system that is 11.7 percent efficient, up to the point of where light is emitted. A poorly designed or badly located fixture wastes much of the light produced,[13] and then people often leave lights on even when they are not near where the light is located. If a traditional incandescent bulb is used, the total system efficiency could be 1 percent or less.

Addressing inefficiency is one of the most powerful interventions that can take place in the electrical system. One important approach is to recover the heat wasted in generation of electricity. This can be accomplished in central power plants through combined cycle generation, which recovers the high temperature waste heat from a combustion turbine and uses it to produce steam to power one or more steam generators. The combined cycle system can reach efficiencies of 50 percent to 55 percent in optimal circumstances.[14]

Even higher efficiencies can be reached by combined heat and power systems, ranging from 60 percent to 80 percent (U.S. Environmental Protection Agency 2012a, Web--Combined Heat), where the waste heat from electric generation is captured to provide hot water, buildings heat, or industrial processes. The basis for combined heat and power is that generation of electricity takes place at or near the same location where both the electricity and the heat can be used. For this reason, combined heat and power is normally a local or distributed energy source. Combined heat and power systems ordinarily use fossil fuels, but it can also greatly improve the efficiency of power generation from biomass, solar, or geothermal sources. Because combined heat and power is such an effective intervention in alleviating the gross inefficiency of electric power generation, this is a key application considered in this RESCO Task 5 report.

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[13] An example is cited in *Economic Issues in Wasted and Inefficient Outdoor Lighting, International Dark-Sky Association (IDA) – Information Sheet #26* (International Dark-Sky Association 2000, Web-Outdoor Lighting), which reports that at least 30 percent of outdoor lighting is wasted by fixtures that misdirect light.

[14] Nameplate efficiencies of combined cycle plants are often shown using the higher heating value, which implies an efficiency of 55 percent to 60 percent. However, the actual efficiency of a combined cycle plant in operation is given by the lower heating value, which is about 90 percent of the factory rating.

Figure 15 is a system diagram of major elements of the Task 5 prototype model, using the Odum symbols. In order to simplify the diagram, not all elements are shown. These elements, and subsystems embedded within these elements, are described in the sections of this report.

Figure 15: Renewable Energy System Prototype Model

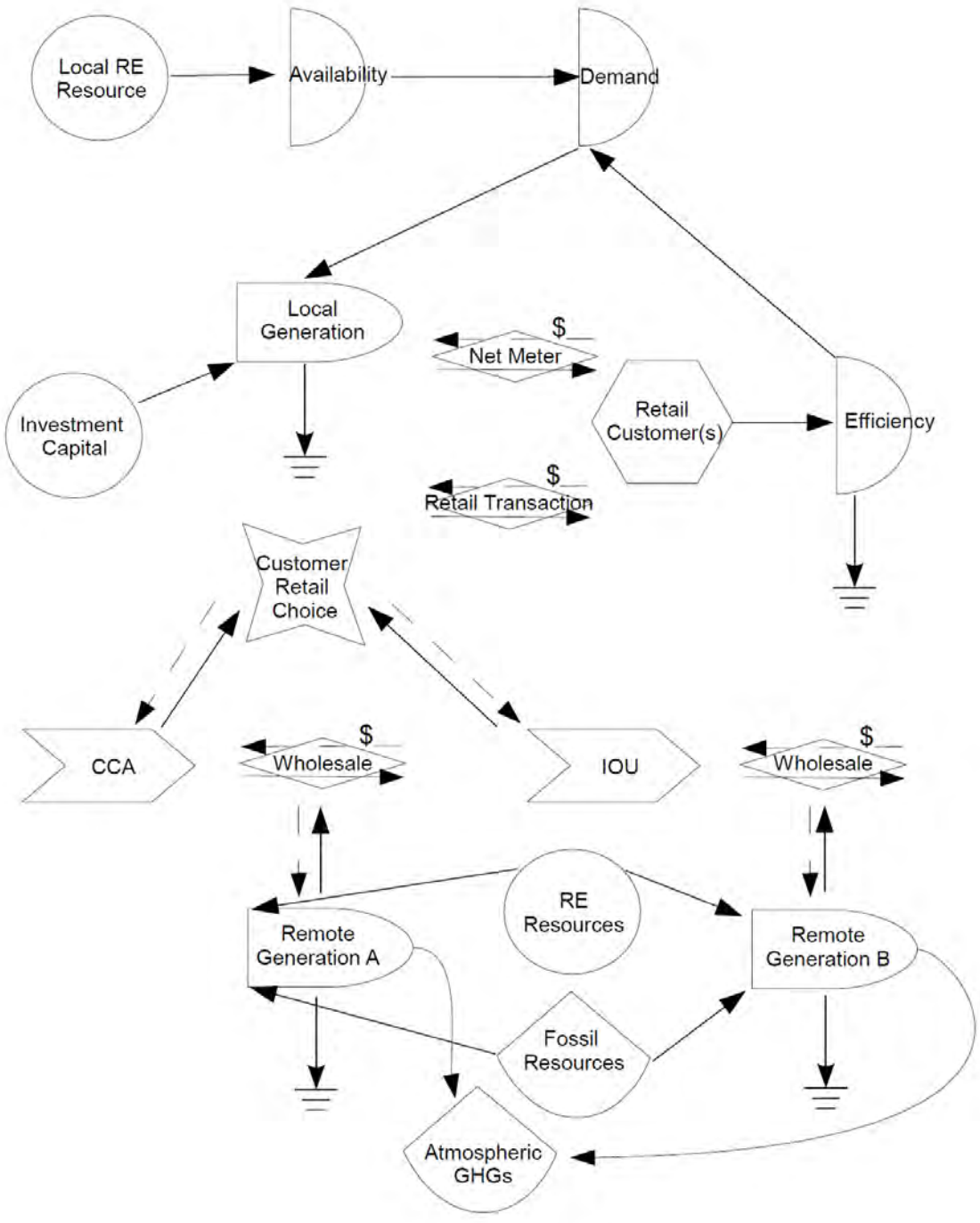

Figure 15 illustrates how local renewable energy enters the model system as a source that is self-limited by availability. The flow and availability of some of these key local resources, focusing primarily on wind and biomass, is investigated in Chapter 4. Demand profiles also place constraints upon the usability of local renewable energy, a factor that is evaluated in Chapter 5. Avoiding waste at the point of consumption is addressed through energy efficiency and other demand management programs described in Chapter 6. Investment sources and other financial transaction tools are described in Chapter 7, while consideration of on-site and remote generation from renewable and fossil sources, as well as service options in the portfolios, is described in Chapter 3.

CHAPTER 3:
Local Renewable Energy Supply Portfolio

Introduction

This section presents three Renewable Energy portfolios for Sonoma County within the framework of RESCO, which are focused specifically upon the development of local resources.

- Portfolio 1. Low case, Business as Usual, where historical development of local resources continues (15 percent local resources)
- Portfolio 2. Mid case, Local Development augments historical programs (30 percent local resources)
- Portfolio 3. High case, Community Energy Service Portfolio & Deployment, where state and local policy goals are attained (50 percent local resources)

Portfolio 1 "business as usual" considers the trajectory of local resource development if they continue at their current pace without any specific local program to accelerate them. The other two portfolios include much higher levels of local resource development, and assume the framework of a community energy supply that is implemented through Community Choice Aggregation.

The local resources would supply a portion of the electric service needs of Sonoma County that varies in each portfolio. While the portfolios in this report have evolved from the original portfolio in the *Community Climate Action Plan* (CCAP), the updated portfolios also have a number of important differences from the CCAP that reflect additional analysis in the RESCO project:

- The original CCAP only presented one portfolio, while this RESCO report presents three portfolios.
- The CCAP, which was created in 2007, focused on a target year of 2015, while this RESCO report has moved the target year to 2020.
- The CCAP only looked at the initial year (2005) and final year (2015) of a ten-year period, while the RESCO portfolios show annual development over the period of 2011 to 2020.
- The CCAP was focused on developing a full-services portfolio to meet the entire county's electricity needs, while the portfolios in RESCO are focused on local resource development.
- The demand projection in the CCAP included all electrical load in the county, while the RESCO analysis in Task 4 has removed water pumping load and the municipal utility of Healdsburg.

- The overall demand projection for Sonoma County has been updated using more recent data than what was available to the original CCAP portfolio.
- Analysis of portfolio resources in the RESCO project has been refined based on much more detailed electrical load data, at the level of substations and customer accounts that was not available to the CCAP.
- The RESCO analysis includes additional methods for financing local projects, such as feed-in tariffs and net metering, and updated technology costs.
- Allocation of resources in the RESCO portfolios is referenced to program implementation data (for example, CSI, SGIP, IOU EE) and policy targets (for example, specific state and local goals for EE, CHP, Solar PV, 33 percent RPS) that were either not available or not considered in the CCAP.
- The RESCO project includes an expanded quantitative and geographic evaluation of the potential for developing local renewable-based energy resources, particularly for biomass, wind, solar PV, and combined heat and power.

The most important modifications in the portfolios in this report are in relation to historical data on actual installation of local renewables, forecast deployment of energy efficiency in the CPUC's planning scenarios, and development of new programs and associated goals.

Local Portfolios

Three RESCO portfolios range from approximately 15 percent to 50 percent local energy resource by 2020. Having a range of local resources tests strategic elements of the deployment strategy, and allows evaluation of some effects of increasing penetration of local RESCO resources. A more detailed discussion of the spreadsheets that the three portfolios are derived from can be found in Appendix A: Sonoma County RESCO Portfolio Resource Spreadsheets Description, beginning on page A-1. Cost assumptions and calculations of cost of energy for the portfolio resources is presented in Appendix B.

The three portfolios illustrate different paces of annual development of local RESCO resources, which are modeled starting from 2010 and with 2020 set as a "target" date for full deployment of the local resources in the portfolio. Further development of these resources could continue beyond that date, but evaluation beyond 2020 is not analyzed in this report. The financial justification for implementing most or all of these local resources will likely improve over time, as grid electric power rates continue to increase.

The three portfolios use a defined set of local resources — energy efficiency, combined heat and power, fuel cells, solar photovoltaics, wind, small hydropower, and energy storage. There is also the potential to develop demand response, but this has not been evaluated in the project. These three local resource development portfolios are designed as follows:

Portfolio 1 — 164 megawatts of capacity by 2020: A Business-as-Usual portfolio that considers what may happen if PG&E continues to provide electric power for Sonoma County; in this case a certain amount of local resources can be expected to be on-line in the modeling period. This portfolio assumes that the combined local resources, including efficiency and local generation, will reach approximately 15 percent of forecast demand by 2020.

Portfolio 1 is based upon several state data sets of small-scale generation in California, from which projects located in Sonoma County have been extracted. The data sets include existing projects that were installed in the past as well as projects that are in the queue for future construction in the state's small scale generation programs, including California Solar Initiative (CSI), the Self-Generation Incentive Program (SGIP), Wholesale Distributed Generation Tariff, and the Energy Commission's database of existing power plants. These data sets show projects that may be installed approximately through 2013, and allow for limited extrapolation beyond that date.

This portfolio takes the conservative assumption that very little new local electrical generation will be built. The primary exception is rooftop solar photovoltaics, which is shown to increase in the model, particularly since solar power has been supported by specific programs. However, the development of rooftop solar, and some other forms of behind the meter generation such as wind and fuel cells, would only expand if support programs are extended or expanded, such as net metering, state rebates, federal tax credits, and feed-in tariffs.

Portfolio 1 projects 75 MW of solar photovoltaics, of which about 40 MW has already been installed. There is also another 12 MW of existing small scale local generation, including natural gas combined heat and power, biomass generation at the landfill with an additional 2 MW of biomass planned, small scale wind, geothermal, and the existing small hydro project. While it is possible that additional local generation might be built through existing policies, they would likely need to be supplemented by local initiatives in Sonoma County in order to be scaled up much further, which is the assumption in portfolios 2 and 3.

Most of the existing and planned generation in Portfolio 1 is self-generation, and a small amount may be wholesale generation in the future. Therefore, the primary cost of producing energy from these sources is assumed by the project owners who benefit from the electricity generated.

Nearly half of the local resource in this portfolio is from energy efficiency supplied by existing programs. These programs are paid for by a mix of public and utility funds, and they provide consumer rebates for efficient appliances and other measures that save energy. This portfolio approximates the planning assumptions for the 2010 to 2020 timeframe for the major Investor-Owned Utilities, including PG&E, as ordered by the California Public Utilities Commission for the Long-Term Procurement Proceeding in 2010 (Table 10). The efficiency portion of all of the portfolios is described in more detail in the efficiency section.

Table 10: Local RESCO Electricity Portfolio 1, Business as Usual — 164 MW by 2020 (15% local resources)

	EE	PV	NG CHP	Geothermal	Biomass	Wind	Hydro	Storage	Local
Year	MW	MW	MW	MW	MW	MW	MW	MW	MW
2011	5.1	41.0	2.7	25.0	6.4	0.2	2.8	0.0	83
2012	10.4	45.0	2.7	25.0	6.4	0.2	2.8	0.0	93
2013	15.9	49.0	2.7	25.0	6.4	0.2	2.8	0.0	102
2014	21.6	52.0	2.7	25.0	8.4	0.2	2.8	0.0	113
2015	27.4	55.0	2.7	25.0	8.4	0.2	2.8	0.0	122
2016	33.4	58.0	2.7	25.0	8.4	0.2	2.8	0.0	131
2017	39.6	59.0	2.7	25.0	8.4	0.2	2.8	0.0	138
2018	46.0	61.0	2.7	25.0	8.4	0.2	2.8	0.0	146
2019	52.6	63.0	2.7	25.0	8.4	0.2	2.8	0.0	155
2020	59.5	65.0	2.7	25.0	8.4	0.2	2.8	0.0	164

Portfolio 2 — 285 megawatts capacity by 2020: The "Mid-Case" portfolio is where local resources meet approximately 30 percent forecast Sonoma County demand in 2020 — more than double the amount in Portfolio 1. In addition to the resources described in Portfolio 1, which mostly reflect legacy programs from the last decade, Portfolio 2 assumes a significant amount of local effort to increase local renewable energy and energy efficiency. These efforts allow the community to get closer to state and local policy goals for energy efficiency, combined heat and power, and renewable distributed generation, but still do not achieve the full policy targets.

Portfolio 2 includes 90 MW of small-scale solar photovoltaics, 30 MW of combined heat and power, and about 73 MW of other local renewable power generation. In addition, 10 MW of energy storage, assumed to be in the form of utility scale batteries, meet less than 2 percent of Sonoma County's peak load.

As in Portfolio 1, a significant portion of the local electricity supply is assumed to be self-generation, partly through net metering. However, a greater portion of this energy is exported to the grid. In the case of combined heat and power — roughly half of the electricity would be used on-site and half would be purchased by a Sonoma County community choice program as wholesale power through a feed-in tariff. Similarly, much of the local wind development would also be purchased as wholesale power.

In important feature of Portfolio 2 is that the additional resources are assumed to be deployed gradually between 2014 and 2020. This minimizes the effect on consumer rates, and allows the portfolio to blend in better with the general increase in energy costs that are forecast to happen in any case. As conventional power supply becomes more expensive, the local generation options become more cost effective, will pose less risk of increasing utility rates, and at certain points in time — depending on the specific technology and project — are likely to begin to be less expensive than conventional power.

Portfolio 2 also increases energy efficiency savings over the decade. Where Portfolio 1 saves about 0.5 percent per year, and cumulatively reduced electricity demand 5 percent by 2020,

Portfolio 2 saves 7.5 percent of demand by 2020 (Table 11). This is still short of the state's climate plan, which calls for 10 percent efficiency savings by 2020.

Table 11: Local RESCO Electricity Portfolio 2, Mid Case — 285 MW by 2020 (30% local resources)

	EE	PV	NG CHP	Geothermal	Biomass	Wind	Hydro	Storage	Local
Year	MW	MW	MW	MW	MW	MW	MW	MW	MW
2011	6.1	41.0	2.7	25.0	6.4	0.2	2.8	0.0	84
2012	12.5	45.0	2.7	25.0	6.4	0.2	2.8	0.0	95
2013	20.3	50.0	2.7	25.0	6.4	0.2	2.8	0.0	107
2014	29.7	55.0	2.7	0.0	8.4	0.2	2.8	0.0	99
2015	40.9	60.0	5.0	0.0	8.4	0.2	2.8	2.5	120
2016	52.3	65.0	7.5	35.0	10.0	2.0	2.8	5.0	180
2017	64.2	67.0	10.0	35.0	12.5	4.0	2.8	7.5	203
2018	77.9	69.0	12.5	35.0	15.0	6.0	2.8	10.0	228
2019	92.1	72.0	15.0	35.0	17.5	8.0	2.8	12.5	255
2020	106.7	75.0	20.0	35.0	20.0	10.0	2.8	15.0	285

Portfolio 3 —425 megawatts capacity by 2020: The "High Case" portfolio achieves the local proportional share of several state policy goals, including the AB 32 climate plan targets for energy efficiency and for combined heat and power. This portfolio would provide 50 percent of forecast electricity demand with local resources in 2020.

Portfolio 3 includes 105 MW of local solar photovoltaics, assumed to be on-site generation that will be net-metered. In addition, there are 40 MW of combined heat and power, which represents Sonoma County's proportional share of the state target of 4000 MW of new combined heat and power by 2020. There is a total of over 160 MW of other types of local renewable power generation, including 50 MW of wind, 70 MW of geothermal, and 40 MW of biomass. Energy storage supplies 45 MW of capacity, which is nearly 8 percent of peak demand. This allows for clean integration of the wind and solar power by balancing the variable output of these two types of renewable generation.

Energy efficiency is greatly augmented by programs administered locally, and achieves double the energy savings compared to Portfolio 1, reaching 10 percent demand reduction by 2020 which is the county's share of the climate plan goal (Table 12). This will require significant commitment of local funds from the community choice program, which is assumed to be necessary for financing this type of efficiency effort.

Table 12: Local RESCO Electricity Portfolio 3, High Case — 425 MW by 2020 (50% local resources)

	EE	PV	NG CHP	Geothermal	Biomass	Wind	Hydro	Storage	Local
Year	MW	MW	MW	MW	MW	MW	MW	MW	MW
2011	6.1	41.0	2.7	25.0	6.4	0.2	2.8	0.0	84
2012	12.5	45.0	2.7	25.0	6.4	0.2	2.8	0.0	95
2013	20.3	50.0	2.7	25.0	6.4	0.2	2.8	0.0	107
2014	30.4	55.0	2.7	0.0	8.4	0.2	2.8	0.0	100
2015	42.9	60.0	5.0	0.0	8.4	0.2	2.8	5.0	124
2016	58.0	65.0	10.0	40.0	10.0	5.0	2.8	10.0	201
2017	75.8	70.0	15.0	40.0	15.0	10.0	2.8	15.0	244
2018	96.4	75.0	20.0	40.0	20.0	15.0	2.8	20.0	289
2019	117.6	80.0	30.0	70.0	25.0	20.0	2.8	25.0	370
2020	142.0	85.0	40.0	70.0	30.0	25.0	2.8	30.0	425

All these portfolios represent significant changes relative to the original Sonoma County Climate Plan. One important difference is that the new portfolios are focused on the RESCO concept, meaning that rather than looking at the entire energy supply of a CCA, they only include local clean energy resources. This is a very important distinction that was mentioned in the Task 4 report and that frames all of Task 5. The local resources fill a block of forecast demand, and the balance of power will need to be obtained from a mix of remote renewable, hydroelectric and conventional sources.

Another difference is the way these resources are deployed over a period of time. The original CCAP portfolio was to be implemented by 2015, and showed the model electricity supply for that year. The current portfolios are shown as being implemented over time, with most of the resources deployed between 2015 and 2020.

Technical Potential

The technical potential for select local resources is evaluated in order to determine a realistic range for implementing these resources in the portfolios. The technical potentials are evaluated in several ways, including using available data and maps showing renewable energy resource locations and quantities, data showing concentration of thermal load that can be used for determining where combined heat and power can best be sited, and data showing local electrical demand profiles that provide indications for where small-scale local renewable energy generation can be sited.

However, the technical potential is not necessarily the same as the values for how much of a given resource is proposed in a given portfolio. Each portfolio varies significantly from the others in how much of each resource is included, and the RESCO report has not evaluated the technical potential for all resources, and in general only a portion of the potential is evaluated. The value of this analysis is that it offers plausible quantified subsets of what the technical capacities may be of given resources.

Furthermore, the relevant constraints for each resource are quite different. For example, the wind resource is limited by geography and wind speed, but greatly exceeds the amount considered for any portfolio. The raw solar resource is for all practical purposes unlimited, but

the technical limit is more closely related to local energy demand and the amount of solar power that can be integrated into the distribution grid. The proposed approaches for developing solar PV are believed to be technically feasible, but may require implementing operational controls, energy storage, and/or grid upgrades if the total quantity of distributed renewables exceeds certain limits.

Cost Effectiveness

Cost effectiveness of technologies in the local energy portfolios is enhanced through applying a four-fold financial model that includes options for providing upfront capital, ownership, revenue, and program structure that is presented in Chapter 7. For example, if a community choice aggregation program purchased wholesale electricity directly from many small-scale rooftop solar projects, this could increase electricity rates more than if the same electrical generation is used on-site. On-site generation may be valued at full retail rate, such as through net metering, thus increasing the threshold for what is "cost-effective." In addition, a net-metered project creates minimal burden upon the general customer rates. Valuing energy at retail rates is an important component of the portfolios, particularly for energy efficiency, solar photovoltaics, and for a portion of combined heat and power. Other resources, including wind, geothermal, and biomass power, assumed to be part of the wholesale energy purchased for a community choice energy program. In Portfolio 3, these wholesale sources collectively supply one third of the retail electricity for Sonoma County.

A more detailed discussion of cost of the resources described in this chapter can be found in Appendix B: Cost of Electrical Generation in Sonoma County RESCO Portfolio, beginning on page B-1.

Feasibility

The assessment of feasibility in structuring the portfolios presented in this report is limited. Actual development of these portfolios may be limited by challenges with permitting, interconnection, suitability of specific sites, engineering problems, availability of financing, political issues, and other factors that are not directly evaluated in this report. The particular focus of RESCO is to increase reliance on local renewable energy resources. A sizable portion of the Climate Plan's proposed portfolio — and nearly all of the current electricity supply — is located outside Sonoma County. It would be possible to continue to locate nearly all electrical generation outside the county in order to minimize challenges facing local renewable energy projects. From a RESCO perspective, this would shift the footprint of local energy usage onto other communities that would then produce electricity for Sonoma County. It would also reduce the economic, energy security, and other benefits that local renewables can provide.

The portfolios address some of the potential challenges by providing a diverse mix of resources that reduce the risk associated with putting all eggs in one basket. For example, while larger renewable energy projects may face permitting or siting challenges, that is less likely to be the case with rooftop solar installations. And while adding large amounts of distributed generation may face increasing problems with interconnection to the grid, energy efficiency measures normally do not. Furthermore, the portfolios have different levels of each resource, providing a

look at the effect on the overall energy portfolio if certain resources are developed to a greater or lesser extent.

Greenhouse Gas Reductions

A larger goal of RESCO, as with the CCAP, is rapid, significant greenhouse gas emissions reduction. The proposed low carbon local portfolios could be an important component of an electric supply that would enable Sonoma County to reach its 25 percent emission reduction goal. Accomplishing this goal will require greatly exceeding California's Renewable Portfolio Standard. This state law mandates that utilities obtain one third of electricity retail sales from renewable sources by 2020, a requirements that also applies to community choice programs. Portfolios 2 and 3 both assume the existence of a community choice program in Sonoma County, and that program would be legally required to meet this standard of 33 percent renewable energy as a minimum.

The RESCO portfolios do not describe entire energy supply for a community choice program, but rather only local resources. Portfolio 3 in particular is designed to meet or exceed certain resource targets of the state's clean energy policies that are outside of the renewable portfolio standard program. This includes 40 megawatts of combined heat and power, incremental energy efficiency savings of 10 percent below the projected demand forecast, and greatly exceeding Sonoma County's share of the California Solar Initiative. All three of these other programs are assigned specific carbon reduction values in the state's Climate Scoping Plan, which together rival the carbon reduction attributed to the 33 percent renewable program. Building out these other local resources, could thus approximately double the effect of achieving the renewable standard alone.

While the local resource Portfolio 3 also meets the states 33 percent renewable requirement, it will be important for the community choice program to secure additional renewable energy supplies beyond what is included even in the preferred portfolio if local climate goals are to be met.

Local Energy Resources

Combined Heat and Power and District Heat

Combined heat and power (CHP) embodies an integrated approach to energy services that includes electric generation, thermal energy for building heating and cooling, and potentially fuel or electricity for transportation. CHP is also based on the sustainability concepts of treating reducing demand for energy on an equal basis with creating new supply, and utilizing energy embodied in waste.

From a whole systems standpoint, the distinguishing feature of the current electrical energy system is its inefficiency. The vast majority of energy embodied in the "primary energy" sources, which for Sonoma County's present electricity supply are mainly fuels such as natural gas, uranium, and to a much less extent coal, are released into the atmosphere as heat without delivering any useful service for utility customers. The portion of energy in a system that is

directed to a useful purpose is called "*exergy*," and a principle design aim of the proposed portfolios is to take advantage of opportunities to increase exergy, either by capturing heat that would otherwise be wasted in the generation of electricity, or by increasing the efficiency with which electrical power is consumed.

Combined heat and power captures waste heat from electrical generation and applies it for useful purposes, and while the main fuel used for CHP is natural gas, it may be applied in the context of any thermal power generation source, including biomass, as well as solar or geothermal heat. There are also different technologies that can be used for CHP; Table 13 shows the typical range of achievable efficiency for standard technologies.

Table 13: Efficiency of Six Most Commonly Used CHP Prime Movers

Steam Turbine	80 percent
Diesel Engine	70-80 percent
Natural Gas Engine	70-80 percent
Gas Turbine	70-75 percent
Microturbine	65-75 percent
Fuel Cell	65-80 percent

Source: *Efficiency Benefits* (U.S. Environmental Protection Agency 2012b)

Development of local CHP in Sonoma County is considered in the portfolios in relation to implementing state policies. California's Climate Change Scoping Plan adopted a target of building an additional 4000 MW of CHP, enough to displace 30,000 gigawatt-hours of electricity from central generating sources, and to reduce projected CO2 emissions by 6.7 million metric tons in 2020 (California Air Resources Board 2008). The Scoping Plan makes several recommendations regarding overcoming some of the barriers to developing new CHP:

> "California has supported CHP for many years, but market and other barriers continue to keep CHP from reaching its full market potential. Increasing the deployment of efficient CHP will require a multi-pronged approach that includes addressing significant barriers and instituting incentives or mandates where appropriate. These approaches could include such options as utility-provided incentive payments, the creation of a CHP portfolio standard, transmission and distribution support payments, or the use of feed-in tariffs." (California Air Resources Board 2008, 44)

California created statutory requirements for a CHP feed-in tariff through AB 1613 (Blakeslee Statues of 2007). The CPUC spent "more than a year and a half of intensive negotiations, three investor owned utilities, four representatives of qualifying facilities (QFs), and two ratepayer advocacy groups," to develop a settlement agreement for implementing the CHP program, which was adopted by decision of the commission in December 2010 (California Public Utilities Commission 2010). In the decision, the CPUC determined that CHP counts toward the resource adequacy of the investor-owned utilities, and therefore certain IOU procurement costs for CHP could be recovered from CCAs under the authority of the SB 695 (Kehoe Statues of 2009) cost

allocation methodology. The decision appeared to leave open the question of a situation where CCAs would procure their own CHP.

> "We remain open to consideration, in a future proceeding, of proposals whereby ESPs and CCAs may opt out of IOU procurement and procure CHP resources on their own behalf" (California Air Resources Board 2008, 56)

If a CCA should procure its own CHP pursuant to AB 1613 in order to meet its share of the AB 32 Scoping Plan goal, the cost effectiveness of the program could be significantly improved if the CPUC would also drop the requirement for the CCA to pay for the IOU procurement of CHP, so that double payment for CHP would be avoided.

The state's investor owned utilities and other parties also challenged the legality of this feed-in tariff at the Federal Energy Regulatory Commission (FERC). FERC issued an order, and denied a request for rehearing by California's investor-owned utilities, upholding the right of states to implement a feed-in tariff based upon state mandates to procure a specific type of electrical generation (Federal Energy Regulatory Commission 2010).

The original Sonoma County Climate Plan portfolio included 116 MW of CHP, half of which was to be fueled by natural gas and the other half by biofuel. These resources, which would supply 28 percent of the county's electricity, were not assumed to be necessarily local, although local resources were preferred to the extent that they were feasible and could be justified financially.

The RESCO portfolios consider a range of potential local CHP capacity. Portfolio 1 includes 2.7 MW of CHP throughout the planning horizon, which is the amount of existing CHP in the county in 2012. Therefore, this scenario assumes no new CHP will be built before 2020. Portfolios two and three assume a gradual building of new CHP that reaches 30 MW in Portfolio 2, and 40 MW in Portfolio 3. This CHP is specified in the portfolio resource tables to be powered by natural gas, since this is the most readily available fuel. However, from a RESCO perspective, natural gas fuel has significant greenhouse gas emissions, is not renewable, and is not locally available. The RESCO profile for CHP could be improved by substituting biomethane for part or all of the natural gas, with the option of delivering the biomethane through the natural gas pipelines. There are financial and resource factors that may limit access to local biomethane; therefore, the RESCO portfolios leave open the option for replacing natural gas with renewable fuel.

As a simplifying assumption, the greenhouse gas model charges all greenhouse gas emissions to the electrical generation, which makes the capture of waste heat greenhouse gas free. Chapter 5 explains the methodology for identifying select areas as more likely candidates for CHP systems serving on-site electrical load while delivering heat through a small-scale heat distribution network. These mini district heat systems diversify the base of thermal load customers, because residential, commercial and government/institutional consumers have very different and often complementary needs for heat over the course of the year. While this approach is more complicated than developing CHP only at individual customer sites, the mini-

district heat system is an opportunity to improve efficiency in the use of waste heat by ensuring a more stable year-round demand.

The mini district heat systems often have more heat demand than demand for electricity at a single site where the CHP generator would be located. State regulations allow "over the fence" transactions whereby two large consumers could be served with the electricity generated "behind the meter," which would increase the value of the electricity. To the extent that excess electricity is generated beyond what can be used on-site, this would need to be exported to the grid. In the RESCO model, the CCA would purchase the excess electricity generation using a feed-in tariff in order to support the market for local CHP and meet greenhouse gas reduction targets.

Local Solar Photovoltaic (PV) Program

Development of solar photovoltaic projects in Sonoma County is considered here from a few perspectives: establishing an overall program size, choosing a deployment strategy, and determining cost. Cost is analyzed in greater detail in Appendix B beginning on page B-3.

For reasons specified in this section, about 55 MW (AC) of installed capacity of local solar PV should be achievable through existing state programs. This is likely to be completed by the end of 2013, either prior or concurrent to the startup of a CCA solar program, and Portfolio 1 projects 75 MW of installed capacity by 2020. To the extent that local solar PV would be built by the CCA, it will be additional to this existing amount. Portfolios 2 and 3 propose construction of 90 MW and 105 MW respectively by 2020.

Establishing a Sonoma County Solar PV Goal

The size of a near term local solar photovoltaic target for Sonoma County is evaluated in the context of the following parameters:

- The amount of solar PV that is being built through California solar program
- Local Sonoma County policy goals
- The relative "fit" of power production from solar PV systems compared to local demand
- The ability to easily interconnect projects to the local distribution grid

The California Solar Initiative Program: The state's current solar photovoltaic program, the California Solar Initiative (CSI), is already on track to build out most of the proposed local target in the form of small-scale, mostly rooftop, systems. As of February 2012, nearly 3500 applications have been submitted for solar PV projects in Sonoma County, totaling 38 MW. Of this amount, 30 MW of solar PV have already been installed. The additional 8 MW are in various stages between initial submissions of application for rebates to near completion.

An estimate can be made of the total local project capacity the CSI can be expected to deliver. Approximately 10 percent of applications drop out before completion in the CSI program. In Sonoma County the dropouts — projects that have been withdrawn, cancelled, or suspended — to date represent nearly 28 percent of the capacity rating. Another limiting factor is the fact that

PG&E's CSI program is near completing Step 9 out of the 10-step program; Step 10 represents 20 percent of the total CSI program capacity. Taking these factors into account, and assuming current trends continue for the next year until the CSI program completes in PG&E's service territory, total installed solar PV should reach close to 45 MW in Sonoma County from CSI.

Legacy Solar Programs: Previous to CSI, California had two main programs supporting solar PV with rebates and net metering. The Emerging Renewable Program (ERP) was administered by the California Energy Commission providing rebates for projects smaller than 30 kilowatts, while the Small Generator Incentive Program (SGIP) was administered by the investor-owned utilities under the auspices of the Public Utilities Commission. The ERP supported installation of about 5 MW (California Energy Commission 2012b) and the SGIP 6 MW (Pacific Gas and Electric Company 2012o) of solar PV in Sonoma County (Table 14).

Table 14: Installed Solar PV Capacity in Sonoma County by Program (Kilowatts)

Program	Nameplate Rating	CEC PTC Rating
CSI Installed	35,325	30,403
ERP Installed	6,147	5,102
SGIP Installed	7,722	6,409
Subtotal Installed	49,194	41,914

Sources: California Solar Photovoltaic Statistics and Data (California Energy Commission 2012b); SGIP — Available Funding and Program Statistics (Pacific Gas and Electric Company 2012o)

In sum, current data shows 42 MW of solar PV has been installed to date in Sonoma County. Another 8 MW of potential installation are pending in the CSI program. Since there is another step to go in CSI, additional applications over the next year are almost certain. It is reasonable to expect that very close to 55 MW will have been installed by the completion of the CSI program, which is likely to occur sometime in 2013. These projects should generate about 90 gigawatt-hours per year, meeting approximately 3 percent of the county's electricity demand.

This raises a question of whether a further, higher target for local solar PV should be established for a proposed CCA that might begin operation in 2013 or 2014. If the full amount of DG is built according Portfolio 3, then certain current limits related to interconnection may be exceeded. These limits are not absolute, but may pose some technical challenges, and incur additional costs for installing high amounts of PV.

One factor for establishing a reasonable quantitative target for solar PV is matching the needs of the demand curve. Because solar PV produces only during the day, it is most efficient to limit the capacity installed to the difference between the normal base load and the daily load at the time when solar production peaks at mid-day. If this amount is exceeded, then one of two things will need to occur in order to compensate. Either the base load resource will need to be reduced in output, or the excess generation of the solar PV will need to be curtailed. If the base load resource ramps up or down in output over relatively short periods of time, then efficiency of that generation may also decrease, especially for natural gas power plants. In addition, some types of base load generation, such as geothermal power, are not designed ordinarily to vary in output. It is technically feasible to curtail excess generation of solar PV when needed, but existing installations are not designed with this feature. Future efforts to expand solar PV in

Sonoma County may need to address this issue sooner than other areas of the state, due to the exceptionally large amount of solar PV compared to the local load size.

Data assembled from the substations in Sonoma County show a rise from baseload to the average demand at 1:00 pm is about 150 MW (Table 15). Without load controls, or deliberate integration of local solar generation with other power generation, risk of problems may increase as the county's solar PV approaches this 150 MW level. One option would be to reduce the output of base load generators during the day to accommodate the extra solar, but this might require having real time data on solar production as well as good forecasting models.

Table 15: List of Substations and Relevant Solar PV Parameters

BUS_NAME	peak	base	15%	1pm average	1pm elevation
ANNAPOLS----(31348)	0.44	0.13	0.07	0.24	0.11
BELLVUE-----(31246)	41.27	15.00	6.19	28.00	13.00
CALISTGA----(32652)					
CLOVRDLE----(31208)	15.86	4.60	2.38	8.30	3.70
CORONA------(31254)	19.41	6.00	2.91	9.60	3.60
COTATI------(31384)	20.65	7.50	3.10	14.10	6.60
DUNBAR------(31396)	13.03	6.50	1.95	6.74	0.24
FORT-RSS----(31350)	0.31	0.10	0.05	0.20	0.10
FTCH-MTN----(31380)	15.72	3.60	2.36	8.50	4.90
FULTON------(30430)	47.64	16.00	7.15	28.00	12.00
GUALALA-----(31346)					
GYSRVLLE----(31368)	1.37	0.39	0.20	0.75	0.36
HELDSBRG----(38050)	5.06	1.50	0.76	2.90	1.40
LAKEVLLE----(31255)	22.63	7.50	3.39	13.50	6.00
MIRABEL-----(31360)	11.05	3.10	1.66	6.10	3.00
MOLINO------(31364)	35.84	11.00	5.38	20.00	9.00
MONROE1-----(31238)	41.27	15.00	6.19	28.00	13.00
MONROE2-----(31239)	35.33	12.00	5.30	22.00	10.00
MONTE-RO----(31356)	11.05	3.20	1.66	6.50	3.30
NOVATO------(32668)					
PENNGRVE----(31248)	26.64	7.00	4.00	14.50	7.50
PETLMA-A----(31390)	23.54	8.50	3.53	15.00	6.50
PETLMA-C----(31388)	18.15	6.60	2.72	12.05	5.45
RINCON------(31250)	33.21	8.90	4.98	17.00	8.10
SLMN-CRK----(31354)	3.69	1.00	0.55	2.10	1.10
SNTA-RSA----(31240)	68.16	24.00	10.22	43.00	19.00
SONOMA------(31258)	42.07	12.50	6.31	22.47	9.97
SUBTOTAL	553.37	181.62	83.01	329.54	147.93

Source: PG&E

Adjustments will be necessary if the state adopts the Governor's proposed 12,000 MW target for renewable DG. At a minimum, it would be helpful to have a more streamlined approach to analyzing distribution circuits for the purpose of approving projects.

Sonoma County's proportional share of various state targets can be estimated by calculating the ratio of Sonoma County's demand to that of the whole state. In 2010, the county is reported to have consumed 2,875 gigawatt-hours, compared to 274,985 gigawatt-hours for all counties in the state combined (California Energy Commission 2012c). Thus, Sonoma County represents very close to 1 percent of the state's total electricity demand.

Table 16 shows various program goals, and Sonoma County's equalized share:

Table 16: Pro-Rata Share of Existing and Proposed California Renewable DG Programs

RDG Goals		GoSolar	SB 32 Feed-in Tariff	IOU Solar Program	RAM	Legacy SGIP, ERP	Subtotal Existing Programs	Governor Brown's Target
State Goal	MW	3,000	750	850	1250	285	6,135	12,000
Sonoma County Share	MW	31	8	9	13	3	64	125

Source: GoSolar program data, CPUC, Energy Commission,
Gov. Brown's Clean Energy Jobs Program

There is no specific statewide policy that the actual deployed renewable DG for each program would match the equalized share of each county, but this table provides a useful guideline for comparison. It allows evaluation of what quantities would be "default" values, and what amount of local development would represent progressive targets compared to existing state policies.

The Governor's goal is similar to one of the CPUC's seven required planning scenarios for Investor-Owned Utilities in the 2010 Long-Term Procurement Proceeding. The "Environmentally Constrained" scenario showed 9,077 MW of small-scale solar PV in California in 2020 contributing toward meeting the state's 33 percent RPS. The 3,000 MW GoSolar Program does not count toward the RPS, which would thus bring the total in-state distributed solar PV to 12,000 MW in this CPUC planning scenario (California Public Utilities Commission 2010). Furthermore, there is roughly an additional 3000 MW of existing and new renewable DG programs that is not necessarily solar PV.

Local Policy Goals: The City of Santa Rosa is one of 25 cities in the nation to become a Solar America City, a program funded by the U.S. Department of Energy. The program intends for communities to realize the following objectives from solar energy (U.S. Department of Energy 2012b):

- Power from secure, domestic energy
- Sustainable, "green" urban development
- Clean energy production that helps meet greenhouse gas reduction targets and climate change goals
- Development of new economic opportunities.

The cities in the program work to overcome market barriers to development of solar power. Local goals for solar energy have been established through the City of Santa Rosa and Solar Sonoma County, funded by a grant from the U.S. Department of Energy (Wright 2010). The program developed a *Solar Implementation Plan* for the county, which adopts a set of three goals (Solar Sonoma County 2012, Page 7):

- Add 25 MW of new solar generation between 2008 and May 2011,
- Over the long-term, replace 250 MW of peak demand with a combination of solar energy generation and energy efficiency, and
- Support countywide GHG reduction targets.

CSI data show that 27 MW[15] of solar PV were added in the county between the beginning of 2008 and May of 2011, and a cumulative 45 MW of local solar PV can be expected for the CSI program at completion given current trends.[16] The first Solar Implementation Plan goal of 25 MW has been accomplished. If 45 MW is reached through the CSI program, this would be much more than Sonoma County's share of the state's general market solar program, which is a 1,750 MW segment of the total 3,000 MW GoSolar program. Based upon relative size of the county's electricity usage compared to the state as a whole, the pro-rata share of CSI for Sonoma County would be 17 MW.

The larger, long-term goal of 250 MW represents a mix of solar PV and energy efficiency, but does not provide separate figures for each.

Deployment Strategies

The potential roles for a CCA, to support building additional solar PV beyond 55 MW, include:

- Strategically placing solar PV behind the meter, where it has greatest value to customers
- Paying for net excess generation using a standard offer feed-in tariff contract
- Purchasing renewable energy credits (RECs) from local projects up to a specified subscription limit
- Facilitating bulk purchases to reduce the installed cost for customers
- Working with local government members of the CCA to set up a commercial Property Assessed Clean Energy (PACE) program

These strategies would help keep reduce costs for meeting local program targets for the general CCA customer rate base.

Placing solar PV "behind the meter" minimizes the cost to a CCA program for achieving any established target. Net-metering has a program limit established by state law equal to 5 percent

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[15] The amount of solar PV added in Sonoma County over this period is 31 megawatts DC, 27 megawatts CEC-AC (the measure used in this report), and 25 megawatts by the CSI program's own AC measurement standard (California Public Utilities Commission and California Investor Owned Utilities 2012).

[16] Existing installations of 30 megawatts to date in February 2012, with 8 megawatts currently pending applications of which 6 megawatts would normally be expected to complete, plus an anticipated 9 megawatts completing in step 10, would result in the total 45 megawatts.

of the utility's peak load. PG&E will reach this amount at the conclusion of the CSI program. Further development of solar or other RE projects will require raising the cap at the state level if additional DG is going to be supported by net metering.

Utility companies tend to resist increasing net-metering caps, and often view it as a subsidy. But the more important issue for utilities is that net-metering erodes their revenue base, since net meter customers are either paying much less or nothing at all for their electric bills which are being erased by the net metering. The need to expand the cap beyond 5 percent poses a political risk for any program that relies primarily on the strategy of net-metering. However, Sonoma County will likely reach 55 MW to 60 MW of solar PV within the current cap.

If the net metering cap is not increased, or if the net metering cap is increased but with adverse rules and utility charges, then further increase in distributed solar PV — as well as other distributed generation — may require alternative policies, such as were discussed in the prior section. Laying out a range of alternative policies allows for flexibility to meet program goals in the face of various risks.

For a CCA, net-metering results in less sales revenue, but this will be offset by reduced energy purchases, the cost of which would otherwise be transferred to customers. The utility loses revenue on its "half of the bill" that would otherwise cover the sunk costs of infrastructure and the costs of operating the utility. Whether this constitutes a subsidy is disputed between proponents of net metering on the one side and utilities and ratepayer advocates on the other. Solar power provides certain benefits for the utility beyond avoided electrical energy purchases, especially because it produces electricity during the day when electricity demand is higher, and this can lower the strain on transmission and distribution systems especially on hot summer days.

Under current rules, a net metering program by itself should not result in extra costs for CCA customers compared to the costs for all PG&E customers. However, if the CCA elects to purchase RECs, this can have an effect on rates. Program administration will also have costs, but these are likely to be of much smaller magnitude. A larger cost would be incurred if the CCA decides to implement a feed-in tariff (FiT) or power purchase arrangement (PPA) with CCA participating customers who own solar PV systems. This cost could be reduced by only purchasing the surplus energy that is not used on-site, similar to the CHP feed-in tariff. On the other hand, a full feed-in tariff that purchases all the electricity generated can be designed to drive down the cost of installed solar power. Solar photovoltaic projects have signed feed-in tariff contracts with PG&E at prices of $105.07 and $108.98 per MWh (Table 17). These projects range in size from 250 kW to 1.5 MW, and cumulatively total 83.7 MW. Six of these projects, totaling 7.3 MW are proposed for Sonoma County (Pacific Gas and Electric Company 2012d, Web).

Table 17: Solar Photovoltaic Feed-in Tariff Contracts in Sonoma County

Project Name	E-SRG or E-PWF	Capacity (kW)	Expected GWh/yr	Technology	Price ($/MWh)	Vintage	Term (yrs)	Execution Date
Ahura Energy Concentrating Systems, Inc. (Ahura Energy Healdsburg 1)	E-SRG	998	0-6.7	Concentrating PV	$105.07	New	20	12/31/2011
Petaluma Solar Millennium Fund LLC (Petaluma Solar #1101)	E-SRG	1,500	0-2.1	Solar PV	$105.07	New	20	9/26/2011
Petaluma Solar Millennium Fund LLC (Petaluma Solar #1102)	E-SRG	1,500	0-2.1	Solar PV	$105.07	New	20	9/26/2011
Cloverdale Solar 1, LLC (FSEC1)	E-SRG	1,500	0-2.1	Solar PV	$108.98	New	20	12/23/2011
Cloverdale Solar 2, LLC (FSEC2)	E-SRG	1,500	0-2.1	Solar PV	$108.98	New	20	12/23/2011
Chalk Hill Solar Project, LLC (CHSP)	E-SRG	305	0-0.4	Solar PV	$108.98	New	20	12/29/2011

Source: Existing Executed Feed-In Tariff Contract, Current Spreadsheet (Pacific Gas and Electric Company 2012d)

Future installation of solar PV in the community can reasonably be expected to have lower installed cost than in the past. Prices will not likely reach what is currently seen in Germany for several years, but local programs can accelerate the decrease in price. Historical costs in the CSI program of $7 per watt-DC should within the next few years be able to be reduced to $5 per watt-DC or less, even for residential photovoltaic systems. The CSI program database shows over 2400 projects in California have been built between the beginning 2011 and early 2012 for prices between $3 and $5 per watt-DC. Reaching these levels should be a local policy goal, and can be facilitated by a number of the program recommendations in the county's Solar Implementation Plan, especially through reducing market barriers and transaction costs, through bulk purchase programs, and by targeting larger local installations in the range of 100 kW to 1 MW.

The cost of energy from these projects depends heavily on the financing structure. If customers purchase solar PV systems outright for $5 per watt installed cost, without any bank loans, and take the 30 percent federal investment tax credit, then the cost of energy is likely to be between 15 and 20 cents per kWh. This is well within the range of current average residential and small commercial utility rates. The cost goes up to approximately 20 to 30 cents per kWh if a loan of 5 to 20 years term and 6 percent interest is taken out to cover the cost, assuming a 25-year financial lifecycle.

Other Local Resources

The energy portfolios include a range of resources that would be located in Sonoma County. Some of these resources already exist, such as over 40 MW of solar photovoltaics, 0.2 MW of wind power, 6.4 MW of biomass generation, and 2.8 MW of hydropower. Most of these existing local resources, which are a focus of Portfolio 1, are not considered as part of the wholesale power supply for a Sonoma County community choice program. The solar PV provides on-site generation, the hydroelectric power is for water pumping use, and energy efficiency is not a form of electric generation.

Nevertheless, these are important RESCO resources that enhance local energy security, and they help to reduce greenhouse gas emissions. Furthermore, additional local resources that have not yet been built may also not be included — or may only be partially included — in a community choice program's wholesale energy supply. Therefore, these portfolios have been developed purely from the standpoint of localization of resources, and while they would intersect a

community choice program in various ways that are described in different places in this report, they are not the same as a CCA wholesale energy portfolio.

Energy efficiency is one of the larger local resources; the efficiency scenarios and program descriptions are presented in detail in Chapter 6. Energy storage is not analyzed in any detail in this report, but targets for procurement are established in order to support integration of renewable energy in the local distribution grid, and bear a general relation to potential state energy storage procurement targets.

In the original *Sonoma County Community Climate Action Plan* energy supply portfolio two forms of energy storage were included: pumped water storage and batteries. Pump storage has great potential benefits for integrating large amounts of wind and solar power, and for supplying electricity for the peak daytime demand, and is still an important potential local RESCO resource that should be further investigated for development. All forms of storage reduce reliance on natural gas power for meeting these same needs, but pump storage has the particular benefit of having much longer durability than batteries. While bulk storage batteries last for 5 to 15 years, a pump storage unit would last for many decades.

Pump storage can also be highly land and resource efficient, especially if an existing water reservoir is used. Lake Sonoma would be a particularly good site for such a facility, given the existing reservoir and the high elevation differential in close proximity. The CCAP's proposed 91 MW pump storage would likely have a relatively small land footprint. For example, SMUD's Iowa Hill pump storage is planned to supply 400 MW and 6 hours of storage, and requires construction of a 100 acre upper reservoir. The lower reservoir already exists, at a height difference of about 1000 feet (Sacramento Municipal Utility District 2012b, Web). The CCAP pump storage is much smaller in capacity, and even though the height differential at Lake Sonoma is less than Iowa Hill, an upper reservoir would likely occupy less than 50 acres, a very small addition compared to the 2700 acres of existing Lake Sonoma.

Despite its benefits, pumped water storage is not included the Sonoma RESCO portfolios because it is considered by the Sonoma RESCO Research Team to be difficult to plan and construct in the 2012 to 2020 timeframe. One of the primary benefits of battery technologies over pump storage is that they can be sited and constructed in a matter of weeks or months, occupy much smaller areas, and can be integrated into residential and commercial environments. Therefore, the storage in the RESCO portfolios are expected to be batteries, most likely NaS batteries because this technology is the most advanced commercially, and can provide highly efficient, long life, deep discharge, multi-hour bulk energy storage.

Regional and Remote Renewables

Because of the several technical and non-technical limiting factors described in this report, the presented Portfolios only provide a portion of the electric power needs of Sonoma County, and although they all would reduce greenhouse gas emissions, the local resources would not by themselves be sufficient to meet the climate goals adopted by Sonoma County. Therefore, the

local portfolios are expected to be supplemented by remote renewable resources to meet the RPS and greenhouse gas reduction targets. These resources would be supplied at similar quantities as was proposed in the CCAP, but modified in each portfolio to account for load and other resource planning requirements.

Geothermal power, preferably developed at the *Geysers* site, would supply baseload power and help to balance out the solar and wind intermittent resources with a stable renewable resource. Nearby wind resource areas could be tapped to provide the balance of wind power that is not met by local wind development in Sonoma County. Remote biomass power, from Mendocino County or the Central Valley agricultural regions, could supplement local biomass generation, while supplying additional baseload power. Remote solar should only be procured to the extent that it may cost less or provide better service than local solar generation. Small hydropower varies seasonally, but is another important source of zero carbon, renewable energy.

From a RESCO perspective, a strategic approach would be to form concentric regions around Sonoma County, and establish a preference for resources that are closer to the county. For example, the Geysers geothermal area is geographically a local resource, located partially inside Sonoma County. However, from the perspective of the grid topology, the electricity from the Geysers is exported through transmission lines toward the Central Valley. Thus, the Geysers can only be partially regarded as a local resource; however, it would provide far more of a RESCO characteristic than to import geothermal power from Southern California or from out of state.

Conventional Resources

The original CCAP portfolio included 66 percent renewable energy, and obtained the balance of electrical power from remote conventional generation. Large hydro, although it does not qualify as renewable under California law, is especially important in that it is relatively low cost compared to qualifying renewable energy, and thus offers zero carbon energy that offsets the higher cost renewables.

Natural gas power would supply the balance of electricity that does not come from local supplies, remote renewables or hydropower. This would be primarily through a mix of short-term, mid-term and long-term power purchase agreements to provide baseload and load following services, both to meet daily demand requirements and to back up intermittent renewables beyond what can be done through energy storage.

Various strategies should be considered for further reducing reliance on natural gas. In the HOMER model, storage technologies can be used to serve the peak, as well as demand response or *deferrable load*. These strategies can be used in the simulation suite in order to determine lowest possible cost. In addition, biomethane can be delivered through natural gas pipelines to reduce carbon emissions at conventional natural gas plants. To the extent that these non-carbon resources can substitute for natural gas, a RESCO would place priority on developing these locally. However, natural gas power also provides a financial hedge against the risk that natural

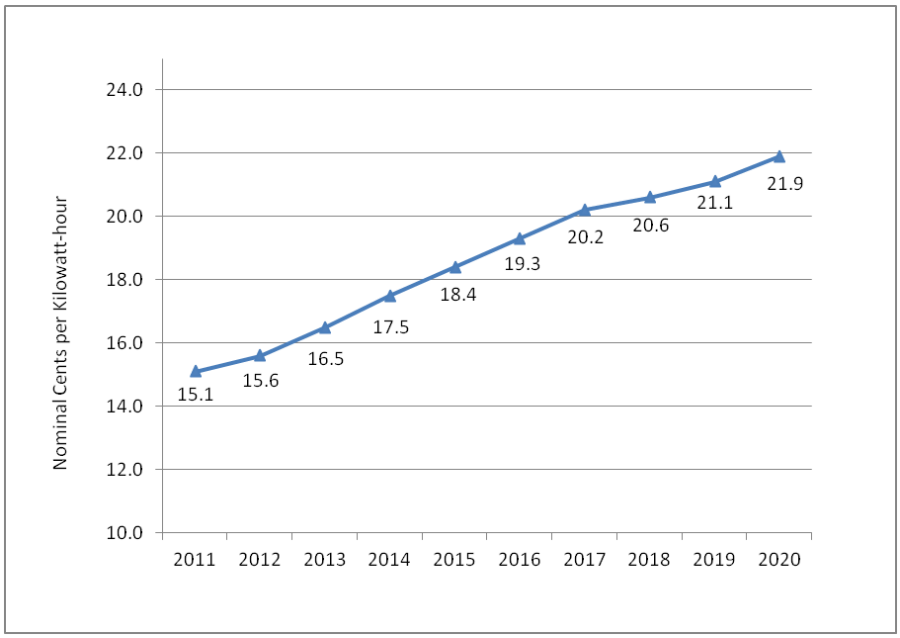
gas power prices are low. This hedge value is important for the cost effectiveness of an energy portfolio, but needs also to consider the opposite risk that excessive reliance on natural gas poses a risk if natural gas prices increase or are highly volatile. The amount of natural gas power in the portfolio is the control lever that regulates this risk.

Cost and Value of Local Energy

A high proportion of the local portfolio resources — including all energy efficiency, most or all solar PV, roughly half of combined heat and power, and possibly much of the energy storage as well — are placed at customer sites behind the meter; thus, the cost effectiveness of these resources depends specifically on retail rates.

Figure 16 shows the current and forecast PG&E average bundled retail electricity rate to 2020. Note that these prices are in nominal cents per kilowatt-hour, and thus differ from other rate estimates that are based upon fixed dollars. Because fixed dollar rates erase the effect of inflation, they may create the impression that out-of-pocket rates by 2020 will be much lower.[17]

Figure 16: 2010 PG&E LTPP Average Retail Rate Forecast



Source: PG&E Bundled Procurement Plan 2010, Mar. 25, 2011, Table PGE-2, sheet # 96.

When the electric customer is served with onsite generation or demand reduction measures on the customer side of the meter, the retail kWh rate is used for the baseline for cost-effectiveness. A slight downward adjustment must be made to the retail rate to account for fixed charges that cannot be eliminated by on-site energy services. Furthermore, there is considerable variation

[17] See Appendix B: Cost of Electrical Generation in Sonoma County RESCO Portfolio, pages B-1 through B-3.

between customer classes, between particular rate schedules, and even between customers on the same rate schedule (Table 18).

Table 18: Energy Commission 2010 Demand Forecast Electricity Prices for PG&E

Form 2.3: Electricity Prices (2007 cents/kWh) - PG&E			
YEAR	Residential	Commercial	Industrial
1980	9.42	11.86	9.08
1981	10.94	13.92	10.48
1982	10.54	13.13	10.60
1983	10.07	12.80	11.25
1984	11.92	15.04	13.43
1985	12.67	16.31	14.51
1986	12.62	16.18	13.42
1987	11.33	13.98	9.90
1988	12.14	13.63	9.26
1989	13.40	14.27	9.73
1990	13.78	14.42	9.62
1991	14.33	14.66	9.85
1992	14.72	15.17	9.65
1993	14.74	14.87	9.25
1994	14.69	14.74	8.87
1995	13.34	13.33	8.51
1996	13.69	12.83	7.75
1997	13.46	12.61	7.30
1998	12.11	8.83	6.83
1999	11.93	8.93	7.45
2000	11.68	8.69	7.39
2001	12.44	8.87	13.64
2002	12.53	12.27	12.30
2003	12.89	13.87	12.51
2004	13.00	13.49	11.58
2005	13.29	13.06	10.85
2006	14.63	13.69	10.67
2007	14.77	13.63	10.02
2008	13.90	12.75	8.96
2009	14.18	13.14	9.42
2010	14.18	13.14	9.42
2011	14.31	13.27	9.51
2012	14.45	13.40	9.60
2013	14.60	13.53	9.70
2014	14.74	13.67	9.79
2015	14.88	13.80	9.89
2016	15.16	14.05	10.07
2017	15.44	14.31	10.25
2018	15.72	14.57	10.44
2019	16.01	14.84	10.63
2020	16.30	15.11	10.83

Showing prices in fixed 2007 cents/kWh

Source: CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST (California Energy Commission 2009, Page 85)

Table 19 Energy Commission 2010 Demand Forecast Electricity Prices for PG&E

Fixed 2007 Cents/kWh			
Year	Residential	Commercial	Industrial
2011	14.31	13.27	9.51
2012	14.45	13.40	9.60
2013	14.60	13.53	9.70
2014	14.74	13.67	9.79
2015	14.88	13.80	9.89
2016	15.16	14.05	10.07
2017	15.44	14.31	10.25
2018	15.72	14.57	10.44
2019	16.01	14.84	10.63
2020	16.30	15.11	10.83

Nominal Cents/kWh			
Year	Residential	Commercial	Industrial
2011	15.49	14.36	10.29
2012	15.95	14.79	10.60
2013	16.44	15.24	10.92
2014	16.93	15.70	11.25
2015	17.43	16.17	11.59
2016	18.12	16.79	12.03
2017	18.82	17.44	12.49
2018	19.55	18.12	12.98
2019	20.30	18.82	13.48
2020	21.09	19.55	14.01

Comparison of Fixed 2007 and Nominal Cents per Kilowatt-hour

Source: Left table — California Energy Commission

Table 19 shows PG&E's forecast retail electricity prices in fixed (inflation adjusted) 2007 cents per kilowatt-hour from the Energy Commission's 2010 demand forecast, while the table on the right converts those prices to nominal cents per kilowatt-hour assuming a 2 percent per year fundamental inflation rate.

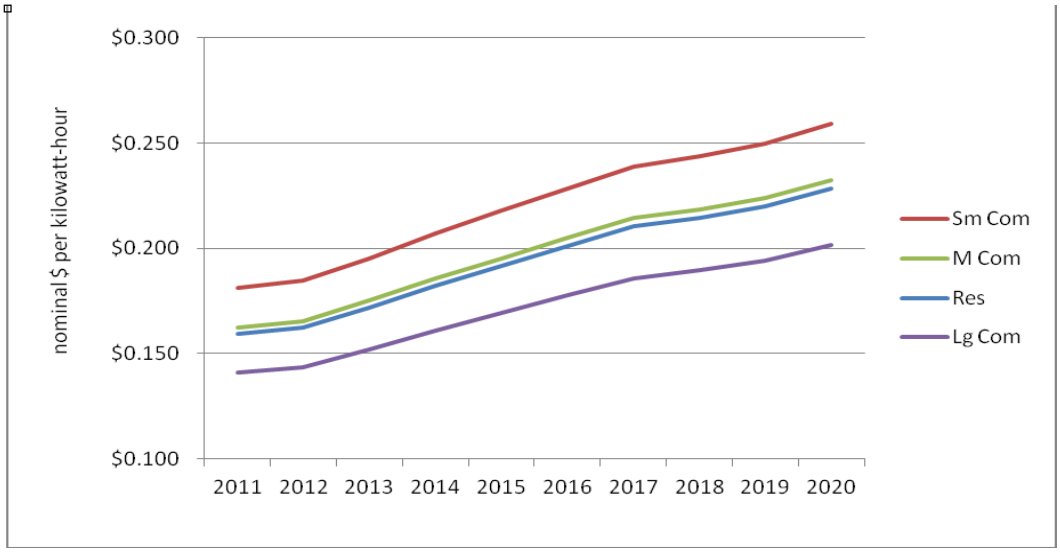
Fixed cents or dollars, also called "real dollars," are frequently used in economic modeling and remove the factor of the decreasing value of a unit of currency, to allow an "apples to apples" comparison of relative prices at different times. Inflation adjusted currency requires a baseline year — in this case 2007 — at which the currency value is "fixed" in order to allow comparison.

Nominal cents or dollars allow a consumer to estimate how much money they will have to pay in actual currency in the forecast year, and factor back in the effect of inflation. In this case, over a period from 2007 to 2020, a 2 percent annual inflation adds substantially to the fixed currency price — adding from 4 to 5 cents per kilowatt-hour to PG&E's forecast electricity rates in the three retail customer sectors. The price of electricity in 2020 for PG&E customers is likely to be close to 20 cents per kilowatt-hour for the residential and commercial sectors, when measured in nominal currency. Forecasting nominal dollars adds an extra degree of risk to the forecast to the extent that it embodies not only a forecast of the real price, but also a forecast of future inflation.

Net Metering Value of Rate Classes

The value of net metering is established by the retail rate each customer pays through crediting each kWh generated against the utility bill. Figure 17 shows an estimate of future average retail rates for four major customer classes — residential, small commercial, medium commercial, and large commercial rates between 2011 and 2020.

Figure 17: PG&E Estimated Average Retail Rates by Rate Class



Source: Pacific Gas and Electric Company(Pacific Gas and Electric Company 2012l)[18]

The fact that electric rates increase over time shows why the net metering rate in the year that a project is installed does not capture the full value of on-site generation to the customer. To capture the full net meter value, it would be more helpful to consider future rates over the financial lifecycle of the solar photovoltaic project, which could be for 20 to 30 years. Averaged over that timeframe, the net meter value would be 20 percent to 30 percent higher than the year in which the project is installed. For example, residential customers in 2016 are shown to have an average retail rate of about $0.20/kWh; a 20-year future average rate would be closer to $0.25/kWh.

Because of the progressive tiered rate structure in the residential sector, individual customers would have a wide range of rates both above and below this average rate. Low income CARE customers in 2012 pay tiered rates ranging from $0.083/kWh to $0.124/kWh, while standard residential rates start at $0.128/kWh and reach as high as $0.335/kWh in Tiers 4 and 5 (Pacific Gas and Electric Company 2012l, Web--Electric Rates). Other rate classes also have a wide range of rates for specific customers, depending upon energy usage patterns. On average, large commercial and industrial customers have lower rates, but also tend to have lower cost for solar energy than the residential sector, due to economy of scale. Small commercial customers have higher than average rates, but also have higher cost for solar energy than larger commercial projects.

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[18] Initial rates for 2011 from PG&E's filing with the CPUC, Application of Pacific Gas and Electric Company for Adoption of Electric Revenue Requirements and Rates Associated with its 2011 Energy Resource Recovery Account (ERRA) and 2011 Ongoing Competition Transition Charge (CTC) Forecasts. http://docs.cpuc.ca.gov/efile/A/118737.pdf Future rates after 2011 are extrapolated from the base case rate projection from PG&E's 2010 Long-Term Procurement Plan, and adjusted according to the deviation from average in 2011 for each rate class.

Cost of Generation Resources

Table 20 shows data from various sources regarding the cost of different electrical generation technologies. The cost assumptions used in Appendix B of this RESCO report, shown in the far right column, are generally within the range of other studies on cost of generation. The RESCO model uses rounded values for inputs, reflecting the lack of precision in these numbers.

Table 20: Energy Cost — Estimates from Multiple Sources

Installed Cost ($/kW)

Resource	Application	EIA 2010	CEC 2009	Lazard v.5 Mid	Sonoma CCA FS	CPUC/E3 LTPP 2010	CA Program	RESCO
Solar PV	Sm DG						$5,620	$5,000
Solar PV	Lg DG	$6,181	$4,550	$4,125		$5,800	$3,800	$4,000
NG Turbine-DG	CHP	$1,400					$3,000	$3,500
Biomass	Direct	$3,849	$3,254	$3,500	$3,254	$4,529		$3,500
Geothermal	Binary or Flash	$1,749	$4,046	$5,925	$3,718	$5,155		$4,500
Wind	On-Shore	$1,966	$1,990	$1,600	$1,990	$2,399		$2,000

Capacity Factor

Resource	Application	EIA 2010	CEC 2009	Lazard v.5 Mid	Sonoma CCA FS	CPUC/E3 LTPP 2010	CA Program	RESCO
Solar PV	Sm DG						18%	17%
Solar PV	Lg DG	25%		22%		16%	18%	17%
NG Turbine-DG	CHP	87%						85%
Biomass	Direct	83%	85%	85%	85%	85%		85%
Geothermal	Binary or Flash	92%	90%	85%	94%	83%		85%
Wind	On-Shore	34%	37%	36%	30%	32%		30%

Fixed O&M ($/kW-yr)

Resource	Application	EIA 2010	CEC 2009	Lazard v.5 Mid	Sonoma CCA FS	CPUC/E3 LTPP 2010	CA Program	RESCO
Solar PV	Sm DG							$60.00
Solar PV	Lg DG	$11.94	$68.00	$20.00		$65.00		$50.00
NG Turbine-DG	CHP	$16.39						$15.00
Biomass	Direct	$65.89	$99.50	$95.00	$99.50	$93.00		$100.00
Geothermal	Binary or Flash	$168.33	$47.44	$0.00	$58.38	$0.00		$60.00
Wind	On-Shore	$30.98	$13.70	$30.00	$13.70	$60.00		$45.00

Variable O&M ($/MWh)

Resource	Application	EIA 2010	CEC 2009	Lazard v.5 Mid	Sonoma CCA FS	CPUC/E3 LTPP 2010	CA Program	RESCO
Solar PV	Sm DG							$0.00
Solar PV	Lg DG	$0.00	$0.00	$0.00		$0.00		$0.00
NG Turbine-DG	CHP	$7.28						$8.00
Biomass	Direct	$6.86	$4.47	$15.00	$4.47	$13.00		$5.00
Geothermal	Binary or Flash	$0.00	$4.55	$35.00	$5.06	$35.00		$5.00
Wind	On-Shore	$0.00	$5.50	$0.00	$5.50	$0.00		$5.00

Level Cost of Energy

Resource	Application	EIA 2010	CEC 2009	Lazard v.5 Mid	Sonoma CCA FS	CPUC/E3 LTPP 2010	CA Program	RESCO
Solar PV	Sm DG				$225.00			$213.00
Solar PV	Lg DG	$210.70	$262.20	$164.00	$225.00	$290.40		$165.00
NG Turbine-DG	CHP							$181.00
Biomass	Direct	$112.50	$104.00	$108.50		$128.00		$125.00
Geothermal	Binary or Flash	$101.70	$83.11	$104.00	$97.00	$115.00		$108.00
Wind	On-Shore	$97.00	$72.41	$54.50	$90.00	$99.00		$116.00

The bottom table, "Level Cost of Energy," gives resulting cost of electricity from each source. In the RESCO portfolios, "Solar PV" and natural gas combined heat and power (NG Turbine DG, with CHP application) are both used for self-generation, and valued against the retail electricity rates shown previously. Biomass, geothermal and wind energy are valued in relation to wholesale energy supply for a community choice program. For more detail on the cost of local energy see Appendix B.

CHAPTER 4:
Local and Site Specific Supply Resources

Chapter 4 examines the potential for development of certain types of local renewable energy generation in Sonoma County, focusing on local solar, wind, geothermal and biomass resources. The approach is geographic but general, to indicate the technical potential using a variety of information sources. The potential is only being evaluated in the context of determining the presence of each resource for the general purpose of developing the portfolios. This section is not intended to provide an exhaustive technical potential, which is outside the scope of this report.

Various approaches are taken with the different resources which reflect their diverse nature. In the case of wind power, the existing data from state wind survey maps is analyzed from the standpoint of clustered development in relatively small areas within the county that have significant technical wind potential. This is because wind is a highly localized resource where energy production would greatly decrease outside the higher wind resource areas. This would therefore have limited carbon benefit, and would also increase the cost of wind energy greatly.

In the case of solar energy, the resource is more evenly distributed; there is limited variation between different places in the county, with the exception of some parts of the coast. While geographic data is provided, a more general evaluation of the solar resource is sufficient to characterize it.

This section does not present a definitive, engineering-grade assessment of site-specific resource availability. Actual site measurements and data collection such as anemometer studies for wind and test well drilling for geothermal resources will have to be conducted before beginning development of any site.

A technical issue that is not resolved in this section is the limitation on the maximum power that can be supplied by generation interconnected on the distribution grid. Since the distribution circuits are not presently designed to handle bidirectional flow, any wind power produced would have to be consumed locally, on the same distribution circuits as the wind generator. For this reason, it is assumed that only a small amount of wind can be developed in this manner, due to the low level of electricity demand in the parts of the county that have higher wind resources. Larger wind development would likely need to be interconnected to substations or to transmission lines.

Solar Energy

The Sonoma RESCO Research Team does not envision utility-scale solar PV projects in any of its portfolios. Solar PV in the context of the Sonoma RESCO portfolios will be deployed as smaller and mid-sized distributed generation behind-the-meter projects on the order of 1 to 1,000 kW. Such projects may be installed on residential, commercial and light industrial facilities on roof-tops, as parking shade structures, and in a limited way as ground-mounted systems.

Sonoma County's annual solar resource, called *insolation*, shown in Table 21, ranges from about 1500 kilowatt-hours (kWh) per square meter along the coast to about 1900 kWh per square meter north of Guerneville. The main inland population centers of the county, including Santa Rosa, receive almost 1800 kWh/square meter (National Renewable Energy Laboratory 2012b).

Table 21: Sonoma County Insolation

	Insolation	
	Daily	Annual
Location	Wh/m^2	kWh/m^2
Guerneville	5156	1882
Sonoma	4977	1817
Santa Rosa	4910	1792
Rohnert Park	4901	1789
Petaluma	4894	1786
Jenner	4453	1625
Bodega Bay	4204	1534
NW County Coast	4038	1474

Navigant Consulting has made estimates of the technical potential for on-site solar photovoltaic power in Sonoma County on available rooftop space (Navigant Consulting, Inc. 2007). This potential starts with the total rooftop area, and then applies general screening factors to account for shading and roof orientation. This leaves between 60 and 65 percent of commercial rooftop area, and 22 to 27 percent of residential rooftop area, interpreted as available for solar photovoltaic development.

The rooftop solar potential is projected to grow over time as solar panels become more efficient and rooftop area increases. In 2016, residential rooftops are estimated to reach 508 megawatts, and commercial rooftops 308 megawatts, of total technical potential in Sonoma County. Assuming a 16 percent direct current *capacity factor*, this quantity of rooftop solar installations would produce about 1,100 gigawatt-hours per year, which is 35 percent of Sonoma County's projected electricity demand in 2020.

The technical potential for solar energy is not limited to the physical area available on rooftops, since photovoltaic projects could also be developed over parking lots, near substations and on open land, and as larger utility scale projects connected to transmission lines. The RESCO team did not find publicly available data regarding the local potential for these other types of solar projects. However, the highest amount of solar photovoltaics in the three portfolio scenarios reaches 85 megawatts in 2020, which is only 17 percent of the estimated technical rooftop potential.

Sonoma County households on average use about 35 percent less electricity than the average US household, while receiving more sunshine. As shown in Table 22, the cost to supply local residential customers with enough solar power to offset 100 percent of on-site consumption is

thus about half of typical US households, saving approximately $40,000 at current average installed prices for solar PV systems, and requiring a much smaller area on the roof.

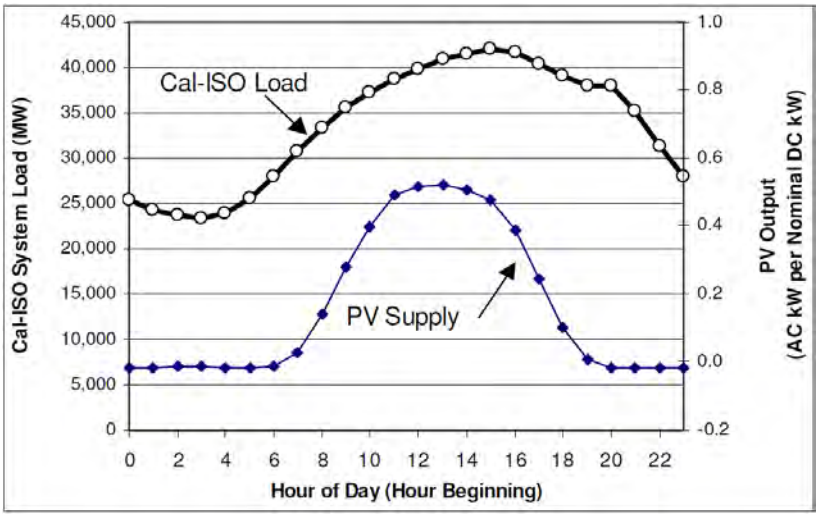
Table 22: Residential Solar PV System to Offset 100 Percent of On-Site Electricity

	Sonoma County	US Average	
Project Size	5.50	11.50	kW (dc)
Specific Yield	1350	1000	kWh/kW-yr
Annual Generation	7425	11500	kWh
Efficiency of Panels	15%	15%	
Specific Area	13.94	13.94	watts/sq. ft.
Area of Panels	395	825	sq. ft.
Specific Cost	$7,000	$7,000	per kW (dc)
Installed Cost	$38,500	$80,500	

The principle technical challenges of using solar energy are that it is only available during the day, and energy production decreases rapidly when a cloud covers the sun. Shading and cloud cover may allow for some production of electricity, but at greatly reduced levels. A PV system starts producing a small amount of electricity at sunrise, which increases to a peak around noon and then decreases during the afternoon until reaching zero at sunset. The power production curve follows a high peaked waveform.

Figure 18 illustrates schematic solar generation profiles.

Figure 18: Comparison Summer Daily Electricity Demand in CAISO Territory/Solar PV



Source: Comparison Summer Daily Electricity Demand in CAISO Territory/Solar PV. (Scheuermann 2004, p. 8)

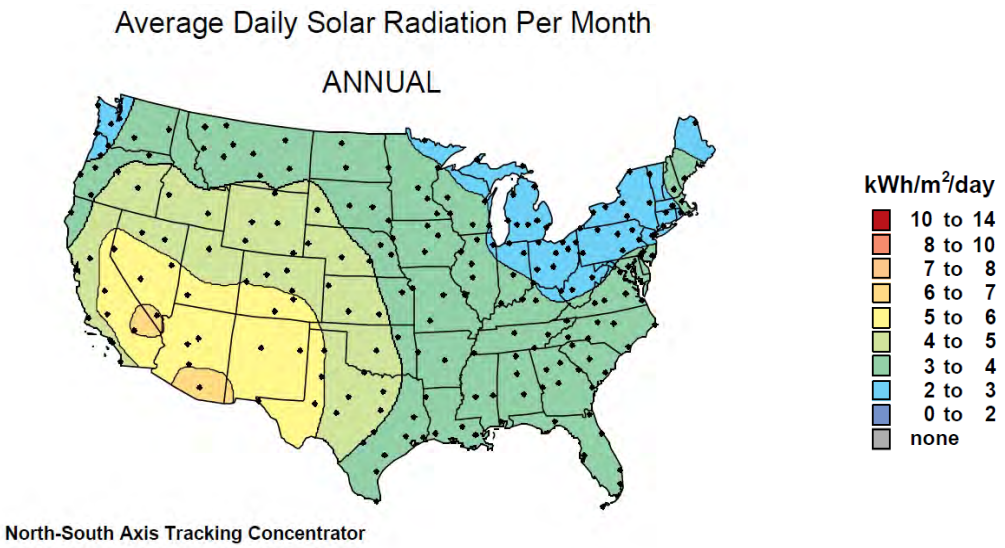
To some extent solar energy production meets the higher demand for electric power during the day, but the shape of the production curve only overlaps part of the daytime demand surge. The match between solar and demand is better during the summer than in the wintertime example shown above in Figure 18, and also a better fit in the hotter areas of the state than in the cooler coastal regions. At low levels of solar PV market penetration the degree of mismatch

to demand is not a significant issue, as the variable output of solar generation would in that case be small in relation to the daily load variation.

The lack of perfect fit between solar supply and energy demand can be addressed through various techniques, including use of technologies such as tracking and energy storage. Distributing a number of solar projects over a wide area also reduces daytime variability due to clouds, and pointing fixed array projects in differing orientations toward the sky can simulate some of the advantages of tracking by allowing a group of projects to be combined through the grid to provide more consistent power over the course of a day. Other key balancing techniques include curtailing excess solar production, and modulating energy demand to better match the variable generation of solar.

Another way to generate electric power from the sun is using solar heat collected by parabolic trough mirrors that track the sun, from east to west over the course of a day. The mirrors concentrate and focus the light on a long tube containing a fluid that transfers the heat to a heat exchanger that in turn boils water to produce hot steam to power a conventional steam turbine. Concentrating solar thermal (CST) power systems require direct access to sunlight, and do not utilize the significant portion of scattered sunlight on both clear and cloudy days. For this reason solar thermal generation works best in locations that normally have clear skies, particularly the southwestern U.S. deserts (Figure 19).

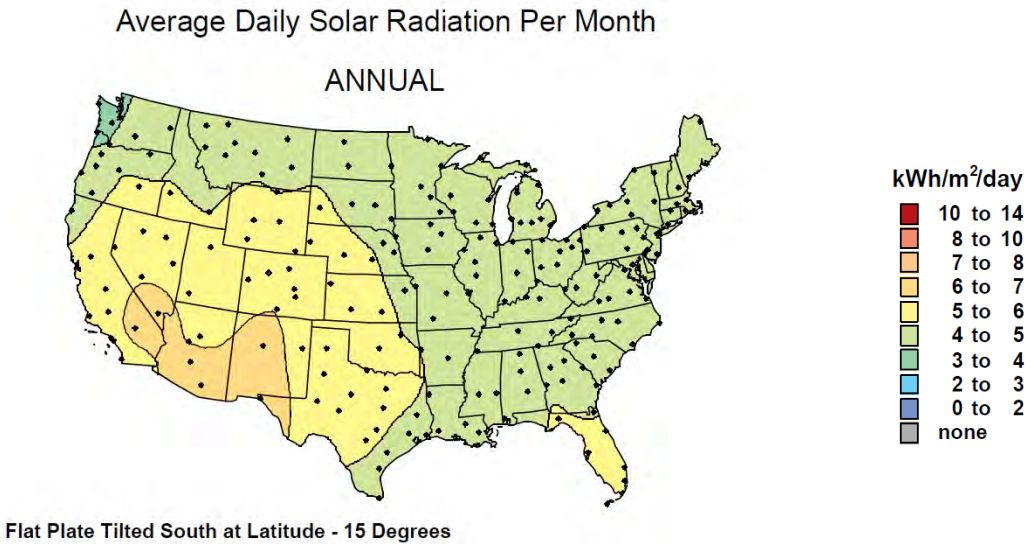
Figure 19: Solar Energy Resource Map of U.S. — Tracking Concentrator



Source: National Renewable Energy Laboratory

The value of the solar resource for a tracking concentrator technology is high in the optimal desert regions, over the course of a year averaging 6 to 7 kilowatt-hours per square meter per day, but this resource decreases to just over 4 kilowatt-hours per square meter per day in the area of Sonoma County, about 30 to 40 percent less than in the desert (Figure 20).

Figure 20: NREL Solar Energy Resource Map of U.S. — Flat Plat



Source: National Renewable Energy Laboratory

A solar photovoltaic panel is a flat plate that directly absorbs sunlight, and when placed on a rooftop is fixed in orientation. This is very different from a device that concentrates sunlight with mirrors and tracks the sun. If a flat, fixed solar photovoltaic panel on a roof is tilted upward at a 23 degree angle so that it faces toward the south, it will receive over 5 kilowatt-hours per square meter per day in Sonoma County, significantly more solar energy than a solar thermal generator. This is because the solar photovoltaic panel can collect both direct solar rays, as well as the indirect rays that are a larger fraction of annual sunlight in cloudier regions.

Furthermore, there is less of a disadvantage to having solar photovoltaic panels in a California coastal area compared to the desert, particularly in the case where the panels are not tracking the sun. The combination of these factors — low solar resource suitable for solar thermal power, and a comparatively better resource for solar photovoltaics — tends to favor photovoltaics over solar thermal power in Sonoma County.

In the past decade, it appeared that solar thermal generation had superior economics compared to photovoltaics which was still quite expensive.[19] This was reflected in the CCAP portfolio, which included 59 megawatts of solar thermal generation and only 16 megawatts of solar photovoltaics, for a total of 75 megawatts of solar power generation. The solar thermal generation was expected to be a single large facility located outside of the county, due to the factors discussed here, while the photovoltaics was assumed to be local and net metered. The new RESCO portfolios provide very similar total capacity of solar power generation as the original CCAP (ranging from 65 to 85 megawatts), but these portfolios shift all the solar energy

[19] A National Renewable Energy Laboratory publication in 2001 stated "Concentrating solar power technologies currently offer the lowest-cost solar electricity for large-scale power generation. *Concentrating Solar Power: Energy from Mirrors*, DOE/GO-102001-1147, FS 128, March 2001.

to local on-site photovoltaics, which removes nearly all of the cost premium for this amount of solar energy from the customer rate base of a Sonoma County community choice energy program.

Wind

Introduction

Sonoma County has significant wind resources both on land and offshore; however, the onshore resource is modest, compared to the large offshore resource. Sites for potential wind energy development are identified using the *AWS TrueWind* GIS data layers obtained from the Energy Commission.

Six local geographic areas, shown on the next page in

Figure 21, were identified that could potentially support a cost-effective wind deployment. These areas were selected for further analysis because:

- They are close to existing transmission
- There is an average annual wind speed of 6.5 meters/second or greater at 30 and 100 meters height
- For offshore locations, the ocean depth is less than 50 meters

There are three deployment classes that are also used in this analysis to guide site selection:

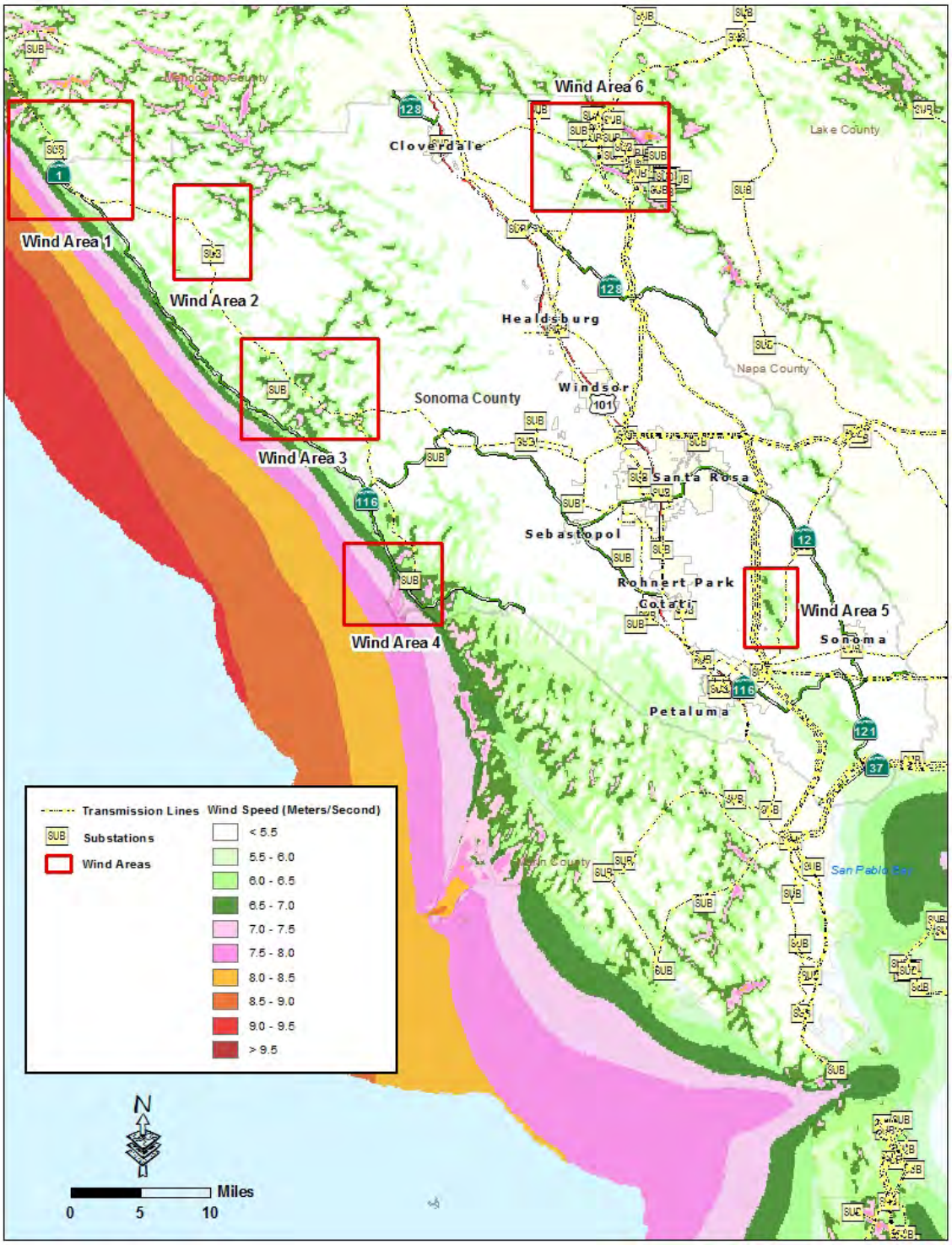
- Individual net-metered small-scale (< 10 kW)
- Shared net-metered (< 1 MW)
- Utility scale (> 1 MW)

These deployment classes are used to select sites that are in close proximity to settled areas, for net-metered deployments. Utility scale deployments need only be in proximity to transmission lines, but it is preferable that they also be located near existing substations.

This section also includes a general presentation of the character of wind resources, as well as the performance and cost of modern wind technology. Additional evaluation of the cost of energy for wind power is presented in Appendix B beginning on page B-9.

Both onshore and offshore wind projects present unique development challenges related to siting and permitting, but are examined in this section independently of these considerations simply to understand the technical potential of wind to contribute toward RESCO goals of local energy self-reliance (Figure 21).

Figure 21: Wind Resource Availability Proximate to Transmission and Substations



There is a unique opportunity for wind development in the Geysers steam field (Area 6) in the northeast portion of the county (Calpine Corporation 2012, Web--The Geysers). This area has some of the highest onshore winds in the county, and there is also available power transmission infrastructure serving the Geysers geothermal electric generation facilities. This juxtaposition of wind resource with existing electricity infrastructure, site development, road access and ease of permitting are all favorable conditions for construction of new local wind generation.

Methodology

Sites for potential wind energy development are identified using the AWS TrueWind GIS data layers obtained from the Energy Commission. This data is not based on actual measurements at each site, but combines measured wind data with geographic models to interpolate local wind speed and power in a 200 meter cell grid, and at specific set of elevations above the ground. Site-specific measurement data would be required prior to any actual deployment.

Measurement data was not available to the researchers. However, the GIS layer was processed to reveal areas in the county that had an annual average[20] wind speed of 6.5 meters per second (m/s) or better (Class 3 or better). These areas were selected for further analysis, based on the other criteria mentioned above.

As mentioned, the site selection was driven first by the proximity of existing grid infrastructure (distribution feeder, transmission line, substation) to an area where the wind speed is Class 3 or better. The researchers determined the area of the candidate site, defined by the extent of AWS True Wind grid squares with desired average wind speed, using the area measurement function of GIS software. The maximum distance from the existing grid infrastructure was arbitrarily selected at 0.25 mi to reduce the interconnection cost.

The approach used here for wind power estimation is described in Gipe (Gipe 2004). Available wind power at 30 meters and 100 meters height about the ground in each of the identified areas based on average wind speed in the area is quantified using the basic wind power calculation:

$$P = \tfrac{1}{2}\, d\, A\, S^3 \xi$$

Where P is power in watts, d is air density, A is swept area of the *wind turbine* blades, and S is average annual wind speed. Air density is assumed to be 1.19 kg/m^3. This formula calculates the total power available in the wind, and then multiplies it by ξ, which is the conversion efficiency of the turbine. The maximum amount of power available to a wind turbine is subject to the *Betz limit* of 59.3 percent. Typical wind turbine efficiency is 30 percent, meaning 30 percent of the power in the wind is converted to electrical power — half of the Betz limit.

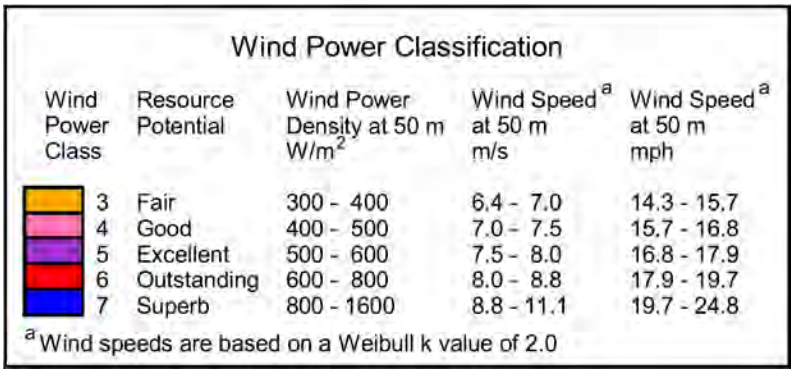
Power density, which is the power that is available per unit of collection area (P/A) measured in watts per square meter (w/m^2), can then be established for each of the candidate sites, based on average annual wind speed. Average annual P/A can be estimated using:

$$P/A = 0.6125\, S^3 \times 1.9$$

[20] Rayleigh distribution or Weibull (k=2)

The most important feature of this formula is that the power is a function of the cube of the speed of the wind. This means that relatively small differences in wind speed make a large difference in the power that can be generated. The power cube relationship is why wind power siting is very tied to specific locations, and why it is often uneconomical to put wind towers in areas with low wind speed (Figure 22). Wind speed and power is described in terms of standardized wind classes, with Class 3 being normally the minimum desirable wind resource, and Class 4 or higher being preferred for commercial development.

Figure 22: Wind Power, Speed, and Classification



Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

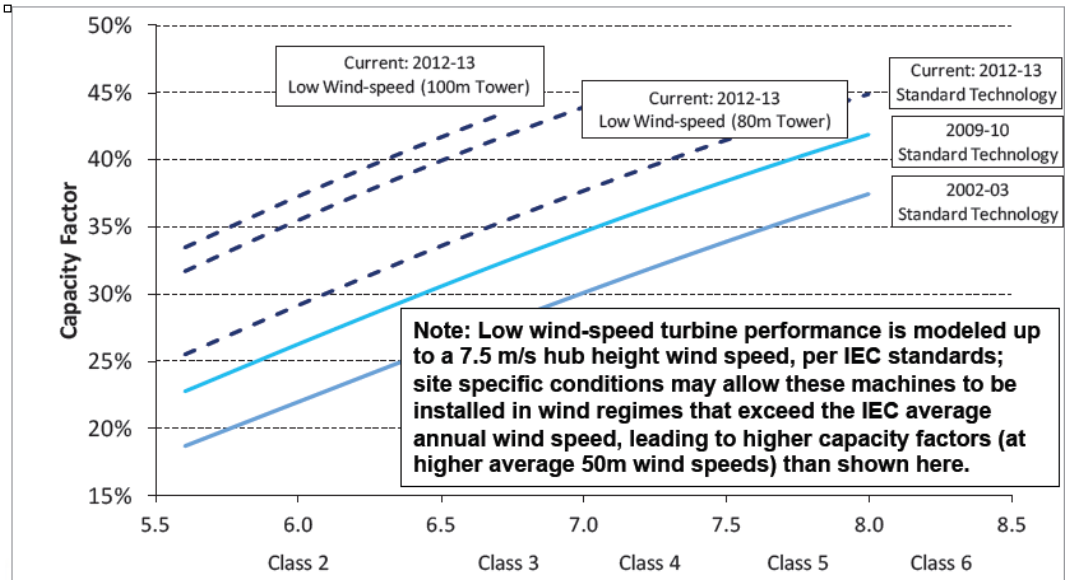
[a] Wind speeds are based on a Weibull k value of 2.0

Source: Wind Power Classification (National Renewable Energy Laboratory 2009)

Total power production capacity for a geographic area is based on the number of turbines that can be installed within the available wind resource, and the total nameplate capacity of those turbines.

Typical wind turbine annual energy generation (kilowatt-hours/year) is about P × 8760 × 30 percent, where P (in kilowatts) is Power Density (of the wind resource at the site, based on the analysis above) multiplied by A, where A is the swept area of rotor, 30 percent is the typical *capacity factor* of a wind turbine, and 8760 is the number of hours in a year. In actuality, capacity factor can vary widely based upon the wind resource at the specific site, and to some extent it is also a function of the design and the manufacturer's nameplate rating of the specific turbine. As shown in Table 23, capacity factor of current low speed and state of the art technology wind turbines can approach 45 percent in winds of Class 3 and above, and at a hub height of 100 meters (over 300 feet).

Table 23: Increased Capacity Factor of Current Low-Speed Wind Turbines



Source: *Increased Capacity Factor of Current Low-Speed Wind Turbines* (National Renewable Energy Laboratory 2012a)

The rotor diameter and related approximate energy production of common turbines used in this analysis is shown in Table 24:

Table 24: Typical Annual Energy Production in kWh for Common Turbine Sizes

Wind Power P/A (w/m^2)	Rotor Diameter 25m (250 kW)	Rotor Diameter 82.5m (1.5 MW)	Rotor Diameter 100m (2.5 MW)
200	258,003	2,809,656	4,128,053
400	516,007	5,619,312	8,256,105
600	774,010	8,428,968	12,384,158
800	1,032,013	11,238,624	16,512,211

The total energy output possible from a particular geographic wind area is related to the average annual wind speed at the height of the wind turbine blades, and the total number of turbines that can be optimally placed in the area. As a general rule, increased height also increases the speed and power of the wind, while the number of turbines is determined by spacing constraints between the turbines which must be separated by a minimum distance in order to insure adequate performance (Table 25). The suggested rule of thumb for minimum turbine spacing is:

- Two to three rotor diameters separation perpendicular to prevailing wind direction
- Eight rotor diameters separation downwind

Table 25: Maximum Turbine Density

Rotor Diameter (m)	Max turbines per square kilometer
25	100
82.5	9
100	6

Cost

As shown in Table 26, costs of standard technology wind turbines have declined since peaking in 2009-2010. Independent wind developers have confirmed that all-in costs of wind development run from $1,500/kW to $2,500/kW depending on a variety of factors including site development costs and interconnection cost.

Table 26: Comparison of Cost Assumptions for Wind Power 2002–2013

Characteristics	2002-2003	2009-2010	Current Turbine Pricing: ~2012-2013		
Technology type	Standard	Standard	Standard*	Low Wind*	Low Wind*
Nameplate capacity	1.5 MW	1.5 MW	1.62 MW	1.62 MW	1.62 MW
Hub height (HH)	65 m	80 m	80 m	80 m	100 m
Rotor diameter (RD)	70.5 m	77 m	82.5 m	100 m	100 m
Installed capital cost	$1,300/kW	$2,150/kW	$1,600/kW	$1,850/kW	$2,025/kW
Operating costs	$60/kW-yr	$60/kW-yr	$60/kW-yr	$60/kW-yr	$60/kW-yr
Losses (availability, array, other)	15%	15%	15%	15%	15%
Financing (nominal)	9%	9%	9%	9%	9%

- Dollar values are all real 2010$
- Financing cost / discount rate reported in nominal terms
- Air density = 1.225 kg/m^3 (sea level wind speed)
- Weibul K Factor = 2 in all scenarios
- 1/7th power law scaling to estimate hub height wind speed
- 20-year assumed project/economic life in all scenarios
- Aggregate income taxes assumed to equal 38.9%

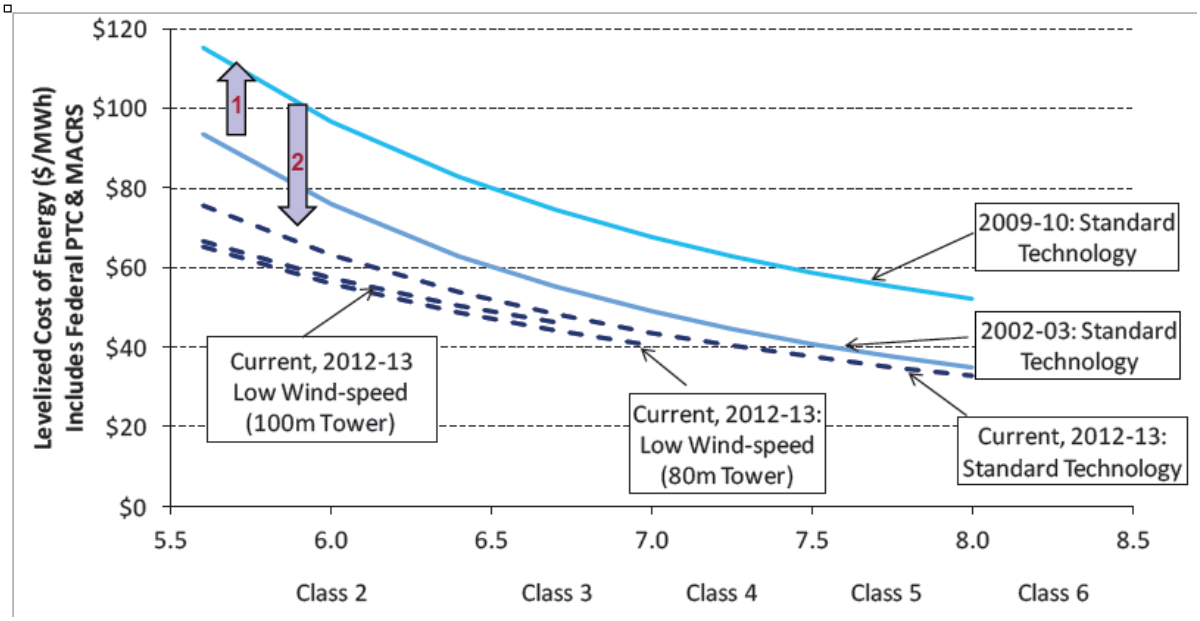
All assumptions intended to reflect representative actual/common conditions; installed costs, operating costs, losses and other assumptions can vary considerably from one project to the next

**These turbines are assumed viable in sites up to the respective IEC Class II and Class III reference average annual wind speed. Depending on site specific gust, turbulence, and air densities these turbines in actuality may be reasonably placed in sites with higher average annual wind speeds than applied in this analysis.*

Source: *Recent Developments in the Levelized Cost of Energy from U.S. Wind Power Plants.* (Lawrence Berkeley National Laboratory 2012)

As shown in Table 27, current turbine designs can achieve a levelized cost of energy (LCOE) of $50/MWh or less in the wind regimes available in Sonoma County, assuming use of the federal tax benefits, and $60 to $70/MWh without these benefits. However, cost of energy can vary significantly for different project sites and for different wind turbine technologies. In general, larger turbines will lead to improved economic viability.

Table 27: Levelized Cost of Electricity Produced by Wind Generation



Source: *Recent Developments in the Levelized Cost from U.S. Wind Power Projects* (Wiser, et al. 2012)

Other Considerations

Sonoma County will have several constraints that limit the total capacity of wind power deployment. These factors require consideration when evaluating the estimates of total resource capacity described in the following sections.

- The estimates of wind capacity presented here are a guide to the availability of Sonoma County wind. They are not intended to be an engineering study or a feasibility cost analysis. They are an indication of an upper limit to the wind potential in the county where cost effective wind development could occur.
- Maximum turbine density that can be deployed in any given area will be limited by the interconnection capacity of the grid. The grid in the area of the wind deployment will possibly need to be upgraded, at a potentially prohibitive cost. The interconnection limits of the local grid must be thoroughly studied before any utility scale resources are connected.
- Maximum turbine density will also be limited by site acquisition considerations. Political resistance to wind turbine deployment, particularly in the coastal and offshore areas can be expected. Optimal packing of turbines in a given area is unlikely to be achieved. Also, the available area near potential grid interconnection sites may be more limited than the extent of the usable wind area.

The areas described in the following sections are likely to yield cost effective wind installations, given the described limits. However, these maximum capacity figures must be placed in the

context of a goal for wind that is set by overall generation portfolio considerations, as well as community goals.

Wind Area 1

The oval area, shown on Figure 23, as group of colored circles, is one of two high quality wind sites off the Sonoma County coast. This area is at the north end of the county and extends to offshore Mendocino County. It has an average wind speed of 8.0-8.5 m/s at 100 meters height. The average depth of the water is less than 50 m, and thus may be suitable for turbine anchorage. The area is about 2 miles offshore, and is about 3.5 miles from a substation. This area is about 5 km in length. P/A = 595-795 w/m^2. There is a settled area onshore that has a 5.5-6.0 m/s average wind speed at 30 m. This might be suitable for other small-scale wind that could be net-metered (Table 28).

Figure 23: Wind Area 1 Resource at 30m

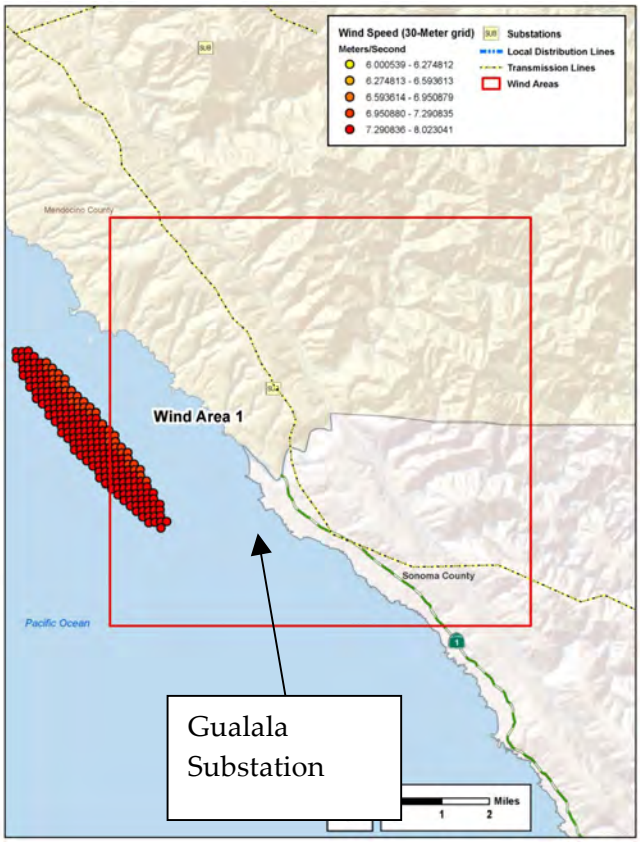


Table 28: Area 1 Energy Availability (Offshore): 30m

Rotor Diameter	Max Turbines	Energy (kWh/yr)
25	100	77,400,989
82.5	30	252,869,031
100	25	309,603,956

Wind Area 2

Wind Area 2, of about 5.5 km², is northeast of the Annapolis substation, which is in the northwest part of the county (Figure 24 and Figure 25). The average wind speed ranges from 6.5 m/s (30m) to 7.0 m/s (100m), and P/A ranges from 320 W/m² to 410 W/m², which falls mostly into Class 3, or "Fair" wind resource (

Table 29 and Table 30).

Figure 24: Wind Area 2 Resource at 30m

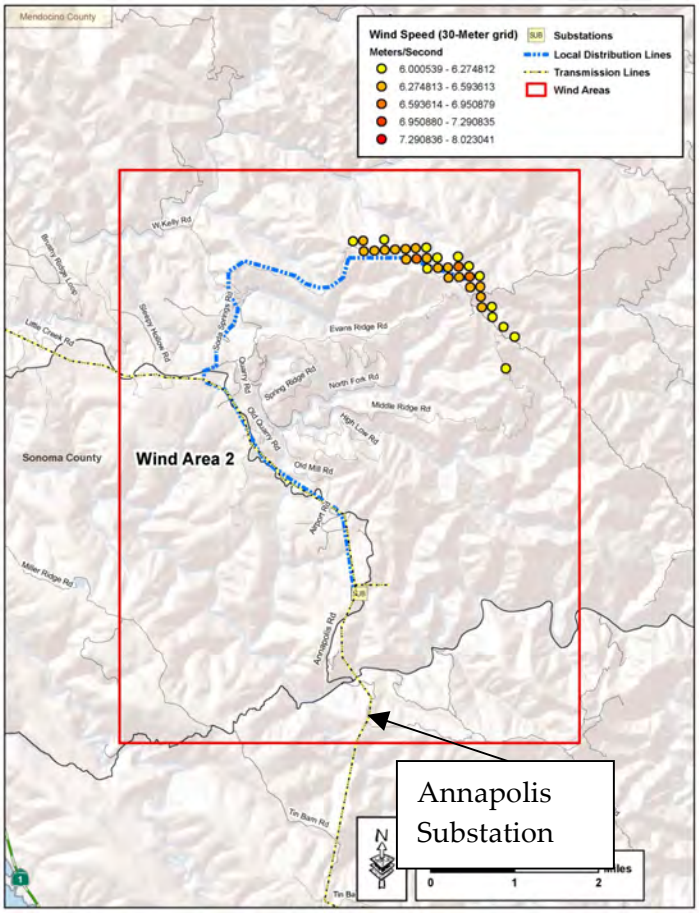


Table 29: Area 2 Energy Availability at 30m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	26	10,719,348
82.5	2	8,979,515
100	2	13,193,044

Figure 25: Wind Area 2 Resource at 100m

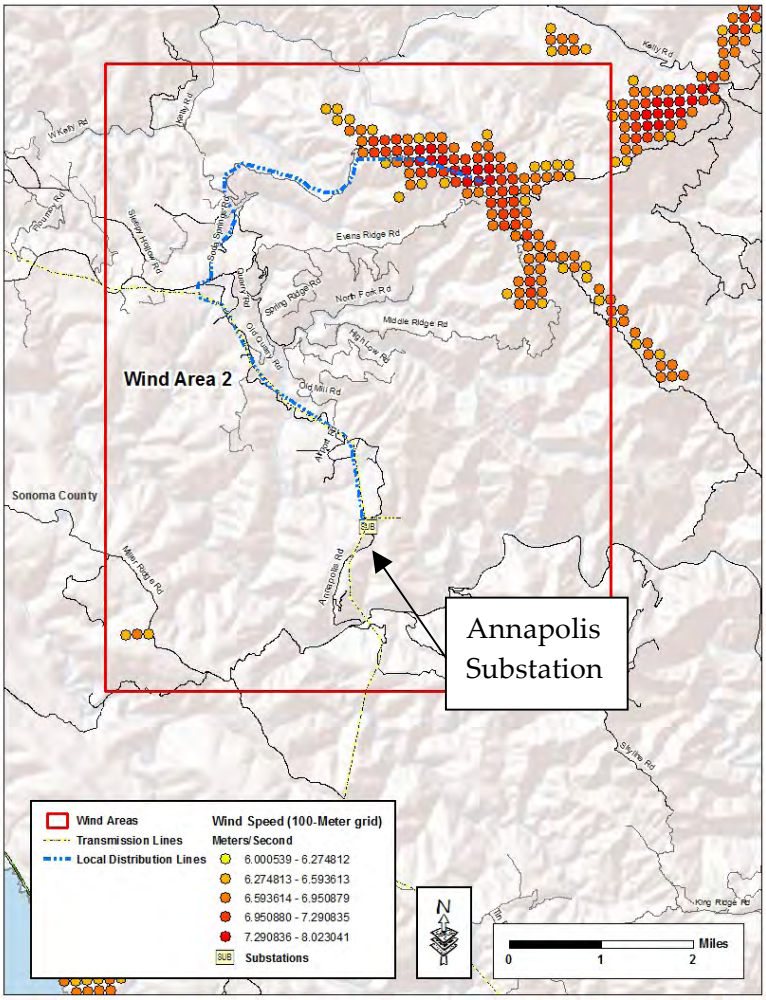


Table 30: Area 2 Energy Availability at 100m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	247	130,486,628
82.5	22	126,566,747
100	15	126,788,627

Wind Area 3

Wind Area 3 extends to the east and south of the Fort Ross substation. The resources at 30m are not significant enough to evaluate, as they mostly are lower than Class 3. At 100m, the resource in this area is more significant (Figure 26 and Figure 27). The total area of the smaller clusters that have a distribution line running near or through them is roughly 11.7 km^2. P/A ranges from 320-410 w/m^2 (Table 31 and Table 32).

Figure 26: Wind Area 3 Resource at 30m

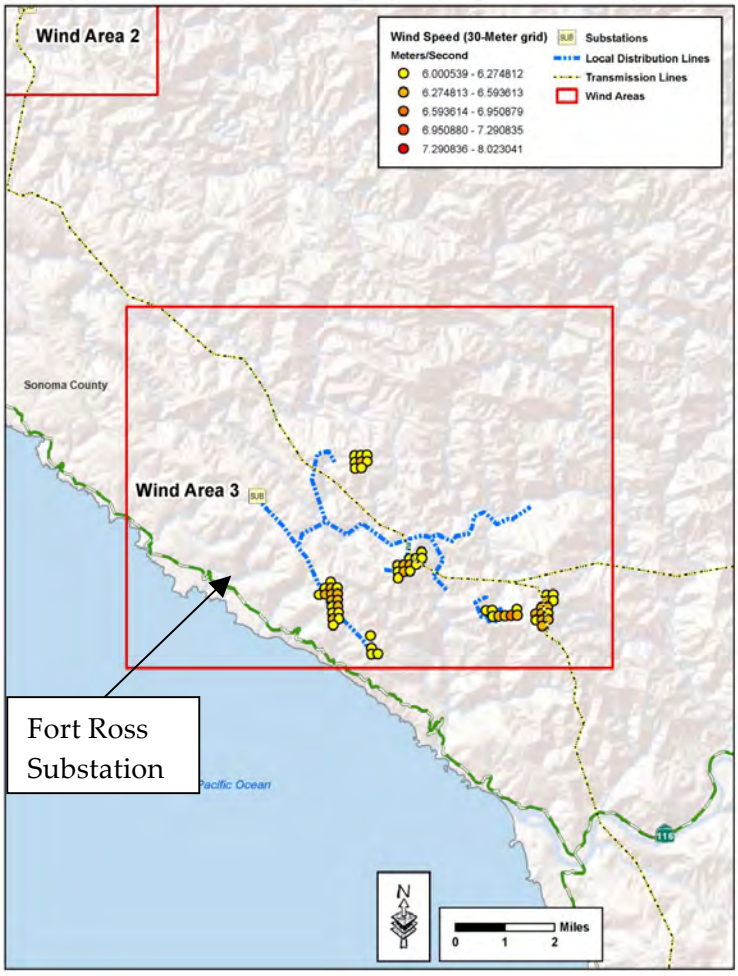


Table 31: Area 3 Energy Availability at 30m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	N/A	N/A
82.5	N/A	N/A
100	N/A	N/A

Figure 27: Wind Area 3 Resource at 100m

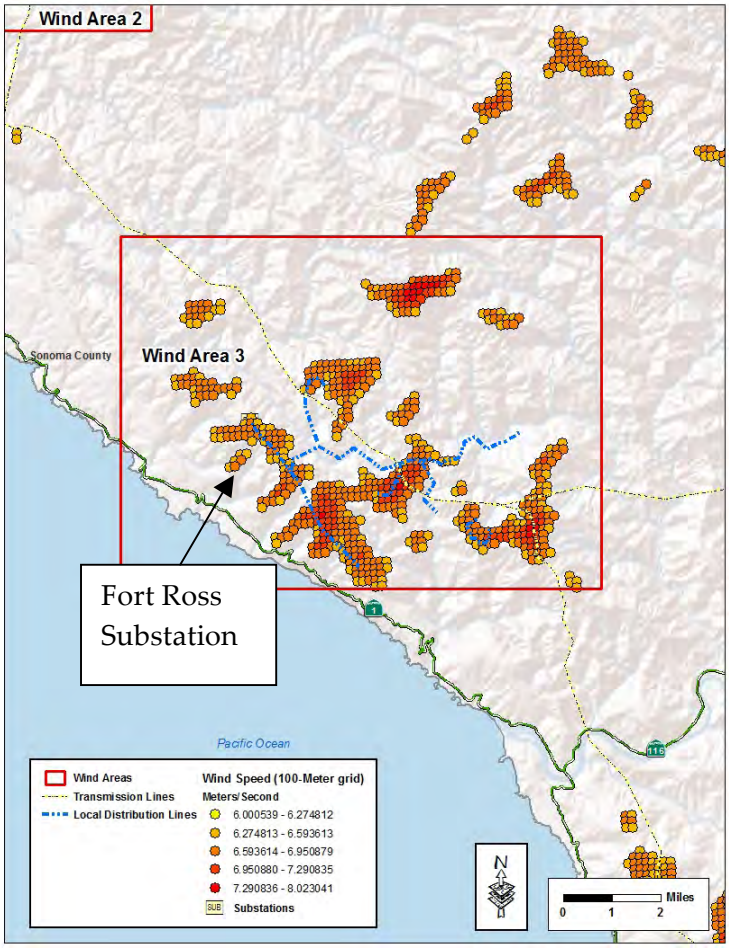


Table 32: Area 3 Energy Availability at 100m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	1177	569,185,455
82.5	106	558,227,305
100	71	549,358,264

Wind Area 4

Wind Area 4 contains the second high quality offshore wind area. About 2.5 miles offshore, southwest of the Salmon Creek substation, it is approximately 5 km^2 in water depth of 50m or less. Onshore and adjacent to distribution lines or the substation, there is a total of approximately 3.2 km^2 that has a P/A ranging from 320-480 w/m^2 at 30m. At 100m, there is 16 km^2 with P/A ranging from 320-530 w/m^2 (Figure 28 and Figure 29; Table 33 and Table 34).

Figure 28: Wind Area 4 Resource at 30m

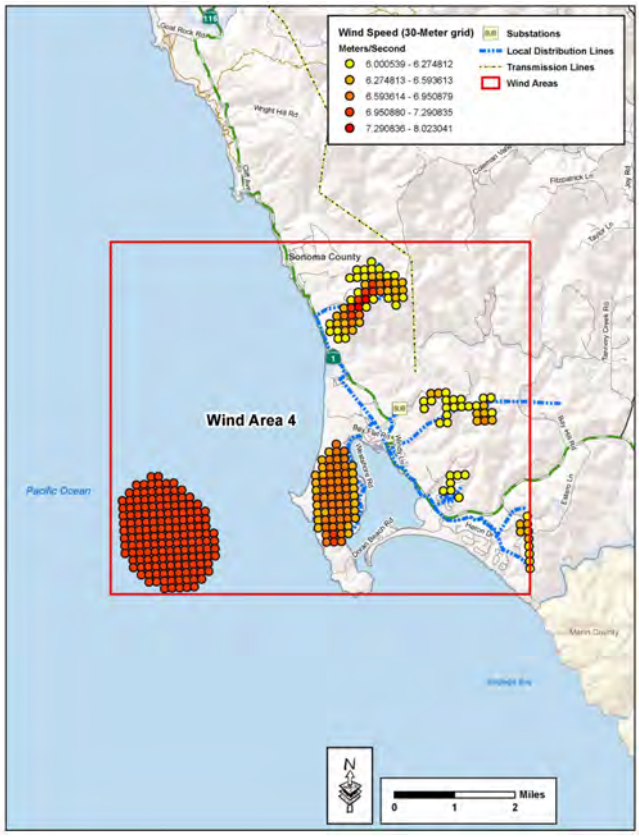


Table 33: Area 4 Energy Availability (Onshore) at 30m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	330	155,774,237
82.5	30	154,216,494
100	20	151,053,805

Figure 29: Wind Area 4 Resource at 100m

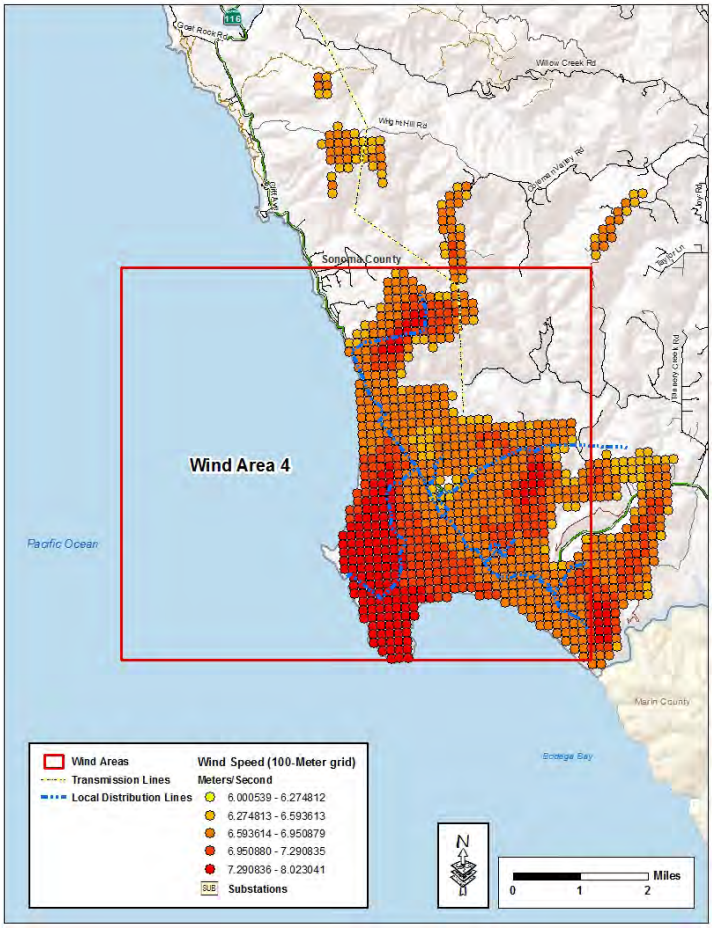


Table 34: Area 4 Energy Availability at 100m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	1600	755,269,026
82.5	144	740,239,172
100	96	725,058,265

Although the technical potential of this area is high, it is likely to be extremely difficult to develop even a fraction of the available wind capacity, due to political factors. The coastal area in California has traditionally been heavily protected from development of any sort. Even a few wind turbines may be very difficult to site here, much less hundreds.

Wind Area 6

Located in the Geysers steam field, Wind Area 6 has one of the most interesting combinations of wind availability, existing transmission and substation infrastructure and improved sites. The area of wind availability is approximately 3.43 km^2 with P/A ranges from 329-382 w/m^2 at 30m. 14.2 km^2 and P/A ranges from 320-573 w/m^2 (Figure 30 and Figure 31; Table 35 and Table 36).

Figure 30: Wind Area 6 Resource at 30m

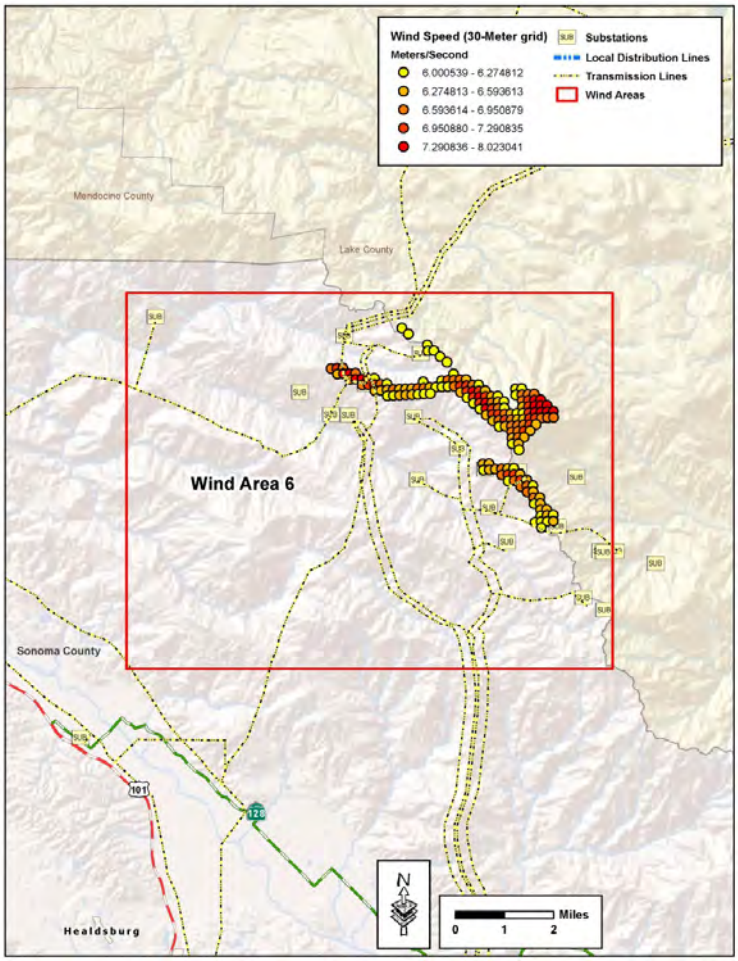


Table 35: Area 6 Energy Availability at 30m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	343	161,910,797
82.5	31	159,357,044
100	21	158,606,495

Figure 31: Wind Area 6 Resource at 100m

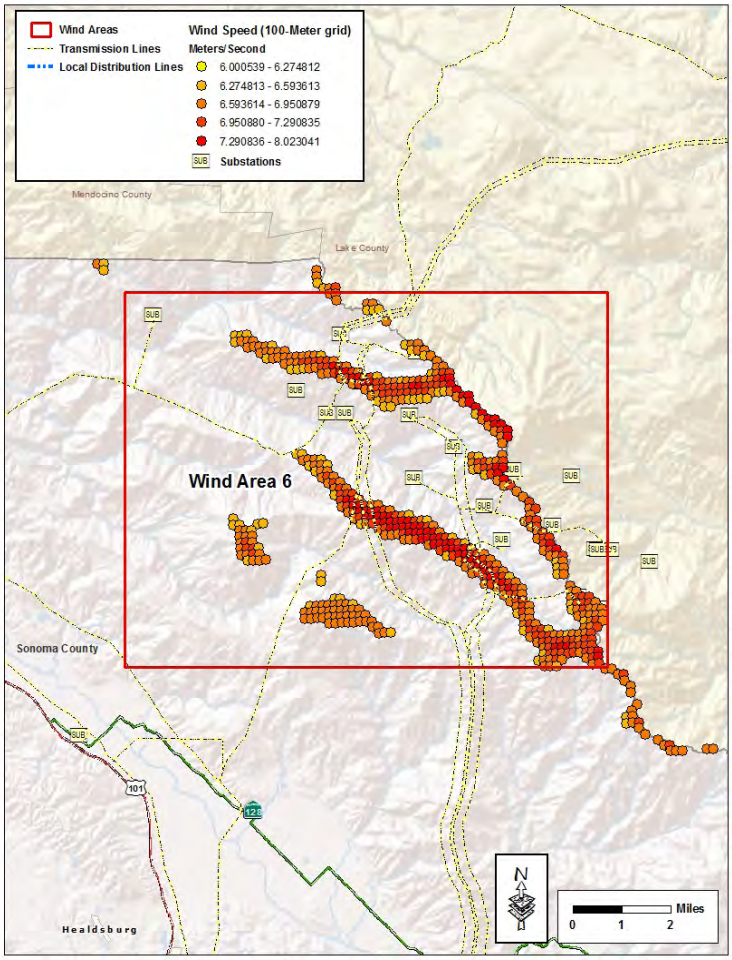


Table 36: Area 6 Energy Availability at 100m

Rotor Diameter	Max Turbines	Energy (kWh/yr 30% CF)
25	1422	701,296,743
82.5	128	687,448,352
100	85	670,719,811

Summary

As mentioned above, there are two major limitations to the development of wholesale wind power in Sonoma County. The first is the lack of transmission capacity. The distribution grid can potentially be used, but for anything other than the smallest wind development, expensive interconnection studies would be required. The second is the environmental sensitivity of the California coastal viewshed. The coastal areas may be extremely difficult to develop, even minimally, due to both statutory protections and the resistance of the local residents. Thus the numbers presented in Table 37 and Table 38 should not be taken as an indication of what is developable, but only as an indication as to the upper limit of the wind resource in the county. The purpose of the analysis is to indicate the technical potential.

Table 37: Annual Wind Production Capacity at 30m and 100m (30 Percent CF)

	Annual Production Capacity at 30m (kWh)	Annual Production Capacity at 100m
Area 1	213,291,325	N/A
Area 2	10,963,969	127,947,334
Area 3	N/A	558,923,675
Area 4	153,681,512	740,188,821
Area 6	159,958,112	686,488,302
Total	**537,894,918**	**2,113,548,132**

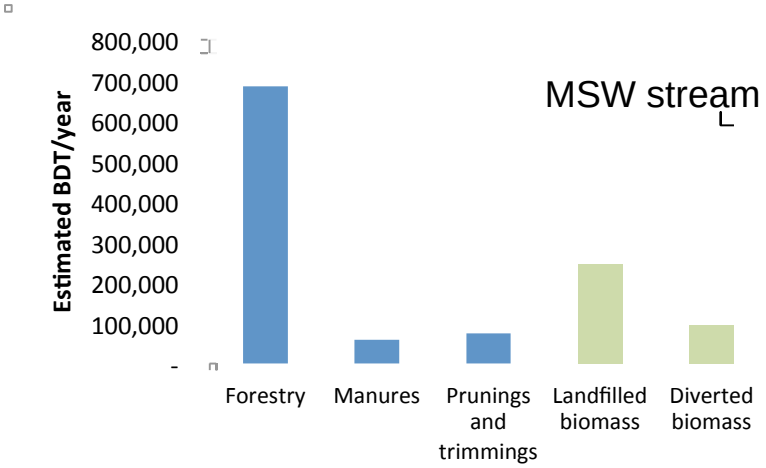
Table 38: Total Nameplate Capacity in Wind Areas

	Total Max MW Nameplate (30m)	Total Max MW Nameplate (100m)
Area 1	81	N/A
Area 2	4	49
Area 3	N/A	213
Area 4	58	282
Area 6	61	261
Total	**204**	**804**

Biomass

Energy in local biomass provides opportunities for power generation, carbon sequestration, composting, and reuse for a variety of applications. Sonoma County produced an estimated 1.3 million *bone-dry tons* (BDT) of biomass in 2007, although not all of this biomass is readily available for use as an energy resource. Sonoma County's available biomass resource allows for the generation of 22-103 megawatts of electric generation potential (MWe), with 32 MWe possible under a base case. Most of this power would be generated using forestry byproducts, dairy manure, and materials currently going to the landfill, such as construction and demolition wood, paper, and other organics (Figure 32).

Figure 32: Estimated Sonoma County Biomass in 2010



Sources: *Draft: an assessment of biomass resources in California, 2007* (Williams 2008); *Evaluation of Sonoma County organic waste resource base for developing anaerobic digestion systems* (RCM International 2010); *Sonoma County Crop Report 2010* (Sonoma County Office of the Agricultural Commissioner 2011); *Preliminary biomass fuel availability and feasibility review for siting biomass power facilities in Mendocino County, CA* (TSS Consultants 2006); *Waste characterization study* (Cascadia Consulting Group; Sky Valley Associates, Inc. 2007); Personal communication (Carter 2011).

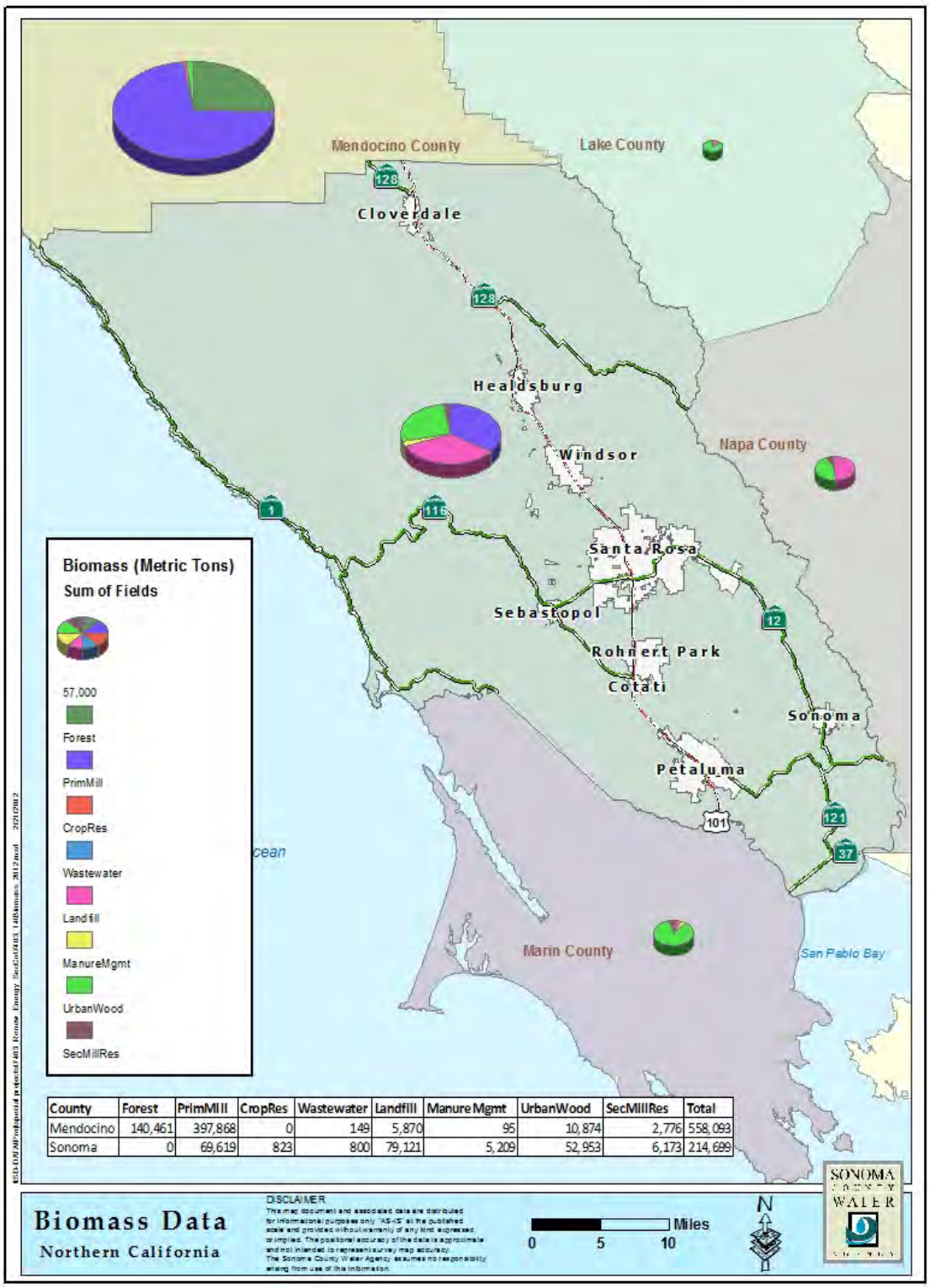
Sonoma County has two categories of biomass:

1. Biomass which is being landfilled or diverted to compost (managed)
2. Biomass outside the waste stream, much of which is land applied (unmanaged)

Managed biomass that is landfilled or composted is considered to be inside the waste stream. It is relatively well characterized, and nearly all of it is already transported to a central site. The number one conservation priority with this material is to keep it out of the landfill.

But most of Sonoma County's potential biomass resource never enters the municipal waste stream, and is harder to access. Material outside the waste stream includes livestock manure, logging and forest management residues, and agricultural residues, primarily from grape growing and wine production. Much of this biomass is currently left on the ground (Figure 33).

Figure 33: Biomass Availability for Sonoma County Region

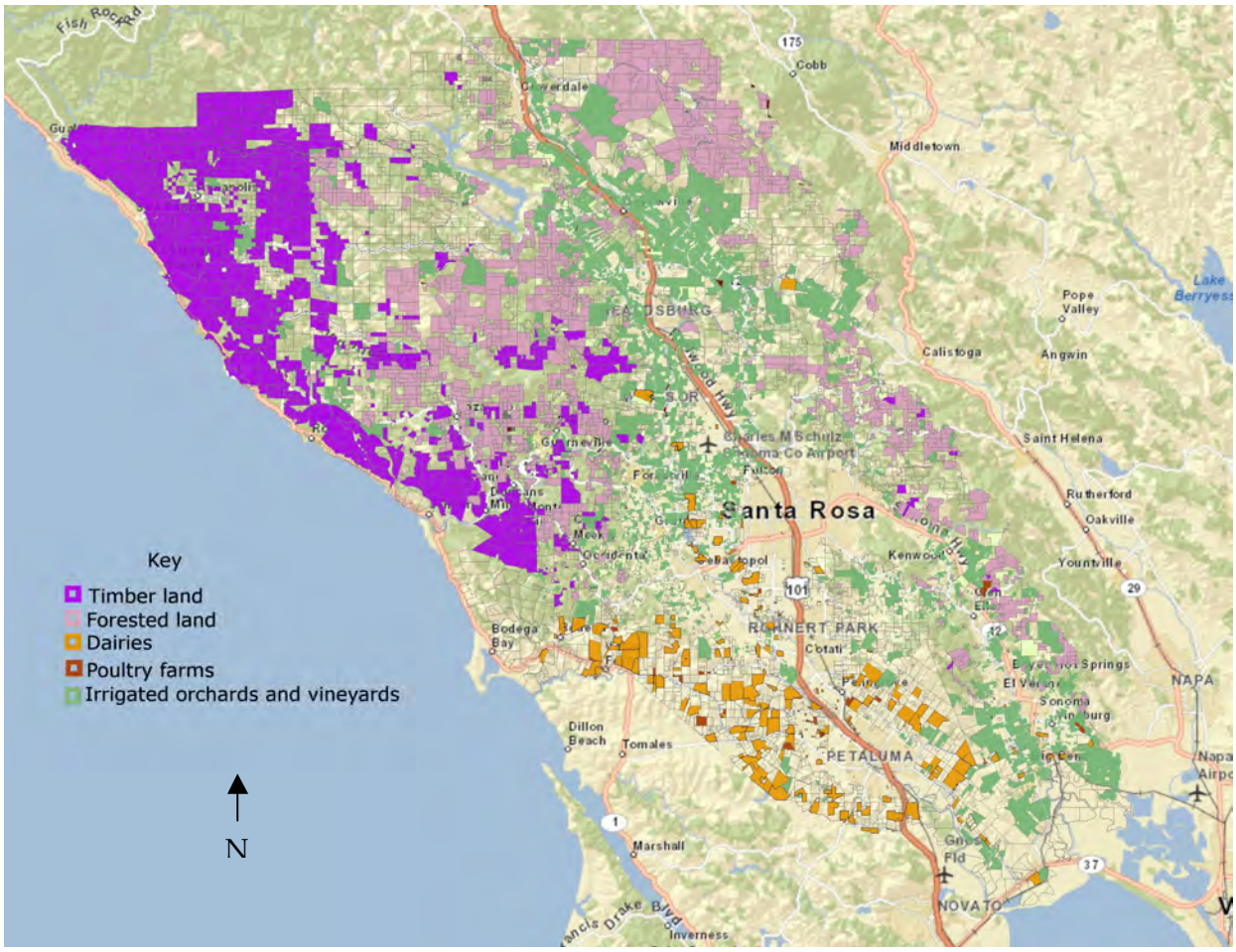


County	Forest	PrimMill	CropRes	Wastewater	Landfill	Manure Mgmt	UrbanWood	SecMillRes	Total
Mendocino	140,461	397,868	0	149	5,870	95	10,874	2,776	558,093
Sonoma	0	69,619	823	800	79,121	5,209	52,953	6,173	214,699

Sonoma County Water Agency (with disclaimer)

The Sonoma County Water Agency's estimate of feedstock availaibility shows that landfilled material, primary mill residues and urban wood waste comprise large portions of Sonoma County's available biomass. Note that the numbers presented in Figure 34 differ slightly from those used in the rest of this report, reflecting an alternative analysis of available feedstock. Importantly, this figure shows how much feedstock may be available in adjacent counties. While the present analysis was limited to Sonoma County, urban wood from surrounding counties or forestry/ mill materials from Mendecino could supplement Sonoma County feedstocks.

Figure 34: Sonoma County Land Use (Predictive of Biomass Feedstock Availability)



Much of Sonoma County's biomass resource is geographically clustered, with manure-producing dairies clustered in the south and wood-generating timberlands predominantly based in the northwest.

Quantification of Biomass Feedstock

Availability of feedstock materials at competitive prices is vital to the success of biomass power projects. Data about the availability of biomass resources is distributed across a wide range of data sources: the National Renewable Energy Laboratory estimates (Millbrant 2005), California

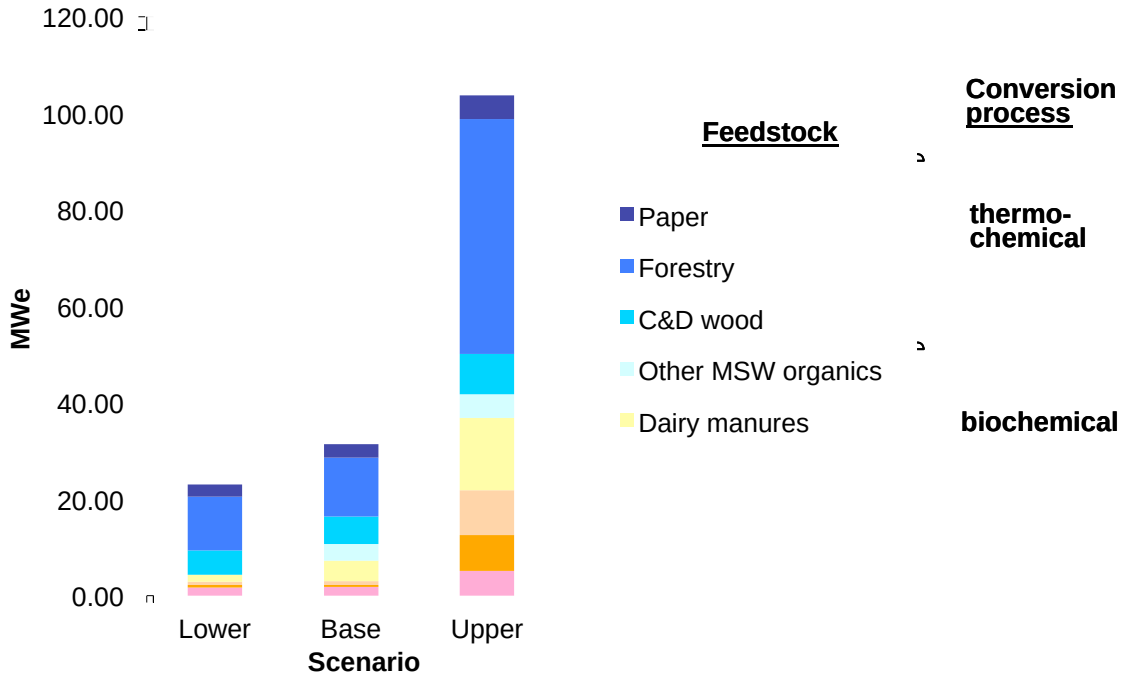
Biomass Collaborative estimates (Williams 2008), Sonoma County Water Agency studies of food waste (Igo 2009) and *anaerobic* digestion potential (RCM International 2010), waste management-related documents (Cascadia Consulting Group; Sky Valley Associates, Inc. 2007), and others. All of this information was compiled into a master spreadsheet, and the best available data was chosen by feedstock category (Figure 35). Reliable County-specific data was given precedence over state or national level estimates. This information was supplemented by a survey of large landowners and knowledgeable stakeholders.

When values were derived for the usable biomass base in the county and the energy potential was calculated, it was found that known Sonoma County biomass could produce 32 MWe.

There remains significant uncertainty about available biomass feedstock and associated energy potential because biomass sources are, in general, poorly characterized. This uncertainty about resource base could pose an obstacle for biomass power production by necessitating an additional step in any feasibility studies.

Energy Potential of Sonoma County Biomass

Figure 35: Sonoma County Energy Capacity by Feedstock



Primary sources: *Evaluation of Sonoma County organic waste resource base for developing anaerobic digestion systems* (RCM International 2010); Draft: an assessment of biomass resources in California, 2007 (Williams 2008); *Waste characterization study* (Cascadia Consulting Group; Sky Valley Associates, Inc. 2007). See text for additional documentation.

An estimated 22–103 MWe of electric power could be generated from available Sonoma County biomass, with 32 MWe possible under a base case (Figure 41). With limited exceptions, the same numbers for gross biomass were used in all three scenarios (lower, base, and upper). However, the scenarios differed in the assumed moisture content, their gross-to-technical conversion factor (Table 39), the feedstock heat content (Table 40), the process efficiency for conversion to electricity (20–30 percent), and the capacity factor (70–80 percent). Much of the variability in MWe depended on the gross-to-technical conversion factor; that is, how much biomass could be realistically obtained for energy use.

Table 39: Energy Calculations for Sonoma County Biomass — Base Case*

Conversion process	*Type*	*Technical potential (BDT)*	*MMBTU*	*Output (MWh)*	*Nameplate Capacity (MWe)*
Bio	Food and food processing	12,037	144,903	10,623	1.5
Bio	Leaves, grass, green waste	2,781	35,868	2,630	0.4
Bio	Prunings and Trimmings	5,001	73,115	5,360	0.8
Bio	Dairy manures	23,519	398,464	29,213	4.2
Thermo	Other MSW organics	24,657	340,261	24,946	3.6
Thermo	C&D wood	32,293	535,921	39,290	5.6
Thermo	Forestry	68,420	1,176,824	86,277	12.3
Thermo	Paper	16,984	259,957	19,058	2.7
	Total	**168,707**	**2,705,354**	**226,131**	**32.3**

*Assuming 25 percent efficiency (before heat recovery) and 80 percent capacity factor.

Table 40: Heat Content of Biomass Feedstock (MMBTU/ short ton)

Forestry	17.2	18.9
Dairy manures	16.9	17.0
Prunings and Trimmings	14.6	18.4
Food and food processing	12.0	17.0
C&D wood	16.6	16.6
Paper	15.3	18.4
Other MSW organics	13.8	13.8
Leaves and grass	12.9	12.9

Sources: *Manure to Energy: Understanding Processes, Principles, and Jargon* (Mukhtar 2006); *The Biomass Research Laboratory for Biomass Characterization* (Buratti 2012); *Biomass Report* (Christa 2012); *Thermodynamic Data for Biomass Conversion and Waste Incineration* (Domalski 1986); *Heat Content of Bark, Twigs, and Foliage of Nine Species of Western Conifers* (U.S. Department of Agriculture, Forest Service 1979);*Guideline for Determining the Renewable Components in Waste for Electricity Generation* (Nolan ITU Pty Ltd, in association with TBU Environmental Engineering Consultants 2001); *Thermal Methods of Municipal Waste Treatment* (C-Tech Innovation Ltd 2003); *Timber Waste as a Source of Energy* (Szyszlak-Barglowicz 2009)

Although most of the feedstocks are fundamentally similar in energy content (Table 40), they must be handled differently and are best converted to electricity using different conversion processes (thermochemical or biochemical). Dry materials lend themselves to thermochemical conversion processes such as pyrolysis, whereas wet materials like food waste and dairy manure are best suited for biochemical conversion processes such as anaerobic digestion. Below, a discussion of feedstock-specific availability, issues, and power potential is presented by feedstock.

Forestry Wastes

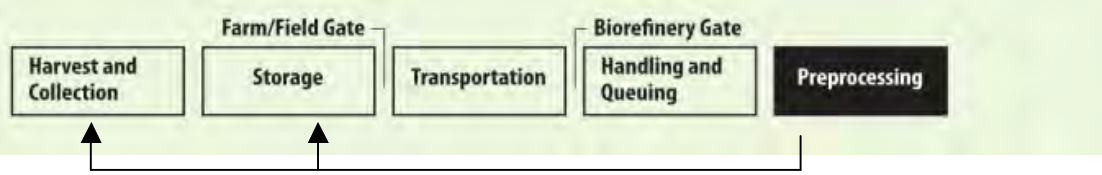
Forestry wastes are comprised of harvest/fuels treatment residuals and forest products manufacturing residuals. The former is widely distributed and is generally left on site to decompose or be burned; the latter is generated by a few Sonoma County milling operations, but is currently put to other uses, such as the landscape market.

Forestry stakeholders agreed that, while considerable residual material was generated by Sonoma County's estimated 225,000 acres of timberland, in most cases it was cost-prohibitive to move this material off site. Removing slash from logged conifers presents difficulties both economically and ecologically. Experts suggested that the most viable source of woody biomass would be tan oak (~18,000 green tons available from current logging practices). Sudden Oak Death is widespread in the county, and may yield potential oak feedstock material. There was some optimism that mandatory fire fuels around buildings and power line clearance treatments could also provide feedstock. In general, biomass power plants have collection areas of ~25 miles, so siting a plant in the Northwest corner of the county would provide access to all those residues that could be feasibly harvested (Figure 25). Note, however, that biomass fuel is amongst the lowest value use of woody materials, and if any other uses exist owners are likely to instead utilize those higher-value, higher-profit options (TSS Consultants 2006).

In addition to residues from logging, ~43,600 BDT of primary mill waste is generated from Sonoma County sawmills. They currently receive about $49–60/ ton for this material at present. One operation along the Highway 101 corridor produces the majority of this material. However, only 2 of 4 businesses responded to inquiries, so this data should be considered incomplete.

In order to make biomass power generation viable, costs of feedstock supply must be kept low. Moving the preprocessing of feedstock forward in the supply chain (Figure 36) has been proposed as a way to help meet aggressive biofuel targets. The same sort of supply chain restructuring can be used to reduce supply costs of biomass-based power. With forestry feedstock, on-site chipping or densification (pelletization/ briquetting) can increase the amount of material that can be feasibly removed from the site. However, this can also lead to less durability in storage (Schroeder 2007). Mobile pyrolysis-type processes could be employed to generate gas, bio-oil, or char on site.

Figure 36: Model for Processing of Forest Biomass



Source: *Sustainable Biomass Supply Systems* (Jacobson 2009)

In general, forestry in Sonoma County is struggling at present, with very few new timber harvest plans. If the present trend continues, forestry biomass resources could shrink over time as timberland is converted to other uses.

Based on the above information, it was estimated that 10–30 percent of Sonoma County's 684,000 BDT of forestry biomass would be available for energy use (Williams 2008) (Table 41). Under a base case, the usable forestry wastes totals ~68,000 BDT and generate 12.3 MWe, providing the largest biomass feedstock by type.

Table 41: Gross to Technical Conversion Factors

	Lower bound	Base case	Upper bound
Dairy manure	20%	40%	80%
Total orchard and vine	N/A	N/A	90%
Total food/ food processing	50%	50%	90%
Total forestry	10%	10%	30%
Paper	80%	80%	100%
Leaves, grass, and green waste	80%	80%	>100%
Other MSW organics	0	80%	90%
C&D wood	80%	80%	100%

Dairy Manure

A 2010 RCM Report quantified available dairy cattle manure based on producer surveys (RCM International 2010). Although other sources of manure are available, manure deposited in rangeland or pasture is not accessible, and two major sources of poultry manure were slated for use in the Sonoma County Water Agency's planned 1.4 MW Farms to Fuel biogas digester-fuel cell. Thus, the RCM number was used as the base data because it was felt that it effectively captures the majority of the available resource.

The logistics of anaerobic digestion are such that, at present, only a portion of this manure could be employed to generate power. The typical Sonoma County dairy is small and, increasingly, organic. Anaerobic digestion generally requires a steady stream of waste material from 500 or more cows — most dairies fall below this threshold, and have variable manure available depending on the season (cows are put out to pasture in fair weather months.) Furthermore,

anaerobic digesters typically require significant capital, time, and attention — all things in short supply in Sonoma County's struggling dairy industry. Dairies are closing on a regular basis; the only Sonoma County dairy with an anaerobic digester currently lies unoccupied.

Regional anaerobic digesters are possible. Much dairy manure is slurried so that it is 99 percent liquids, making it impractical to transport long distances. Five miles is commonly cited as the upper limit of transport. Yet the geographic arrangement of Sonoma County's dairies could support a regional digester and economies of scale favor it.

One of the benefits of anaerobic digestion generally is that the biogas produced can be cleaned up to pipeline-quality gas. It can then be distributed to users and converted to electricity in locations where the waste-heat can also be readily utilized, increasing the overall process efficiency from 20–30 percent to ~75 percent. See section on "Anaerobic digestion and pyrolysis/ gasification."

Based on the difficulty associated with anaerobic digesters, it was estimated that 20–80 percent of known dairy manure could be used to generate power. Because of this uncertainty in feedstock potential, there is also a wide range in the possible power that could be generated (1.43 – 15.1 MWe, depending on scenario).

Prunings and Trimmings

The vast majority of Sonoma County's prunings and trimmings are generated from its nearly 60,000 acres of vineyards, but this material may not be usable for power generation. Of the material generated from yearly grape prunings, an estimated 80 percent of it is disked back into the soil as a nitrogenous amendment. Because grape growers are quite particular about the amendments they use, it may be hard to shift them away from this practice. Furthermore, centralized biomass power for vineyard prunings has failed to take off because these prunings can be difficult to handle, frequently contain metal, and may only be sporadically available. Thus, in the lower bound and base case scenarios, it was assumed that vineyard prunings would not be available for power generation. Subtracting vineyard biomass sources, ~5000 BDT of agricultural residues are available each year, yielding 0.8 MWe.

Leaves, Grass, and Green Waste

In general, leaves, grass, and green waste will be diverted to compost. As of November 2011, Sonoma County compost operations were permitted for 156,000 tons of compost per year, and more than 90,000 tons of material was taken in at Sonoma Compost (adjacent to the landfill site). This material is going to an alternative use for which there is already a well-developed market and environmental benefits. Among policy-makers and waste management experts, source reduction and diversion to uses such as compost or vermicompost is considered the highest priority. Compost, it can be argued, can be produced relatively cleanly, builds soil carbon, and displaces nitrogenous fertilizers. Energy is frequently considered a second tier use for this material.

It is estimated that if material going to Sonoma Compost were instead used to generate power it could produce up to 7.5 MWe. However, because of the barriers associated with generating

biogas electricity from this material, it was not considered part of the resource base except in the "upper bound" scenario.

Usable Biomass in Municipal Solid Waste

The feedstock listed below — construction and demolition wood waste, food waste, and paper — are all found in the MSW stream. Although they are also available outside of the waste stream, analysis was limited to the quantities already going to Sonoma County's central landfill site, as they have been well-quantified and are already centrally managed, thus lending themselves to power production. Alternative fates for biomass, and particularly organics, have been studied extensively by the Sonoma County Solid Waste Advisory Group.

Food Waste

Of particular interest in this report is potential use of the organics that are currently being disposed in landfill. According to the best available data this may amount to over 120,000 tons per year, primarily of food waste (Sonoma County Solid Waste Advisory Group: Research Committee 2011). This material has high value for production of biomethane for direct use and/or energy conversion to electric power.

In the current analysis, only food currently within the MSW stream was included in energy calculations. Food processor wastes not being landfilled were not included because available data was incomplete (Table 42). Including these sources would generate an additional 0.3–0.5 MWe.

Table 42: Daily Biogas Outputs for Some Sonoma County Food Processing Wastes (Outside MSW)

Waste source	Biogas (ft^3/ day)	BTU/ day	Current disposal practice
A1	25,800	15,480,000	Sludge to EBMUD
A2	69,860	41,916,000	Pay haul away
B	31,000	18,600,000	Sent to EBMUD
C1	1,491	894,600	Sent to EBMUD
M	8,600	5,160,000	Sent to EBMUD
O	8,250	4,950,000	Hauling away
P1	1,000	600,000	Pay haul away
P2	13,500	8,100,000	Pay haul away
Total	**159,501**	**95,700,600**	

Source: *Evaluation of Sonoma County organic waste resource base for developing anaerobic digestion systems* (RCM International 2010)

It was estimated that 50 percent to 90 percent of the food waste currently within the MSW stream could be recovered for power generation, either through diversion or through establishing a materials recovery facility at the central landfill site.

Construction and demolition wood

Power generation from construction and demolition (C&D) waste is considered a low priority use of the materials compared to reuse and recycling. Nonetheless, C&D does present an attractive feedstock, because much of it currently ends up in the landfill or is trucked to power generation facilities as far afield as Redding, CA. The C&D waste going into the landfill could yield 5.3–8.4 MWe. With the addition of compost "overs" and C&D being managed outside the MSW stream there is likely to be even greater potential for power generation, if permitting, policy, and economic issues could be surmounted.

Paper

Paper currently going into the landfill could, theoretically, generate 3.1–4.9 MWe of energy. From a systems perspective, it is unclear if power generation would be preferable to recycling or composting of this material, assuming that it could be separated out.

Other MSW Organics

Other MSW organics include textiles, carpet, carpet padding, and items that are primarily organic but include other materials such as cotton balls, hygiene products, hair, rubber products, and animal carcasses. These materials could yield 3.6 MWe under a base case.

Other Feedstock

Additional feedstocks not addressed above include wastewater, biosolids, and field, seed, and vine. Preliminary calculations showed that most of these resources were not large enough to warrant inclusion. For example, field, seed, and vine would only produce 0.02 MW of energy under an "upper bound" scenario.

However, there may be significant opportunities from power generation from winery wastewater ponds, lees (sediment from wine vats), and crushed-grape pomace (estimated 43,000 wet tons/ 2007) (Igo 2009). As with vineyard prunings, there are questions about how viable these materials are for energy generation given their seasonality.

Collection and transportation logistics

Generally, possible ways to transport feedstock include:

- Trucks (one-directional or with backhaul)
- Train (freight options only available Napa to Windsor, along equivalent paths to Highways 101 and 37)
- Pipelines (only possible for pulped solids, liquids, and gases)

Transportation incurs both distance fixed costs and distance variable costs. Distance fixed costs are significantly lower for trucks than for trains, while the reverse is true for distance variable costs. Thus, trucks tend to be favored over shorter distances. This, combined with limited access to trains near central biomass collection points, means that train transport of biomass is unlikely to be practical for Sonoma County. The same is true of pipeline transportation, which tends to be economical over longer distances (Kumar 2004).

In general, trucks are the most likely form of biomass feedstock transportation. Fixed trucks with enclosed beds may be the optimal option for Sonoma County, although that will depend on existing infrastructure (Jacobson 2009). Truck time costs $60-70 per truck-hour (RCM International 2010). According to data from Henry Alden, representative for Gualala Redwoods, a truck usually carries 25 tons/ load (Linney 2012). Hauling accounts for $85 of the $255 it costs to deliver a thousand board feet of lumber. Higher costs are incurred with feedstocks that have lower bulk densities or higher moisture contents, that require longer loading/ unloading times, or that have to be moved farther.

Woody biomass has a solid loading volume of 0.15–0.20, compared to 0.35–0.45 for chipped or chunked biomass, and 0.7 for bundled biomass (Rummer 2007). It is generally better to increase biomass density closer to the source location. This can be done by chipping, grinding, mulching, pelletization, briquetting, bundling, or baling.

Like woody biomass, wet biomass benefits from a higher energy density during transportation. Liquid-rich dairy manure can only be transported about 5 miles from point of origin (RCM International 2010). More energy rich food processing wastes can be transported much farther.

Because of the difficulties transporting dairy manure, and the relative abundance of this feedstock material, a "hub-and-spokes" model has been proposed as an alternative to centralized anaerobic digestion. In this system, gas collection would occur on individual dairies. The gas would be transported, via low pressure pipes, to a centralized location which could produce power or biomethane. Potential benefits of the hub-and-spokes model include a reduction in on-farm biogas processing costs, economies of scale at the central location, and incremental scalability. Research into the viability of such a system is ongoing (California Environmental Protection Agency 2012).

The optimal biomass feedstock processing mechanisms will depend on the supply chain and supply curve characteristics. Existing models may help determine optimal system arrangements, particularly when integrated with GIS path modeling of potential road pathways from a given series of sites (Leboreiro 2010). A model should be calibrated in conjunction with any specific plans for centralized power generation.

Conversion Processes: Anaerobic Digestion and Pyrolysis/Gasification

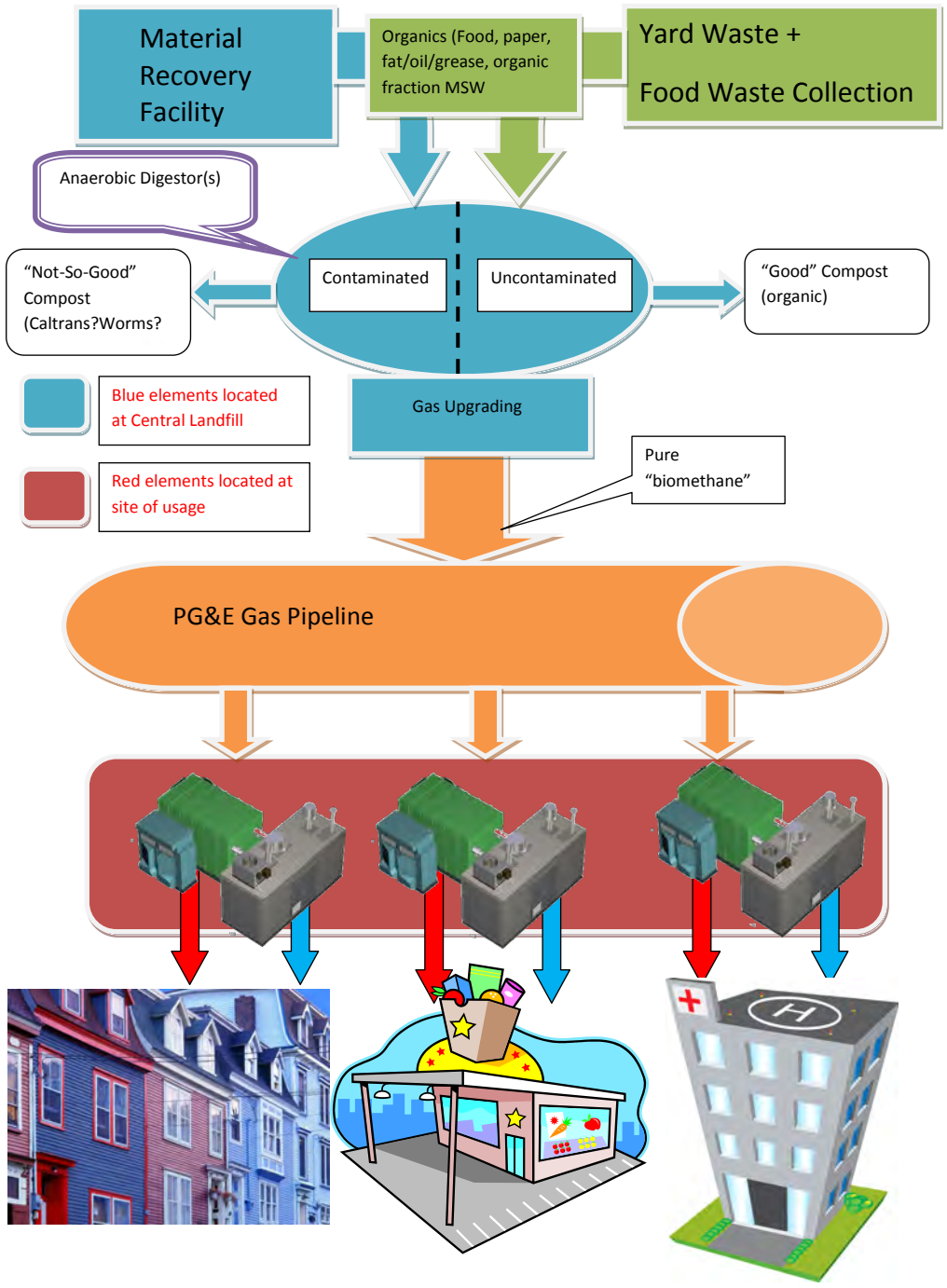
In general, wet waste lends itself to biochemical processes such as anaerobic digestion, whereas dryer waste can be converted to energy using thermal processes. Anaerobic digestion produces a methane-rich biogas which can be upgraded to pipeline quality gas and distributed.

This report incorporates a model developed by the Sonoma County Water Agency and its contractors for using "directed biogas" to fuel either fuel cells or other distributed generation equipment (Figure 37). A directed biogas transaction involves the injection of pipeline-quality biomethane into the natural gas transmission network. Distributed generation (DG) equipment is connected to the natural gas network, and the injected biomethane is credited to the DG as a renewable fuel through a contractual arrangement.

Biomass combined heat and power processes can yield 75 percent total conversion efficiencies, compared to only ~30 percent efficiency without heat recovery. When there is a large need for heat on-site — as there may be on dairies or at food processing plants — an anaerobic digester can be coupled with a combined heat and power facility in the same location. However, where the heat isn't needed on site, the methane can be distributed and used in locations that do employ the waste heat, increasing overall process efficiency and maximizing the usefulness of available resources.

In the base case, 1 million MMBTU of heat per year can be recovered from conversion processes. Of this, 230,000 MMBTU is generated through thermochemical conversion processes. These thermochemical conversion processes would produce thousands of million standard cubic feet (mmscf) biomethane/ year (the number is likely to vary greatly depending on the type of digester and other factors).

Figure 37: Model for Directed Biogas



Barriers

Barriers to biomass power production include, but are not limited to:

- Feedstock availability (uncertainty, volatility)
- Institutional resistance and alternative uses
- Siting and permitting issues

Feedstock availability is essential to biomass power. At present, biomass is poorly characterized, and the numbers presented in this report are fundamentally imprecise. Furthermore, some of the resources are volatile, seasonally or year-to-year. Seasonal variation in feedstock poses complications for power facilities that aim to operate at maximum capacity. Year-to-year volatility (for example, in the timber and dairy industries) threatens long-term contracts and financing.

Institutionally, there may be resistance to using biomass for power. In many cases, biomass is currently providing useful services. For example, forest slash can help forest ecology; disking vineyard prunings can reduce the need for synthetic fertilizers; and compost application can help rebuild soils. In some situations, the services provided by source reduction, composting, recycling, or alternate uses may be more beneficial than power production (Tellus Institute, Cascadia Consulting Group, Sound Resource Management 2008). Even where this is not true, it may be perceived to be the case, and there may be considerable institutional resistance to considering biomass power.

Finally, Biomass power facilities face the same sort of siting and permitting difficulties as other facilities. The Southern half of Sonoma County is within the Bay Area Air Quality Management District, which has fairly tight restrictions on air particulate emissions. Thermochemical conversion processes in particular are likely to encounter not only permitting issues, but also community resistance. Sonoma County has high property values, significant population density, and an engaged civic, social, and environmentally conscious community, all of which can complicate siting.

Geothermal

Geothermal-electric energy is a mature technology that provides reliable baseload electric power that is a qualified renewable resource under state law. Capacity factors for geothermal power plants are typically above 85 percent with many plants operating nominally at above 90 percent (National Renewable Energy Laboratory 2012c). Sonoma County has the largest high temperature geothermal-electric facility in the world, the Geysers, located largely within its borders as well as adjacent Lake County. The Geysers covers approximately 45 square miles in the Mayacamas Mountains.

Existing Generation

Three entities, Calpine Corporation (Calpine), the Northern California Power Agency (NCPA), and Bottle Rock Power, Inc. own and operate a total of approximately 870 megawatts of electrical generation at the Geysers, with the majority of that power generated by Calpine.

Calpine generates about 725 megawatts of electricity from 15 geothermal power plants (Calpine Corporation 2012). Contracts for this power are staggered so that opportunities for entering into the market arise periodically. Currently most of the power is under contract with the three major investor owned utilities in California, Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric.

In addition to Calpine's existing production, in November of 2011 permits were approved for two new 49 megawatt-capacity plants for an expanded generation capacity of nearly 100 megawatts (Calpine Corporation 2011). Calpine is actively pursuing customers for this power in the form of long-term power purchase agreements.

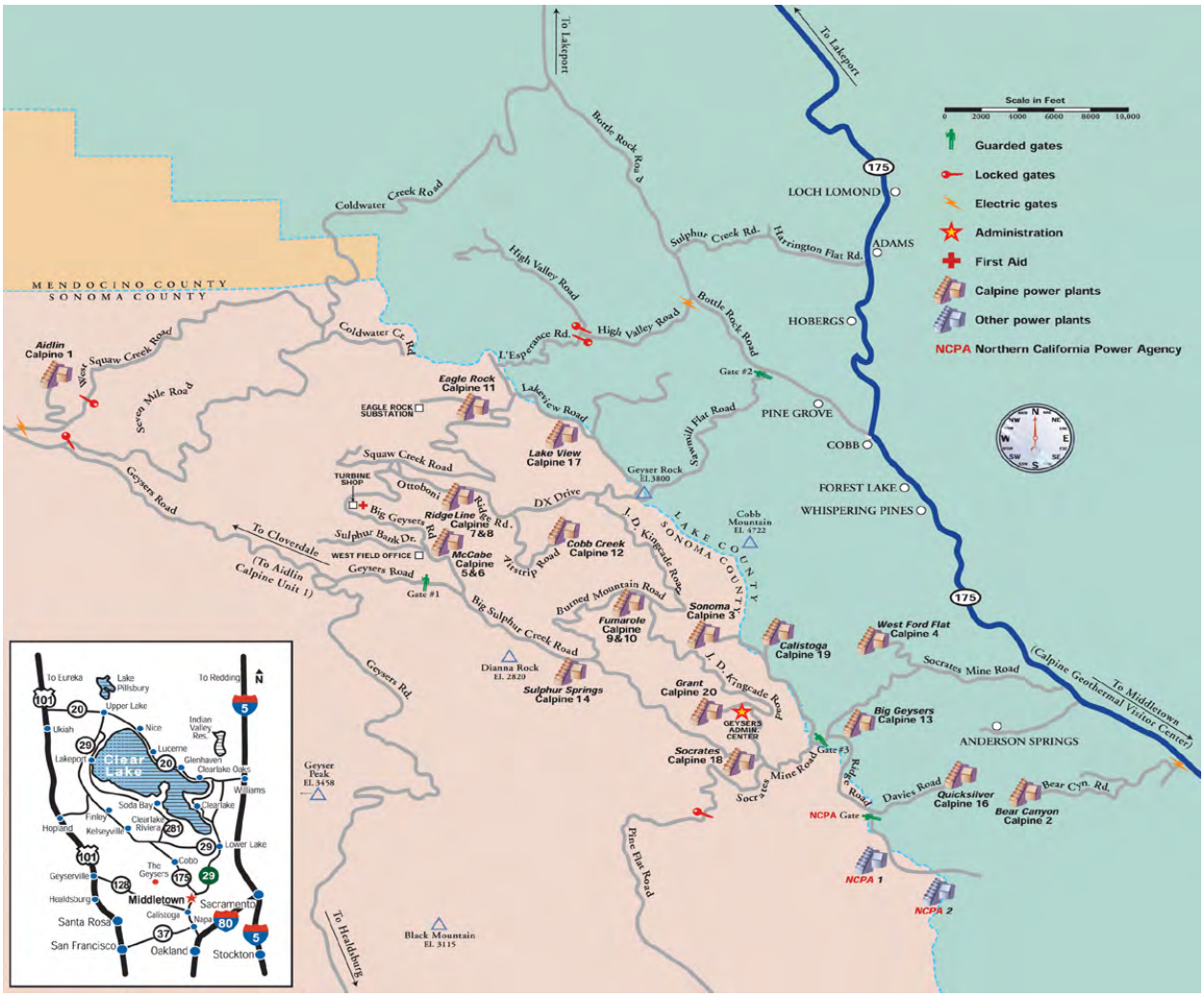
The NCPA operates two geothermal power plants that together generate about 220 megawatts of electricity (Geothermal Energy Association 2012). Geothermal power generated by NCPA is sold to its members. A community choice aggregation program in Sonoma County would have the ability to join the NCPA to access this power.

Bottle Rock Power operates a 55-megawatt power plant at the Geysers and has plans for increasing power production (Bottle Rock Power 2011). Bottle Rock sells its power to PG&E.

In addition to the above three generators, Ram Power Corp. is permitted to construct a 26 net megawatt capacity plant at the Geysers. This power is under contract with the NCPA. At the time of this writing that plant is not yet operational (Ram Power 2012).

The following map (Figure 38) depicts the main areas of activity at the Geysers in the northeast corner of Sonoma County.

Figure 38: Geysers Geothermal Field



Source: Calpine Corporation: http://www.geysers.com/img/Geysers_Map.jpg

Technical Capacity Potential

On the low side of projections a recent study at Stanford asserts that capacity at the Geysers will decline to about 700 MW over the next two decades, even taking into account current planned capacity expansion (Sanyal 2011). However, the report points out that innovation in the management of the steam field has led to a 33 percent higher generation level today than was forecast two decades ago. The report also notes that enhanced geothermal technology could open up far more capacity than has been heretofore estimated (U.S. Department of Energy EERE 2011). The California Renewable Resource Portal estimates total technical potential capacity at the Geysers of 1400 megawatts, meaning a net of another ~500 megawatts (California Renewable Resource Portal 2010). A 2004 GeothermEx, Inc. report estimated capacity over the next 30 years at between 1200 and 1400 megawatts (California Energy Commission 2004, Table 3). Based on conversations with representatives of Calpine in November 2012, new capacity beyond the 98 permitted megawatts can be developed but 1400 MW may be a little on the optimistic side given existing conventional technology.

Cost of Developing Geothermal Power

There are two main types of high temperature geothermal-electric generation, dry steam flash plants and binary plants. Flash plants use the superheated steam directly to spin turbines. Binary plants incorporate a secondary unit that contains a fluid that is more volatile than water and thus can produce steam and spin turbines at lower temperatures. The cost estimates that follow are for the more common flash plants.

Various sources estimate the capital cost of developing geothermal power. US DOE estimates about $2500 per installed kW (U.S. Department of Energy EERE 2012c). The 2004 GeothermEX Report estimates 2950/kW (California Energy Commission 2004). The Sonoma County CCA Feasibility Study, published in October of 2011, estimated installed capital cost at $3718/kW (Sonoma County Water Agency 2011). The National Renewable Energy Laboratory, in its 2008 Geothermal Technologies Market Report estimates capital cost at between $3000 and $4000 per kW (U.S. Department of Energy EERE 2009). A Sonoma County-based geothermal engineering firm estimates capital costs as high as $5000 for flash plants.[21]

According to the US Department of Energy power at the Geysers is sold wholesale at $0.03 to $0.035 per kWh and a new plant built today would generate power that would cost about $0.05 per kWh (U.S. Department of Energy EERE 2012c). The Renewable Energy Policy Project estimates levelized cost of geothermal power at $0.015 per kWh to $0.07 per kWh. At the high end, EGS, Inc. estimates an average of about $0.10 per kWh (Renewable Energy Policy Project 2012).

The federal government offers two tax credits for geothermal power development. The Business Energy Investment Tax Credit (ITC) (DSIRE 2012a) and the Renewable Electricity Production Tax Credit (PTC) (DSIRE 2012b). The ITC offers a tax credit of 10 percent of the expenditures to develop a geothermal electric source. The credit excludes any costs associated with transmission. The ITC is due to expire in 2016. In order to take advantage of the credit systems must begin operation on or before December 31, 2016. The PTC offers a subsidy of $.022/kWh and is set to expire in 2013. To qualify, projects must be generating power by December 31st, 2013. A policy recommendation would be to extend the PTC placed-in-service deadline for new geothermal projects to December 31st, 2016 to provide parity with solar projects and the ITC deadline, and then pursue extension of some form of both beyond 2016.

Other Geothermal Resources

In addition to high temperature geothermal fluid availability in the Geysers steam field itself, there are regions of high probability geothermal energy availability that could be further developed. The areas south and west of the Geysers, and particularly in Sonoma Valley, might provide excellent opportunities for lower temperature direct use applications, such as geothermal district heat (U.S. Department of Energy EERE 2012d). Geothermal hot water temperatures might also be sufficient to support deployment of small-scale low temperature organic *Rankine cycle* generators, which are systems that convert heat into useful work. Cost

[21] Based on conversation in Nov. 2012 with principal at EGS, Inc. (EGS, Inc. 2012)

effectiveness of both of these measures is difficult to assess without more detailed site-specific data.

Conclusion

The Sonoma RESCO Research Team finds that even in a worst-case scenario there will be opportunities in the 2010 to 2020 timeframe of the Sonoma RESCO analysis to procure electrical power from the Geysers at the levels specified in all three portfolios either via power purchase agreement or as a partner in new capacity development.

Power from Moving Water

Hydrokinetic power is energy from motion in bodies of water, such as oceans, tidal basins, bays, etc. Hydrokinetic technologies produce renewable electricity by harnessing the kinetic energy (motion) of a body of water. Hydrokinetic power is generally distinguished from conventional hydroelectric power to the extent that hydroelectric power generally involves the capturing the energy of water falling from an elevation due to the force of gravity, and frequently involves a dam and the impoundment of water in a reservoir. Hydrokinetic energy usually does not rely on impounded water, but more often uses the natural movements, such as currents, waves or tidal flows in a free stream or open body of water. Although significant hydrokinetic power in the form of ocean wave energy is a technically possible to develop off the coast of Sonoma County, it is not included in this portfolio.

Recent attempts to develop this local resource have encountered technical, regulatory, environmental, and financial challenges.[22] In April 2009, the Federal Energy Regulatory Commission (FERC) accepted three project applications submitted by the Sonoma County Water Agency to investigate the use of offshore areas deemed to have significant potential for wave energy production. Terms of the permits allowed the Water Agency to study the feasibility of developing 2 to 5 MW of wave power at each location and to assess the potential for expansion to over 40 MW at each of the three sites. During the time that the Water Agency had the FERC permits, they were unable to secure funding or partners to develop a pilot project, and were unable to make progress in any other respect.

In July 2011 the FERC rescinded the three preliminary permits that had been granted in 2009. FERC requires continual progress toward development of a hydrokinetic project in order to maintain the permits and the costs of required studies made the effort infeasible for the Water Agency to continue meaningful progress.

Current wave technology systems are in early stages of commercialization and are quite expensive. Installed cost has been reported in the range of $4000 to $15,000 per kilowatt, but this

[22] For a discussion of environmental and economic issues, see*: Developing Wave Energy in Coastal California: Potential Socio-Economic and Environmental Effects*, (California Energy Commission and California Ocean Protection Council 2008).

cost is expected to decrease over time as production of wave technology is scaled up. The cost can also be mitigated by financial subsidies such as federal tax credits (Minerals Management Service and Renewable Energy and Alternative Use Program 2006). There is ongoing research and development of innovative wave energy machines as well as efforts to commercialize these products, particularly in Europe.

Sonoma County's offshore wave resource potential is relatively high, with each meter of wavefront estimated to deliver about 32 kilowatts of average continuous power over the course of a year (Kane 2005). Along the full coastline of 127 kilometers, this amounts to over 4000 megawatts of power capacity; over the course of a year this is equivalent to over 35 million megawatt-hours of energy. Wave machines are only able to convert a portion of this energy into electricity, and it is not likely to be environmentally acceptable to use more than a fraction of the 80 miles of wave front located offshore from Sonoma County. Even with such restrictions, tapping only 10 percent of the energy from this offshore wave resource would be sufficient to provide all of the electric power for Sonoma County (Table 43).

Table 43: Raw Wave Power Potential near On-Shore Load Centers

Zone	Zone Landmark	Energy Flux Density kW/m	Primary Sites Available km	Primary Sites Available MW	Secondary Sites Available km	Secondary Sites Available MW
1	San Diego	32.18	-	-	162	5213
2	Los Angeles	32.18	35	1126	104	3347
3	Santa Barbara	26.43	127	3357	-	-
4	Monterey	29.65	-	-	127	3766
5	Santa Cruz	28.03	-	-	127	2838
6	San Francisco	30.26	104	3147	18	545
7	Sonoma	32.18	127	4087	-	-
8	Mendocino	28.53	130	3709	-	-
9	Humboldt	33.71	116	3910	-	-
10	Del Norte	27.81	81	2253	-	-
		Total	720	21589	538	15709

Source: *California Small Hydropower and Ocean Wave Energy Resources* (Kane 2005)

Other sources of water-based energy, such as non-conventional ocean tidal, current, and thermal power, do not appear to be technically capable of providing meaningful contributions to Sonoma County's overall energy supply. Ocean thermal (OTEC) generation requires special temperature conditions, primarily warm surface waters such as occur in tropical locations like Hawaii,[23] and which are not present off the coast of Northern California. Temperatures of surface water off Sonoma County range between 50 and 55 degrees (National Oceanographic Data Center 2013), while ideal water for OTEC should be at least 10 to 15 degrees warmer.

[23] Ocean Thermal Energy Conversion, U.S. Department of Energy, a temperature gradient of 35 degrees Fahrenheit is considered optimal for OTEC, while deep ocean waters are not colder than just above freezing. This implies a recommended surface temperature near 70 degrees or higher (U.S. Department of Energy EERE 2011).

Tidal power normally requires concentration of the tidal force, such as a bay, narrows, or large artificial impoundment. The Golden Gate is considered the only viable tidal resource in California, and the potential energy in the tidal movements at that location is estimated at 12 to 24 megawatts,[24] of which only a fraction could be practically extracted. The geographic conditions on the Sonoma County shore are far less suitable for this type of energy, and the research team did not find any data for local tidal energy potential.

The potential for conventional hydropower resource onshore is small, but can play a role in Sonoma County's efforts to make use of local energy resources. For this reason, it is included in all the RESCO portfolios. One estimate of the local small hydropower potential is only 269 kilowatts (Navigant Consulting Inc. 2006). However, the current amount of permitted hydropower capacity is 2.8 megawatts at the Warm Springs Dam.[25] Historically, the energy from this hydro facility has been sold by Sonoma County Water Agency to PWRPA, where the energy then becomes a small part of the mix of resources that are purchased back by the Water Agency. Thus, Sonoma County has not directly benefited this local resource. One of the objectives of the Water Agency in pursuing its "Carbon-Free Water by 2015" program has been to take direct ownership of the local energy production from Warm Springs Dam.

[24] URS and Black & Veatch made estimates of the Golden Gate tidal resource, which are noted in URS' report for the San Francisco Public Utilities Commission (URS 2008).

[25] The FERC hydropower license database shows a permitted capacity of 2790 kilowatts, and the California Energy Commission Power Plant Database lists this facility as 2.8 megawatts. www.ferc.gov/industries/hydropower/gen-info/licensing/licenses.xls

However, the Water Agency states on its website that the generator is 2.6 megawatts, with an annual average generation ranging from 11,800 to 14,800 megawatt-hours. This is between 50 percent and 65 percent capacity factor. http://www.scwa.ca.gov/energy-sustainability-projects/

CHAPTER 5:
Community-Scale Electricity Demand Analysis

In Chapter 2: Methodology and Approach, a bottom-up approach was described as a significant component of the research. In this chapter, a community scale electric demand analysis constitutes the heart of that bottom-up approach, where information about electricity use at the distribution system and the individual meter level is analyzed in a way such that options for deployment of resources can be tailored or optimized based on realities on the ground at the neighborhood level. The ability to do this work depends upon access to high-resolution electric load data.

The primary focus of this chapter is on developing combined heat and power (CHP), which in Portfolio 3 contributes nearly 10 percent of Sonoma County's forecast demand for 2020. CHP is also an important climate protection measure, responsible in the state's Climate Scoping Plan for reducing Carbon Dioxide emissions by 6.7 million tons per year in 2020. Portfolio 3 provides Sonoma County's pro-rata share of the state's goal for CHP. CHP is a key measure for improving efficiency of electrical generation, which on average only converts about 30 to 35 percent of primary fuel into delivered electrical energy. CHP can reach efficiency of primary thermal energy use between 60 and 90 percent, far higher than even large combined cycle power plants. The fundamental reason why CHP works is because electrical generation is put at or near the site where there is energy demand. It for this reason is by necessity a local and distributed resource. CHP is the main tool in the generation of electricity increasing for increasing exergy, which is the share of primary energy that is directed for useful purposes.

The primary model for developing CHP is to build a thermal generator at a site that has high electricity usage. The generator can be overbuilt and provide electricity for use by immediate neighbors that are "over the fence." The electrical generation then serves as a seed point for distributing heat that would otherwise be wasted. In the simplest form, the heat is used at the same site as the generator.

A variation of this model expands the heat distribution to larger or smaller groups of neighboring buildings, a concept that is explored in this chapter. The multi-building heat distribution network poses a number of technical and financial challenges. However it can have several major benefits, including a great expansion of the local resource potential for CHP beyond what is possible using the most limiting single-building approach. Such multi-building heat distribution systems exist throughout the world, serving schools, military bases, and urban downtown areas. Building a larger CHP unit often produces an economy of scale.

A more capital intensive and legally complex option, which is not developed here, would be to construct microgrids so that the electricity could also be distributed to an entire neighborhood, yet appear to be "behind the meter" from the standpoint of the utility. The financial model in the resource portfolios uses quite a different mechanism for expanding the size of CHP projects, which is to have the community choice program purchase excess generated electricity beyond

what can be used on site through a long-term standard offer contract, paying a fixed feed-in tariff rate to the customer and/or project owner.

Data Sources

A request for data under the *E-CCAINFO* tariff was made by the nine cities of Sonoma County and the County. This data request process is described in the RESCO Task 3 Data Collection report. The data items that were received under this tariff and how they were organized are described in the Appendix of Task 3.

Gaps in PG&E data

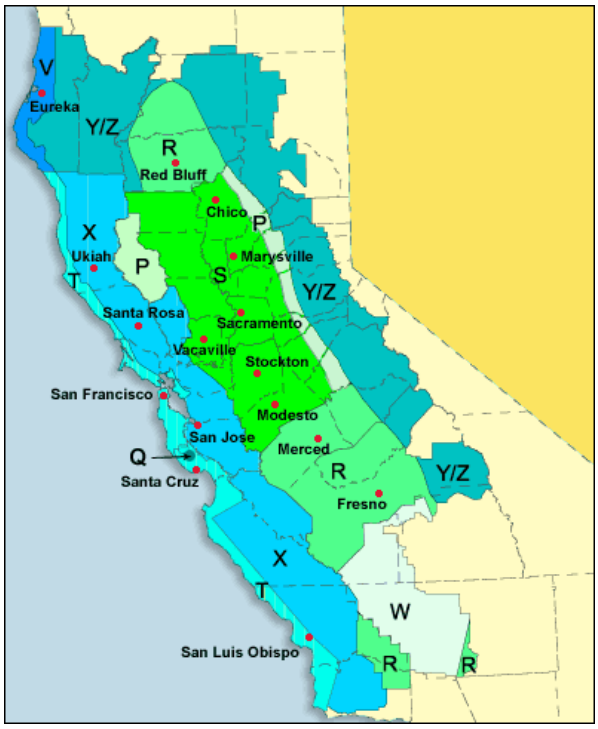
The E-CCAINFO tariff is somewhat limited in scope. Although it enables access to the monthly customer data (Item 16) and the hourly data from large commercial customers (Item 17), detailed hourly load profile information at the substation level is not available. The normalized load profile (Item 3) actually applies to all of Baseline Territory X, (Figure 39) and is not specific to Sonoma County. This creates a possible problem with accuracy in estimating the load profile at very small-scales, particularly in attempting to correlate local temperature or other climate conditions with estimated load.

There are other specific items related to the distribution system that are not included in the tariff. Information about distribution feeder characteristics is also not included in the tariff, nor is any supervisory control and data acquisition (SCADA) information that relates to substation or distribution system operation. These data are required for detailed analysis of the effects of distributed generation on the local distribution grid.

Ultimately, the PG&E data available through this tariff is most useful for revenue analysis and understanding overall load distribution among the customer classes. However, the Item 3 normalized load profile was applied to monthly data to derive substation level information as described below to make estimates on generation sizing.

One of the main purposes of the demand analysis was to identify areas suitable for development of combined heat and power. Efficient and accurate assessment of this potential would require access to data for natural gas consumption. This data was also not supplied through the CCAINFO tariff.

Figure 39: PG&E Baseline Territory X



Sonoma County is mostly within PG&E Territory X (sky blue).

Source: *Baseline Quantities by Territory for Single Family Dwellings* (Pacific Gas and Electric Company 2012a)

Database Construction

The Sonoma RESCO Research Team constructed a Microsoft Access database using data from Items 16 and 17 to populate the database. The record structure for the customer meter data is the same as in the original data, described in the PG&E Data Dictionary. This made the data more usable, by putting it all in one place, rather than in multiple files for each jurisdiction and year. The database query facility allows a very streamlined access to the data that facilitates access across all years and customers. This is not possible with the data in the form it was supplied.

The database was structured as a set of four database files for each year (2005-2008). These four files are linked to a master database file. This allows comparison of usage patterns of specific customers or multiple customers across the 4-year span of data.

Mapping Interface

There are three primary database types that are used in this analysis:

- Geographic Information Systems (GIS) *shapefile* and *raster data*
- PG&E customer data

- Sonoma County Assessor Parcel database

All the databases used in this project must be integrated using the *ArcGIS* 10, proprietary geographic analytical software. The PG&E Item 16 data was *geocoded* on the basis of service address and added as a GIS layer.

Substation Service Areas

Substation Service Areas (SSAs) are polygonal shapes that indicate the geographic extent of the area served by each substation. These areas were supplied in GIS form by the LANL Grid Resilience team. The Sonoma RESCO Research Team used GIS shapes for these areas to select customer data from the PG&E Item 16 database.

Development Methodology

The Sonoma RESCO Research Team worked with personnel at LANL to identify the service area of each substation in Sonoma County. The LANL personnel have developed a unique method for computing these areas based on a grid model. The technique is described in a paper by Toole, et al. (Toole, Linger, & Burks, 2001). Quoting from the paper:

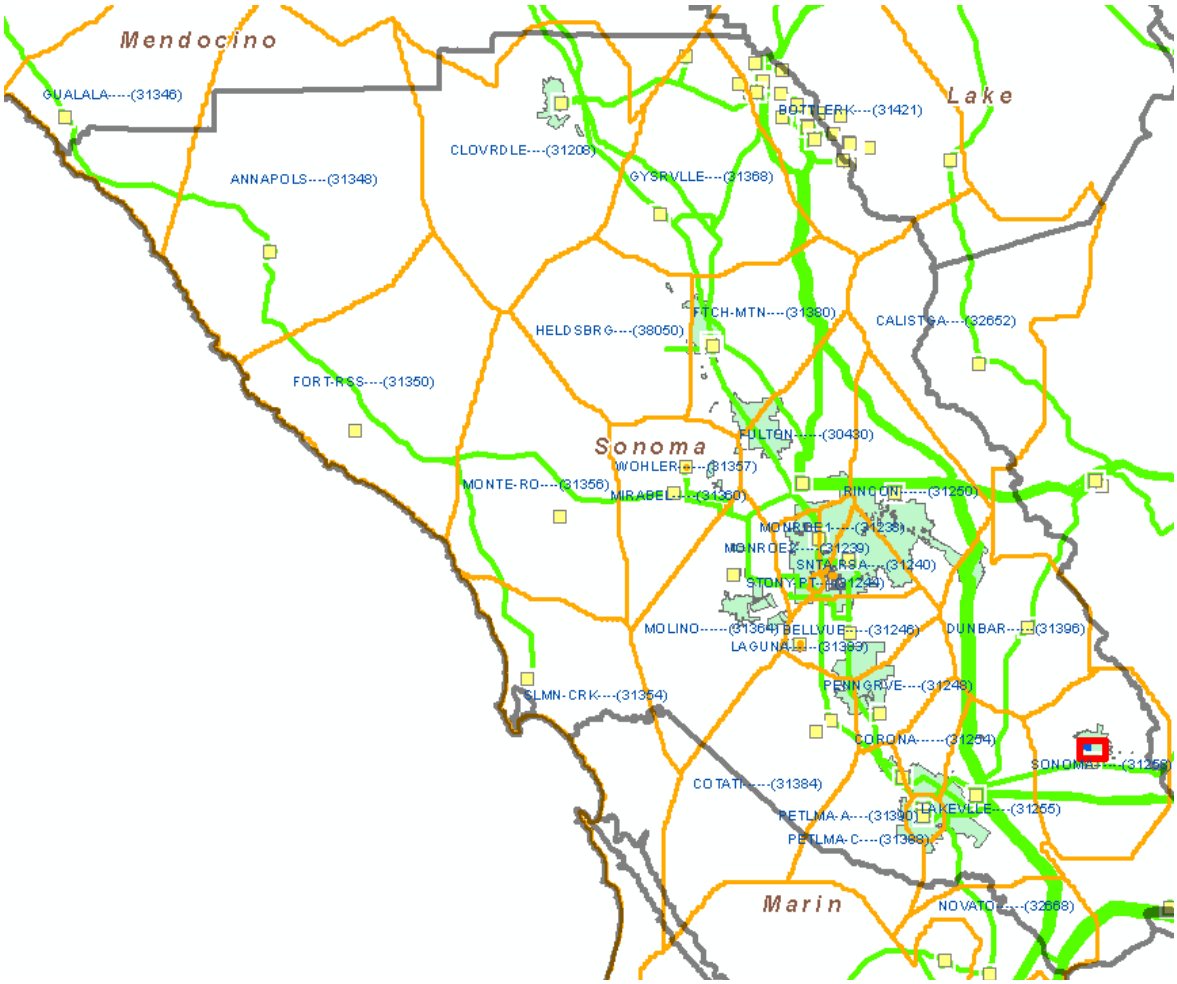
> **"Service and outage areas**
>
> "Distribution systems can be characterized by an associated geographic area that encompasses customers who are served, defined as the service area. Under normal operating conditions, the feeder network is configured to deliver power to customers who are located within tightly meshed corridors, typically along roads or within compact developments such as malls. Distribution feeders cannot extend beyond the physical constraints of acceptable voltages or currents, and this feature usually limits the service area boundary. A distinction is often made between "direct" and "total" service area. The "direct" case includes only the geographic area encompassing actual feeder corridors. However, in the process of constructing networks along available corridors, many service areas capture unused (and electrically unserved) areas adjacent to the feeder. In some instances, 40 percent or more of the service area is unused but within reach of the feeder to allow for future development. Estimates of the direct area plus the unserved area therefore comprise the feeder's total service area.
>
> "Los Alamos National Laboratory has previously developed software models and related analysis to estimate service and outage areas for electric-power substations. Commercial GIS applications have been used in concert with these models to process and render geographic data and areal results. The approach described in this paper uses cellular automata (CA) based algorithms that can be applied to a variety of situations requiring advanced planning under emergency electrical conditions."

Geographic Description

Substations located in Sonoma County and their associated service areas are shown in Figure 40. Amber lines represent the substation boundaries and the bright green lines are transmission lines. The little red box in the lower right is the Energy Development Zone that will be explained later in this chapter.

The list of substation names, with associated peak and baseload metrics is in Table 44.

Figure 40: Sonoma County Substation Service Areas



Source: Based on data from Los Alamos National Laboratory (G. Loren Toole 2012)

Table 44: Substation Names and Associated Peak and Baseload Metrics

Substation Name	peak (MW)	baseload (MW)
ANNAPOLS----(31348)	0.4	0.1
BELLVUE-----(31246)	41.3	15.0
CALISTGA----(32652)		
CLOVRDLE----(31208)	15.9	4.6
CORONA------(31254)	19.4	6.0
COTATI------(31384)	20.6	7.5
DUNBAR------(31396)	13.0	6.5
FORT-RSS----(31350)	0.3	0.1
FTCH-MTN----(31380)	15.7	3.6
FULTON------(30430)	47.6	16.0
GUALALA-----(31346)		
GYSRVLLE----(31368)	1.4	0.4
HELDSBRG----(38050)	5.1	1.5
LAKEVLLE----(31255)	22.6	7.5
MIRABEL-----(31360)	11.1	3.1
MOLINO------(31364)	35.8	11.0
MONROE1-----(31238)	41.3	15.0
MONROE2-----(31239)	35.3	12.0
MONTE-RO----(31356)	11.0	3.2
NOVATO------(32668)		
PENNGRVE----(31248)	26.6	7.0
PETLMA-A----(31390)	23.5	8.5
PETLMA-C----(31388)	18.2	6.6
RINCON------(31250)	33.2	8.9
SLMN-CRK----(31354)	3.7	1.0
SNTA-RSA----(31240)	68.2	24.0
SONOMA------(31258)	42.1	12.5
Totals	**553.4**	**181.6**

Substation Service Area Load Profiles Used in Modeling

The Sonoma RESCO Research Team developed load profiles used in the modeling from the following substations:

- Lakeville
- Petaluma A
- Petaluma C
- Penngrove
- Bellevue
- Molino
- Monroe

- Santa Rosa A
- Fulton
- Cloverdale

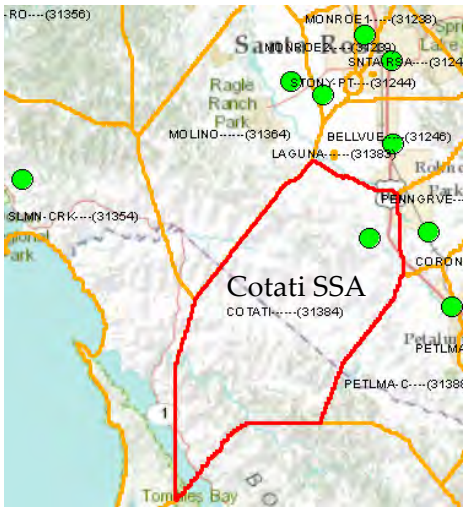
The substations identified above exhibited hot spots that are presented in the section of this Chapter titled Hot Spot Demand Resource Areas. The hot spots were further analyzed to determine specific localized areas that have the following characteristics:

- It contains a public safety facility that requires high reliability or emergency backup power, (for example, a fire station, police department or hospital)
- It contains other facilities that might require emergency backup power such as schools, government buildings, water or wastewater infrastructure, or communications infrastructure
- It contains other government or public property that might be suitable for siting generation equipment

Analysis Methodology

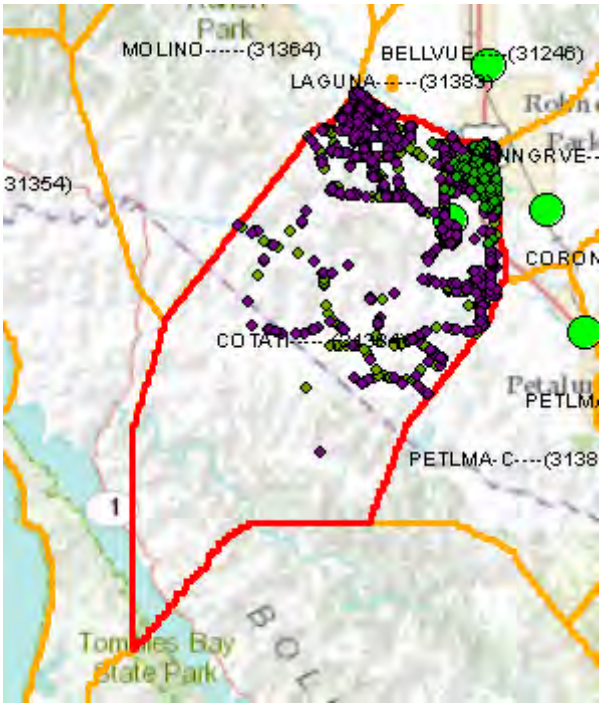
The Cotati Service Area, shown in Figure 41, is used for this example:

Figure 41: Cotati Substation Service Area Map (red outline)



Using GIS software, all customers within each SSA are selected, as shown in Figure 42.

Figure 42: Customers Served by Cotati Substation



ArcMap©, a component of ArcGIS 10, allows selected data to be exported to a database format file. Using this function the project team exported the set of selected customer data to a file, which was then added to the Access database as a table. The Sonoma RESCO Research Team created an Access database query with selected customer service agreement IDs (SA_ID), to pull up monthly kWh usage and rate schedules for all identified customers. This data was then combined on a single Excel spreadsheet. In Excel, PivotTable function is used to sum up monthly kWh totals by rate class. An example of this output is shown in Table 45 and Table 46.

Non-Residential

Table 45: Cotati Substation Non-Residential Monthly Energy Use (Jan 2008 – May 2008)

	Values				
Row Labels	Sum of KWH_JAN_20	Sum of KWH_FEB_20	Sum of KWH_MAR_20	Sum of KWH_APR_20	Sum of KWH_MAY_20
A1	624083	667651	606295	618911	604856
A10S	369392	392189	395889	442753	425604
A10SX	66240	81120	74160	66000	75120
A1L	12701	16937	10484	7593	6175
A6	78468	83401	74623	77958	93349
AG1A	33882	34836	35553	33577	42090
AG1B	32653	39230	39982	38400	37678
AG4A	13199	17654	13633	14626	12065
AG4B	1766	1894	1687	2555	3850
AG4C	0	0	0	0	0
AG5A	42084	28957	48546	37035	36844
AG5B	417822	463688	426143	417812	471702
AG5C	222	231	218	239	238
AGVA					
E19S					
E19SV	250190	281396	270743	291164	265402
E20P	746075	855422	775250	828656	760726
LS1	13630	14999	13650	14093	13626
LS2	102684	100143	109098	99698	102684
LS3	30	30	30	30	30
OL1	3330	3389	3294	3406	3162
STOUS	5760	0	0	0	0
STOUT	0	0	0	29	6453
TC1	2374	2388	2333	2292	2194
Grand Total	2816585	3085555	2901611	2996827	2963848

Residential

Table 46: Residential Energy Use Cotati (Jan 2008 – May 2008)

	Values				
Row Labels	Sum of KWH_JAN_20	Sum of KWH_FEB_20	Sum of KWH_MAR_20	Sum of KWH_APR_20	Sum of KWH_MAY_20
E1	2228928	2182567	1901369	1868612	1783273
E1L	341304	345255	289268	278578	258625
E1M	89674	86683	71730	68153	64078
E1S	630	2689	1079	1406	1333
E1TL	27440	25600	25120	23760	21920
E6	16098	21355	16439	10416	16944
E7	214732	198643	165390	151513	140220
E7L	7959	9570	8178	7515	7452
E8	115870	106976	92893	85759	78427
E8L	8456	7861	6901	6281	5362
Grand Total	3051091	2987199	2578367	2501993	2377634

The Sonoma RESCO Research Team calculated estimated hourly load profiles using the following process:

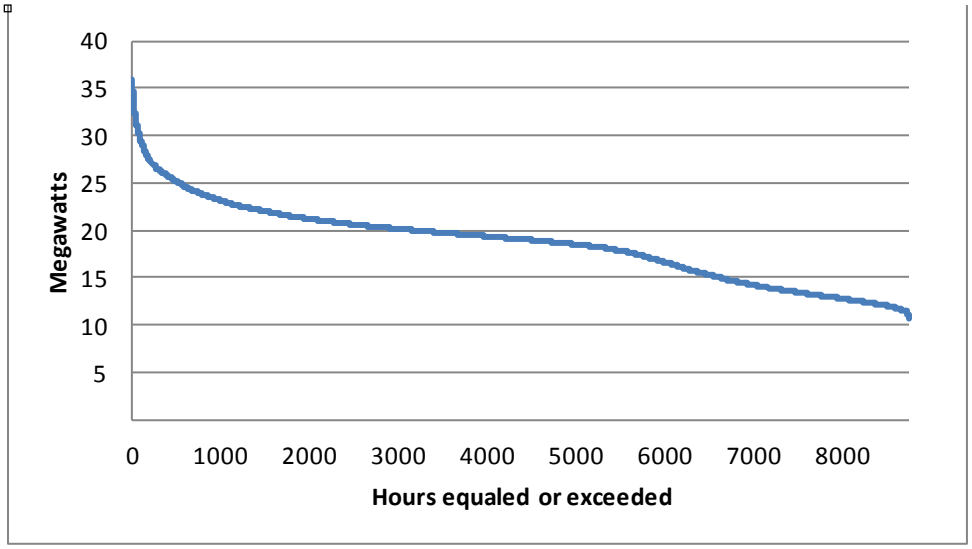
- Break down monthly totals using the normalized load profiles for residential and non-residential loads.
- Generate an 8760 (8760 = the number of hours in a year) hourly profile that is the sum of the residential and non-residential profiles.
- Import this hourly load profile into the HOMER software
- Use load profile to generate further metrics and test generation technology packages.

Figure 43 and Figure 44 below are the metrics that were generated for the Cotati substation.

Figure 43: Detailed Load Metrics for Cotati Substation

	Baseline
Average (kWh/d)	291,128
Average (kW)	12,130
Peak (kW)	20,649
Load factor	0.587

Figure 44: Load Duration Curve for Cotati Substation



Hot Spot Demand Resource Areas

Selection Metrics

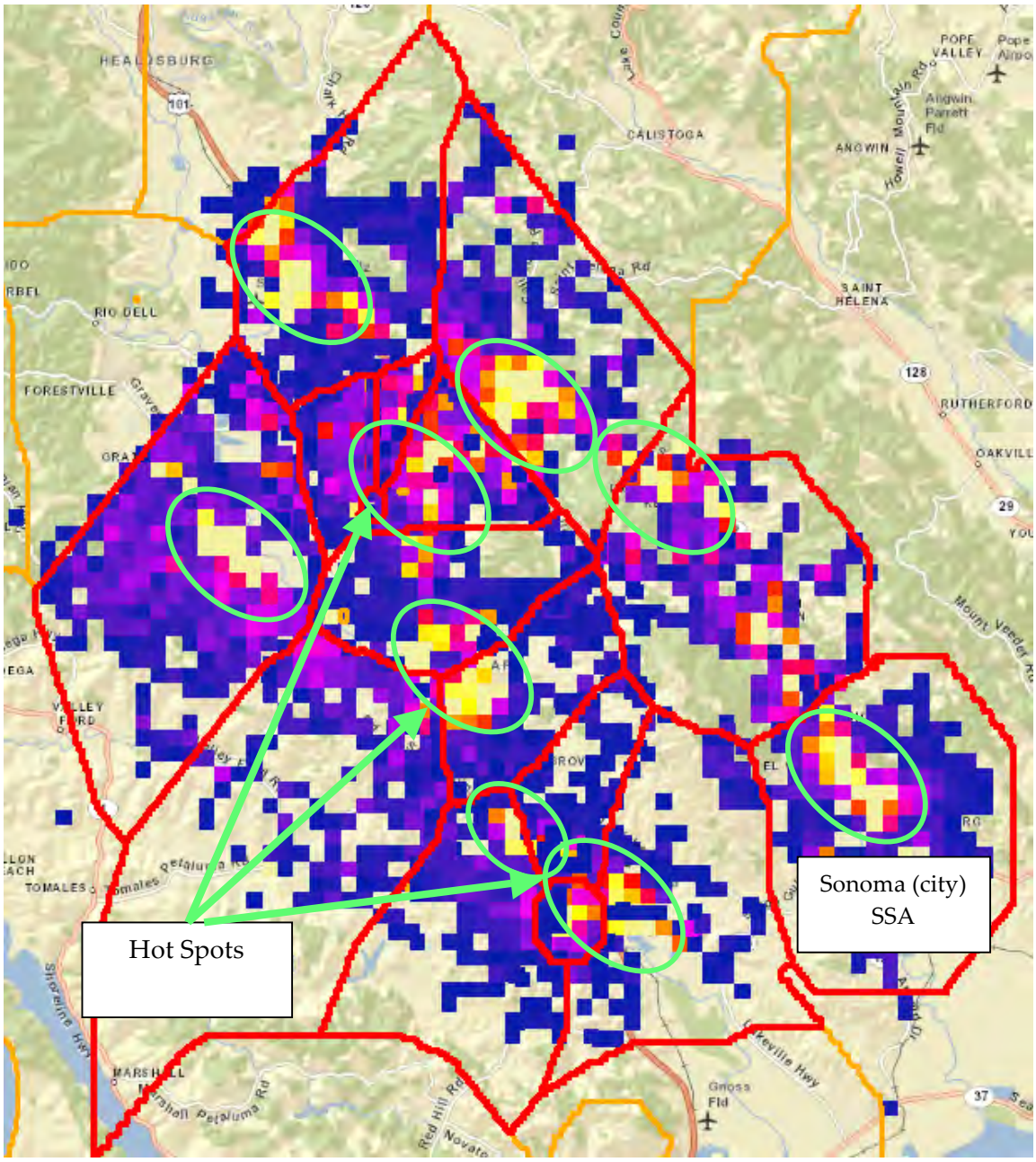
The Sonoma RESCO Research Team used geocoded meter data in conjunction with GIS software to evaluate concentrations of energy use. *Geocoding* is a process of finding geographic coordinates from geographic data such as street addresses or zip codes. These concentrations of energy use guided further evaluation of specific locations using the following criteria developed in Task 4:

1. Individual customers have energy use characteristics that appear optimal for a RESCO-type portfolio resource (DG, CHP, Solar PV, other small scale RE as available).
2. The location can support a specific set of supply resources whose output matches the load curve of the residential/nonresidential demand into which they would be aggregated, in a cost-effective manner.
3. The location has concentrations of "optimal loads." These loads are evaluated for proximity and potential interoperability with identified public or private energy security enhancement opportunities.

Hot Spot Analysis

The Sonoma RESCO Research Team used a technique for identifying these locations, called *hot spot analysis.* The Team used a feature of the GIS software called *Point to Raster Conversion*, to portion the substation service area into a grid. The Team added the annual total kWh usage for each customer inside each grid square, and then assigned a color to the grid square based on the total demand. The color ramp displays high values as yellow, medium values as red, and low values as blue. In Figure 45, areas emerge that have a higher total annual electricity use relative to surrounding areas. Not surprisingly, these high-density energy-use areas typically correspond to the most densely developed areas and include both commercial and residential properties. The Team examined these areas further for opportunities to deploy DG, and potentially CHP.

Figure 45: Highest Intensity Energy Use Areas



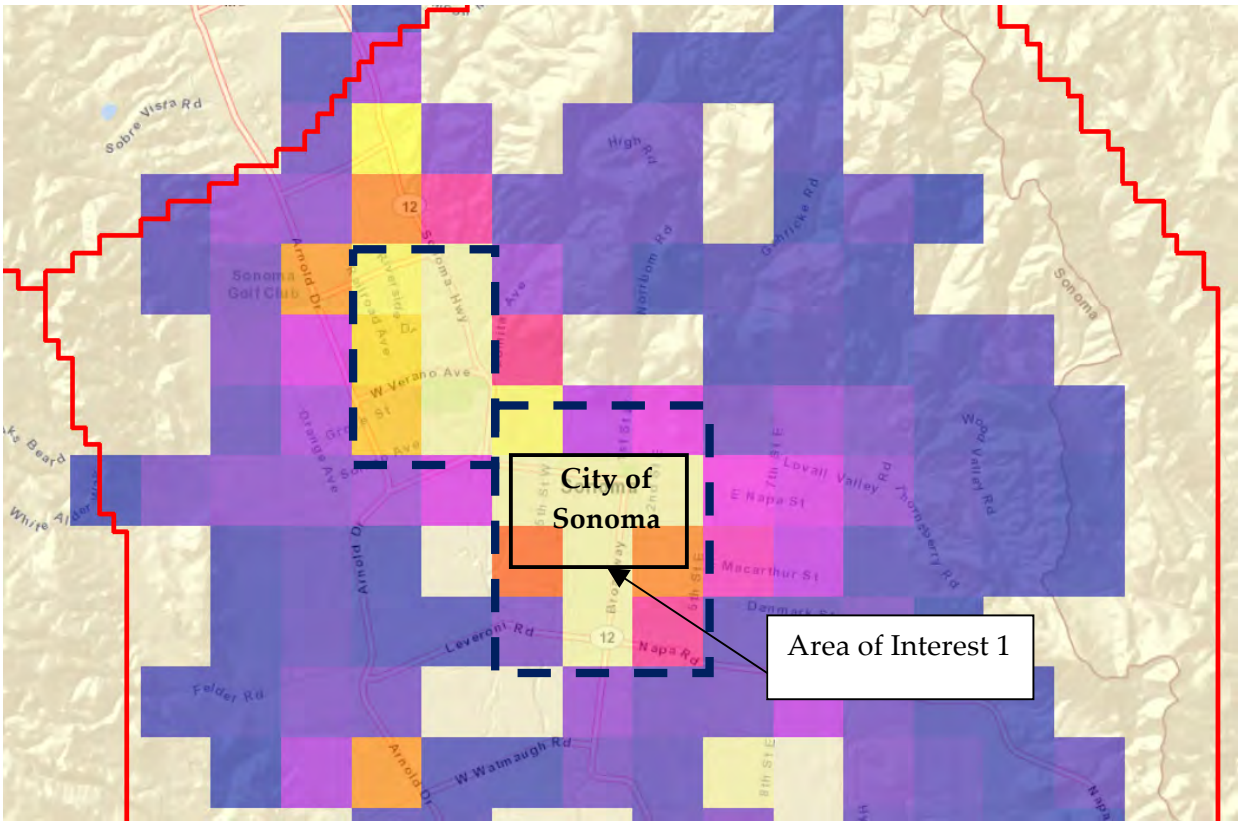
The yellow and red areas in the figure show the higher energy demand areas relative to other areas in the service area of the substation.

Locations

Figure 46 below shows the City of Sonoma Substation Service Area, with the high intensity energy use area shown in light yellow.

The Area of Interest 1 Hot Spot

Figure 46: Area of Interest 1 Hot Spot



The Area of Interest 1 Hot Spot encompasses two areas that represent most of downtown. Figure 47 below shows the area of interest that will be further analyzed for energy resource siting. This area covers a good portion of the main downtown Sonoma area that includes both residential and non-residential areas.

Figure 47: Area of Interest 1

Area of Interest and Energy Development Zone Identification

The Sonoma RESCO Research Team selected a more targeted area, based on the mix of non-residential and residential customers. Commercial customers tend to have higher *load factors* and larger annual loads than residential customers, so an optimal mix will balance out peak and average power consumption patterns in these two sectors.

Residential/Non-Residential Breakdown

Based on land use codes in the Sonoma County Assessor's parcel database, each parcel in the area of interest was identified and classified as either residential or non-residential. Figure 48 and Figure 49 illustrate the parcels that were identified. It can be seen that this area has a diverse mix of building types, including a supermarket, a school, a hospital, multi-family residential, condominiums and single-family dwellings.

As shown in Table 47, there are approximately 550,000 square feet of residential building space, including multi-family, and 300,000 square feet of commercial building space.

Figure 48: Commercial/Industrial/Institutional Properties

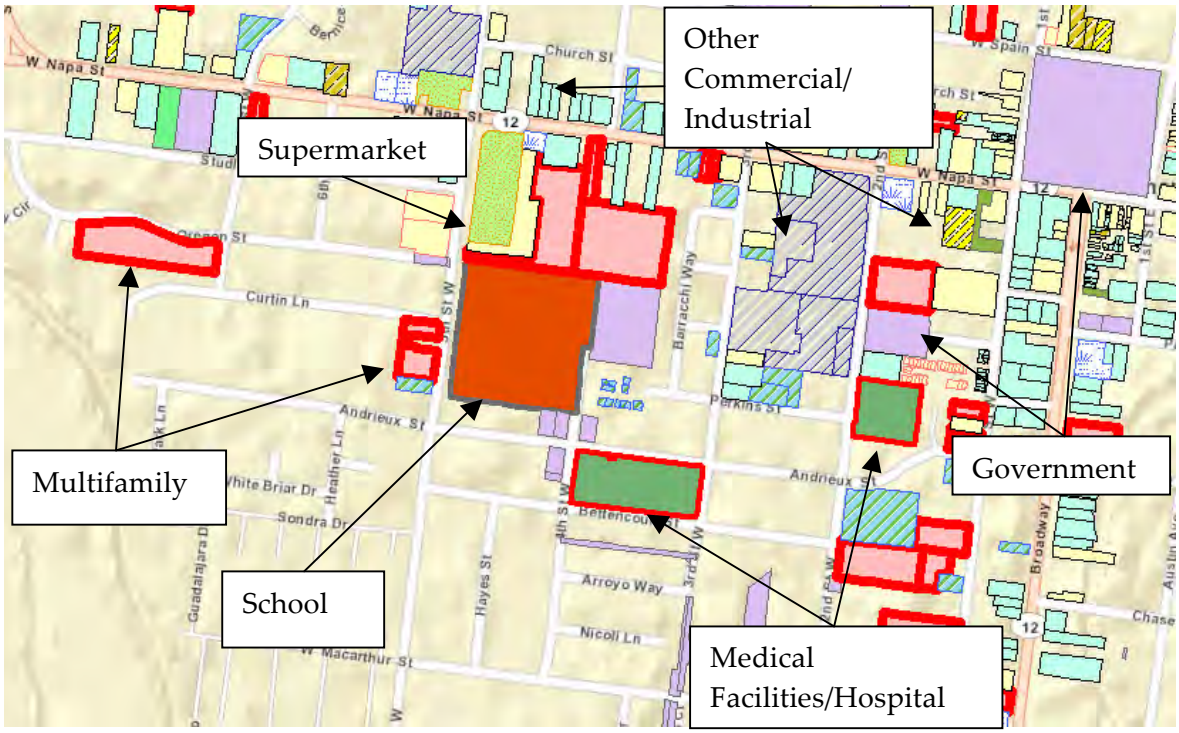
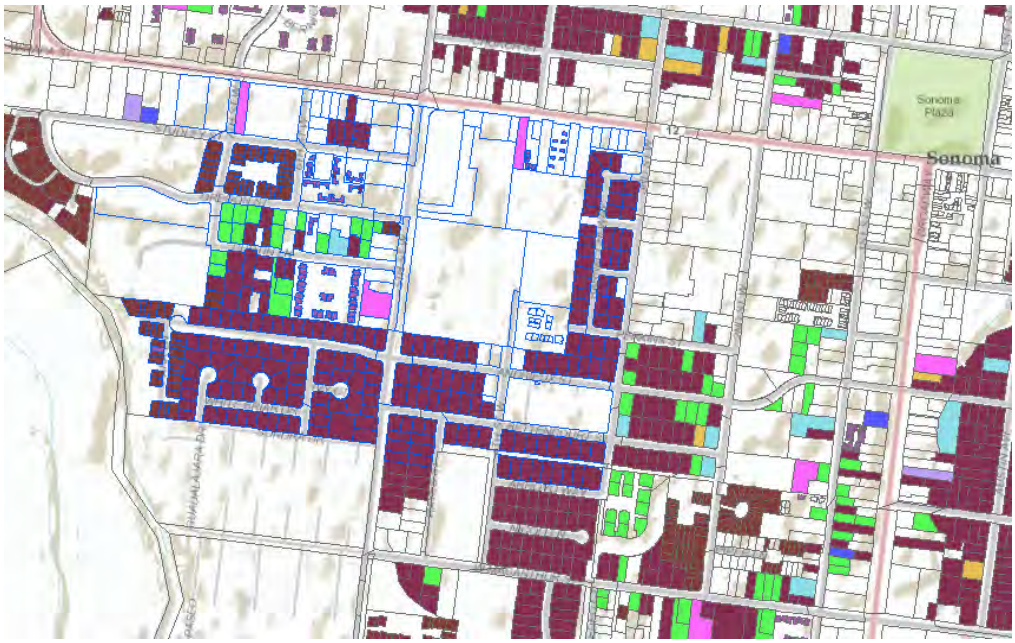


Figure 49: Single Family Dwellings/Other Residential



The Energy Development Zone shown in Figure 50 shows the set of parcels in the area selected for the Energy Development Zone.

This zone was chosen based on the following criteria:

- Mix of residential and commercial
- Relatively high load factor (>0.5)
- Total load matched to available interconnect capacity on distribution feeders

Figure 50: Area of Interest 1 Energy Development Zone

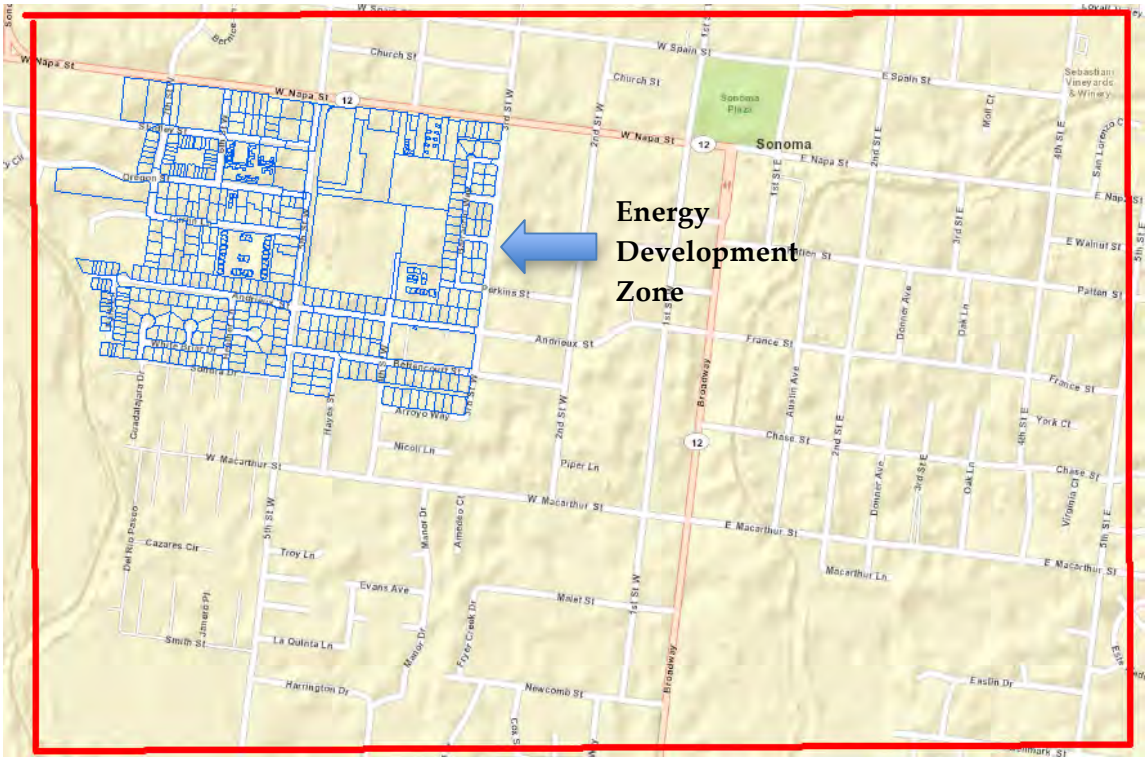


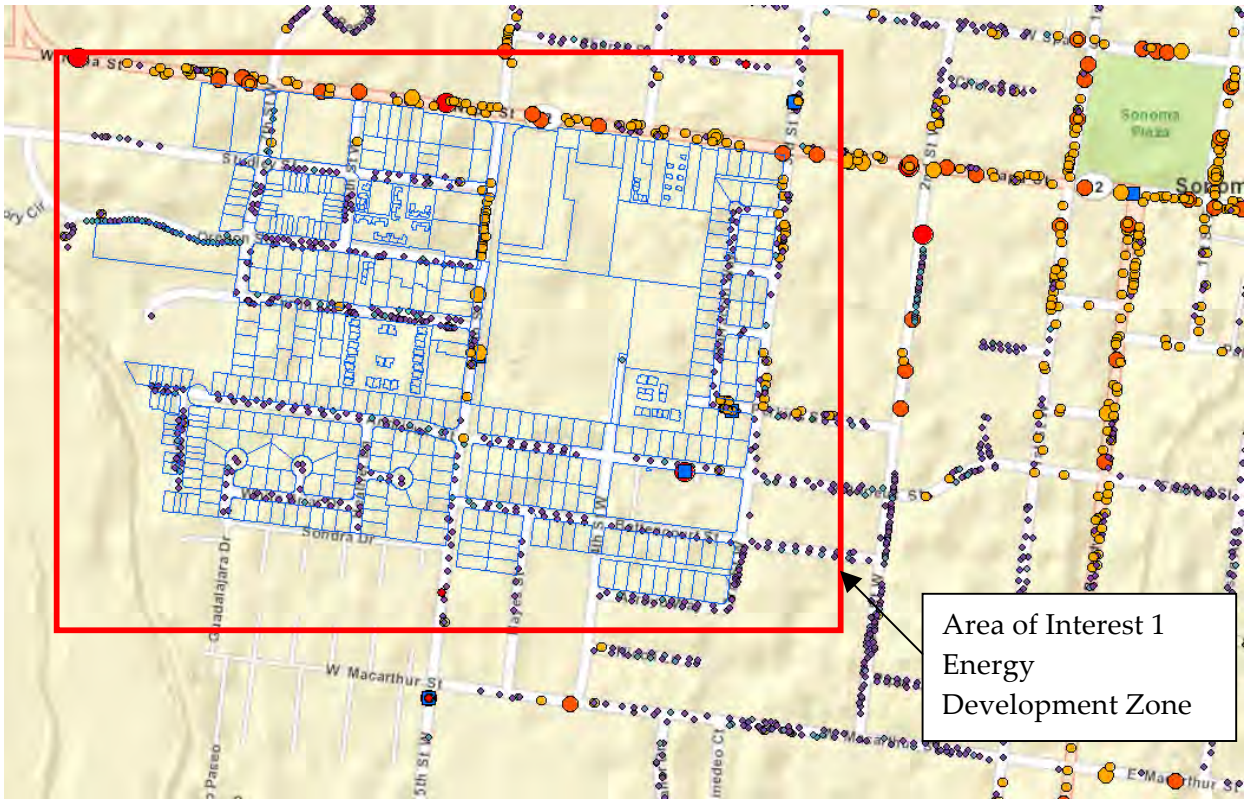
Table 47: Breakdown of Building Types/Square Footage in Area of Interest 1 Energy Development Zone

Building Category (Landuse code)	Total Commercial area	Total res area	Multi-Fam area
1 stry ofc bldg	9,095	1,333	0
1 stry store	23,195	0	0
41-100 units	0	29,704	0
5-10 res units/2 or more structures	0	0	4,572
Alternate use	1,245	1,545	0
Attached unit in PUD	0	99,147	0
Auto and truck repair	1,623	0	0
Auto sales w/svc ctr	13,440	0	0
Auto specialty shop	0	0	0
Bank	5,087	0	0
City bldg	10,891	0	0
Comm'l use not categorized	7,664	1,132	0
Condominium unit	0	79,879	0
Dental ofc	4,320	0	0
Detached unit in a PUD	0	1,350	0
Full-service station	1,000	0	0
Full-svc hospital	41,592	0	0
Lot with misc improvements	0	0	0
Medical office	5,173	0	0
Mult combo store/office	15,312	0	0
Mult-ofc/res unit	1,064	1,064	0
One duplex	0	24,603	4,259
Prof ofc condo unit	129,926	0	0
SFD non-conforming	0	5,009	0
Single family dwelling	0	269,914	0
Single fourlplex	0	2,984	6,554
Supermarket	31,180	0	0
Three units/2 or more structures	0	6,402	984
Two single family dwellings on single parcel	0	2,739	0
Grand Total	**301,807**	**526,805**	**16,369**

Electrical Account Rate Schedule Breakdown

The mix of electrical account rate classes was analyzed using PG&E meter data records for all accounts within the Energy Development Zone (Figure 51). Table 48 and Table 49 show the number of accounts, the total annual kWh and estimated revenues in each rate schedule.

Figure 51: Commercial and Residential Electric Account Mix



This figure shows the mix of residential accounts (small blue diamonds) and commercial accounts (orange and red circles)

Table 48: Non-Residential Accounts and Types in Area of Interest 1 Energy Development Zone

NRS Rate Schedule	Number of Accounts	Annual kWh	Total Usage Revenue	Total Demand Charge
A1	92	741,387	$131,768	
A6,A10S,E19,LS1,OL1,TC1	17	7,169,082		
Total	109	7,910,469		

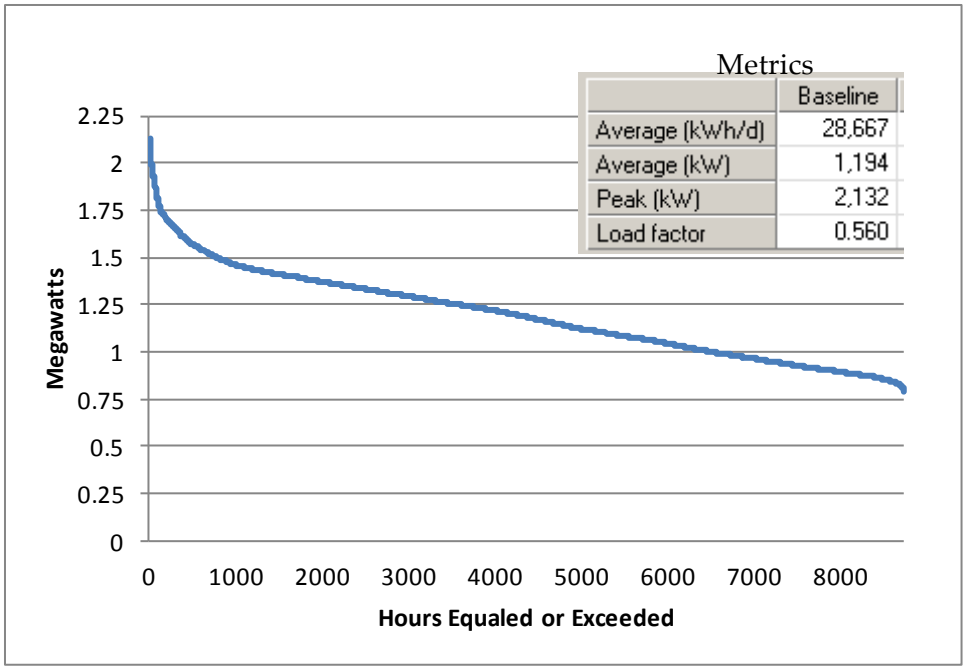
Table 49: Residential Accounts and Types in Area of Interest 1 Energy Development Zone

RES Rate Schedule	Number of Accounts	Annual kWh	Total Annual Revenue
E1	551	2,092,955	$350,646
E1L	142	448,378	$39,599
Other	Under 15	39,120	n/a
Total		2,580,453	

Electric Load Characteristics

Using the analysis method described above, the monthly residential and non-residential kWh usage for all accounts in the Energy District were combined and processed using the estimated annual load profiles supplied by PG&E. These results are shown in Figure 52. The load duration curve indicates a baseload for the Zone of approximately 750 kW.

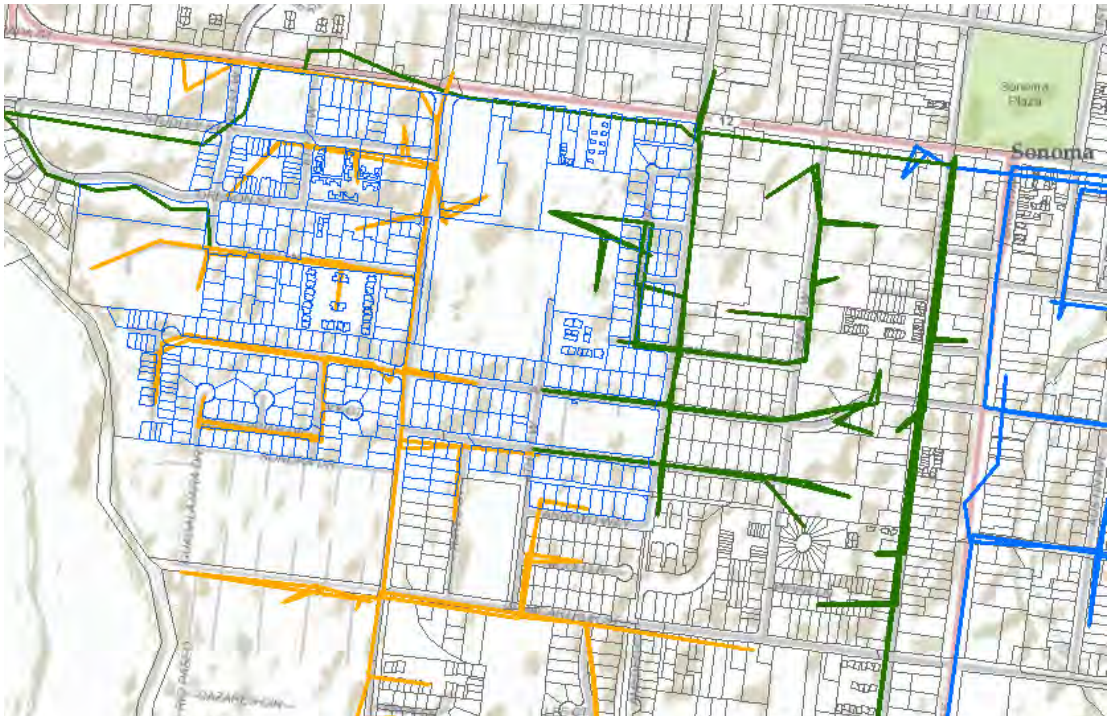
Figure 52: Load Characteristics and metrics for Area of Interest 1 Energy Development Zone



Distribution Grid for Area of Interest

Figure 53 shows the distribution grid circuits and their layout for the area of interest. The Renewable Auction Mechanism (RAM) Program Map was used to determine the geospatial layout of the distribution feeder circuits in the Energy Development Zone. The specifications for these feeders are also available using the RAM maps. These specifications are shown in Table 50 below.

Figure 53: Distribution Grid Infrastructure



Distribution grid layout in Area of Interest 1 downtown area. Distribution circuit SONOMA 1102 is shown in amber. Distribution circuit SONOMA 1106 is shown in dark green.

Source: Second Renewable Auction Mechanism (Pacific Gas and Electric Company 2012m)

Table 50: Area of Interest 1 Distribution Feeder Characteristics

Distribution Feeder Name	Projected Peak Load (MW)	Circuit Capacity (MW)	Existing DG (MW)	Queued DG	15% of Peak (MW)
Sonoma 1102 (Amber)	8.42	13.09	0.0293	0.0	1.263
Sonoma 1106 (Green)	8.97	12.44	0.0092	0.0	1.355

Source: Second Renewable Auction Mechanism (Pacific Gas and Electric Company 2012m)

Heat Load Estimation for Area of Interest 1 Energy Development Zone

No data on heat load for the Energy Development Zone was available. A variety of tools were used to estimate the heat load for the residential buildings in the Zone.

The total heat and electrical consumption has been measured as an average per square foot by the Energy Information Agency (EIA) in a survey in 2005. As shown in Figure 54 the average energy consumption intensity for a 1,618 square foot home in the Pacific region was 58.7 thousand BTU per square foot per year.

Based on this average, the researchers used the square footage of the residential buildings to calculate the total annual residential energy consumption for the Energy Development Zone at 30,554,690,000 BTU. The total residential electrical consumption is 2,580,453 kWh, which is converted to 8,804,505,636 BTU. This gives an estimated annual total heat energy consumption of 21,750,184,364 BTU.

Figure 54: Residential Energy Consumption Intensities

2.1.10 2005 Residential Delivered Energy Consumption Intensities, by Census Region

Region	Per Square Foot (thousand Btu) (1)	Per Household (million Btu)	Per Household Members (million Btu)	Percent of Total Consumption
Northeast	**73.5**	**122.2**	**47.7**	**24%**
New England	77.0	129.4	55.3	7%
Middle Atlantic	72.2	119.7	45.3	17%
Midwest	**58.9**	**113.5**	**46.0**	**28%**
East North Central	61.1	117.7	47.3	20%
West North Central	54.0	104.1	42.9	8%
South	**51.5**	**79.8**	**31.6**	**31%**
South Atlantic	47.4	76.1	30.4	16%
East South Central	56.6	87.3	36.1	6%
West South Central	56.6	82.4	31.4	9%
West	**56.6**	**77.4**	**28.1**	**18%**
Mountain	54.4	89.8	33.7	6%
Pacific	58.0	71.8	25.7	11%
U.S. Average	**58.7**	**94.9**	**37.0**	**100%**

Note(s): 1) Energy consumption per square foot was calculated using estimates of average heated floor space per household. According to the 2005 Residential Energy Consumption Survey (RECS), the average heated floor space per household in the U.S. was 1,618 square feet. Average total floor space, which includes garages, attics and unfinished basements, equaled 2,309 square feet.

Source(s): EIA, 2005 Residential Energy Consumption Survey, Oct. 2008.

Source: U.S. Energy Information Administration 2005 Residential Energy Consumption Survey (U.S. Energy Information Administration 2008).

The researchers then obtained a heat load profile of a 1,600 square foot residence in the Sonoma climate zone by running a building simulation using Energy-10 software. ENERGY-10™ is a software tool developed by the National Renewable Energy Laboratory that helps architects, builders, and engineers quickly identify the most cost-effective, energy-saving measures to take in designing a low-energy buildings. This profile is shown in Figure 55. This profile was normalized to percentages, which were then applied to the total heat energy consumption determined above. The result is shown in Figure 56.

Figure 55: Heat Load Profile for Typical Residence in Sonoma

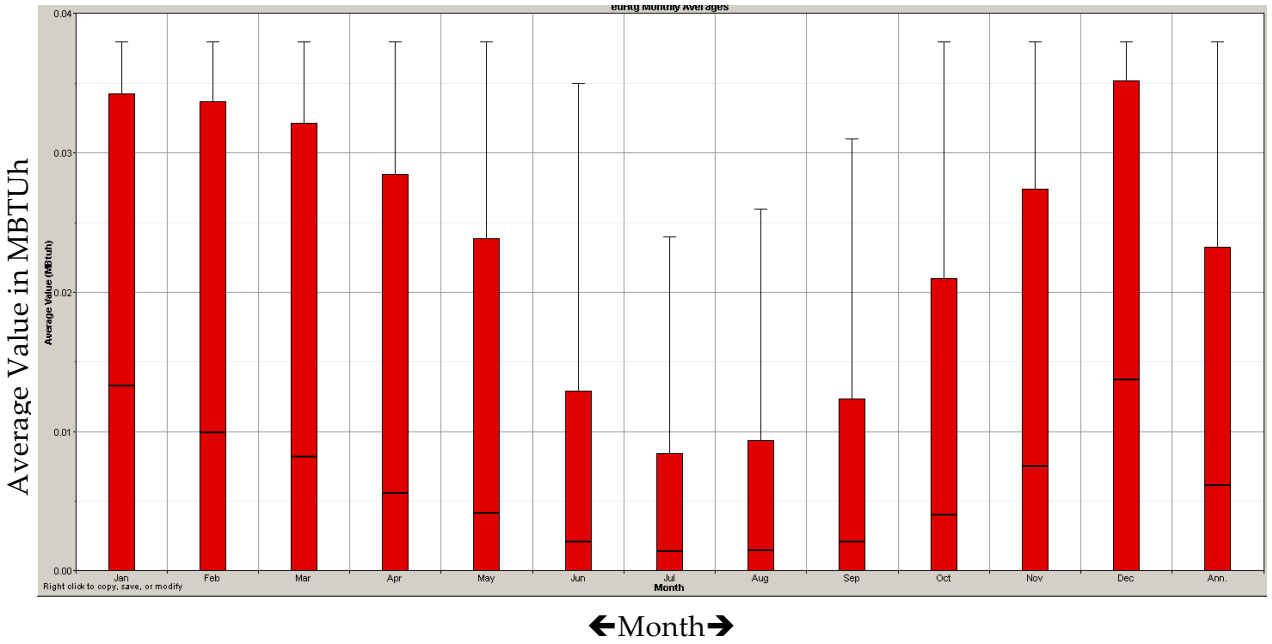
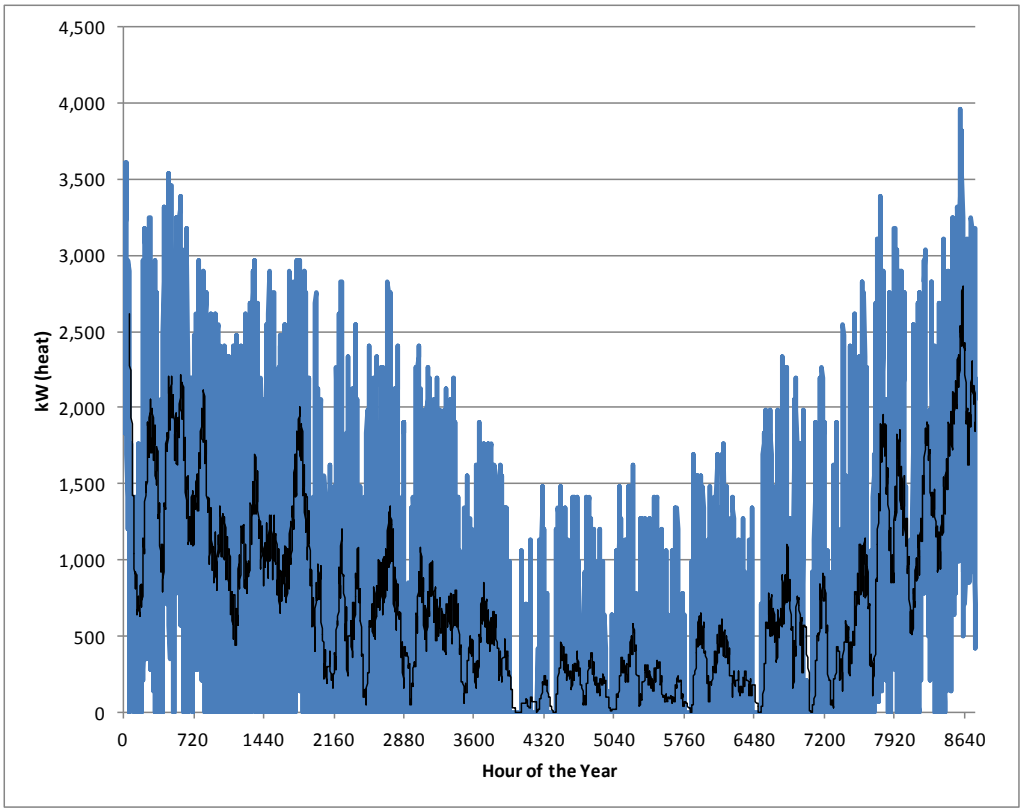
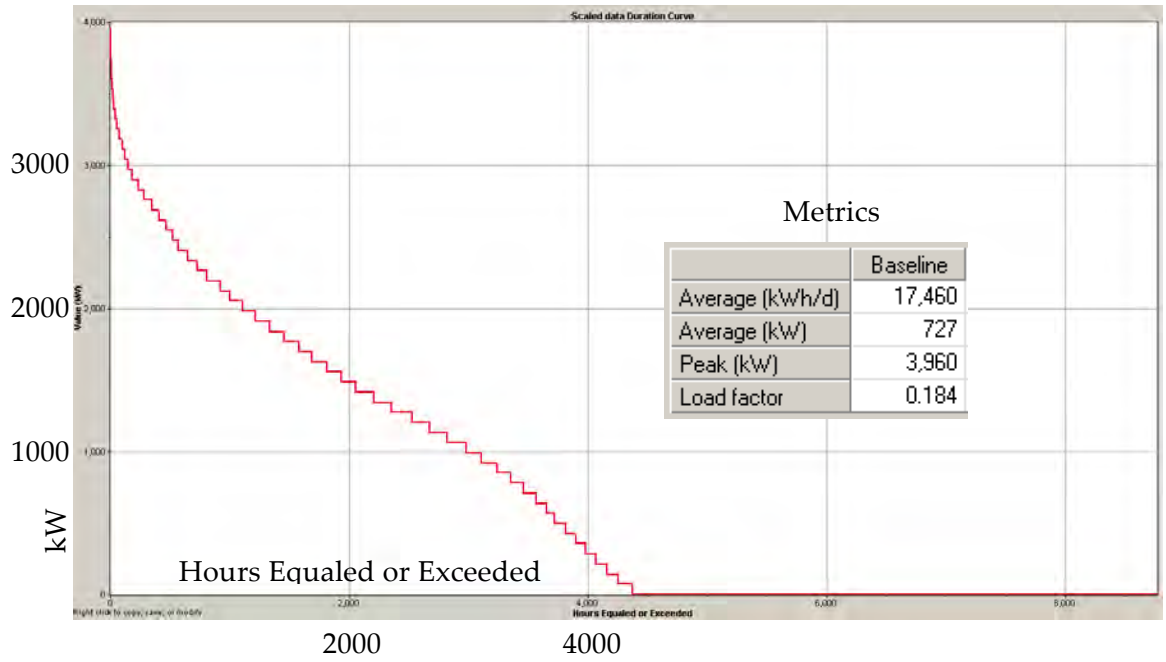


Figure 56: Residential Heat Energy Consumption Estimate for the Area of Interest 1 Energy Development Zone



Dark line is 30 day moving average. Hour marks correspond to month.

Figure 57: Residential Thermal Load Duration Curve and Metrics for Energy Development Zone



Based on the optimal load factor and number of customers, the Sonoma RESCO Research Team determined a generation package consisting of CHP and PV, based on HOMER simulations. For the group of customers in the Energy Development Zone within the red square (Figure 57), the baseload is 650 kW and average annual maximum is 1.5 MW. These customers could best be served with a total of 3 MW of net-metered PV and a 1 MW CHP system powered by biogas, natural gas, or a blend of these; with the most economical choice depending upon current fuel prices.

Barriers to Implementation of Energy Development Zones

Analysis of Sonoma County electric and heat load distribution shows that there are many areas that can be developed into low carbon energy zones, using combined heat and power (CHP), storage, district heat/cool, solar hot water, aggressive energy efficiency and demand response. A well-designed technology package including biogas-powered CHP, rooftop solar photovoltaics, batteries and a thermal distribution system can reliably serve a large portion of the electric and thermal needs of the identified zones, while dramatically reducing the greenhouse gas emissions and the need for large scale centralized power. However, as in any energy supply system, a control and monitoring element is required in order to make the system function in an optimal way. At this time, properly deploying this element is the most significant barrier to developing a community energy supply.

Other Energy Development Areas of Interest in Sonoma County

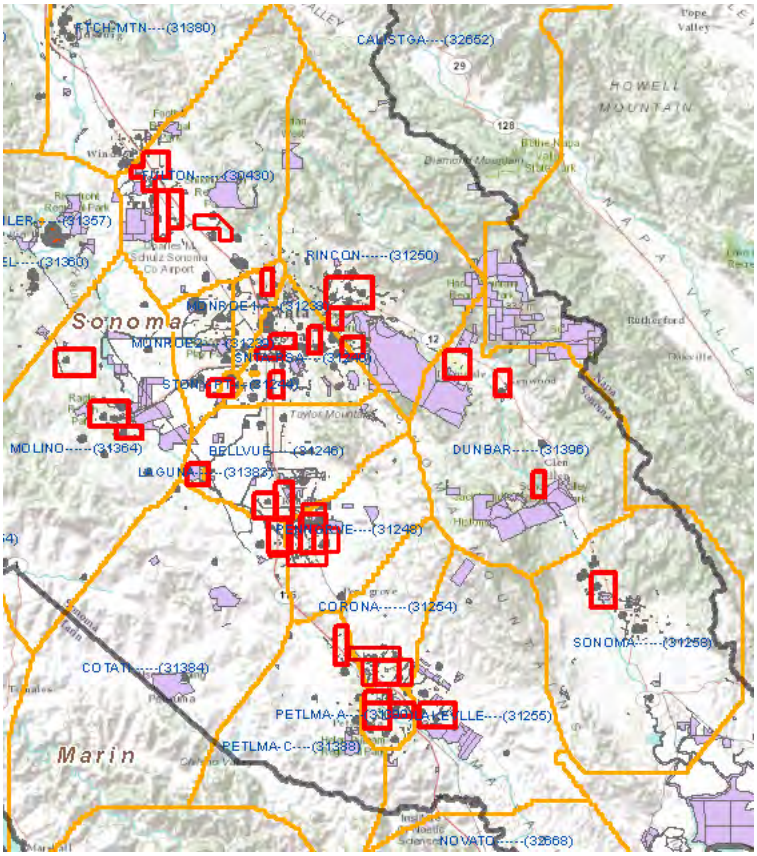
As shown in Figure 58, there are numerous "areas of interest" within Sonoma County for community scale energy development. Each of these areas is associated with a particular substation. The substation service areas are shown in yellow. Each area of interest is within the

red rectangle. As described in the load analysis section, the areas of interest can contain multiple "energy development zones." However, the areas of interest were not further analyzed to identify the energy development zones. This is further work that will have to be done as part of future specific project development.

These areas were selected on the basis of the following criteria:

1. High density of energy use (kWh/yr/unit area) within the substation service area (as indicated by the hot spot analysis).
2. High development density (number of developed parcels with energy use per unit area)
3. Availability of potential sites for location of a small scale (<10MW) generation unit. This was considered to be any site that could potentially be a combined heat and power user, such as any public building, a police or fire station, a hospital or other medical facility, a school or a multifamily dwelling. If the site was publicly owned, that was considered a more likely candidate, due to lower site acquisition cost.

Figure 58: Sonoma County Energy Development Areas of Interest



These criteria were used in order to identify areas that:

1. Would be more likely to have opportunities for cost-effective combined heat and power deployment, including district heat.
2. Would be more likely to ultimately have opportunities for micro-grid deployment, including demand response, storage and *virtual power plant* development.
3. Would tend to have a lower cost of deployment because of the high number of customers in a relatively small area that could be served with a single development project. Single development projects for multiple customers minimize the number of truck rolls, personnel and equipment needs, and materials needed for new infrastructure such as piping for district heating systems.

Using this methodology, many, if not most, of the areas within Sonoma County that have a high probability to support the above described development were identified. However, this is not an exhaustive list. There are most likely many more areas that could provide a "platform" for a small scale, highly efficient, low carbon energy system. Any potential developer would need to perform a more exhaustive analysis of the type described in order to identify all the cost-effective deployment opportunities.

CHAPTER 6:
Demand Side and Loan Balancing Resources

Electricity generation is referred to as the supply side, and electricity consumption as the demand side. *Load balancing* refers to systems that match the availability (supply) of electricity with the need (demand) for electricity. Because energy efficiency is the principal demand side measure, discussion of energy efficiency constitutes most of this chapter. Other demand side resources and distribution system improvements that can reduce demand and balance renewable resources are listed at the end of this chapter.

Energy Efficiency

Introduction

Developing energy efficiency as a local resource requires understanding the existing policy and program framework. State policy on energy efficiency has evolved over the past 30 years to put increasing emphasis on efficiency as a zero-emission, least-cost energy resource. This position has become even more important as the State works to address climate change and its aggressive greenhouse gas reduction goals.

Since 1980, the state has been successful in stabilizing the per capita energy use despite population growth. It has created policies and regulations that recognize the need to engage market forces and industry partners, partner with local governments as agents of public health and safety for environmental and economic issues, use science-based approaches and support emerging technologies, and achieve all cost effective means for significant results for residential and non-residential buildings.

In the context of climate change, the State has already charted a new course from the traditional single measure or "widget" model to an integrated approach that uses building science, energy modeling, and trained energy professionals to achieve higher efficiency results from every project. Known as market transformation, this new approach requires a high level of collaboration between energy stakeholders, coordination of services, cooperation among energy and financing professionals, and a robust consumer education campaign to establish the personal and community benefits of building energy upgrades. This efficiency activity also creates local jobs, improves the durability and value of local buildings, stabilizes household and business energy costs, and provides a viable means to reaching our State and local climate protection goals.

Energy efficiency provides the local RESCO portfolio a practical tool to manage energy demand and make clean energy resources go farther by leveraging cheap efficiency before more expensive new generation. In addition, it is in homes and businesses that most citizens first encounter core principles about resource conservation and climate protection that are shaping all areas of community life.

This chapter begins with a discussion of several policies that form the basis for three energy efficiency scenarios for Sonoma County that lay out potential local program implementation options. A key feature of these scenarios is concern that the investor-owned utilities, including PG&E, have been expected to fall short of the state's climate protection goal for energy efficiency unless major new policy and program innovations are implemented. A few case studies are also presented to illustrate the site-specific character of this resource.

Policy Targets and Legal Framework

Energy Action Plan Makes Efficiency a Priority for Reliable, Affordable Energy

For over 30 years, California State policy has acknowledged the importance of energy efficiency in maintaining a reliable and affordable energy supply. In 2003, the State adopted an *Energy Action Plan* (California Energy Commission 2003) to: Ensure that adequate, reliable, and reasonably-priced electrical power and natural gas supplies, including prudent reserves, are achieved and provided through policies, strategies, and actions that are cost-effective and environmentally sound for California's consumers and rate payers. The Plan goals included "meeting California's energy growth needs while optimizing energy conservation and resource efficiency and reducing per capita electricity demand." (California Energy Commission 2005)

The *Energy Action Plan* established a new unprecedented level of cooperation between State agencies; instituted a strategy to use market forces and regulations to optimize long-term energy results; recognized the health and safety role of government in facilitating the economic and environmental benefits of reducing fossil-fuel energy use; established an iterative process for evaluating progress and optimizing planning; and confirmed *loading order* as a core principle of State energy policy.

In 2004, the California Public Utilities Commission adopted aggressive 10-year energy savings goals and actions to eliminate energy outages and excessive price spikes in electricity and natural gas as well as reward investments in efficiency and new energy infrastructure, as outlined in the *Energy Action Plan*. (California Energy Commission 2003)

Executive Order S-3-05 Sets Greenhouse Gas Reduction Targets

In 2005, Governor Schwarzenegger issued Executive Order S-3-05 (G. A. Schwarzenegger 2005), which sets aggressive greenhouse gas (GHG) reduction targets to reduce emissions to:

- 2000 levels by 2010
- 1990 levels by 2020
- 80 percent below 1990 levels by 2050

The order also cited California's leadership role in setting high building and appliance efficiency standards and the job creation potential of supporting GHG technology companies and reducing consumer energy costs as efficiency-related reasons for adopting the targets.

Senate Bill 1037 Establishes Loading Order

That same year, Senate Bill 1037 (Kehoe, California Senate Bill 1037, Chapter 366 Statutes of 2005) established a "loading order" policy that requires California electric utilities to access low-cost energy through efficiency and demand reduction before implementing additional power generation (that is, reduce before produce). In addition, the legislation required the California Public Utilities Commission (CPUC) and California Energy Commission (Energy Commission) to identify cost-effective, achievable electric and natural gas efficiency savings and set goals to achieve them, and to review utility energy procurement plans to ensure they take advantage of conservation opportunities.

Assembly Bill 549 Report Defines New Approach

The 2005 AB 549 (Longville Statutes of 2001) Report to the Legislature recommended establishing (1) energy efficiency requirements for building alteration projects, (2) a home energy rating system, and (3) implementing benchmarking and retro-commissioning of commercial buildings — setting the stage for a move away from "widget"-based programs to a whole-building science-based approach to resolving energy waste issues and documenting a building's "energy performance."

Assembly Bill 2021 Set 10 Year/10 Percent Goal

Assembly Bill 2021 (Levine Statutes of 2006) enhanced the SB 1037 mandate by directing utilities to treat efficiency as an energy procurement investment to achieve a 10 percent savings over 10 years. AB 2021 established a three-year planning cycle to regularly identify emerging cost-effective strategies for obtaining efficiency savings, set annual efficiency targets and estimates of energy efficiency potential for the next 10 years, and established evaluation, monitoring, and verification processes for program savings for publically owned utilities (POUs). The results of utility efficiency programs have been documented in annual Integrated Energy Policy Reports since 2007.

Assembly Bill 32: Global Warming Solutions Act

Assembly Bill 32: Global Warming Solutions Act of 2006 (Nunez Statutes of 2006) established a process for reducing GHG emissions to 1990 levels by 2020. The California Air Resources Board was tasked with developing the *Climate Change Scoping Plan* (California Air Resources Board 2008), which calls for coordination of activities by State and Federal agencies, energy companies, and customers. The scoping plan set energy efficiency targets and cited two key opportunities to achieve those targets: innovative new initiatives and improvements to traditional approaches to building standards and utility programs. The core efficiency strategies include zero net energy[26] targets for new residential (2020) and new commercial (2030) buildings; improved codes and standards to achieve greater energy and water efficiency for buildings and appliances; voluntary and mandatory whole-building energy upgrades for existing buildings; innovative financing to overcome up-front cost barriers to efficiency and renewable building improvements; more aggressive utility programs to achieve long-term

[26] A Zero Net Energy building is a building that consumes only as much energy as it produces onsite.

savings; and selected strategies for energy/water nexus savings; local government implementation of planning, land use, and code compliance opportunities; additional industry and agricultural initiatives; and consumer-focused real time energy monitoring to encourage energy-saving behaviors.

The goal of the scoping plan is "reducing greenhouse gas emissions to 1990 levels, [which] means cutting approximately 30 percent from business-as-usual emission levels projected for 2020, or about 15 percent from today's [2008] levels." In every day terms that means reducing per capita annual emissions from 14 tons of carbon dioxide equivalent for every man, woman, and child in California down to about 10 tons per person by 2020. To achieve this goal, the scoping plan sets the following targets above savings currently assumed to be incorporated in the Energy Commission's 2007 demand forecasts:

- Energy efficiency (utility efficiency programs, stronger building codes/appliance standards, additional efficiency/conservation programs): 32,000 gigawatt-hour (GWh) reduction
- Energy efficiency (utility efficiency programs, stronger building codes/appliance standards, additional efficiency/conservation programs): 800 million-therm reduction in natural gas use.

The current CPUC efficiency goals for the state's major investor-owned utilities are higher than previous three-year funding cycles because the scoping plan includes potential energy savings from both traditional utility programs and "programs designed to produce deeper and more comprehensive savings" in its target calculations. To support the more aggressive reduction targets, the three-year $3.1 billion energy efficiency budget is 42 percent higher than the prior planning cycle's budget (California Public Utilities Commission 2009/2012).

Energy Action Plan II

The need for more aggressive energy use reductions was echoed in the *2008 Update Energy Action Plan,* which notes that between 1980 and 2005, California's per capital use of electricity has experienced an average 0 percent growth as compared to national per capita electricity use, which has risen by 50 percent in the same time period (California Energy Commission 2008a). However, the report goes on to say: "While this stabilization of per capita electricity use is something we are proud of, it is not nearly enough to meet our AB 32 goals. To address this emissions reduction challenge for electricity, we will need to bend this curve downward, because, among other reasons, the population of California continues to grow rapidly, causing overall electricity use in the state to continue to rise by between one and two percent every year."

To achieve greater GHG reductions, the *2008 Energy Action Plan* cites four strategies: coordinate and integrate overall actions of State agencies across all targeted resource areas; engage local governments in GHG reduction implementation in community planning, land use, and transportation and energy infrastructure; partner with industry; and pursue cross-sector

options such as improving the grid to support increased renewable energy generation and the electrification of vehicles — in order to achieve all cost-effective energy efficiencies.

The report also showed that while improved appliance and building standards yielded steadily increasing energy savings, "the contribution from utility energy efficiency programs has remained about the same since the mid-1980s." To address the lack of growth in utility program results, the report proposed a strategic planning process, a comprehensive approach to upgrading existing buildings, and a risk/reward incentive mechanism that rewards IOUs for meeting or exceeding CPUC energy reduction goals. However, even with these extra incentives and planning structures, the CPUC planning scenarios to 2020 show all IOUs achieving only about half of their share of the state's climate plan target for energy efficiency.

It is clear from programs run by other utilities that significantly higher performance is possible. A recent Energy Commission analysis of the Sacramento Municipal Utility District (SMUD), a publically owned utility, shows that almost all growth in electrical energy demand after 2012 is removed by SMUD's energy efficiency programs. In the base case demand forecast, and unmanaged growth rate of 1.5 percent per year is reduced to only about 0.2 percent per year, with annual savings ranging from 1.2 percent to 1.6 percent per year from SMUD's efficiency programs (Fugate 2011).

Non-Residential Benchmarks

Assembly Bill 1103 (Saldana, California Assembly Bill 1103, Chapter 533 Statues of 2007) and Assembly Bill 531 (Saldana Statues of 2009) mandated that non-residential building owners disclose energy performance information (that is, energy use data and how it compares to a set standard or benchmark) to prospective buyers, lessees, or lenders and created a compliance process.

California Energy Efficiency Strategic Plan

The new loading order directive established in 2005 was formalized in the *California Energy Efficiency Strategic Plan* (California Air Resources Board 2008) (Strategic Plan), which provides a road map across all energy sectors to ensure California is able to increasingly meet its energy needs through efficiency. Between 2009 and 2020, the Strategic Plan focuses on a comprehensive strategy including the whole-building approach, rebates, financing options, energy ratings, and quality installation to realize the full efficiency potential of existing buildings. This same year, the Energy Commission adopted phase two of the California Home Energy Rating System (HERS) to provide whole-house energy ratings that quantify home energy performance. Local governments are cited as key partners to provide, among other things, energy efficiency and climate protection programs.

Assembly Bill 758

In 2009, passage of Assembly Bill 758 (Skinner Statues of 2009) required the Energy Commission to implement comprehensive building efficiency programs for residential and non-residential properties. That same year, the Federal American Recovery and Reinvestment Act (ARRA) provided a $133 million State Energy Program grant through 2009–2012 to develop and implement a comprehensive residential energy upgrade program. These two resources enabled

the State to found the Energy Upgrade California™ program (Energy Upgrade California 2011, Web) — a one-stop-shop Web-based consumer program for residential properties providing education, energy ratings, whole-building services, rebates, qualified contractors, consumer protections, and financing options in partnership with the Energy Commission, Investor Owned Utilities, regional government entities, and local county governments and agencies. ARRA funds also supported commercial/municipal retrofit programs providing energy use assessments and targeted measure upgrades, development of Property Assessed Clean Energy financing pilots, and the Clean Energy Workforce Training Program to train workers for jobs in sustainable green industries.

Local Policies and Programs

Locally, Sonoma County government partners have initiated the following efficiency policies and programs to support State and local goals:

- Set countywide GHG reduction goal (that is, 25 percent below 1990 levels by 2015).
- Published *Sonoma County Community Climate Action Plan,* which outlines local GHG targets and proposed actions (Climate Protection Campaign 2008).
- Founded Sonoma County Energy Independence Program to provide property assessed clean energy financing.
- Established Sonoma County Regional Climate Protection Authority to coordinate local climate protection activities.
- Implemented Energy Upgrade California in Sonoma County building efficiency program.
- Adopted CalGREEN building codes countywide for uniform implementation of efficiency standards.
- Supported initiatives proposed in the *Sonoma County Solar Implementation Plan,* which sets a goal to replace 250 megawatts of peak demand with solar and efficiency (Solar Sonoma County 2012).

Overcoming Challenges to Achieving Energy Efficiency Goal

The CPUC mandated move to market transformation and deep energy efficiency means increased challenges and opportunities. Recent experience by the Retrofit Bay Area partnership (that is, eight of the nine Bay Area counties through the Association of Bay Area Governments) in developing and launching Energy Upgrade California sheds light on how to leverage this new model to meet State and local GHG goals. At the heart of the matter is the fact that the whole building approach to efficiency is a new concept to most property owners and is a considered purchase that generally requires financing, since a retrofit can cost from $5,000 to $40,000-plus for residences, and even more for non-residential properties.

To-date, the Energy Upgrade program has established a regional marketplace for science-based, whole-building efficiency services; aligned State, regional, and local governments and IOU

partners; and continues to pursue its core objectives: provide financing mechanisms, demonstrate effective marketing and outreach, and streamline program processes.

In its Final Report (Association of Bay Area Governments 2012b), the Retrofit Bay Area partnership identified the following challenges and opportunities (Table 51):

Table 51: Market Transformation Challenges and Opportunities

Challenge	Opportunity
Lack of consumer awareness of whole-building and efficiency/renewables project benefits	• Leverage established Energy Upgrade California marketing campaign • Expand local education to make efficiency and clean energy a community priority
Coordination of services and benefits from multiple partners to deliver clear consumer message	• Build on Energy Upgrade partnership to integrate local administration of efficiency programs and efficiency/renewable services
Reduced property owner borrowing capacity because of economic recession	• Affordable financing from Sonoma County Energy Independence Program • Develop additional financing options and credit enhancements to accommodate different financial circumstances • Establish financing clearing house
Limited access to upgrade project energy metrics	• CCA may be able to address access to electricity use data
Lack of alignment between IOU whole-house incentive budget and State and local GHG targets	• CCA could plan efficiency funding according to GHG targets

Source: *Retrofit Bay Area Final Report* (Association of Bay Area Governments 2012b).

In addition to the programmatic challenges list above, the PACE financing for residential properties is currently facing a legal challenge from the Federal Housing Finance Agency, which claims that a PACE assessment voluntary and has a longer term than typical assessments it is not a valid assessment, but is a loan that should not be senior to a mortgage. The July 2010 challenge led to the closure of PACE residential services for many fledgling PACE programs; some programs elected to keep their non-residential PACE programs while the residential issue is resolved. A rulemaking process is currently underway to determine the legitimacy of the residential PACE model. The Sonoma County Board of Supervisors decided to lead the fight for residential PACE in the courts and maintain the Sonoma County Energy Independence Program, which is the only residential and non-residential PACE program in the nation. The PACE model was designated as a key financing tool for Energy Upgrade California until the legal challenge.

The whole-building focus of market transformation is based on building science, which shows that a systematic science-based process achieves deep energy reductions. The whole-building

approach sequences combinations of efficiency measures to get a result greater than the sum of the individual measures. Many traditional single measures, such as replacing light bulbs with CFLs, take advantage of easy, low-hanging fruit savings; however, when packaged with a set of measures the low-hanging fruit measures can support more costly measures whose impact is deeper and longer lasting, such as air sealing, insulation, and furnace/ductwork replacement. The whole-building approach also offers significant non-energy benefits including improved building durability, improved indoor air quality, better comfort, and combustion appliance safety testing.

The Retrofit Bay Area partnership's Policy Recommendations (Association of Bay Area Governments 2012a) also identified the following priorities for the next phase of market transformation:

- Leverage existing local government partnership for Energy Upgrade phase two.
- Launch regional financing strategies (for example, loan loss reserve).
- Continue consumer marketing and outreach.
- Support Participating Contractors with training and marketing resources.
- Provide neutral "third-party" assistance for property owners.
- Pilot a lower-cost building upgrade option.
- Increase incentives and monitor participation response.
- Obtain project specific disaggregated data to support marketing.
- Launch large-scale multi-family program (currently five pilots statewide).
- Expand partnership with real estate industry.

Energy Upgrade California is the framework with which future efficiency and renewable programs will be integrated to make it easier for property owners to participate.

Energy Efficiency Financing

There is a range of financing tools for consumers to address the upfront cost and overall cost effectiveness of efficiency projects. These include incentive programs to bring down project cost for consumers and financing programs to underwrite costs over time. In addition, Federal funding supports program implementation at the State, regional, and local level.

PG&E Rebates and Public Goods Charge Funding

PG&E offers residential customers a range of single measure rebates for home appliances, air sealing and insulation projects, heating-ventilation-air-conditioning (HVAC) equipment replacement, pool pump upgrades, recycling of old refrigerators and freezers, and installation of ENERGY STAR®–qualified compact fluorescent lights. Commercial property owners may also access rebates for lighting projects, upgrades that reduce natural gas use, and building retrofit measures such as HVAC, boiler, chiller, and other infrastructure improvements. These rebates and other efficiency program services, such as demand response and commercial

property programs, are funding by ratepayers through the Public Goods Charge and from IOU procurement funds.

Grants

Federal grant funding is available through the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) to business and government implementers as well as consumer. Funds authorized by Congress include competitive grants and cooperative agreements with businesses, industries, universities, and other entities. Grants are available directly from EERE for all types of renewable and efficiency initiatives. EERE also funds State activities including the California State Energy Program that underwrote the Energy Upgrade California, clean energy workforce trainings, and Energy Efficiency and Conservation Block Grant programs, as well as the Federal Weatherization Assistance Program. EERE also funds the Smart Communities Network to help communities enhance local economic activity and environmental quality. In addition, consumers may directly receive EERE assistance through Federal tax credits for energy efficiency, ENERGY STAR® appliance rebates, and state incentives for renewable and efficiency technologies.

On-Bill Financing

PG&E currently offers 0 percent on-bill financing for commercial and municipal projects. Funding is available for lighting, refrigeration, HVAC, and LED street light projects. Proposed projects must show an estimated energy savings equal to or greater the amount needed to repay the loan within the maximum loan term. Commercial projects are eligible for $5,000 to $100,000 with up to 60-month repayment term; municipal projects are eligible for $5,000 to $250,000 with up to 120-month repayment term. Project may be installed by the building owner or a qualified contractor. PG&E performs pre- and post-project inspections to verify project scope and results.

Loan Programs

As part of the Energy Upgrade California initiative, the Energy Commission co-funded the CHF Residential Energy Retrofit Program, which provided $23.6 million in Federal stimulus funds and $2 million in CHF funds to provide 0 to 3 percent loans over 15 years to income qualified homeowners to finance whole-house energy upgrades. Currently the program is funding only projects on the wait list. It was very successful and may be renewed at a later date.

Other types of loan financing include unsecured loan programs such as contractor-originated GEO-Smart loans through the Electric and Gas Industries Association and some banks and credit unions, leases and power purchase agreements for solar installations, home equity loans, and the U.S. Department of Housing and Urban Development (HUD) PowerSaver loan program that provides $25,000 over 20 years for efficiency improvements.

CCA Procurement Budget

In California, utility rates are determined through a procurement planning process that allows IOUs and POUs to estimate needed investments and costs to provide reliable affordable energy. The public utilities code directs utilities to address "unmet resource needs through all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible." As an energy procurer, a CCA would have procurement funding from the portion of customer

bills that pay for energy supply, a small portion of which could be used to acquire energy reductions from all building sectors. This funding is in addition to the Public Goods Charge mentioned above, and is similar to the way in which IOUs provide additional financial support for energy efficiency. The three major investor-owned utilities currently pay about $700 million per year out of their procurement budgets for energy efficiency, which would be equivalent to roughly $10 million per year for Sonoma County on a pro-rata basis.

Property Assessed Clean Energy (PACE) Financing

The Sonoma County Energy Independence Program is a Property Assessed Clean Energy (PACE) financing program that offers affordable financing for energy efficiency and renewable energy generation improvements that are permanent to the property specifically to reduce greenhouse gas emission from buildings. The PACE model employs a contractual assessment (land-secured financing used by local agencies in California to finance public benefit projects) that stays with the property. The assessment is repaid on the participating property owners' property tax bills over a term of 5 to 20 years, reflecting the expected system life of the improvements. PACE is completely voluntary. The program is available for residential properties (that is, detached single family homes, duplexes, tri-plexes, four-plexes, townhouses, twin homes, and multi-family and tenancy in common properties with up to four units) and non-residential properties (that is, commercial, industrial, large multi-family [of four or more units], and non-profit properties subject to property taxes). To-date the Energy Independence Program has funded 1648 residential and 54 commercial projects loaning $56,364,785 and creating 683 local jobs. The Energy Independence Program is an Energy Upgrade California partner.

The Sonoma County Energy Independence Program is currently fighting a legal challenge to the residential PACE model from the Federal Housing Financing Agency. The program continues to offer residential and non-residential PACE financing. The program enjoys strong support from the local clean energy industries; however, efficiency and renewables contractors report that consumers feel the current 7 percent interest rate is high. There is a possibility that when the legal issue is resolved, the program may be able to reduce the interest rate through the process of selling its bonds in the bond market.

Pay-As-You-Save®

The Pay As You Save® (PAYS®) system, developed by Energy Efficiency Institute, Inc., is an innovative market-based system in which customers, vendors, and capital providers, acting in their own interests, produce unprecedented resource efficiency investment that is also in society's interest using an "offer that works" (Energy Efficiency Institute, Inc. 2012, Web--PAYS) This offer allows water utility customers to purchase cost-effective water and energy measures with (1) no up-front payment, no new debt obligation, (2) no credit checks, and no liens; (3) a guarantee that their monthly surcharge is lower than their estimated savings; (4) the assurance they will pay the surcharge only while they remain customers at the location where the measures were installed; (5) none of the typical risks associated with contracting for or installing measures; and (6) a promise that failed measures will be repaired or the payment obligation will end — resulting in high participation rates. The model serves property owners

and renters providing water and energy efficiency measures tailored to the goals of the implementing entity (such as a CCA), paid for through a bill surcharge, and funded either by a private capital provider, the implementing entity, or, in the case of solar, third-party lessor. Quality assurance is provided by a Certification Agent, who oversees certified contractors/ suppliers and provides customer service. PAYS® provides an all-cost-effective energy supply that delivers cleaner energy, more efficiency, and lower rates by leveraging future savings, tax credits, and other financial benefits based on customer's actual energy behavior. PAYS® is able to stabilize energy/water costs with tools such as Request for Proposal protocols to secure best possible prices, limiting supply and distribution investments to mitigate problems of efficiency depleting revenues, and providing customers with immediate real benefits.

Energy Efficient Mortgages

Energy Efficient Mortgages are available through HUD that allow home buyers or home owners to add up to 5 percent of the home value to the mortgage to make efficiency improvements. EEMs may be used for home purchase or refinancing, are administered by the Federal Housing Authority (FHA) to support first-time and other home buyers who might not otherwise qualify for a convention loan, and represent the most affordable efficiency financing option.

Sustainable Energy Bonds

The Sonoma County Water Agency is currently developing a Sustainable Energy Bond program to fund large-scale energy efficiency retrofit projects at public facilities. Under the new bond program, a third-party contractor would design and implement energy improvements to yield a specific dollar value of energy savings. The facility owner promises to remit to the Sustainable Energy Bond program a portion of the cost savings, and the third-party contractor guarantees the cost savings that constitute repayment to the bond program in an arrangement similar to the energy service provider model. The bond program issues tax-exempt revenue bonds leveraging future income from the secured bond payments. Through this arrangement, the public entity makes no upfront expenditure and incurs no indebtedness for the energy improvements. The bond program takes advantage of the fact that it is cheaper to save 1 kW than to buy 1 kW of new power.

Scenarios for Achieving AB32 Efficiency Goals

The State's AB 32 Climate Scoping Plan calls for energy efficiency measures to decrease electricity use 32,000 gigawatt-hours by 2020.[27] This is equivalent to about 10 percent of the State's forecast electricity demand in that year. Sonoma County has almost exactly 1 percent of the State's electricity consumption, implying that the county's "share" of the AB 32 Scoping

[27] CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST (California Energy Commission 2009, Page 40) shows total forecast electricity consumption of 316,280 GWh in 2020; 32,000 GWh is slightly less than 10 percent of the base forecast consumption in that year.

Plan goal would be to save about 320 gigawatt-hours per year in 2020.[28] This goal would be achieved incrementally over the decade, adding about 1 percent savings per year on average. In practice, this may mean obtaining more than 1 percent per year savings in the latter part of the decade, if PG&E falls short in the earlier years.

This chapter examines three scenarios for achieving this goal:

1. "Business as usual" (50 percent of AB32 goal) that maintains the traditional single measure rebate approach
2. "Market transformation" (75 percent of AB32 goal) that includes the CPUC's Energy Upgrade California™ umbrella brand for a streamlined market focused on deeper energy reductions and the transfer of existing IOU efficiency program to local CCA administration
3. "Community administration" (100 percent of AB32 goal) that highlights expanded opportunities for CCA-led and administered initiatives to achieve deeper energy retrofit results and reach AB32 energy efficiency targets for residential and non-residential properties (Table 52)

Scenario 1, business as usual scenario, includes only traditional IOU efficiency programs and *not* savings realized through programs that involve local community participation, such as Energy Watch partnerships or the new Energy Upgrade California whole-house program. Scenario 2, the market transformation scenario, looks at the capacity of the Energy Upgrade program and CCA implementation of traditional residential and non-residential programs to achieve 75 percent of the AB32 goal. Scenario 3, the community involvement scenario, includes options for enhancing efficiency results through CCA-sponsored programs that promote the adoption of new technologies and address underserved markets to achieve Sonoma County's proportional share of the full AB 32 goal, which would be saving 10 percent of local forecast electricity demand by 2020 through new energy efficiency measures.

[28] California Energy Commission data for electricity consumption in the state's counties showed Sonoma County using 2,875 GWh in 2010; by comparison, Form 1.2 (cited above) showed statewide electricity consumption of 280,843 GWh in the same year; Sonoma County would be 1.02 percent of the state total.

Table 52: Efficiency Scenarios for Residential and Non-Residential Through 2020

	Scenario 1 Business As Usual	Scenario 2 Market Transformation	Scenario 3 Community Administration
	50 Percent of AB 32 Target	75 Percent of AB 32 Target	100 Percent of AB 32 Target
Year	Low Local New EE Savings (Res and Non-Res)	Mid Local New EE Savings (Res and Non-Res)	High Local New EE Savings (Res and Non-Res)
	GWh	GWh	GWh
2013	15	18	18
2014	15	21	23
2015	16	25	29
2016	16	26	34
2017	17	27	40
2018	17	31	47
2019	18	32	48
2020	18	33	55
	133	**215**	**295**

Scenario 1 — Business as Usual

Investor Owned Utilities: Single Measure Incentives / Demand Response Programs

Program strategy/design: Traditionally, Investor Owned Utilities have been tasked by the CPUC to deliver energy efficiency programs funded by the State's Public Goods Charge and utility procurement funding. From 1978 to 2005, the primary approach was to incentivize select single measures that were determined to meet cost-effectiveness standards in residential and non-residential properties; in 2005 policy began moving toward a collaborative market transformation strategy emphasizing a whole-building approach to achieve deeper energy reductions.

Residential: Prior to 2010 and the establishment of the Energy Upgrade California program, efficiency programs for residential properties consisted of a suite of IOU-administered rebates for single measure upgrades; in the PG&E service territory these single measure rebates included home appliances, air sealing and insulation projects, heating-ventilation-air-conditioning (HVAC) equipment replacement, pool pump upgrades, recycling of old refrigerators and freezers, and installation of ENERGY STAR®–qualified compact fluorescent lights. Residential consumers may also use an online energy analysis service that allows them to provide basic energy use data and receive recommendations for efficiency improvements.

Non-Residential: Efficiency programs for non-residential properties continue to be implemented through Energy Watch partnerships between IOUs and local governments and IOU-administered incentives and demand reduction programs that reduce the load on the energy grid during peak demand hours. Energy Watch partnership services include energy analysis, upgrade measures, and retro-commissioning of existing municipal buildings; design assistance for new municipal buildings; installation of efficiency equipment for small businesses and single- and multi-family residences; greenhouse gas reduction planning tools; and community education and vendor training. Demand response programs facilitate and reward

customers for reducing peak energy demand through participation in business-focused programs, aggregator managed portfolios, and demand response technologies such as control systems. IOUs also offer third-party administered efficiency programs providing a range of general and industry-specific assistance. In addition, IOUs are launching a new Time Varied Pricing program that adjusts the energy rate to the level of demand, rewarding those who conserve energy during peak demand hours.

Funding: Beginning in 1997, efficiency programs have been partially funded by bill payers through the Public Goods Charge program, which raises $356 million annually to fund the energy efficiency programs cited above ($288 million), provide subsidies for renewable energy facilities such as solar plants and wind farms ($65.5 million), and fund Public Interest Energy Research into new clean energy technologies ($62.5 million). The CPUC has set an annual $1 billion budget for the IOUs to spend on energy efficiency that includes the Public Goods Charge funds supplemented by IOU procurement funds; these programs outlined in the 2009 CPUC Decision Approving 2010 to 2012 Energy Efficiency Portfolios and Budgets (California Public Utilities Commission 2009/2012), which states: "By law, the utilities' efficiency portfolios must be cost-effective and program expenditures must be just and reasonable."

Performance: Over the past three decades, the PGC-funded energy efficiency programs have saved enough energy to equal the annual energy demand of 5 million homes, and avoided the need to build 10 large power plants (500 megawatts each). Between 1980 and 2005, California's per capital use of electricity has experience an average 0 percent growth as compared to the national average of 50 percent growth per year (California Energy Commission 2008a); during the same period the state population has increased by 1.6 percent per year. This population growth, combined with the need to reduce GHG emissions, means that the historical performance of these programs will no longer suffice for meeting policy goals. The 2008 *Community Climate Action Plan* (Climate Protection Campaign 2008) notes that based on the IOU's then long term plans for energy procurement and efficiency, the county would fall short of its GHG reduction target by 40 percent in the electricity and natural gas sectors.

The values used for energy efficiency in Scenario 1 are not based upon historical performance, but rather are an approximation for Sonoma County of the 2020 planning assumption for energy efficiency required by the CPUC for use in the IOU procurement plans in the 2010 Long-Term Procurement Proceeding. The commission ordered IOUs to adopt the Energy Commission IEPR load forecast and additional energy efficiency savings, referred to as "uncommitted efficiency," were to be "the mid-case results for all values except Big Bold EE strategies, for which the low-case results shall be used" (California Public Utilties Commission 2012a, Page 10). Uncommitted efficiency is the same category as the AB 32 Scoping Plan efficiency savings, and represents efficiency savings *beyond what is already included* in the baseline forecast. The "mid case results" for all three IOUs combined is shown in the Table 53 (California Energy Commission 2012d):

Table 53: 2020 Incremental Impacts of 2008 Energy Efficiency Goals Update Report Policy Initiatives beyond Those Included in 2009 IEPR Demand Forecast

Utility	Savings	Scenario		
		Low	Mid	High
PG&E	Energy (GWh)	4,634	5,130	6,087
	Peak (MW)	1,731	2,245	2,722
SCE	Energy (GWh)	4,971	5,874	6,848
	Peak (MW)	1,941	2,593	3,160
SDG&E	Energy (GWh)	1,091	1,222	1,440
	Peak (MW)	363	514	602
Total IOUs	Energy (GWh)	10,658	12,225	14,374
	Peak (MW)	4,034	5,352	6,484

The "Mid-Case Scenario" has uncommitted efficiency savings of 12,225 GWh annually in 2020. However, the CPUC planning assumption for efficiency savings required subtracting 504 GWh from this figure, since it used the Low Case value for the Big Bold energy efficiency strategy, which would adjust the figure to 11,721 GWh.[29] The three IOUs are estimated to represent approximately 75 percent of total state retail electricity sales,[30] and therefore taking 75 percent of the AB 32 Scoping Plan target of 32,000 GWh implies a combined IOU target of 24,000 GWh. Therefore, a planning assumption of 11,721 GWh is slightly less than half of the AB 32 target.

Source: Itron and California Energy Commission (California Energy Commission and Itron 2009).

Flexibility: AB 2021 established a three-year planning cycle that allows the IOUs to incorporate increasingly effective technologies on a regular basis to constantly improve the efficiency performance of the entire IOU PGC portfolio.

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[29] In *Incremental Impacts of Energy Efficiency Policy* (California Energy Commission 2012d, Page 44), Table 7 shows the "Low Savings Scenario" with Big Bold Initiatives savings of 1,552 GWh in 2020, while the "Mid-Savings Scenario" in Table 8 showed 2,056 GWh, with the difference between these figures being 504 GWh. This difference must be subtracted from the Mid-Savings Scenario to derive the planning assumption for the CPUC's 2010 Long-Term Procurement planning assumption for uncommitted energy efficiency savings for 2020.

[30] In *Incremental Impacts of Energy Efficiency Policy* (California Energy Commission 2012d, Page 4) while the assumed 75 percent IOU share of statewide retail sales is used here, this Energy Commission Committee report re-interpreted the AB 32 Scoping Plan efficiency savings goal as only 22,000 GWh, on the assumption that the Scoping Plan based its target on the level of demand in 2020. The Scoping Plan (California Air Resources Board 2008) was based upon the 2007 forecast, and by the time the 2009 forecast was made the projected demand for 2020 had been significantly reduced. The Committee report assumed that the reduced demand forecast, caused by the global recession, could be "counted" toward the AB 32 Scoping Plan efficiency target. However, the Scoping Plan stated that the efficiency savings goal is 32,000 GWh. This target is not measured by reaching a specified level of demand in 2020, but rather is presented in the Scoping Plan as a specified amount of efficiency savings that is additional to the "committed" efficiency savings embedded in the 2007 IEPR demand forecast. For this reason, the original Scoping Plan target is assumed in this report.

Scenario 2 — Market Transformation

Local Administration and Energy Upgrade California: Deep Efficiency Results

Scenario 2 includes the expansion of the Energy Upgrade California market transformation program to include multi-family and non-residential buildings and a significant participation in single-family residential sector, and the transfer of existing IOU efficiency programs to the administration of a local CCA.

Program strategy/design: In 2008, the State confirmed its commitment to market transformation in the *California Energy Efficiency Strategic Plan* (California Public Utilities Commission 2008), which calls for a comprehensive strategy to create a streamlined market place that provides all the tools a property owner needs to improve building efficiency. This goal became a mandate in 2009 with the passage of AB 758, which required the Energy Commission to implement a comprehensive building efficiency program that uses loading order and building science to achieve deeper energy efficiencies. This mandate resulted in the founding of Energy Upgrade California (Energy Upgrade California 2011) in partnership with local governments who applied their ARRA funding toward the statewide program. Traditional single measure rebates for residential and non-residential properties continue to be available through the IOUs.

The Energy Upgrade California program fulfills several CPUC goals. The May 10, 2012, CPUC Decision 12-05-015 for the 2013–2014 PGC funding cycle (California Public Utilities Commission 2012e) cites local governments as key partners in the areas of "building local partnerships for training, and [implementing] locally tailored outreach and marketing that builds on such partnerships and on local government's contacts with private and public sector leaders in their communities." The Decision goes on to say "a goal of the local government pilots should be to achieve deep energy efficiency savings." That goal is achieved using a science-based whole-building approach that includes an energy analysis (testing and data analysis) to identify energy waste problems and recommend solutions, an integrated project plan that captures the best efficiency opportunities and meets property owner goals and budget, implementation by a Building Performance Institute–certified home performance contractor, applicable rebates, and the availability of local financing through the Sonoma County Energy Independence Program, as well as additional financing options.

The ARRA-funded Energy Upgrade program created a comprehensive consumer resource for integrated efficiency that provides efficiency education, rebates, qualified contractors, consumer protections, and financing for single family residences statewide; multi-family services are currently being piloted and commercial services integrated into the model to serve all building types. Key to the program model is a highly trained building-science workforce that meets industry and IOU quality assurance standards. The Energy Upgrade program also includes the California Solar Initiative program to provide both efficiency and renewable energy generation options. However, the California Solar Initiative will soon end, and a local program may need

to be implemented to assure continuity.[31] Options for accomplishing this continuity are discussed in the solar energy and financing sections of this report.

Locally the Energy Upgrade California program was administered by the Sonoma County Regional Climate Protection Authority and Sonoma County Energy Independence Program (local residential/commercial PACE program), each of which received State Energy Program funding for whole-house program design/ implementation and Property Assessed Clean Energy financing development and replication, respectively. The County of Sonoma and cities of Santa Rosa, Rohnert Park, and Petaluma each contributed 10 percent of their ARRA Energy Efficiency and Conservation Block Grant funds to establish a countywide building efficiency/renewables program and positioned Sonoma County to play a leadership role at the state level.

Table 54 shows how many whole-house upgrades would be needed to meet 75 percent and 100 percent of the AB32 efficiency target for electricity for the residential sector. Column two shows the total kWh reduction needed; column three shows the average electricity reduction for a whole-house project; column four shows the number of whole-house retrofit needed to achieve the target in that year; column five shows the amount of the whole-house incentive to be paid for the electricity reduction; and column six shows the total project cost. Sonoma County has nearly 204,000 residences.

[31] The California Solar Initiative provides approximately $1.9 billion for rebates in ten graded steps, and PG&E's allocated rebates are on step 9 and step 10 for the residential and commercial sectors respectively, as of May 2012, implying completion of the program no later than 2013 (California Energy Commission 2012a, Web--Trigger Tracker).

Table 54: Residential Efficiency Scenarios

Based on **Energy Upgrade California™** for San Francisco Bay Area average project metrics
Total projects: 1,029
Average total project cost: $14,439
Average kWh savings: 1,163
Average therm savings: 391
Average total rebate amount: $3,200
Source: Retrofit Bay Area Final Report, Association of Bay Area Governments, 2012
Adjusted rebate for just electricity is estimated at $928 per project

Scenario 2 — Market Transformation
Home Energy Upgrades (HEUs) -- Mid Efficiency Scenario (75% of AB32 Goal)
Current and projected IOU single measure rebate savings already deducted from AB32 target numbers.

Year	Total New kWhs Savings	Average kWh Savings per HEU (ABAG EUC average)	Number of HEUs	HEU Incentive Amount (Electricity only: $928/HEU)	HEU Project Cost (Avg. $14,439/HEU)
2013	1,338,923	1,163	1,151	$1,068,375	$16,623,132
2014	2,763,787	1,163	2,376	$2,205,326	$34,313,259
2015	4,277,847	1,163	3,678	$3,413,450	$53,110,774
2016	4,413,342	1,163	3,795	$3,521,566	$54,792,994
2017	4,552,245	1,163	3,914	$3,632,402	$56,517,507
2018	6,259,510	1,163	5,382	$4,994,691	$77,713,727
2019	6,454,116	1,163	5,550	$5,149,974	$80,129,819
2020	6,653,588	1,163	5,721	$5,309,140	$82,606,321
	36,713,357		**31,568**	**$29,294,923**	**$455,807,533**

Scenario 3 — Community Administration
Home Energy Upgrades (HEUs) -- High Efficiency Scenario (100% of AB32 Goal)
Current and projected IOU single measure rebate savings already deducted from AB32 target numbers.

Year	Total New kWhs Savings	Average kWh Savings per HEU (ABAG EUC average)	Number of HEUs	HEU Incentive Amount (Electricity only: $928/HEU)	HEU Project Cost (Avg. $14,439/HEU)
2013	1,338,923	1,163	1,151	$1,068,375	$16,623,132
2014	3,454,734	1,163	2,971	$2,756,658	$42,891,574
2015	5,703,796	1,163	4,904	$4,551,266	$70,814,366
2016	8,091,128	1,163	6,957	$6,456,205	$100,453,822
2017	10,621,904	1,163	9,133	$8,475,604	$131,874,182
2018	13,301,459	1,163	11,437	$10,613,718	$165,141,670
2019	13,714,996	1,163	11,793	$10,943,694	$170,275,866
2020	16,633,969	1,163	14,303	$13,272,849	$206,515,802
	72,860,908		**62,649**	**$58,138,369**	**$904,590,414**

Funding: The ARRA funding for Energy Upgrade California ended in April 2012. Future funding will come through the CPUC's Public Good Charge, which will assign a portion of the annual $356 million budget to several new Regional Energy Networks composed in part of ARRA grantee partnerships. These partnerships are currently developing Program Implementation Plans that will include a portfolio of efficiency programs and pilots that as a group must meet the PGC's Total Resource Cost benchmark. The Bay Area Regional Energy Network (BayREN), of which Sonoma County is a member, will include continued funding for Energy Upgrade California marketing and workforce development in its portfolio to continue

building market demand for program services. The CPUC has committed to supporting the Energy Upgrade approach and whole-house incentives over the next ten years.

Performance: Energy Upgrade California launched its Web service in February 2011followed closely by local government marketing campaigns. Between the launch of the Energy Upgrade pilot in August 2010 through March 2012, the nine Bay Area counties completed 1652 whole-house energy upgrades; Sonoma County completed107 upgrade projects and 217 home energy analyses through a local rebate for California Home Energy Rating System (HERS) services. Bay Area–wide as of March 31, 2012, the average project cost was $14,439, the average energy savings was 32 percent, and the program created 190 jobs (Association of Bay Area Governments 2012b). Sonoma County exceeded the Bay Area average garnering an average 35 percent energy savings per project, 15 percent over the local per-project goal of 20 percent.

The local goal, as outlined in the *Community Climate Action Plan* (Climate Protection Campaign 2008), is to upgrade 80 percent of Sonoma County residential and non-residential buildings to the "highest possible efficiency level" using a whole-building approach, which is now provided through the Energy Upgrade California, to reduce GHG emissions by 168,000 tons. The Energy Upgrade California program provides a sliding scale of incentives ($1,000 for 10 percent reduction to $4,000 for 40 percent reduction).

Flexibility: The new Regional Energy Network funding system encourages innovation through a combination of pilot programs and improvements to the Energy Upgrade California infrastructure. The Bay Area partnership is currently looking at multi-family and commercial pilots to expand the regional Energy Upgrade California scope. The Energy Upgrade California in Sonoma County lead agencies are committed to expanding the one-stop-shop model to integrate income qualified efficiency programs such as PG&E's Energy Partners and the DOE Weatherization Assistance Program, implementing a multi-family program, coordinating with the Sonoma County Energy Watch partnership and expanding services to small- and medium-sized businesses, and establishing building efficiency as a high priority for the local community.

Scenario 3 — Community Administration

Community Choice Aggregation — Integrating Efficiency/Renewables to Meet Climate Goals

Program strategy/design: Achieving clean power is two-step process: improve efficiency to decrease demand for fossil fuels and increase renewable power generation. As State policy acknowledges, energy saved is a zero-emissions, least-cost resource. Sometimes these savings are also known as *negawatts,* that is, units of energy saved. Making the move from stable amounts of energy use to reduced energy use means reaching near zero net energy status in existing as well as new buildings — and marrying efficiency and renewables, building-by-building, at the local level.

Community Choice Aggregation is in a unique position to expedite local energy efficiency activities:

1. **Local program administration:** An initial opportunity is more cost-effective, local administration of established electricity-focused energy efficiency programs currently run by PG&E (for example, traditional programs such as single measure rebates for electrical appliances, demand response programs). Several studies show the potential for efficiency programs to achieve better results than what is forecast for PG&E over this decade. For instance, the Western Governors' Association (WGA) convened a task force that produced a report in 2006 on potential efficiency savings by 2020. Their survey of seven major energy efficiency potential studies concluded that "In general, the efficiency potential studies show it is possible to reduce electricity demand growth by 0.5–2 percent per year through more concerted energy efficiency efforts" (Western Governors Association 2006, Page vi). The report recommended adopting an efficiency target for the Western U.S. states of 20 percent reduction in forecast electricity use by 2020, implemented at a rate of 1.4 percent per year; this is much higher than the Long-Term Procurement planning assumption of saving approximately 0.5 percent per year through utility programs during the same period. The WGA report noted that the evaluated efficiency potential was dependent on what measures were included in the specific study, with expanded programs providing the most economic benefit: "Studies that consider a wider set of efficiency measures and more aggressive implementation strategies tend to project savings at the higher end of this range, while those with more limited measures and/or more conservative assumptions about measure adoption are at the lower end. The studies that examined potential net economic benefits all found that more aggressive, multi-year energy efficiency efforts could save consumers and businesses billions of dollars over the lifetime of the measures, with very favorable benefit-cost ratios" (Western Governors Association 2006).

   Another example is Sacramento Municipal Utility District (SMUD), which is forecast by Energy Commission staff to have increased demand from about 10,250 GWh in 2010 to approximately 12,200 GWh in 2020 in a mid-case scenario, assuming that demand is not managed by new efficiency programs. In the mid-case scenarios that look at efficiency savings, SMUD's projected demand in 2020 is about 10,750 GWh, reflecting a reduction of over 10 percent relative to unmanaged growth (Fugate 2011).

   This illustrates that it is not unreasonable to aim for higher efficiency savings than what was projected in the 2010 Long-Term Procurement Plan, and that locally administered programs, such as in the case of SMUD, could reach efficiency savings that achieve the AB 32 Scoping Plan target.

   This option would require an evaluation of the program administration scopes, identification of cost-effective implementation strategies, and an assessment of how local administration would align with the CPUC's recent goal to have a consistent and streamlined regional marketplace under the Energy Upgrade California brand. An

example of a dual utility partnership implementing Energy Upgrade California is the Sacramento Municipal Utility District (electricity) and PG&E (natural gas). Integrating a CCA into the statewide whole-house incentive program — the key tool for deep energy reductions — would require close coordination with PG&E's incentive process to maintain a streamlined consumer-facing program per the CPUC's guidance.

The design of a local electric efficiency portfolio would also be affected by cost-effectiveness criteria required for administration of the Public Goods Charge, to the extent that this source of funding is used to underwrite these local programs.

2. **Incentivized financing:** A significant challenge to widespread participation in efficiency and renewable improvements is the impact of the economic recession on property owner borrowing capacity and the lack of financing tools with flexible credit requirements and low interest rates. A CCA could play an important role, in collaboration with the Sonoma County Energy Independence Program, to design financing options to provide lower interest rates for projects combining efficiency and renewables for zero or near zero net energy results, or for projects achieving a set efficiency goal (for example, 40 percent energy reduction). Both renewable and efficiency contractors report that consumers complain about currently available interest rates and financing credit requirements, which prevent access to persons with financial challenges such as an underwater mortgage, a condition that affects 28 percent of all Sonoma County homes (Digitale 2012, Web--Underwater Mortgages). Research is needed to identify how CCA funding options and local financing programs can be integrated to expand and optimize financing options for property owners, as well as cash-flow tools for clean energy businesses seeking to grow capacity.
3. **Zero net energy nexus:** Buildings are the nexus where efficiency (cheapest energy) and renewables (distributed and utility scale) realize their full zero-net-energy potential. Moving toward deep energy upgrades also means valuing a range of project benefits from cost-effectiveness (that is, monthly energy savings meet or exceed project financing payment) to non-energy benefits (that is, improved comfort and indoor air quality, health and safety, and building durability) to proactive GHG emission reductions through integration of deep efficiencies, clean energy generation (distributed or utility), and transition from natural gas to renewable energy technologies. The CPUC has identified deep energy upgrades as a key deliverable for local government partners.

   Sonoma County's mild Mediterranean climate, affordable subsidized fossil fuels, and the economic recession pose a challenge to achieving strictly cost-effective deep energy upgrades. A CCA is well positioned to mitigate this challenge by identifying and piloting strategic technological and financial tools and trigger point programs to make deep energy efficiencies more economically attractive. Technological innovations often cost more until their effectiveness is verified and their sales volume supports more competitive pricing. As an energy procurer, a CCA could potentially fund the monitoring and documentation of short-term and long-term energy and GHG impacts of emerging technologies and expedite their adoption to transition the building stock away

from natural gas use.

For example, research for the *Community Climate Action Plan* states that water and space heating, which account for 53 percent of average household energy demand, represent "the biggest opportunities for reduction in emissions from natural gas," citing geothermal and solar hot water as key natural gas reduction technologies. Solar hot water offers additional benefits when combined with a hydronic space heating system that uses the solar pre-heated water for indoor air heating (Local Power Inc. 2008).

A CCA could also support additional incentives (for example, rebates or low-cost financing) for projects that combine deep efficiencies with renewable energy generation. This offer could be initially focused on properties with distributed generation potential.

Table 55 shows the three scenarios for non-residential buildings and the quantity of electrical energy reduction required to meet the AB32 goal. An expansion of non-residential programs coupled with available financing through the Sonoma County Energy Independence Program are important tools for achieving higher participation and integration of whole-building strategies that can results in deeper energy reductions.

Table 55: Non-Residential Efficiency Scenarios

	Scenario 1 — Business As Usual	**Scenario 2 — Market Transformation**	**Scenario 3 — Community Administration**
	50 Percent of AB 32 Target	75 Percent of AB 32 Target	100 Percent of AB 32 Target
Year	**Low Local New EE Savings (Non-Res 55% of Total)**	**Mid Local New EE Savings (Non-Res 55% of Total)**	**High Local New EE Savings (Non-Res 55% of Total)**
	GWh	**GWh**	**GWh**
2013	8	1.6	1.6
2014	8	3.4	4.2
2015	9	5.2	7.0
2016	9	5.4	9.9
2017	9	5.6	13.0
2018	10	7.7	16.3
2019	10	7.9	16.8
2020	10	8.1	20.3
	73	**45**	**89**

Funding: Funding to support deep energy upgrade projects would likely come from non-Public Goods Charge/procurement sources. The majority of cost would be covered by loans repaid by consumers. A smaller portion, approximately 20 percent of the cost, is expected to be funded by rebates that could be provided through the using a small portion of the CCA's energy procurement budget, in the same way that PG&E currently supplements the Public Goods Charge funds for its retail customers.

Performance: To meet the short-term local GHG reduction goal (that is, 25 percent below 1990 levels by 2015) means upgrading 80 percent of all properties by an average efficiency savings, according to the *Community Climate Action Plan* (Climate Protection Campaign 2008). In the residential sector, the 2008 *California Long Term Energy Efficiency Strategic Plan* (California Public Utilities Commission 2008) echoes this goal, stating: "Energy consumption in existing homes will be reduced by 20 percent by 2015 and 40 percent by 2020 through universal demand for highly efficient homes and products," and calling for all new homes to be zero net energy by 2020 and all new non-residential buildings by 2030. All these goals need proactive initiatives to make existing programs go farther and seek out new opportunities that expand participation and per-project results.

Flexibility: A CCA can use a wide range of tools to meet its energy goals. An important strategy will be to select initiatives that enhance existing services, address under- or un-served opportunities, support emerging technologies, and expedite consumer participation.

Case Studies

Residential

Table 56 and Table 57 provide profiles of small and large residential energy upgrade projects. The small project includes improvements to the building shell; the large project also includes an upgrade of the heating/cooling equipment and duct system.

Table 56: Residential Project Snapshot — Small Project

Location	Santa Rosa
Building type	Single-family, one story residence
Building size	1,352 sq. ft.
Project measures	Attic and crawlspace air-sealing, attic and crawlspace insulation
Total project cost	$6,770
Program incentive	$2,000 — Energy Upgrade California
Customer cost	$4,770
Estimated annual savings	22.2 percent reduction / $263
Estimated annual kWh saved	401 kWh
Estimate annual therms saved	170 therms
Avoided CO2 emissions	1.02 metric tons per year
Financing	Owner Financed

"As much as we wanted to do the right thing and spend the money to do this retrofit, I must admit that there was some hesitation, even after the rebates, to spend thousands of dollars on a home improvement where we have nothing visible, like a granite kitchen counter, to enjoy. But I can now safely say that we are patting each other on the back and are very happy we did what we did, not just because it is the right thing to do for the environment, but because it is now clear that it will make a big difference in the comfort in our home." — Homeowner

Source: Applied Building Science

Table 57: Project Snapshot — Large Project

Location	Santa Rosa
Building type	Single-family, 1 story residence
Building size	2,345sq. ft.
Project measures	Attic and crawlspace air-sealing, attic insulation, conditioned crawlspace, upgrade HVAC and ductwork, new windows
Total project cost	$36,000
Program incentive	$4,000 — Energy Upgrade California
Customer cost	$32,000
Estimated annual savings	46.1 percent reduction / $2,367
Estimated annual kWh saved	4,811 kWh
Estimate annual therms saved	636 therms
Avoided CO2 emissions	4.87 metric ton per year
Financing	Owner Financed

Source: Applied Building Science

Non-Residential

The following case studies of non-residential properties show a large multi-facility project (Table 58), a medium project concentrating on lighting upgrades (Table 59), and a small project, also concentrating on lighting improvements (Table 60).

Large Comprehensive Non-Residential Project

Table 58: Project Snapshot — Comprehensive Energy Project

Location	Sonoma County, California
Building type(s)	Complex of 30 County of Sonoma buildings
Project measures	Variable frequency drives on air handlers, chillers, and boilers, lighting retrofits, new cooling tower, HVAC system replacement/ rebuild, water conservation retrofits, 1.4 megawatt fuel cell cogeneration plant
Total project cost	$22,272,029 (saved money from day one)
Program incentive	$3,941,226
Customer cost	$18,730,803
Implementer	Aircon Energy (energy services company)
Estimated annual savings	40 percent reduction /
Estimated annual kWh saved	13,365,226 kWh
Avoided CO2 emissions	6,135 tons per year
Financing	Bank of America, 16 year term

Note: Energy services company inventoried County facilities (represent 90 percent of the County government's energy use), performed an investment grade audit, proposed, implemented targeted energy upgrade measures, served as project manager for the fuel cell plant, and will provide ongoing monitoring of efficiency performance.

Source: Sonoma County Energy Watch Program

Medium Non-Residential Project

Table 59: Project Snapshot — Sonoma County Central Library

Location	Santa Rosa, California (inland area)
Building type	Non-residential municipal structure
Building size	60,000 sq. ft.
Project measures	Lighting retrofit
Total project cost	$120,251
Program incentive	$10,622 — Public Goods Charge incentives through Sonoma County Energy Watch/PG&E
Customer cost	$100,629
Estimated annual savings	$13,806
Estimated annual kWh saved	Up to 98,615 kWh
Avoided CO2 emissions	2.49 metric tons per year
Financing	Self-financed

Source: Sonoma County Energy Watch Program

Small Non-Residential Project

Table 60: Project Snapshot — Occidental Community Center

Location	Occidental, California (coastal area)
Building type	Non-residential veteran's building
Building size	7,752 sq. ft.
Project measures	Lighting retrofit
Total project cost	$5,957
Program incentive	$1,510 — Public Goods Charge incentives through Sonoma County Energy Watch/PG&E
Customer cost	$4,447
Estimated annual savings	$1,972
Estimated annual kWh saved	Up to 12,327 kWh
Avoided CO2 emissions	3.22 metric tons per year
Financing	Self-financed

Source: Sonoma County Energy Watch Program

Other Demand-Side Resources

Energy efficiency was the primary demand side resource in the original Climate Plan. However, other demand side resources, as well as distribution grid system improvements, can be deployed to support implementation of distributed generation, some of which are briefly described here.

Combined Heat and Power

Combined heat and power can serve two roles in a RESCO system: it can recover heat that would otherwise be wasted in generating electricity, and—less commonly—it can potentially be used as a load balancing resource that can follow electricity demand, offset variability of intermittent wind and solar power, and provide regulation services as a *spinning generator*. Tapping this expanded potential for combined heat and power would require monitoring and control systems for the combined heat and power system, and could be further enhanced by smart grid technologies that monitor the state of other small-scale generation as well as demand on the local distribution grid. This use was not specifically researched by the Sonoma RESCO Research Team, but is a topic for further exploration and could significantly enhance the viability of high levels of distributed generation.

Energy Storage

There are a variety of energy storage systems that may be applied in a local energy supply portfolio. Some examples are pumped hydro storage, chemical batteries, flow batteries, flywheels, hydrogen, and compressed air. Energy storage can serve multiple functions, two of which are particularly important to deploying high volumes of distributed generation: the ability to provide stable power to back up intermittent renewable generation, and the ability to provide "dispatchable demand" to absorb excess generation, especially from solar or wind power. The extra cost of energy storage systems can be offset through the variety of services it provides, as well as its capacity to enable load shifting where electricity generated and stored during low rate off peak hours can be dispatched during high rate peak hours. Energy storage also reduces the environmental impact of backing up intermittent renewable energy that would otherwise require operation of inefficient load-following operation of natural gas power generators that consume limited resource, emit air pollutants including greenhouse gas emissions.

Demand Response/Regulation

Demand response (DR) is defined as a method of remotely controlling electrical devices such that their electricity consumption can either be reduced or interrupted temporarily. Utility DR programs may be automated for large commercial or industrial customers, or they may be market-based systems where customers offer demand response services to the utility at certain contractually agreed prices. This technique is used by utilities to reduce peak demand during the summer when grid resources are strained, and is offered as a way for those large customers to reduce their energy costs or receive some income while helping to avoid system outages.

Distribution Grid Modifications and Upgrades

Smart Grid

Smart Grid refers to the application of computer information systems to the electrical grid (U.S. Department of Energy 2012a, Web--SmartGrid). A digitally enabled electrical grid is capable of gathering, distributing, and acting on information about the behavior of all participants, including suppliers and consumers, in order to improve the efficiency, reliability, economics, and sustainability of electricity services. In addition to enhancing metering data, a Smart Grid also provides for transmission and processing of data from Supervisory Control and Data Acquisition (SCADA) systems. SCADA systems are used to monitor the status of the generation resources and control aspects of their operation. SCADA can also be used as part of SmartMeter™ operation to monitor load conditions on the customer side of the meter (Pacific Gas and Electric Company 2012n, Web--SmartMeter).

Microgrids

Microgrids are essentially scaled down or localized versions of the larger macrogrid and that are interconnected to the macrogrid. They feature components analogous to the macrogrid including generation, distribution, regulation, and end use. Microgrids are emerging as a new electricity supply scenario in large part as a result of the emergence of distributed generation resources like fuel cells, combined heat and power, and solar photovoltaics. Applications for microgrids include municipalities, business campuses, educational institutions, industrial facilities, hospitals, etc. Although a microgrid application is not described in this report, the University of California, San Diego, is developing a microgrid on campus for its RESCO project.

Islanding

Islanding refers to the ability of a portion of the distribution grid to continue supplying power during a disturbance or failure of the larger electrical grid. In normal grid operation this is considered a hazard, because the charged circuits pose a risk to repair crews that expect the power to be off. Intentionally engineering such a capability is performed for the purpose of providing local grid reliability that can have significant economic and security benefits. Islanding is made more possible because of the increasing proportion of distributed generation. Although islanding is not explored in this report, it is a subject that is worth investigating in future RESCO research.

Distribution Grid Impact Minimization

Distributed generation (DG) interconnection necessarily affects normal distribution grid function, especially at higher degrees of penetration. Pursuant to Assembly Bill 578 (Blakeslee, California Assembly Bill 578, Chapter 627 Statues of 2008) that required the California Public Utilities Commission to submit to the legislature a report on the impacts of DG on California's distribution grid, the CPUC commissioned a report, released in January 2010, that found that given the low degree of penetration of DG to date, there are "no noticeable impacts on the distribution and transmission infrastructures, based on performed studies" (Itron 2010).

However, given the inevitable growth of DG, impacts should be expected. These impacts are not insurmountable barriers to increased DG, and should be seen as opportunities to develop

consistent interconnection policies so that the benefits of DG, including its feature of reducing peak demand, can be maximized.

A program that intends to expand DG beyond a relatively small portion of electricity supply will very likely need to implement specific technologies and operational capabilities, such as distributed energy storage, inverters that can perform load curtailment, and distribution grid monitoring equipment, so that technical limitations of the current distribution grid do not limit further deployment of local power generation.

CHAPTER 7:
Finance Structures

Securing the necessary financial resources is essential for building local clean energy projects. The initial construction cost of energy infrastructure, including renewable energy, entails borrowing and/or finding suitable investors. The upfront investment usually carries an additional cost burden in the form of interest payments and profit returns that, over the lifecycle of the project, might easily rival the initial construction cost. Thus, reducing financing costs can be a major tool for making renewable energy more affordable. Financing, in the sense it is used here, refers to the following four categories that should be properly coordinated with each other:

- Obtaining money to cover upfront costs.
- Channeling streams of revenue and value to repay the investment costs.
- Deciding on the forms of ownership.
- Creating program structures to support the financial transactions above.

These elements feed into one another in numerous possible ways. For example, a community choice aggregation program can provide different possible revenue streams for renewable projects through the money collected from retail customers. These might take the form of purchasing the electricity generated; paying for renewable energy attributes; or providing direct subsidies. By creating one or more of these value streams, the community program can then become the basis for projects to secure investment funds.

Various forms of ownership will reallocate who bears the cost of paying for the renewable project. For example, private ownership of rooftop solar projects will have a different effect on community energy costs than if the community energy program directly owns the project. Furthermore, certain subsidies either in the form of cash or tax benefits may only be available to certain types of owners, or for specific types of financing.

A local resource may be physically available, and there may even be a need for it. Financing is the "third element" that ties these together and actually builds projects. Different financing arrangements have different effects, such that a resource option that looks infeasible or too difficult under one arrangement can open the door for project development using a different set of financing tools. Program developers should become aware of the available options to find what works best for each community.

The discussion in this section will focus mainly on financing solar photovoltaic projects in order to simplify and focus the narrative. However, the concepts can be applied to other sources of local clean energy, even if specific factors — such as financial risk, available subsidies, project costs, and the energy generated — will be different in each case.

Capital

The initial investment in renewable energy projects must be sufficient to pay for all facets of project development, including planning, investigating the resource availability, permitting and fees, construction, and interconnection with the grid. Three main sources for upfront money are discussed here: bank loans, bonds, and ownership equity.

Bank Loans

Bank loans are a common way to help fund energy infrastructure. For a commercial project, the bank will lend an amount covering a major fraction, often ranging from 50 percent to 70 percent, of the capital cost. The balance of funds is supplied by one or more investors who own the project. For non-commercial projects, such as a homeowner who buys a solar PV system for their roof, their share would appear as a down payment. Obtaining loan money of any sort requires showing creditworthiness of the borrower as well as demonstrating a revenue cash flow on the project sufficient to repay the loan. The revenue cash flow needs to exceed the loan repayments and other fixed operating costs by a certain fraction, referred to as the debt service ratio.

The loan may be secured by the cash flow or by having the project itself as collateral in a manner similar to a home mortgage. The fact that a solar PV project is attached to the roof or other part of a building may help a bank to see a loan to a PV system as more like a mortgage than a home equity loan, and gain the benefit of lower interest rates. This cannot be assumed, however, but could be arranged by a community energy program, especially if the program offers other types of financial support to projects seeking loans.

One of the characteristics of a bank loan that is particularly relevant for renewable energy project costs is that both the principal and the interest are paid over time. Thus the interest is paid on a declining principal. This reduces the cumulative interest expense to a much lower amount — by about half — compared to what it would cost if the principal were paid back at the end of the loan period.

The time required for paying back loans is a double edge sword from the standpoint of making renewable energy affordable. If a loan is financed over a longer period, then the annual payments are lower than if the project were financed over a shorter period. However, longer period loans will accumulate much more interest over time than a short period loan.

Table 61 shows a simple model for the cost of a 4-kilowatt residential rooftop solar PV system installed at a cost of $6000 per kilowatt of capacity, with an assumed 30-year financial lifecycle. All assumptions are the same, except the term of the loan ranges from as long as the full 30 year financial lifecycle to as short as 5 years. In actual cases the interest would be somewhat higher for longer-term loans than for shorter term, but this model makes the simplifying assumption that the interest rate is the same for all loan terms over the full range of durations. The energy production is 1400 kilowatt-hours per year for every kilowatt of capacity installed, decreasing at the rate of 0.5 percent per year, and the project is assumed to last for 30 years. The O&M expense is assumed to cover both regular maintenance as well as periodic replacement of the inverter.

Table 61: Solar Energy Cost Based on Loan Terms

Simple Model of Cost of Solar Energy at Various Loan Terms					
Project Size	4	4	4	4	kW
Specific Cost	$6,000	$6,000	$6,000	$6,000	per kW
Installed Cost	$24,000	$24,000	$24,000	$24,000	
Interest Rate	5%	5%	5%	5%	per year
Loan Term	30	20	10	5	years
Cumulative Interest	$20,607	$12,682	$5,601	$2,397	
O&M	$75	$75	$75	$75	per kW-yr
Total Lifecycle Cost	$53,607	$45,682	$38,601	$35,397	
Specific Yield	1400	1400	1400	1400	kWh/kW-yr
Lifecycle	30	30	30	30	years
Lifecycle Generation	151,200	151,200	151,200	151,200	kWh
Monthly Loan Payment	$124	$153	$247	$440	
Cost of Energy	$0.355	$0.302	$0.255	$0.234	per kWh

The 30-year long-term loan results in monthly payments of only $124, while paying down the project over only 5 years results in monthly payments of $440. Spreading out the loan over many years clearly makes the monthly payments much more affordable. On the other hand, the longest period 30-year loan accumulates over $20,000 in interest, while the 5 year loan only costs about 1/10th as much in total interest payments. Paying the loan over 30 years result in a cost of energy of over 35 cents per kilowatt-hour, while paying down the loan in 5 years cuts to cost of energy to 23.4 cents per kilowatt-hour, a reduction of 33 percent.

The practical implication is that for those people who can pay down the upfront cost of their solar project in a shorter period of time, solar energy will reach *grid parity* much sooner than for people who need a long term loan to make the monthly payments affordable. Furthermore, stretching out the loan over a long period is also important for owners of solar PV projects that are engaging in electric power sales or solar lease arrangements, in order to bring the loan payments closer in line with the stream of revenue.

Bank loans have versatility in that they may be obtained relatively quickly, and over a wide range of financial needs — from very small to very large projects.

Bonds

A bond is a financial instrument though which money is borrowed from investors who "purchase" each bond for a certain price. Bonds are in some ways like a hybrid between bank loans and stocks. The bonds pay a percentage rate of return on the initial cost of the bond, called the "coupon." The bond is structured to borrow the money for a specific length of time, in which respect it is more similar to a fixed term bank loan than a stock.

However, unlike a conventional energy project loan, the principal is usually not paid down over time on a given bond. Rather the full rate of interest is paid on the initial amount of money borrowed through issuing the bond for the full length of the bond, when the bond principal is repaid. A bond will for this reason pay much more cumulative interest than a declining balance loan, assuming that the loan's interest rate is the same rate as the coupon on a given bond.

Often a bond coupon will actually be much lower than the interest rate on a conventional loan, which can to a certain degree level the playing field between the two sources of borrowed money.

The date of repayment is called the "maturity." Between the date of initial issuance of the bond, up to the time it is retired, the bond may be bought and sold by various investors, and the price of the bond may vary somewhat.

Bonds may be taxable, meaning that investors must pay income tax on the coupon payments they receive. Local governments have long been given a special provision under the U.S. tax code whereby they can issue tax-exempt bonds. This means that investors do not pay tax on the coupon payments that they get. This in turn allows municipal governments to pay a lower interest rate on tax-exempt bonds which offsets the tax savings of the investor.

If tax-exempt bonds are used, they often carry implications for subsidies which may be decreased or unavailable for renewable energy projects. So, while bonds can lower the cost of renewable energy, it is necessary to make financial comparisons for specific projects to determine the least cost financing option.

Another important implication of tax-exempt bonds is that they must be used for non-profit purposes. Energy infrastructure that is financed in this way, in addition to reducing the interest cost on borrowed money, eliminates the cost of paying for profits.

Tax-exempt bonds also have political implications in that the projects financed in this way become, in an important way, public infrastructure rather than serving private gain. Furthermore, the project risks and benefits become more tied to the political structure. If a local government has too much uncertainty about energy infrastructure, as well as the bond financing mechanism, this can create hesitation on the part of political leaders to use bond financing. On the other hand, local publicly owned utilities routinely issue bonds for constructing energy projects.

Bonds issued by governments need to be attached to a specific revenue stream that can repay the bond. If the bond is tied to tax revenues of the government agency, then it is called a "general obligation bond," and can put a burden and risk upon the taxpayers. Alternatively, if a renewable energy project produces income, then this stream of income can assure repayment. A bond that is repaid the income from the project is called a "revenue bond," which is not generally tied to tax revenues. Revenue bonds are considered by investors to carry a significantly higher risk than general obligation bonds, which is offset by revenue bonds carrying a higher rate of interest or "coupon."

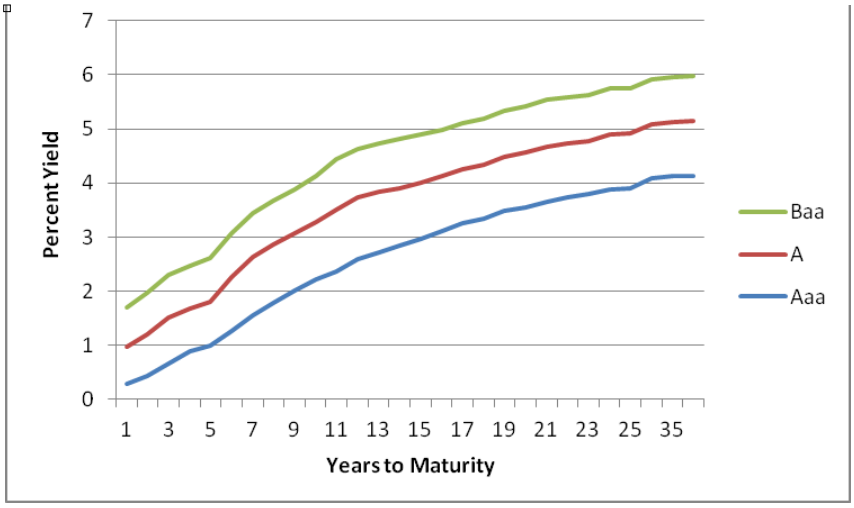
Another important feature of bonds is that they carry significant transaction costs. For this reason, it normally does not make sense to issue bonds to finance small energy projects. Bonds are thus issued to raise multiple millions of dollars at a minimum.

As in obtaining a bank loan, bond issuers must demonstrate a financial capability to repay the loan as well as general creditworthiness. Establishing credit for a new agency can take some time. Supplementing the cash revenue stream from specific energy projects with the general

revenue of a community energy program is one way to enhance the financial viability and creditworthiness of specific projects as it can help assure a better debt service ratio. On the other hand, excessive indebtedness which is relatively large in comparison to the agency cash flow could undermine good credit as well as fiscal prudence. Investments need to be balanced between these factors.

Figure 59 shows municipal bond annual yields for maturities ranging from 1 year to 40 years. Rates increase as the time to maturity increases. Financing renewable projects with 20-year maturity bonds would carry a rate between approximately 3.5 percent and 5.5 percent, depending on the credit rating of the bond-issuing agency. This shows the importance of good credit. Rates would be somewhat higher for revenue bonds.

Figure 59: Municipal Bond Yields



Equity

The cost share of the project which investors or other project owners have paid for with their own money is the equity or ownership share. In commercial transactions, equity usually carries the cost burden of producing a rate of profit. Profit rates may be significantly higher than interest rates on loans, and the profit is made on the initial investment. In some cases, the equity share may decrease over time as the property value depreciates. Utility profit rates may be calculated based on depreciating equity value.

Equity does not always have to carry a rate of profit. For example, a homeowner may pay upfront for part or all of a solar PV system and not take a profit. Similarly, a public agency or non-profit organization may own all or part of a solar PV system and not take any profit from it. This will greatly reduce the lifecycle cost of energy from the project. Equity also has implications for being able to take advantage of certain tax credits.

Revenue

In order to secure financing, and in order to justify the expense, renewable energy projects need to generate revenue for their owners. This revenue can take different interesting forms. For example it may involve direct payments to the project owner by a utility or a community choice program, in compensation for electricity supplied by the project. Alternatively, the "revenue" can take the form of avoided expenses, such as utility bill savings created by rooftop solar projects, or taxes that do not need to be paid by project owners. In the same way that the structure of capital investments can affect tax liability, the various forms of revenue for renewable energy projects may also have tax implications.

Some revenue streams are governed by state regulations, while other revenues may be established, or modified and enhanced, by community energy programs.

Net Metering

Net Energy Metering (or "net metering") allows customers who have solar PV systems on their roof or property to apply a monthly credit to their electric bill based upon how many kWh their solar PV system generated in that month. This support policy ties the value of solar energy to the electric retail rate of the customer. Net metering was originally designed to provide a higher value than if solar PV were to sell power in the wholesale electricity market. Typically, the average wholesale cost of electricity is roughly half of the total customer rate. For instance, PG&E's wholesale energy component of the customer bill is about 8 cents per kWh, while the average retail rate is close to 18 cents per kWh for most residential customers (Pacific Gas and Electric Company 2012k, Web--Rate Filings) (Pacific Gas and Electric Company 2012e).

Historically the cost of solar energy has been much higher even than the retail rate of electricity. However, decreasing prices for solar installations has brought solar energy closer over time to the retail rates in parts of the country that a) have higher retail rates, and b) have better solar resources. Most of California has both of these features. Having the cost of solar energy reach the retail rate — a concept known as "grid parity" — is a major policy goal for solar PV programs that provide subsidies and other forms of support for this technology. Grid parity is where the market for solar energy should at least in theory no longer require subsidies such as rebates.

However, this issue of grid parity is more complex than it first appears. Grid parity is not a simple price point, especially for customers of the Investor-Owned Utilities in California which have somewhat complex rate structures (Table 62). Residential customers of PG&E have a tiered rate structure that progressively charges higher rates as the customer consumes more energy in a given month. This structure is designed by state regulators to encourage energy conservation, since the higher tiers are much more costly than the Tier 1 or "Baseline" rates.

Table 62: PG&E Basic Residential Rates in 2011

Rate Schedule	Rate Design	Minimum Energy Charge (per meter per day)	Discount (per dwelling unit per day)	Minimum Average Rate Limiter (per kWh per month)	Energy Charge[1, 2] ($/kWh)					"Average" Total Rate[3] (per kWh)
			ES, ET, ESL & ETL Only	ES, ET, ESL & ETL Only	Tier 1 (Baseline)[4]	Tier 2 (101-130% of baseline)	Tier 3 (131-200% of baseline)	Tier 4 (201-300% of baseline)	Tier 5 (Over 300% of baseline)	
Residential Schedules: E-1, EM, ES, ESR, ET	Tiered Energy Charges	$0.14784	ES = $0.10579 ET = $0.37925	ES and ET $0.04892	$0.12233	$0.13907	$0.29276	$0.33276	$0.33276	$0.18299

Source: PG&E Residential Rates in 2011 (Pacific Gas and Electric Company 2012h)

For customers who are frugal electricity consumers, their electric rates will be 12.2 and 13.9 cents/kWh, while "energy hogs" will pay 33 cents/kWh — almost three times the "Baseline" rate. The amount of electricity allowed to be consumed at the Tier 1 rate is set according the climate zone, and the higher tier rates are based upon consumption at percentage ranges that are higher than the maximum allowable energy for the baseline rate. Baseline consumption is adjusted according to various climate zones to avoid inequitable treatment of customers based merely upon where they happen to live. The difference in weather can have a large effect on utility customer electricity consumption; the coastal climate is temperate and customers tend to have low energy use, while the inland climate is more variable with high temperatures in the summer that imply reliance on air conditioning that consumes a lot of energy.

Nearly all of Sonoma County is in PG&E's Zone X, in which most residential customers are allowed to use about 11 kWh per day and pay the baseline rate; the daily allowed usage is multiplied times the number of days in a given month to determine the baseline kWh in a given month. The other rate zone in Sonoma County is a narrow strip along the coast, which is in Zone T and has lower usage baselines that are adjusted according to the lower average coastal electricity consumption levels. Assuming an average month of 30 days, up to 330 kWh per month will be charged at the low baseline rate for customers in Zone X. The baseline rate of 12.3 cents/kWh is paid for the first 330 kWh in Zone X for the summer, and slightly more electricity use is allowed during winter (Pacific Gas and Electric Company 2012p).

Those who use more electricity than the baseline allowance in each zone pay for the extra amount at successively higher rates according to how much electricity they use above the baseline, but the net overall bill rate will be an average of the electricity blended at the different rates. Even though the Tier 3 rate is much higher at 29.3 cents/kWh, the customer's average rate will gradually increase as they use more electricity above the limit of usage for the 13.9 cent/kWh rate. The average blended rate for all residential customers in PG&E's territory is estimated by the utility at 18.3 cents/kWh, which is much less than the cost of energy from solar PV, given the assumption of Q3 2011 CSI project prices, a 30 percent tax credit, and financing costs of 7 percent.

The higher tier prices of 29.3 and 33.3 cents/kWh are much closer to the cost of solar PV, but only become effective for valuing solar PV when the customer consumes a lot of electricity at these higher rates — in other words, they have to be consuming far more than the average residential customer. Only a fraction of customers actually consume enough electricity at these higher rates to make investing in a solar PV system into a reasonable proposition; however, this

assumes that solar PV cost of energy for a residential customer can reach into the range of 30 cents/kWh. In 2008 and 2009, PG&E had a five-tier rate structure where the highest tier rates exceeded 40 cents/kWh. The utility prevailed upon the CPUC to reduce the number of tiers from 5 to 4, and also to reduce the top tier from 48 cents/kWh to 33 cents/kWh. This reduction had to be done without unduly changing the total revenues, which could only be accomplished by increasing lower tier rates to offset the cut in the high tier rate.

An average residential solar PV system in California is 3 to 5 kW in size. A 4 kW PV system will generate about 500 kWh per month, which is 150 percent of baseline. Since net metering is only a credit on the bill against kWh used, its value is closely tied to the customer's utility rate. For a customer on a tiered billing rate, the solar PV system will first remove the highest rate electricity, then the next highest rate, and so on. Thus, the value of solar is better if 1) the customer uses electricity in the higher rate tiers, and b) for customers that do not use extreme amounts of electricity, the solar PV system produces less than the customer uses such that its value is skewed more toward removing higher rate tiers.

For a customer that consumes 616 kWh per month, the average of a Sonoma County residence, a 5 kW system will generate about the same amount of electricity as that customer uses, and this will zero out the customer's average monthly bill. Of course, some months will have higher or lower consumption over the course of a year, and similarly, the solar PV system will also fluctuate in generation over the year — producing more in summer and less in the winter. Net metering compensates for this by allowing excess electricity in a given month to "roll over" into subsequent months until it is used up. The maximum credit period for rollover solar credits is usually a year, during which time the solar production and customer consumption should average out in a more balanced way compared to the month-to month fluctuations.

In the example of a residential customer with 616 kWh average consumption per month, their current rate will be about 17.7 cents per kW-hour. Thus, a 5 kW system that generates exactly this amount of electricity will also be worth about 17.7 cents per kW-hour. This is not exactly correct, since the utility also maintains a certain minimum charge that the customer must pay even if they don't use any net amount of electricity from the grid. In fact, utilities can actively undermine the value of net metering through adding charges that are imposed on net metering customers. However, ignoring the minimum charge, the solar electricity will be worth the rate value of the electricity removed from the bill. Since the higher tiers are removed first, under-sizing the solar PV system will increase its value. Table 63 shows the results of modeling the increase in the net meter value of solar PV as the solar PV projects gets smaller relative to the customer bill.

Table 63: Net Meter Rate Value of PV System

Net Meter Rate Value of PV System		
PV Project Size	Monthly Solar Generation	Rate Value
kW (ac)	kWh	per kWh
5	625	$0.176
4	500	$0.189
3	375	$0.212
2	250	$0.254
1	125	$0.293

The Net Metering structure strongly rewards under-sizing the PV system compared to the on-site demand, valuing far more the electricity from a 1 kW project than a 5 kW project. This is a perverse incentive to the extent that (1) larger PV systems are more cost effective than smaller ones, and (2) larger PV projects mean more development of the local renewable energy potential.

Table 56 is focused on the typical residential customers, but there are other customer classes that do not get the same value for solar PV. For instance, low income customers pay discounted rates as part of the CARE program; this program helps many people to afford their utility bills. The residential CARE rates for PG&E in 2011 are 8 to 9 cents/kWh, and only includes the lower two tiers, which spares low-income customers the burden of the high Tier 3 and 4 rates. Since net metering values solar PV at the customer retail rate, CARE net metering customers would only receive a bill credit of 8 to 9 cents/kWh for energy generated by an on-site solar PV system. The unequal benefit for solar PV for low-income customers represents a "policy hole" in the net metering program. Most support programs for solar have policy holes where one or market segment will be underserved.

In net metering, the solar PV system is said to be "behind the meter," which is true partly because the system is physically and electrically connected to wires that are in fact behind the customers meter from the perspective of the utility. The PV system is also behind the meter in a functional sense, in that it does not appear as a power generator on the grid. Rather it appears as something that reduces the on-site demand. In this sense it is almost like a negative generator, which removes revenue from the electricity retail seller. And just as the customer value is established by the highest tier that is first removed, in the same way the kWh that pay the highest customer rate will also be removed from the utility's revenue stream first.

The financial effect of net metering for a CCA program is related to the fact that CCA revenue is only tied to the energy portion of the bill. In PG&E's rate structure there are independent charges for the electrical energy supply (called the energy charge), and the infrastructure and utility operations charges (called the distribution charges). The new rates for PG&E will in the future be a flat charge that has no tier structure for the energy supply portion of the bill, and a heavily tiered structure for the distribution charges. Since CCAs only deal with the energy charge, this means that setting customers up with net metering, and specifically targeting

customers that have high energy consumption, should not affect revenues of the CCA in a disproportionate way as it would have when the energy charges were also tiered.

There are several important limitations that are part of ordinary vanilla net-metering:

- Net-metering requires a project to be physically located at the same site as a customer. In many cases this may be satisfactory. But the on-site limitation can also eliminate many customers from participation in the net metering program. For instance, homes or businesses with excessive shading or inadequate roof conditions may not be suitable for solar installations. Also, renters may be excluded from the program because they do not own the roof, or they may move frequently so that investing in a solar project that has a long payback period is not worthwhile. The onsite requirement, if narrowly construed, ties one solar project to one utility meter; this could be a significant barrier to allowing multiple customers to share a single larger, and more economical, project in common.
- Net-metering limits the size of individual projects to the amount of electricity that a customer uses in a year or less than that amount. The excess electricity over what a customer uses in a year is historically given to the utility for free, although a new California law (AB 920) requires payment for the excess generation. However, the payment is so low that it is a substantial financial loss for a customer to generate excess electricity. The customer can address this problem by building a smaller project, but this reduces the solar projects to much less than the physical rooftop potential. Smaller projects also cost more per kW. Thus, net-metering limits can actually increase the cost of solar electricity.
- Net metering also has program caps for the utility's entire service territory. In California the program cap is 5 percent of the utility's peak load. Since California's peak load is about 60,000 megawatts, the 5 percent program cap is just enough to fit the CSI program of 3000 megawatts, however this would not be enough to include solar projects built prior to the CSI program, or other small-scale generation in California that is net metered but not solar. The CSI program in PG&E's service territory is expected to reach the cap some time in 2012. This puts the entire small-scale solar market at risk unless the cap is increased. The fact that net metering drains all the revenue for the utility from net meter customers creates an inherent tension between utilities and net metering. Utilities claim that a net meter customer is using the utility services by drawing power from the grid at night when the solar project is not generating electricity, and exporting excess power during the day. But the net meter customer is not paying for these services since net metering "zeros out" the bill. In response to this challenge to their basic business model, the utilities are proposing network charges for net metering that — if implemented — would reduce the value of net metering. Alternatively, it may become increasingly difficult to increase the net meter program cap as utilities try to draw a line in the sand to protect their business revenues. Thus, net metering is likely to face major problems in scaling up beyond the current modest levels.
- As discussed above, Net Metering ties the value of solar for the customer to the utility retail rate. This is a double edge sword. Initially it increased the value of solar above the

wholesale cost of electricity and provides the net meter customer with the higher value of the retail rate. However, this creates certain mismatches between the cost of solar and the complex and ever changing retail rates. Low-income customers are treated unfavorably by net metering for solar, by the same rates that benefit these customers by reducing their retail bills. In addition, high-energy use customers are rewarded with high value for solar, while customers that conserve energy will tend to be pushed out of the range where solar makes financial sense. Over time the price trends for retail rates and solar energy are travelling in opposite directions. Retail rates will increase as solar costs decrease. At some point in the future, net metering may actually overpay for solar which could become an increasing problem in the next decades.

Surplus Net Metering

Net metering places the solar project behind the meter and the customer only gets credit on their bill; no payment is made by the CCA. The budget impact to the CCA should be minimal, if the CCA actually reduces procurement of wholesale energy in proportion to the amount of net-metered energy. The net-metered energy will tend to offset a higher amount of procured energy due to the fact that off-site generation involves line losses in the transmission and distribution network of approximately 9.6 percent in PG&E's service territory.[32] This represents loss of both energy and capacity. If the general PG&E line loss figure is applied to the CCA, then the CCA will need to purchase about 10 percent more energy on the wholesale side to make up for the equivalent of what is not developed locally either in the form on-site generation or demand reduction measures.

One important policy gap that a local CCA program can address is the purchase of excess electricity from net meter projects. PG&E will purchase the excess generation of a net-metered solar project, but only on a very low rate schedule based upon daily wholesale prices that are far below the actual average cost of PG&E's electricity supply (Table 64), since the utility only buys a small fraction of its power on the open market.[33] The Net Surplus Compensation Rate is far lower than the cost of generating solar power on customer rooftops, and in 2011 decreased from 4 cents/kWh to 3.6 cents/kWh (Pacific Gas and Electric Company 2012f, Web--Net Surplus Rates). Another ruling of the CPUC is supposed to establish an additional payment rate per kWh that covers the "renewable value" of the surplus solar power which should increase these prices somewhat in the future.

[32] The published values are 9.6 percent of energy, and 9.7 percent of peak load (California Energy Commission 2009, Page 50).

[33] The method for determining the Net Surplus Compensation Rate was set by the CPUC in Decision 11-06-016 (California Public Utilities Commission 2011).

Table 64: PG&E Net Surplus Compensation Rates

True-up Month	NSC Rate* ($/kWh)
Jan. 2011	0.04026
Feb. 2011	0.03906
Mar. 2011	0.03789
Apr. 2011	0.03675
May 2011	0.03619
Jun. 2011	0.03617
Jul. 2011	0.03597
Aug. 2011	0.03609
Sept. 2011	0.03618
Oct. 2011	0.03643
Nov. 2011	0.03616
Dec. 2011	0.03607
** Per D.11-06-016, the electricity portion of the NSC rate is the simple rolling average of PG&E's default load aggregation point price from 7 a.m. to 5 p.m., corresponding to the customer's 12-month true-up period.*	

Source: *Net Surplus Compensation Rates for Energy* (Pacific Gas and Electric Company 2012f)

The surplus payment is arranged through a tariff price calculated monthly by the utility. The customer needs to agree to sell the excess power to the utility in this program, which is independent of the net meter agreement. Only a small fraction of net meter customers have signed up to receive these surplus payments.

A CCA could set up a program to pay higher rates than PG&E's offer of 3.6 cents/kWh for surplus solar power while avoiding significant increase in CCA customer bills. The surplus energy beyond what the customer uses on-site would be transferred by contract to the CCA through a power purchase agreement that sets the price and provides for purchase of the rights to renewable energy credits associated with the energy. A similar program has been developed by Marin Energy Authority (Marin Energy Authority 2012, Web--Net Energy Metering).

This particular structure of purchasing the surplus energy from net-metered solar PV assumes that the net metering continues in the future through an increase in the net metering program cap. While this is likely to happen, CCAs have other options for supporting local solar projects.

Solar Shares and Remote Net Metering

An important enhancement of net metering is to overcome the initial limitation that projects must be located at the same site as a customer's electric meter. A customer's particular roof space may not be ideally suited for solar projects; there may be excessive shading, inadequate roof structure, or the customer may be a renter who does not own the roof. In addition, if a residential customer has small electricity demand putting an excessively small solar project on the site will significantly increase the cost per unit of installed solar. California has adjusted its policy to include the flexibility to build solar projects on a roof where the benefits of the bill credit are shared by multiple tenants, a limited expansion of net metering.

Further reforms are being considered by the state legislature that would allow utility customers to obtain net metering credit for solar projects that are remotely located in ideal places for solar

power, such as large flat commercial or industrial rooftops, or on suitable locations on the ground. These projects, referred to as "community solar" or "solar gardens," are much less costly on a unit basis than residential rooftops. Individual customers could purchase small "shares" of the larger system, and credit their bills based upon the energy generated by their share of the remote solar project. This would have large cost savings for consumers while allowing customers to own shares even if they are renters, or if they should move to another location within the area. The specific rules for such legislation will determine if the program is viable.

There are efforts by utility companies to impose extra charges for remote net metering that would undermine the benefits and feasibility of this approach. A community energy program that intends to develop solar gardens would need to insure that potential utility charges do not interfere with the financial viability of remote net metering.

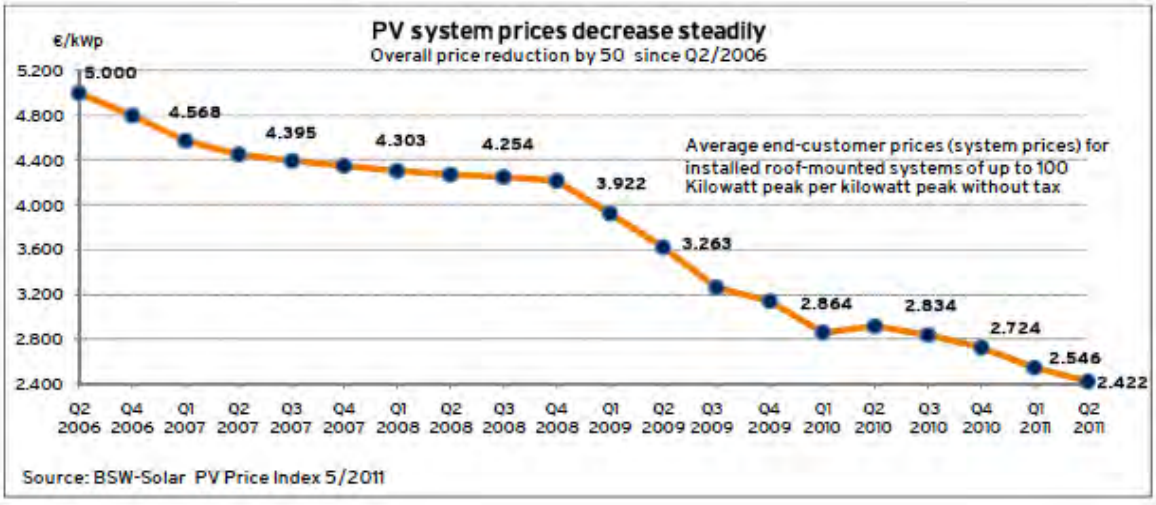
Feed-in Tariffs

One of the most effective policies for promoting development of solar energy is to purchase electricity from solar projects a fixed price schedule called a *feed-in tariff*. Feed-in tariffs are purchases of electricity, usually by utility companies, from solar project owners through a long-term contract typically lasting 20 or more years. The long-term contract helps reduce the price per kWh partly by spreading the cost over more years, and partly through standardized terms which reduce the cost and risk to developers. The lower risk can result in lower financing costs. A best practices feed-in tariff sets prices based upon the full lifecycle cost of generation, including equipment, installation, operation, financing and a modest profit. The price must also relate to the solar resource in the area where the projects are to be built.

California has created feed-in tariffs that can be used for solar projects, but in PG&E's service territory the prices have been too low to include smaller scale solar projects.

The feed-in tariff has similar advantages to the performance-based incentive (PBI) in that it rewards improved electric generation from the solar project. The feed-in tariff has the further benefit that it also encourages project owners to look at the full benefit to cost equation much more carefully. This framework of "benefit to cost" can put downward pressure on installed and lifecycle costs of solar. The solar feed-in tariffs tend to start relatively high, which is seen by policymakers as an initial investment that delivers future gains. Then it is decreased on a schedule at a percentage rate called a "degression." In this regard it is very similar to California's rebate structure of decreasing rebate payments over time. A combination of systematically pushing down solar cost through structured decreasing tariff payment rates over time, building up market volume to achieve economies of scale, creating a predictable market pricing framework, and reducing barriers for small-scale solar can be very effective. In Germany, prices for small-scale rooftop solar projects less than 100 kW, shown in Figure 60, have decreased by 50 percent since 2006. In 2012, small-scale rooftop solar projects in Germany cost half what they do in California, at only about $2.40/watt (dc) in U.S. currency (1.85 Euro per watt [dc]). This shows how well designed feed-in tariffs can be used to overcome one of the primary objections to solar energy, by greatly improving its affordability.

Figure 60: German PV System Price Decrease



Source: *Photovoltaic System Prices Decrease Steadily* (German Solar Industry Association (BSW-Solar) 2011-2012a)

Current German feed-in tariffs in December 2012 are about 16 to 24 cents/kWh in US currency (Bundesverband Solarwirtschaft 2013). This is remarkable considering there are no tax benefits, rebates or other financial supports for solar PV like there are in the US, and the solar resource is much lower in Germany.

Power Purchase Agreements

A power purchase agreement is established usually through a negotiated contract with a third party supplier. A contract with an existing renewable energy project may be comparatively short term, such as 5 or 10 years. However, a power purchase agreement can also be used to bring about the construction of new energy projects, in which case the contract generally needs to be for a long enough term to recovery the initial investment cost at a reasonable rate per kilowatt- or megawatt-hour.

Power purchase agreements can be made at almost any scale. A number of solar companies allow customers to enter into power purchase agreements where an investor owns the project and takes the tax credits. The third party developer arranges for an installer to construct the project and arranges for maintenance over the life of the contract. The third party takes any available rebates, and also sells renewable energy credits to help cover the cost of building, financing, owning and operating the solar project. The customer avoids any upfront cost, which eliminates one of the main barriers to "going solar," and the vendor tries to arrange a deal where the cost of the solar energy on a per kilowatt-hour basis is lower than the customer's current utility rate. This rate is usually increased at a fixed percentage per year for the duration of the contract. The customer must usually also be eligible for net metering. All these elements are necessary to make the "deal" possible.

Power purchase agreements are the norm for renewable energy projects that supply power to utilities and community energy agencies, such as municipal utilities or community choice

aggregators. The advantage of a power purchase agreement is that it transfers a number of burdens from the purchaser to the seller, including:

- Securing project financing
- Project planning, permitting, development and construction
- Operation and maintenance tasks
- Operational and performance risks
- Commercial and financial risks

On the other hand, a power purchase agreement from a third party owner requires the customer or community energy program to pay enough to cover the cost of profits as well as the risks assumed by the third party. This will offset some of the benefits of third party ownership.

The conditions and requirements of the contract can significantly affect the viability of a project, including its ability to secure financing and to provide energy at a reasonable cost. One way to simplify third party purchases is to devise a standard contract which can reduce time, risk and transaction costs associated with contracts that are individually negotiated. A standard contract with an administratively fixed price would be a feed-in tariff, but in another contract structure the prices could be left open to negotiation even if the contract terms and conditions are standardized. A community choice program could be involved with the contracting process for wholesale power, or the power contracts could be managed by the energy service provider.

Subsidies: California Solar Rebates

One of the most important market supports for solar PV in California has been paying customers rebates. The rebates are a state program that is funded by a very small surcharge on all customer bills. In most cases, each utility processes the rebate payments. The current rebates in California are offered as part of the GoSolar program, while allocates $3 billion to support installation of 3,000 megawatts of new solar PV. The average program rebate is worth $1.00 per watt, but is structured in “steps” where the first solar projects get the highest rebate, and rebates are decreased as specific amounts of solar are built and funded by the program.

The GoSolar program has several components, the largest of which is the California Solar Initiative, which provides rebates to customers of the State’s three largest investor-owned utilities. In the CSI program there are 10 steps with pre-established rebate payment rates that were originally intended to be paid out over a ten-year period from 2007 to 2016. The initial rebate step paid $2.50 per watt for most customers, and progressively decreases until only 25 cents and 20 cents per watt are paid in steps 9 and 10.

One of the other financial supports for solar PV is a federal tax benefit that provides a credit worth 30 percent of the initial cost of the solar PV system. However, this credit is only available to residential and commercial customers that have tax liabilities. Government agencies and non-profit organizations are tax exempt, and so cannot take direct advantage of the tax credit. The

CSI program compensates for the federal tax support policy hole by paying higher rebates to government and non-profit customers.

Another important feature of the CSI program is that payments are calibrated according to the performance of solar PV projects, which is measured according to how much electricity is generated by the solar PV system (Table 65). For small projects, the future performance is estimated using known data about the system components, the angle and orientation of the solar panels, and the amount of shading at the site. The rebate is paid up front, adjusted according to the expected performance. Larger projects are paid a performance-based incentive (PBI) at a rate per kWh generated by the project, according to the schedule of program steps.

Table 65: California Solar Initiative Incentive Payment Schedule

		EPBB Payments (per Watt)			PBI Payments (per kWh)		
Step	Statewide MW in Step	Residential	Non-Residential		Residential	Non-Residential	
			Commercial	Government/ Non-Profit		Commercial	Government/ Non-Profit
1	50	n/a	n/a	n/a	n/a	n/a	n/a
2	70	$2.50	$2.50	$3.25	$0.39	$0.39	$0.50
3	100	$2.20	$2.20	$2.95	$0.34	$0.34	$0.46
4	130	$1.90	$1.90	$2.65	$0.26	$0.26	$0.37
5	160	$1.55	$1.55	$2.30	$0.22	$0.22	$0.32
6	190	$1.10	$1.10	$1.85	$0.15	$0.15	$0.26
7	215	$0.65	$0.65	$1.40	$0.09	$0.09	$0.19
8	250	$0.35	$0.35	$1.10	$0.05	$0.05	$0.15
9	285	$0.25	$0.25	$0.90	$0.03	$0.03	$0.12
10	350	$0.20	$0.20	$0.70	$0.03	$0.03	$0.10

Source: Go Solar California, California Solar Initiative, Statewide Trigger Tracker (Go Solar California 2012a, Web--Trigger Tracker)

The performance-based structure was designed to encourage higher energy production for solar projects, and results from CSI program suggest that this may have been effective. The rate of generation was higher than the program designers originally expected in the commercial sector where the performance incentives were paid and the generation of projects measured with meters (Itron and KEMA February 2010). The higher performance caused a shortage of rebates funds in 2011, a gap that had to be filled by an extra allocation of $200 million to complete the program steps for commercial customers.

The CSI program illustrates an important principle of solar program design, that rewarding performance can generate value. On the other hand, the performance-incentive rebate structure itself does not directly work to reduce the high installed cost of solar PV. And there is evidence that upfront rebates in particular tend to inflate costs in the short term in a manner that offsets about 60 percent of the rebate payment (Galen Barbose 2012). Thus, upfront rebates are not an optimally efficient way to stimulate market transformation, although they do directly and effectively address the single largest market barrier for solar PV, which is high upfront cost. Over time, the rebates also work to stimulate market scale, which in turn reduces installed cost.

The CSI program has been so successful that the rebate claims are years ahead of schedule, and new applications are already in Step 9 in PG&E's service territory, which means new rebates

will only be 25 and then 20 cents per watt in 2012 (Go Solar California 2012a, Web--Trigger Tracker). Furthermore, SB 585, the state legislation that continued funding for the solar program, requires reductions of 4 percent in the performance incentive payments below the original plan which only pay 2.5 and 3 cents/kWh for the first 5 years of a solar project. It is also likely that the program will be fully subscribed within the next year or two, after which current law specifies no further rebates. Thus, any Sonoma County plan for solar beyond 2012 should not expect availability of state rebates from the CSI program.

The average cost of solar projects has decreased over the course of the CSI program from $9.22 per watt (ac) in Q1 2007 to $7.68 per watt (ac) in Q3 2011 — a reduction of $1.54 per watt (ac). During the same period rebates decreased from $2.50 per watt (ac) to $0.30 per watt (ac), a decrease of $2.20 per watt (ac). Thus the decreasing price of solar projects offset 70 percent of the reduction in rebates. Prices of small-scale solar projects will need to go down another $1.00 per watt to bring net customer costs (after accounting for rebates) to the same level as Q1 2007. On the other hand, the federal solar tax credit was expanded in 2008 for residential customers by lifting the $2000 cap and allowing them to take the full 30 percent credit. This offsets the increased net installed cost for residential solar project owners, but not for other small-scale solar market sectors.

Renewable Credits

Renewable energy credits (RECs) are a type of energy derivative where the renewable character or "attribute" of the energy supply is given a market value. In one theory, the REC value is the amount of premium that a renewable energy source costs over conventional grid power. So, if conventional power costs 5 cents per kilowatt-hour and the renewable energy costs 8 cents per kilowatt-hour, the REC would be "worth" 3 cents per kilowatt-hour to cover the difference.

RECs come in several flavors:

- "Bundled RECs" are tied to and delivered contractually with the renewable energy itself to a single buyer; the buyer can then refer to the electricity they purchased as "renewable."
- "Unbundled RECs" may be purchased by a different party than the one who is buying the electricity; in this case the electricity is sold as though it were conventional grid power and the electric energy buyer loses the ability to call it "renewable energy," while the purchaser of the RECs owns the renewable attribute without actually receiving any electric power. If the REC buyer is a retail seller of electricity, then they will need to buy actual electricity from non-renewable sources to supply customer energy needs. California law limits the percentage of unbundled RECs allowed to count toward state renewable energy requirements.
- Tradable RECs (T-RECs) are unbundled RECs that can be bought and sold in a market, perhaps changing hands several times before the final purchaser "retires" the RECs. Tradable RECs require careful tracking by government agencies to insure that they are validly used.

- Solar RECs (S-RECs) are RECs that come specifically from solar projects; solar RECs often arise in jurisdictions that have a certain set-aside requirement for solar energy that retail electricity sellers need to meet. S-RECs are usually significantly more expensive than standard T-RECs.
- Compliance RECs are renewable credits that "count" toward a utility company's or a public agency's state required mandate to obtain a certain amount of energy from renewable sources; there are usually specific requirements for the types of renewable energy that qualify in the state programs.
- Voluntary RECs are bought and sold to individuals, businesses, non-profits, or government agencies that have no legal requirement to meet a standard for renewable energy procurement; voluntary RECs are often purchased as "offsets" to compensate for emissions of carbon dioxide for grid power that is privately consumed, and are purchased to achieve personal or organizational goals. Voluntary RECs are often less expensive than compliance RECs that utilities and other retail seller might be required by law to purchase.

RECs can range in price from a fraction of a cent per kilowatt-hour to ten or more cents per kilowatt-hour, and they may come with a certain "expiration" date after which they are no longer valid for certain legal purposes. RECs that are used in the certain year to meet state requirements are then "retired" so that they could not be double counted in future years. State governments and private certification entities, such as Green-E, develop tracking, accounting and verification systems to attempt to insure that the RECs are valid and not double counted.

RECs can be a way to reduce the cost or increase ease of compliance with mandated or local voluntary renewable energy targets. While the theory of RECs is that they cover the gap in price between renewable energy and conventional energy, this is not always the case in specific markets. If unbundled RECs are priced below that "gap" level, then the RECs may be less expensive than buying renewable energy directly. In addition, unbundled RECs avoid the need to pay for long-distance transmission of the electric power source that supplied the RECs. On the other hand, an unbundled REC purchase increases exposure of retail electricity seller to volatile conventional electricity market prices that are necessary to "back up" the RECs with real energy. In this way, some key benefits of direct renewable energy purchases are lost. One of these benefits is the ability to lock in fixed price actual renewable energy on long-term contracts as "insurance" against electricity market price risk.

Ownership

Different ownership structures for renewable energy projects can allocate costs, risk and benefits in various ways. Each ownership structure has potential benefits as well as potential drawbacks, and affects the ability to take advantage of tax benefits, the type and cost of financing, and who pays for the energy provided. Ownership also has important implications for meeting planning goals, as well the social and political value of specific projects.

Public

Public ownership, on a political and social level, can create the experience of infrastructure that is intended for the common benefit of a community rather than private property intended only for personal or commercial gain. Public renewable energy projects may be constructed by private businesses, but ownership is held by a governmental entity, such a city, school, or agency. In general, public agencies cannot take advantage of federal tax benefits, since these agencies do not pay taxes that the tax benefits would allow them to avoid — and tax benefits are usually credits against tax owed.

On occasion, the federal government has made direct cash payments to local governments to substitute for the tax credit benefits. However, these payments are often available for limited times, and then may be allowed to lapse for years. Community Renewable Energy Bonds, (CREB-Bonds) can side step the fact that local governments cannot take tax credits by transferring the tax benefits to bond holders. The bondholders are given a tax credit in lieu of bond interest (coupon) payments from the local governments. In addition, local governments can issue tax-exempt bonds, where the investor does not have to pay income tax on the coupon payments. This alternative is normally available at any time, but may be limited by factors that affect the ability to issue bonds.

Another major feature of public ownership is the ability to own infrastructure at cost, without the burden of paying for profit or caring about the "payback period" for renewable projects. Projects that take a long time to pay back could thus be acceptable in a non-profit public context, where these projects would be completely unacceptable for commercial owners. Public ownership allows public agencies to take a much longer term planning horizon than what normally is taken by private, for profit businesses.

On the other hand, public ownership also puts project delivery, performance and cost all on to the public entity that owns the project. This may be mitigated, but probably not eliminated, by contract structures that reassign various risks and task to private suppliers. For instance, hydro project owners may join into a risk pool with other hydro owners such that a problem with one site can be covered by other sites until the specific event(s) are addressed.

Third Party

Third parties can play multiple roles in financing a project. One of these has already been discussed in the context of revenue flow in a power purchase agreement. Third parties are also often able to take advantage of tax benefits that are unavailable to non-profit organizations, local public agencies, or corporations that do not generate a profit. Some customers may only be able to take advantage of a portion of the existing tax benefits. These situations create a role for the third party owner. For instance, residential customers are usually only eligible for the federal investment tax credit, currently set at 30 percent. They are not ordinarily able to take advantage of the accelerated depreciation write-off. Another financing element that third party owners may bring in is a marketing apparatus for selling renewable energy credits, which can reduce the cost of energy for customers.

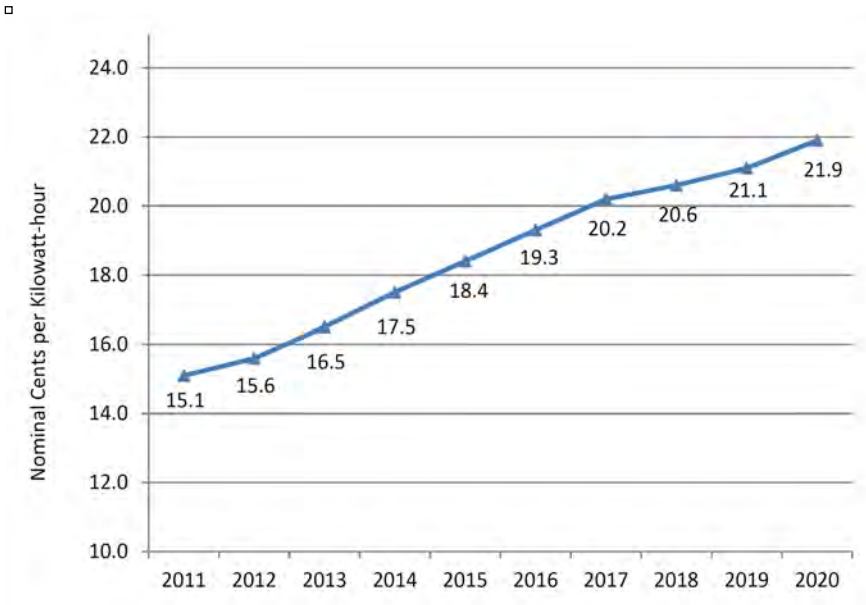
Furthermore, customers may not have the ability or the desire to assume the debt load, risks, or responsibility for performance and maintenance, associated with ownership. A third party owner may be able to supply all of these elements for "the customer" — who could be individuals, businesses, a group of these, or the community energy program.

Customer

An important element of a renewable energy program is to allow utility customers to purchase, finance and own their renewable energy project. This benefits a community energy program by reducing the cost burden on the general rate base for more expensive sources of energy such as solar PV. The customer-owner will then value the energy produced at the retail rate of electricity rather than the wholesale price. For instance, PG&E's wholesale cost of energy for residential customers ranges from 4.8 to 10.2 cents per kilowatt-hour (Pacific Gas and Electric Company December 30, 2011), (Pacific Gas and Electric Company 2012i) after all energy supply charges are included, the average residential retail rate is 18.5 cents per kilowatt-hour in PG&E's service territory (Pacific Gas and Electric Company 2012b, Web--Electric Rates).

As shown in Figure 61, PG&E's current average retail rate for all customers combined is about 15 cents per kilowatt-hour, and future retail rates are expected to increase rapidly over the next decade to 18 cents per kilowatt-hour by 2015 and 22 cents by 2020 (Pacific Gas and Electric Company 2012g). If residential rates maintain the current premium of 2 cents per kilowatt-hour above the average retail rate, 2020 average residential rates can reasonably be expected to cost about 24 cents per kilowatt-hour if PG&E's forecast is correct. Most of these rising energy costs are likely to affect both PG&E's bundled customers as well as CCA customers, since about half of the costs are on the non-energy side of the bill.

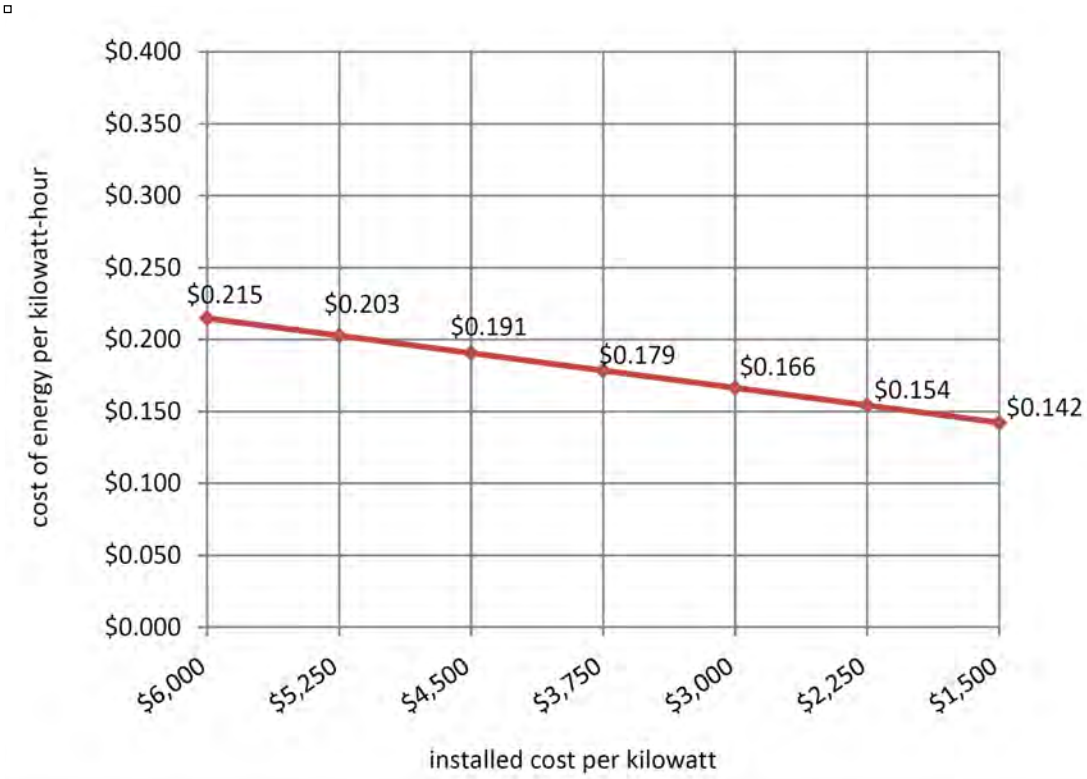
Figure 61: Forecast PG&E Retail Rate



Source: PG&E Bundled Procurement Plan, Mar. 25, 2011, Table PGE-2, sheet # 96.

A renewable energy project, which can be expected to produce electricity from 20 or more years, will thus have value significantly higher than the current electric power rate. If a residential renewable energy project start with an average value of 20 cents per kilowatt-hour in 2015, over the life of the project may be worth 25 to 30 cents per kilowatt-hour on a nominal cash flow basis. If a solar PV project can be installed on a rooftop for less than $5.00 per watt-dc it may start to be competitive with the retail rate of an average customer over the economic life of a PV project, as early as 2015. Smaller scale fuel cells may also become competitive. Figure 62 shows a range of installed cost per kilowatt for fuel cells and the corresponding cost of energy.[34]

Figure 62: Cost of Energy from a Fuel Cell Generator



Where 20 to 25 cents per kilowatt-hour for electricity is well above average residential rates in 2012, this is not likely to be the case in 2020. Even assuming high installed costs of up to $10,000 per kilowatt, a fuel cell may become competitive with retail residential rates by 2020 and beyond. If fuel cell costs can be brought down, through increased volume of manufacturing and learning curves, or through bulk purchase programs, then the competitive picture for fuel cells improves and may become competitive significantly earlier than 2020.

A "discounted cash flow" calculation that is usually performed for business decision-making, will underestimate the future out-of-pocket nominal dollar expense for retail electricity bills. The distributed electric generation project, by locking in a comparatively more definite cost of

[34] Assumes $10/mmbtu fuel, 40 percent efficiency, 6 percent interest on a loan, and a 20-year lifecycle.

energy, provides an "insurance value" against these rising rates, an effect that significantly increases the value of self-generating electric power for many customers.

Hybrid

It is possible to combine some of the ownership elements to optimize the benefits from each type. An example is the *Minnesota Flip*, where a third party developer owns a project for the initial years to take advantage of a tax benefit, and then sells the project at a minimal cost to customers. This transfer can be built into a power purchase agreement, with a schedule of purchase prices based upon the year that the project ownership is transferred.

The low resale price means that the second owner may have inexpensive energy after the transfer. For example, a solar photovoltaic system that is sold after 10 years may still have decades of useful life. If the project was originally constructed for $6000 per kilowatt, a resale price of $3000 per kilowatt accelerates the profit for the initial owner, while securing a valuable energy asset for the second buyer at a much lower cost. With photovoltaics this can accelerate local ownership, but the resale price of the project needs to be evaluated against the potentially lower cost of new PV systems in 10 or more years when the project changes ownership.

Program Design

There are various policy options for a community energy program to support local development of solar photovoltaics. Some of these policies may also benefit other clean energy technologies, but are considered here in relation to solar PV. Local programs can help to fill the gaps in existing programs, and they mostly can be implemented with minimal effect on customer utility rates. All of these programs have been used in local communities, and some, such as feed-in tariffs and solar shares, were invented by communities.

The surplus payment is arranged through a tariff price calculated monthly by the utility. The customer needs to agree to sell the excess power to the utility in this program, which is independent of the net meter agreement. Only a small fraction of net meter customers have signed up to receive these surplus payments.

A CCA could set up a program to pay higher rates than PG&E's offer of 3.6 cents/kWh for surplus solar power while avoiding significant increase in CCA customer bills. The surplus energy beyond what the customer uses on-site would be transferred by contract to the CCA through a power purchase agreement that sets the price and provides for purchase of the rights to renewable energy credits associated with the energy. A similar program has been developed by Marin Energy Authority (Marin Energy Authority 2012, Web--Net Energy Metering).

This particular structure of purchasing the surplus energy from net-metered solar PV assumes that the net metering continues in the future through an increase in the net metering program cap. While this is likely to happen, CCAs have other options for supporting local solar projects. If a CCA's objective is to maximize uptake of distributed generation while reducing the cost burden to the CCA bill payers, then it may be best to adopt more than one strategic program for achieving this goal.

Community Choice Aggregation (CCA)

A CCA program is a right of local governments, either a city, a county, or a group of these, to serve as buyer of electricity for all the customers located in their jurisdiction. This right is established by state law, AB 117 (Midgen Statues of 2002), an implemented by rules created by the CPUC. By law, customers are automatically enrolled, but have the right to opt out of the program. A community choice program allows local governments to contract with an energy service provider, and the energy service provider would then secure the actual power supply on the wholesale market. This allows local governments to participate in the program even if they do not have the "expertise" to actually engage in management of electric power supply.

An important feature of community choice programs is their ability to implement local clean energy initiatives. For example, Cape Light Compact in Massachusetts retains an energy service company (ESCO) to provide energy efficiency services for its customers. This program has benefitted tens of thousands of the CCA's customers. A different type of efficiency program has been established through the energy service provider for NOPEC, the community choice program in northeastern Ohio. The energy supplier, as part of their service contract, awards annual grants to local governments that compete for the best-designed efficiency program. In California, Marin Energy Authority (MEA) has created a local feed-in tariff, initially of a small size as a kind of pilot program, where the CCA will purchase electricity from local renewable energy projects at specified prices.

Other types of programs that could be emulated by a community choice program have been created by local publicly owned utilities. For example, Palo Alto allows customers to sign up for PaloAltoGreen, which supplies 100 percent renewable energy in the form of voluntary RECs (City of Palo Alto 2012, Web--Green Program). The RECs are purchased by the City of Palo Alto's public utility and resold to customers that choose to pay an extra 1.5 cents per kilowatt-hour on their bill. A small fraction of RECs from local solar projects is mixed in with RECs from a large wind farm. Since wind RECs are low cost, and solar RECs tend to be more expensive, this blending strategy is a good way to market to customers an affordable financial package which supports local clean energy projects.

CCAs can also purchase energy directly from local clean energy projects, which would be mixed into the larger portfolio of power supply, or they can support local renewable energy projects by serving as a bulk purchasing agent to get discounts, for example purchasing solar panels at low wholesale price or direct from manufacturers rather than having customers pay full retail price.

Another major element that a community choice program can bring to the table is securing borrowed money to cover the upfront cost of installation of local renewable energy projects. There are several options:

1. Issuing revenue bonds that would be repaid through the income from either specific renewable energy projects or from a small fraction of the revenue stream of the entire community choice program. Tax-exempt bonds, or CREB bonds if they are reissued by the federal government, lower the cost of borrowed money, but also take

away the possibility for obtaining tax credits. Taxable bonds are a way around this limitation, but carry a higher coupon rate. Bonds are of limited use for individual smaller projects; however, a group of projects could be aggregated into a financing package where the borrowing is large enough to make issuing bonds cost effective. A limitation on issuing bonds is that a community choice program will first have to establish a certain level of credit before they can sell bonds.

2. Obtaining bank loans for projects can be made much easier by a community choice program through supplying the project with some form of financial backing. This can be in the form of a long-term power purchase contract, a long-term REC purchase contract, or possibly in the form of a revenue guarantee where the community program insures repayment of the loan.
3. Playing a supporting role in third-party leases to individual customers, where the third party is actually securing financing for the project. The community choice program can support these projects in multiple ways, such as providing support for marketing, purchasing RECs from local projects, becoming a back-up purchaser of the energy if the on-site customer defaults, or making an offer to take ownership of a project at the termination of the lease.

CCAs can establish these programs because they take over two functions that would otherwise be provided by the utility company: (1) they engage in the purchase of energy from energy suppliers, and (2) they sell electricity to customers and thus have access to the revenue from customer bills. These two cash streams, and the decision-making over these cash streams, create the ability for a CCA to implement a wide variety of energy programs that would otherwise be either entirely closed or highly limited for local governments.

CCAs, in their role as planning agencies, can set community targets for different types of renewable resources. These targets can be general, such as an overall renewable energy goal for the total community energy supply, or they can be quite specific, such as planning the deployment of distributed generation in specific locations in their service territory. In this report the "portfolio" approach considers characteristics of the power supply for the entire community.

PACE

Property Assessed Community Energy (PACE) programs are set up by local governments using their power to levy taxes. In a PACE program, customers voluntarily agree to have a tax assessment on their property to pay for energy efficiency or renewable energy projects developed on the site. PACE programs can support borrowing through bonds or bank loans through the assurance of the revenue stream that they produce. A limitation of PACE is that it is almost exclusively a financing program rather than a planning program, and cannot offer supplemental revenue streams outside of the voluntary tax assessment. Nevertheless, they can and have successfully financed installation of many local clean energy projects, and are an important energy policy tool for local government.

Recent decisions of federal mortgage agencies have disallowed PACE encumbrances on home mortgages. This has created a severe barrier for applying PACE programs to residential properties. However, commercial PACE programs have been moving ahead, and offer a potentially large market for development of local clean energy resources.

Community choice programs can also take advantage of PACE. This benefits the community choice program since it supplies an alternative source of revenue other than customer bills for supporting local clean energy projects. And the community choice program can augment the PACE program in several ways, through purchasing RECs from the project, agreeing to pay for excess electric generation, or as a backup purchaser of energy, or of the project itself, in case of default of the customer-owner.

CHAPTER 8:
Conclusions: Benefits, Barriers, and Opportunities

The Sonoma RESCO Research Team concludes that Sonoma County can significantly increase the use of new local renewable energy resources in a cost effective manner. One example of a successful local initiative is the *Sonoma County Solar Implementation Plan* (Solar Sonoma County 2012), which adopted a target of adding 25 MW of new solar photovoltaics between 2008 and May 2011, during which time 27 MW were actually built. Sonoma County is currently among the top ten counties in the state for solar photovoltaics, with 34.3 MW installed and an additional 5.6 MW pending as of July 2012 (Go Solar California 2012b, Web--Geographical Statistics). Another local initiative is the commercial PACE program, which has expanded the deployment of energy efficiency. Such efforts could be continued or expanded in the future.

Much larger expansion of local renewable-based energy resources could be developed through a more comprehensive locally controlled community choice aggregation program, using an integrated, multi-technology approach. The cost effectiveness of such a program would depend in part upon the financing tools used as well as the deployment strategy. Projects can benefit from the higher value of energy services located at customer sites, using net metering, feed-in tariffs, or other financial compensation structures. Flexible use of ownership models, including ownership by customers, third parties, or the community choice program, can also expand opportunities for development of projects and mitigate various risks.

The ability to take action exists today, and can be done in such a way that the economic environment remains not only unharmed but is enhanced.

Benefits to California

In 2011 the California State Legislature did not reauthorize the Public Goods Charge, a portion of which funds the Public Interest Energy Research program that provided a grant for this RESCO research project. A repeated refrain in committee hearings was, "Where is the *tangible ratepayer benefit?*" The stated purpose of the PIER program is to bring to market energy technologies that provide environmental and economic benefits to California's ratepayers.

- This RESCO research team finds many tangible benefits to California ratepayers by the move toward a new, localized energy infrastructure paradigm. A description of benefits follows.
- Reducing the cost of electricity for ratepayers on a long-term basis: Renewable energy is primarily tied to an upfront investment. Once the initial investment has been made, the cost of energy is stable over time and ultimately becomes less when compared to fossil sources that are likely to become more expensive as these sources are depleted.

- Stabilizing rates in the near term: Long-term contracts lock in energy supply prices that are relatively predictable over time, thus enabling suppliers and administrators of local energy programs to offer more stable retail rates.
- Providing local economic benefits and jobs: The energy supply portfolio described in Task 5 includes new local infrastructure that requires a workforce to build it.
- Expanding private enterprise opportunity in the energy sector: A community choice aggregation program, the most likely governance structure to administer a RESCO-like portfolio, has the authority to establish policies that can incentivize businesses of any kind to invest in clean energy generation such as solar photovoltaics on warehouse rooftops.
- Improving grid system reliability and resilience: The portfolio outlined in Task 5 would be enhanced by intelligent grid system management, substation-level energy planning, and incorporation of islandable microgrids. Such features enhance reliability and diminish the likelihood of system-wide disruptions.
- Enhancing energy security and independence: Localization of generation, combined with local control of that generation, releases local governments and communities from dependence on distant decision-making and distant power supply.
- Increasing local control and community participation: As outlined in Task 9 and Sonoma County's CCA Feasibility Study, a portfolio of the type described in Task 5 depends on local government engagement. Because a CCA is a public entity, greater public participation is likely in energy policy decision-making. Such increased public participation is a benefit to ratepayers.
- Offering a model mechanism for California to achieve its GHG reductions goals: Lacking federal or state level policy mechanisms that strongly incentivize renewable deployment pursuant to State goals, responsibility for action goes to local governments. In fact, representatives of the Governors' office have stated explicitly that the Governor expects local governments to play a lead role in achieving the State goals.
- Helping to achieve California State energy goals: California has set a goal that 33 percent of the State's electricity be derived from renewable energy sources by 2020. That goal does not define all of the necessary policy mechanisms or programmatic models. The RPS for 2010 was 20 percent and none of the State's IOUs achieved the target by 2010. In 2011, a year late, two of the state's major IOUs — SCE and SDG&E — appear to have achieved the target, while PG&E, at the time of this writing in 2012, is at 19.4 percent. The Sonoma RESCO renewable energy portfolios offer models for how local governments and communities can achieve State goals in a way that has local multiplier effects. The portfolios in Task 5 involve approximately 300 to 1500 GWh per year of new renewable distributed generation. Such an investment entails significant job creation.

The Task 5 model includes features described in user-friendly ways for other California communities to use for planning.

Barriers

Barriers described in more detail immediately below include:

- Sociopolitical
- Distribution Grid
- Interconnection
- Regulatory
- Distributed Generation Technology and Operation
- Financial

Sociopolitical

The most significant barriers to deployment of a RESCO-type local renewable energy portfolio are not technical, they are social and political. RESCO occurs in the context of a worldwide transformation in the energy sector moving toward a new clean distributed, intelligent, multidirectional electricity system. RESCO is part of this transformation, disrupting the status quo and challenging vested interests built up around the hundred-year-old centralized linear electricity model. Significant resistance to RESCO-type efforts has occurred in the past and should be expected to continue.

Distribution Grid

One of the largest barriers to deploying larger amounts of distributed generation is the distribution grid itself. While fixes to these challenges exist, they nonetheless cannot be ignored. Potential impacts of power generation on a distribution radial line include post-fault energized island (for example, in the case of a black-out on a sunny day, solar powered facilities may become dangerous to line workers); overload of system components; effects on system protection, operating voltage and power quality.

Although there are general rules governing distributed generation, the distribution utility has primary authority regarding decisions about particular distributed generation installations. The utility also has all the technical information required for modeling the distribution network, and is under no obligation to share the information, or provide access to any monitoring systems. This highlights the need for close cooperation between the distribution utility and distributed generation projects in order to allow accurate and optimal design of distributed generation systems. Furthermore, the utility does not necessarily have processes in place to efficiently handle and provide support for grid impact analysis of large volumes of applications for distributed generation. This can result in considerable delay and excessive financial charges for engineering services for project developers.

Interconnection

Electric Rule 21 governs the interconnection for distributed generation to the electric grid in California. Until September 2012 the rule included a provision that limited new interconnected distributed generation to 15 percent of the peak load on a given circuit. This was a highly problematic restriction and would have posed a significant obstacle to implementing the portfolios presented in this report. The revised Rule 21 retains the 15 percent of peak load screen but now in the event that an interconnection applicant fails that screen, the Rule permits further evaluation of generating capacity on the line section against 100 percent of minimum load on the line section. This change is more reasonable and permits higher penetration levels of distributed generation without significantly increasing the time or expense of the interconnection process.

Regulatory

- Several regulatory barriers exist to greatly expanding the use of distributed generation:
  - Some of the current distributed generation programs, such as the investor-owned utility Renewable Auction Mechanism and Solar PV programs, have minimum size limits, complex bidding structures, and lengthy contracts, all of which can be formidable for small scale renewable energy projects.
  - Currently, the PG&E Gas Rule 21 prohibits transmission through pipelines of biomethane produced in an anaerobic digester from any feedstock other than agricultural waste. This poses difficulties for the use of biomethane since alternatives include transportation of feedstock by truck which has high cost and environmental impact, or use in local sites which can often be inefficient and expensive due to the small scale of electric generation.
  - A large amount of local distributed generation is not ordinarily recognized by the CAISO as providing resource adequacy; to qualify for this status, a project must undergo a deliverability study (California Public Utilities Commission 2012c, 8). Furthermore, the CAISO may not effectively model many distributed generation projects in its Energy Management System (California Independent System Operator 2012b, 56).
  - An effective market structure for services that would integrate distributed generation, such as for energy storage and ancillary services from small generators, currently does not exist.

Distributed Generation Technology and Operation

- Technologies that could address several problems associated with integrating large amounts of distributed generation are not currently widely implemented in California. For example, inverters exist that can take commands to reduce the output of solar photovoltaic systems, but these are not required or deployed in California. Even if they were deployed, it would still be necessary to create the support systems that monitor local grid conditions and create the framework for issuing commands for curtailment.

Significant curtailment of electrical output would also need to be factored into financial and business models for distributed generation.

- Another important technology is energy storage, but current distributed storage technology options — electric batteries — are relatively expensive, and even more importantly lack the control systems that would allow for optimizing generation on the distribution grid.

Financial

Most renewable energy technologies involve major upfront financial costs. These could be addressed through various tools, but some of these tools also face hurdles.

For example, the PACE program can help secure financing for renewable energy projects through assuring a cash stream for repayment of loans. However, the federal mortgage agencies have placed formidable challenges for residential PACE by refusing to accept PACE claims on a mortgage. On-bill financing could provide an effective alternative to PACE, but has not been implemented yet in California. Even with PACE programs, interest rates can be relatively high, which makes this program less attractive than it could otherwise be.

A community energy program could also implement on-bill financing, but such a system has not yet been set up and would require the cooperation of the investor-owned utility performing the billing function to set up special line item charges for participating customers in a community choice program.

Another set of major financing barriers face the community choice aggregation program itself. While initial startup costs are quite small compared to the revenues of the community choice programs, these upfront funds must be secured prior to availability of this revenue. Local communities must either provide this upfront cash out of existing funds, which can be quite difficult especially in the current financial climate, or they must secure loans from banks or other private lenders, which can also be difficult because there is no assurance that the program will succeed sufficiently to repay the loan. Lack of established credit for new community choice agencies constrains their ability to borrow needed start up and operating funds.

Renewable energy projects are often assisted by federal tax credits, and these have limited authorization times. The 30 percent investment tax credit is currently set to expire in 2016, which places additional risks on efforts to plan beyond that timeframe. There are also important market limitations because many customers do not have tax liabilities and therefore are not eligible for these tax benefits. Such customers include local governments, schools, non-profit organizations, people with low income, and businesses that do not operate at a profit.

Opportunities

Barriers provide opportunities for enterprising, dedicated individuals, businesses, agencies, and communities. The Sonoma RESCO Research Team identified many opportunities, as addressed below.

- Sociopolitical
- Distribution Grid
- Interconnection
- Community Choice Aggregation
- Further Research
- Other Actions

Sociopolitical

Although significant institutional resistance to RESCO-type development has been experienced and should be expected to continue to occur, there is ample reason to believe that over time efficient, integrated, distributed renewable energy-based electricity systems like the portfolios described in this report will emerge and increase in presence in the electrical grid. The technologies that make it possible are becoming more available and lower in cost year after year, and poll after poll shows widespread public support for a transition to clean energy.

Distribution Grid

Some of the impacts of distributed generation on the distribution grid can be mitigated by specific technologies, general program features, local grid upgrades, and/or project design. For instance, current standards require inverters to take a distributed solar photovoltaic project off line in the case of a power failure to avoid energizing the local grid. Adding new features to inverters, such as real time telemetry and the capability to take instructions from the grid operator or automated controls, could allow curtailment or modification of the generation profile of the solar photovoltaic system, and potentially avoid one or more of the conditions listed above. At high levels of penetration of distributed generation, implementing these measures is likely to become necessary to avoid destabilizing the operation of the local electric grid.

Related to the concern about cost, the addition of significant distributed generation in a particular geographic locale may require upgrades to either distribution wiring or protection circuitry components. Upgrades to distribution network equipment will be required to support the operation of microgrids or islanding.

Another feature that would improve the resilience of the local distribution grid is to add the capability to handle bidirectional flow of electricity. Such features can include control systems at substations that allow export of excess power from the distribution circuits to the

transmission grid, and building double circuits into the distribution network as is done in Germany. While there would be significant costs associated with these upgrades, there would also be important improvements to local power quality, and upgrades could be deployed in an economically efficient manner by selecting specific upgrades that provide the largest benefits at least cost to customers and to support distributed generation.

Interconnection

Designing projects in a more coordinated fashion by a local planning entity could help overcome some of the technical, cost, regulatory and operational issues associated with interconnection of distributed generation. The local planning agency could also provide support for updating rules and procedures for interconnections.

Community Choice Aggregation

A local energy program could help to address a number of barriers to developing the local renewable energy resources identified by Sonoma RESCO Task 5.

In Sonoma County an effort concurrent and closely related to the RESCO research project is underway. In 2005 the Sonoma County Climate Protection Campaign identified community choice aggregation (CCA) as the most promising means of deploying renewables at the speed and scale required to achieve the greenhouse gas emissions reductions targets set by the County, and subsequently the State goals established by AB 32.

That effort has received support and funding from the Sonoma County Water Agency (SCWA). In March 2011, the SCWA launched a CCA Feasibility Study that concluded in October 2011 with a finding that a CCA program in Sonoma County is feasible. The Feasibility Study found that "CCA implementation would significantly reduce greenhouse gas emissions, create local jobs, and have a substantial positive effect on the local economy." The study investigated four electricity "supply scenarios" that provided various amounts of renewable energy — ranging from 33 percent to 85 percent — that were modeled to be deployed by 2020. Scenario four was modeled in part upon the Sonoma County Climate Plan electricity portfolio. While the original local Climate Plan portfolio had 66 percent renewables portfolio in 2015, while the Feasibility Study modeled an 85 percent renewables portfolio for 2020.

The Feasibility Study found that this very high penetration of renewable energy, which also included the highest amount of local renewable energy projects, had a *lower* annual cost of electricity than the 75 percent renewable energy portfolio in scenario three. Scenario four had an average annual incremental cost of $18.2 million, and ranged from a high of $29.3 million annual extra cost to a low of $0.4 million per year savings. The Sonoma RESCO Task 5 analysis found that a portion of the extra cost of highest renewable energy scenario in the feasibility study can be reduced through a combination of rebalancing the portfolio and using financial tools such as net metering (Table 66).

Table 66: Additional Aggregate Annual Customer Cost for CCA Feasibility Study Scenarios

	Average $ millions	Highest Year $ millions	Lowest Year $ millions
Scenario 1	$14.10	$18.60	$8.70
Scenario 2	$16.10	$26.30	
Scenario 3	$34.30	$54.60	$4.60
Scenario 4	$18.20	$29.30	

Report on the Feasibility of Community Choice Aggregation in Sonoma County
(Dalessi Management Consulting LLC; MRW & Associates 2011)

The SCWA has approved further evaluation of a community choice program, and has named the Sonoma County CCA effort "Sonoma Clean Power." The RESCO work dovetails with this initiative, in that it investigates ways to support local government efforts to accelerate deployment of local renewables.

Further Research

Several subjects related to this RESCO research project were either not investigated or were investigated only to a limited degree. Highlights of these subjects follow.

Transportation Energy Requirements: Electric vehicles could play an important role in helping to integrate local distributed generation by providing dispatchable demand, but also could pose significant challenges, such as high localized distribution system loads and significant extra energy demand, if they are deployed in large numbers; however, this topic was not investigated by the Sonoma RESCO project.

Detailed Thermal Energy Requirements: The Sonoma RESCO Research Team did not have access to customer-specific data for natural gas use, and thus had to use proxy assumptions about on-site thermal energy needs that have a large margin of uncertainty. This lack of access may have affected the results regarding site potential for combined heat and power. Future additional work is needed to determine suitability of sites for deployment of this resource.

Further Analysis of Distributed Generation on the Local Grid: There are significant limitations to the data that was used to analyze the ability of local demand profiles to absorb electricity production from distributed generation. The demand profiles for local substations had hourly resolution, and 15-minute data from a specific solar photovoltaic project was scaled to model the integration of local solar power generation with the demand profile of specific substations. Furthermore, the load curve shapes are generic to the climate zone, and do not represent actual hourly data from the substations. Both data sets also only reflect the conditions of a single year. Future analysis would benefit from using actual substation data, data from additional solar photovoltaic projects and other local renewable generation sources, data from multiple years, and data resolution on time scales smaller than one hour.

Other Actions

The Sonoma RESCO Research Team identified other needs as it worked on Task 5. The following recommended actions correspond with Task 5 sections.

- Methodology and Approach
  - Continue work to identify and develop site specific opportunities for distributed generation based upon the further application and refinement of RESCO findings regarding resource availability as well as energy use patterns and load volumes in different neighborhoods and municipalities in Sonoma County
  - In the case of combined heat and power, obtain natural gas data to update and expand analysis of "hot spots" where both heat and electrical power demand coincide at a large enough scale to merit consideration; analysis will also need to be refined to consider more site-specific factors that are critical for developing actual projects, and also to assemble specific technology packages using analytical tools such as HOMER
  - Continue to utilize the CLEAR model to assess new renewable energy projects
- Local Renewable Energy Supply Portfolio
  - Adopt program targets for developing local resources, including on-site generation for residential and commercial customers, energy efficiency, energy storage, and demand response.
  - Continue to develop on-site self-generation using solar PV and CHP that is placed "behind the meter" in order to increase the value of these resources, and to reduce the cost for a CCA to expand local RESCO resources
  - Coordinate strategies to significantly reduce project costs using financing tools, bulk purchasing, and deployment strategies
  - Streamline the approach to analyzing distribution circuits for the purpose of approving projects; this will require coordination with the utility company as well as state regulators
  - Raise the statewide net-metering cap to increase the amount of distributed generation that can be built; however, a CCA is not limited by net metering, and can use a net-surplus feed-in tariff to compensate excess electrical generation that is not consumed on-site
- Local and Site Specific Supply Resources
  - Conduct actual site measurements and data collection such as anemometer studies for wind, test well drilling for geothermal resources, and assessment of specific biomass feedstocks, before beginning site development
  - Explore the possibility of tapping energy from coastal ocean energy resources; while technology is at an early stage, and offshore resources may take years to develop, the local potential is large— just 10 percent of the identified resources would be sufficient to provide all of the electric power for Sonoma County

- Community Scale Electric Demand Analysis
  - Obtain detailed hourly load profile information at the substation level, distribution feeder characteristics, and supervisory control and data acquisition (SCADA) information that relates to substation or distribution system operation through the E-CCAINFO tariff
- Demand Side and Load Balancing Resources
  - A robust energy efficiency program in Sonoma County will require evaluating the program scope, identifying cost-effective implementation strategies, and developing local administrative capacity
  - Perform an assessment of how local administration would align with the CPUC's recent goal to have a consistent and streamlined regional marketplace under the Energy Upgrade California brand
  - Coordinate closely with PG&E's incentive process to integrate CCA into the statewide whole-house incentive program
  - Expand access to financing options for efficiency improvements, including PACE, on-bill financing, use of CCA procurement funds, available subsidies, as well as bank loans and public bonds
- Financing
  - Set up programs that provide access to low interest financing for local and distributed generation, using public issuance of bonds, loan guarantees to support traditional loans, or through special loan programs for small scale renewable energy projects, similar what is has been developed in Germany
  - Establish a State level revolving loan fund to help establish CCAs in the State
  - Establish a State level program that supports the ability of CCAs to issue bonds to finance and build local renewable energy projects

WORKS CITED

Association of Bay Area Governments. *American Recovery and Reinvestment Act: Recommendations for Energy Upgrade California in the Bay Area.* Association of Bay Area Governments, 2012a.

—. *Retrofit Bay Area Final Report.* Association of Bay Area Governments, 2012b.

Bioenergy Interagency Working Group. *2011 Bioenergy Action Plan.* CEC-300-2011-001-CTF, California Energy Commission, 2011.

Blakeslee, Assemblyman Sam. "California Assembly Bill 1613, Chapter 713." State of California, Statues of 2007.

—. "California Assembly Bill 578, Chapter 627." State of California, Statues of 2008.

Bloomberg.com. *Key Rates.* 2012. http://www.bloomberg.com/markets/rates-bonds/key-rates/ (accessed 2012).

Bottle Rock Power. *Welcome to Bottle Rock Power.* 2011. http://www.bottlerockpower.com/ (accessed 2012 *йил* 30-November).

Bundesverband Solarwirtschaft. *Das Netzwerk de Solarbranche.* 2013. http://www.solarwirtschaft.de/eeg-update/ (accessed 2013).

Buratti, C., I. Costarelli, F. Cotana, L. Crisostomi, and F. Fantozzi. *The Biomass Research Laboratory for Biomass Characterization.* http://www.cotana.it/File/Pubblicazioni/pdf/1248.pdf, University of Perugia Biomass Research Centre, 2012.

California Air Resources Board. *Climate Change Scoping Plan: A Framework for Change.* http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm, California Air Resources Board, 2008.

California Energy Commission and California Ocean Protection Council. *Developing Wave Energy in Coastal California: Potential Socio-Economic and Environmental Effects.* CEC-500-2008-083, California Energy Commission, California Ocean Protection Council, 2008.

California Energy Commission and Itron. *California Energy Commission 2009 Integrated Energy Policy Report.* http://www.energy.ca.gov/2009publications/CEC-100-2009-003/CEC-100-2009-003-CMF.PDF, California Energy Commission, 2009.

California Energy Commission. *California Energy Demand 2010-2020 Adopted Forecast.* CEC-200-2009-102-CMF, Form 1.2, California Energy Commission, 2009.

—. *California Solar Initiative -- Statewide Trigger Tracker.* 2012a. htt://www.csi-trigger.com/ (accessed 2012).

—. *California Solar Photovoltaic Statistics and Data.* 2012b. http://energyalmanac.ca.gov/renewables/solar/1998-2006.html (accessed 2012).

—. *Electricity Consumption by County.* 2012c. http://www.ecdms.energy.ca.gov/elecbycounty.aspx (accessed 2012).

—. *Energy Action Plan.* Sacramento: California Energy Commission, 2003.

—. *Energy Action Plan 2008 Update.* Sacramento: California Energy Commission, 2008a.

—. *Energy Action Plan II: Implementation Roadmap for Energy Policies.* Sacramento: California Energy Commission, 2005.

—. *Incremental Impacts of Energy Efficiency Policy Initiatives Relative to the 2009 Integrated Energy Policy Report Adopted Demand Forecast, Committee Report.* CEC-200-2010-001-CTF, 2012d.

—. *New Geothermal Site Indentification and Qualification.* Consultant Report, http://www.energy.ca.gov/pier/project_reports/500-04-051.html: CEC Public Interest Energy Research Program, 2004.

—. "Public Interest Energy Research, Program Opportunity Notice for Renewable-Based Energy Secure Communities Research, Development, and Demonstration PON-08-004." Program Opportunity Notice, 2008b.

California Environmental Protection Agency. *Hub & Spokes Partners kick-off Project.* 2012 *йил* 11-April.

California Independent System Operator. *Small and large generator interconnection procedures.* 2012a. http://www.caiso.com/275e/275ed48c685e0.html (accessed 2012).

—. *The Business Practice Manual (BPM) for Managing the Full Network Model.* https://bpm.caiso.com/bpm/bpm/version/000000000000118, Folsom: California Independent System Operator, 2012b.

California Office of Planning and Research. *Renewable Energy in California.* 2011. http://opr.ca.gov/s_renewableenergy.php (accessed 2012 *йил* 30-November).

California Public Utilities Commission and California Investor Owned Utilities. *California Solar Statistics.* 2012. http://www.californiasolarstatistics.ca.gov/ (accessed 2012).

California Public Utilities Commission. *California Long-Term Energy Efficiency Strategic Plan: Achieving Maximum Energy Savings in California for 2009 and Beyond.* California Public Utilities Commssion, 2008.

—. "CPUC Decision Approving 2010 to 2012 Energy Efficiency Portfolios and Budgets (A.08-07-021 et al)." California Public Utilities Commission, 2009/2012.

—. *CPUC Resolution for the RAM Program (Resolution E-4489).* http://docs.cpuc.ca.gov/word_pdf/FINAL_RESOLUTION/164684.pdf, San Francisco: California Public Utilities Commission, 2012c.

—. "Decision Adopting Proposed Settlement: Decision 10-12-035." California Public Utilities Commission: http://docs.cpuc.ca.gov/WORD_PDF/FINAL_DECISION/128624.PDF, 2010 йил 16-December.

—. *Decision Providing Guidance on 2013-2014 Energy Efficiency Portfolios and 2012 Marketing, Education, and Outreach.* CPUC Rulemaking 09-11-014, 2012e.

—. *Electric Energy Storage.* 2012f. http://www.cpuc.ca.gov/PUC/energy/electric/storage.htm (accessed 2012 йил 30-November).

—. "Net Surplus Compensation Rate." *CPUC Decision 11-06-016.* San Francisco: California Public Utilities Commission, 2011 йил 9-June.

—. *Standardized Planning Assumptions (Part 2 -- Renewables), for System Resource Plans, Scoping Memo Attachment 2, 2012 Long-Term Procurement Proceeding.* http://docs.cpuc.ca.gov/efile/RULINGS/130670.pdf, California Public Utilities Commission, 2010.

—. *2010 Long-Term Procurement Proceeding Scoping Memo, Attachment 1, Standardized Planning Assumptions (Part 1) for System Resource Plans.* R.10-05-006, California Public Utilities Commission, 2012a.

California Renewable Resource Portal. *Geothermal Potential by County / Public Interest Energy Research (PIER).* 2010 йил 28-January. https://calrenewableresource.llnl.gov/geothermal/potential-by-county.php (accessed 2012 йил 30-November).

Calpine Corporation. "Permits Approved for Two New Calpine Geothermal Plants at The Geysers." 2011 йил 9-November. www.geysers.com/docs/11092011_Permits_Approved_for_Two_New_Calpine_Geothermal_Plants.pdf (accessed 2012 йил November).

—. *The Geysers.* 2012. http://www.geysers.com/ (accessed 2012).

Carter, Patrick, interview by Alex Dolginow. *Program Manager* (November 2, 2011).

Cascadia Consulting Group; Sky Valley Associates, Inc. *Waste Characterization Study.* Sonoma County Waste Management Agency, 2007.

Christa, K. and W. Elizabeth. *Biomass Report.* http://www.mixbiopells.eu/fileadmin/user_upload/WP2/D2_3_biomass_report_enhanced_final_2.pdf, European Commission, 2012.

City of Palo Alto. *Palo Alto Green Program.* 2012. http://www.cityofpaloalto.org/forms/pagreen/index.html (accessed 2012).

Climate Protection Campaign. *Sonoma County Community Climate Action Plan.* Santa Rosa: Climate Protection Campaign, 2008.

Climate Protection Campaign, Local Power Inc., and Los Alamos National Laboratory. *RESCO Task 3 -- Data Collection.* PIR-08-038: Sonoma County Water Agency, 2012.

C-Tech Innovation Ltd. *Thermal Methods of Municipal Waste Treatment.* http://www.hm-treasury.gov.uk/d/Thermal_Methods_mass_balance.pdf, Biffaward Programme on Sustainable Resource Use, 2003.

Dalessi Management Consulting LLC; MRW & Associates. *Report on the Feasibility of Community Choice Aggregation in Sonoma County.* Santa Rosa: Sonoma County Water Agency, 2011.

Digitale, Robert. *Press Democrat, Real Sonoma Blog: Underwater Morrgages Decline Slowly in Sonoma County.* 2012 *йил* 2-March. http://realestate.blogs.pressdemocrat.com/12607/underwater-mortgages-decline-slowly-in-sonoma-county/ (accessed 2012).

Domalski, E.S., T.L. Jobe Jr., and T.A. Milne. *Thermodynamic Data for Biomass Conversion and Waste Incineration.* http://www.nrel.gov/biomass/pdfs/2839.pdf, National Sureau of Standards, National Renewable Energy Laboratory, 1986.

DSIRE. *Federal Incentives/Policies for Renewables and Efficiency: Business Energy Investment Tax Credit (ITC).* 2012a *йил* 13-November. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=0&ee=0 (accessed 2012 *йил* 30-November).

—. *Federal Incentives/Policies for Renewables and Efficiency: Renewable Electricity Production Tax Credit (PTC).* 2012b *йил* 22-May. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&re=0&ee=0 (accessed 2012 *йил* 30-November).

EGS, Inc. *Services.* 2012. http://www.envgeo.com/Index.html (accessed 2012 *йил* 30-November).

Energy Efficiency Institute, Inc. *PAYS America.* 2012. http://www.paysamerica.org/ (accessed 2012).

Energy Upgrade California. *Energy Upgrade California.* 2011. http://www.energyupgradecalifornia.org (accessed 2012).

Federal Energy Regulatory Commission. "134 FERC 61,004, Order Denying Rehearing." Washington DC: Federal Energy Regulatory Commission, 2010 *йил* 20-January.

Fugate, Nick. "California Energy Demand 2011-2022 Preliminary Staff Report." *IEPR Committee Workshop Presentation.* California Energy Commission, 2011.

G. Loren Toole, MS, E.E., interview by Dave Erickson/Climate Protection Campaign. *Los Alamos National Laboratory -- CCS-3/Information Sciences* (2012 *йил* February-March).

Galen Barbose, et al. *Tracking the Sun IV: An Historical Summary of the Installed Cost of Photovoltaics in the United States from 1998 to 2010.* Lawrence Berkeley National Laboratory, 2012.

Geothermal Energy Association. *Major Companies: Norther California Power Agency (NCPA) Link.* 2012. http://geo-energy.org/Major_companies.aspx#NorthernCaliforniaPowerAgency (accessed 2012 *йил* 30-November).

German Solar Industry Association (BSW-Solar). *PV System Prices Decrease Steaily.* 2011-2012a *йил* May. http://www.solarwirtschaft.de/en/start/english-news.html (accessed 2012).

—. *Statistic Data on the German Solar Power (Photovoltaic) Industry.* German Solar Industry Association, 2011-2012b.

Gipe, Paul. *Wind Power: Renewable Energy for Home, Farm, and Business.* White River Junction, Vermont: Chelsea Green Publishing, 2004.

Go Solar California. *California Solar Initiative -- Statewide Trigger Tracker.* 2012a. http://www.csi-trigger.com/ (accessed 2012).

—. *California Solar Statistics: Geograhical Statistics.* 2012b. http://www.californiasolarstatistics.ca.gov/reports/locale_stats/ (accessed 2012).

HOMER Energy LLC. *Optimizing Clean Power Everywhere.* http://homerenergy.com/software.html (accessed 2012).

Igo, Kristine. *Food Scraps to Energy -- Making the Case for Anaerobic Digestion in Sonoma County.* Santa Rosa: Sonoma County Water Agency, 2009.

International Dark-Sky Association. *Economic Issues in Wasted and Inefficient Outdoor Lighting -- Information Sheet #26.* http://www.darksky.org/assets/documents/is026.pdf, International Dark-Sky Association, 2000.

Itron and KEMA. *California Solar Initiative: Final 2007-2008 Impact Evaluation.* San Francisco: California Public Untilities Commission, February 2010.

Itron. *Impacts of Distributed Generation.* http://www.cpuc.ca.gov/PUC/energy/DistGen/impactreport.htm, San Francisco: California Public Utilities Commission, 2010.

Jacobson, J., E. Searcy, D. Muth, E. Wilkerson, S. Sokansanj, B. Jenkins, P. Tittman, N. Parker, Q. Hart, and R. Nelson. *Sustainable Biomass Supply Systems.* Idaho National Laboratory, U.S. Department of Energy, AICHe Spring National Meeting, 2009.

Kane, M. *California Small Hydropower and Ocean Wave Energy Resources, in Support of the 2005 Integrated Energy Policy Report.* http://www.energy.ca.gov/2005publications/CEC-500-2005-074/CEC-500-2005-074.PDF, California Energy Commission CEC-500-2005-074, 2005.

Keating, Raymond J. *Small Business Survival Index 2007: Ranking the Policy Environment for Entrepreneurship Across the Nation.* Oakton: Small Business and Entrepreneurship Council, 2007.

Kehoe, Senator Christine. "California Senate Bill 1037, Chapter 366." State of California, Statutes of 2005.

—. "California Senate Bill 695, Chapter 337." State of California, Statues of 2009.

Kumar, A., J.B. Cameron, and P.C. Flynn. "Pipeline transport of biomass." *Applied Biochemical Biotechnology*, 2004: 27-39.

Lawrence Berkeley National Laboratory. *Recent Developments in the Levelized Cost of Energy from U.S. Wind Power Projects.* http://eetd.lbl.gov/ea/ems/reports/wind-energy-costs-2-2012.pdf, Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory6, 2012.

Leboreiro, J. and A.K. Hilaly. "Biomass transportation mdoel and optimum plant size for the production of ethanol." American Institute of Chemical Engineers, 2010.

Levine, Assemblyman Lloyd. "California Assembly Bill 2021, Chapter 734." State of California, Statutes of 2006.

Linney, Joan. *Sonoma County Biomass (unpublished).* Climate Protection Campaign, 2012.

Local Power Inc. *Community Choice, Lessons Learned and Best Practices.* San Francisco: San Francisco Public Utilities Commission, 2009.

—. *Energy Solutions: Sonoma County Community Climate Action Plan.* Local Power Inc., 2008.

—. *RESCO Task 4 -- Data Integration and Pre-Analysis.* CEC Grant No. PIR-08-038, Santa Rosa: Sonoma County Water Agency, 2010.

Longville, Assemblyman John. "California Assembly Bill 549, Chapter 905." State of California, Statutes of 2001.

Los Alamos National Laboratory. *CLEAR Model.* 2012. http://public.lanl.gov/dp/CLEAR.html (accessed 2012).

Marin Energy Authority. *Net Energy Metering.* 2012. https://marincleanenergy.info/net-energy-metering (accessed 2012).

Meadows, Donella. *Leverage Points: Places to Intervene in a System.* 1996-2013. http://www.donellameadows.org/archives/leverage-points-places-to-intervene-in-a-system/ (accessed 2013).

Midgen, Senator Carole. "California Assembly Bill 117, Chapter 838." California State Legislature, Statues of 2002.

Millbrant, A. *A Geographic Perspective on the Current Biomass Resource Availability in the United States.* http://www.nrel.gov/docs/fy06osti/39181.pdf, National Renewable Energy Laboratory, 2005.

Minerals Management Service and Renewable Energy and Alternative Use Program. *Technology White Paper on Wave Energy Potential on the Outer Continental Shelf.* U.S. Department of the Interior, 2006.

Mukhtar, S. and S. Capareda. *Manure to Energy: Understanding Processes, Principles, and Jargon.* http://tammi.tamu.edu/ManurtoEnrgyE428.pdf, Texas A&M Cooperative Extension, 2006.

National Oceanographic Data Center. *Pacific Coast: Central.* January 12, 2013. http://www.nodc.noaa.gov/dsdt/cwtg/cpac.html (accessed 2013).

National Renewable Energy Laboratory. "Increased Capacity Factor of Current Low-Speed Wind Turbines." 2012a. http://eetd.lbl.gov/ea/ems/reports/wind-energy-costs-2-2012.pdf (accessed 2012).

—. *Solar Prospector.* 2012b. http://maps.nrel.gov/prospector (accessed 2012).

—. "United States -- Wind Resource Map." http://www.nrel.gov/gis/pdfs/windsmodel4pub1-1-9base200904enh.pdf: U.S. Department of Energy, 2009 *йил* 6-May.

—. *Utility-Scale Energy Technology Capacity Factors.* 2012c. http://www.nrel.gov/analysis/tech_cap_factor.html (accessed 2012 *йил* November).

Navigant Consulting Inc. *Statewide Small Hydropower Resource Assessment.* CEC-500-2006-065, California Energy Commission, 2006.

—. *California Rooftop Photovoltaic (PV) Resource Assessment and Growth Potential by County.* CEC-500-2007-048 September 2007, California Energy Commission, 2007.

Nolan ITU Pty Ltd, in association with TBU Environmental Engineering Consultants. *Guideline for Determining the Renewable Components in Waste for Electricity Generation.* Office of Renewable Energy Regulator, Australia, 2001.

Nunez, Assemblyman Fabian. "California Assembly Bill 32: Global Warming Solutions Act of 2006, Chapter 488." State of California, Statutes of 2006.

Pacific Gas and Electric Company. *Baseline Quantities by Territory for Single Family Dwellings.* 2012a. http://www.pge.com/myhome/customerservice/financialassistance/medicalbaseline/understand/ (accessed 2012).

—. *Electric Rates: January 1, 2012.* 2012b. http://www.pge.com/tariffs/electric.shtml#RESELEC (accessed January 1, 2012).

—. *Electric Schedules.* 2012c. http://www.pge.com/tariffs/ERS.SHTML#ERS (accessed 2012).

—. *Existing Executed Feed-In Tariff Contract, Current Spreadsheet (Rev 6.28.12).* 2012d *йил* 28-June. http://www.pge.com/includes/docs/word_xls/b2b/energysupply/wholesaleelectricsuppliersolicitation/standardcontractsforpurchase/Contract_Updates_Spreadsheet.xls (accessed 2012).

—. *GP&E Long Term Procurement Plan.* San Francisco: California Public Utilities Commission, 2012e.

—. *Net Surplus Compensation Rates for Energy.* http://www.pge.com/includes/docs/pdfs/shared/solar/AB920_RateTable.pdf, Pacific Gas and Electric Company, 2012f.

—. *Net Surplus Compensation Rates for Energy.* 2012f. http://www.pge.com/includes/docs/pdfs/shared/solar/AB920_RateTable.pdf (accessed 2012).

—. *Pacific Gas and Electric Company: 2012 Long Term Procurement Plan.* San Francisco: Pacific Gas and Electric, 2012g.

—. *PG&E Basic Residential Rates in 2011.* 2012h йил November. http://www.pge.com/tariffs/electric.shtml (accessed 2012).

—. *PG&E Electric Schedule A-1: Small General Service, Sheet 1.* http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_A-1.pdf, Pacific Gas and Electric Company, 2012i.

—. *PG&E Electric Schedule A-1: Small General Service, Sheet 4.* San Francisco: Pacific Gas and Electric, December 30, 2011.

—. *PG&E Rate Filings.* 2012k. http://www.pge.com/about/rates/ (accessed 2012).

—. *Residential Electric Rates.* 2012l йил 1-July. http://www.pge.com/nots/rates/tariffs/electric.shtml (accessed 2012).

—. *Second Renewable Auction Mechanism.* 2012m. http://www.pge.com/rfo/RAM/ (accessed 2012).

—. *See Your Power: What Is a SmartMeterTM?* 2012n. http://www.pge.com/smartmeter/ (accessed 2012).

—. *Self-Generation Incentive Program: Available Funding and Program Statistics.* 2012o. http://www.pge.com/mybusiness/energysavingsrebates/selfgenerationincentive/availablefundingandprogramstatistics.shtml (accessed 2012).

—. *Understanding Baseline Quantities.* http://www.pge.com/myhome/customerservice/financialassistance/medicalbaseline/understand/, San Francisco: Pacific Gas and Electric, 2012p.

Ram Power. *Geysers.* 2012. http://ram-power.com/current-projects/geysers-california (accessed 2012 йил 30-November).

RCM International. *Evaluation of Sonoma County Organic Waste Resource Base for Developing Anaerobic Digestion Systems.* Santa Rosa: Sonoma County Water Agency, 2010.

Renewable Energy Policy Project. *Chapter 5 -- Economics.* 2012. http://www.repp.org/geothermal/geothermal_brief_economics.html (accessed 2012 йил 30-November).

Rummer, Bob. *Harvesting and Transportation of Forest Biomass.* Auburn, AL: Weed Center, 2007.

Sacramento Municipal Utility District. *Greenergy.* 2012a. https://www.smud.org/en/residential/environment/greenergy/ (accessed 2012).

—. *Iowa Hill Pumped Storage Development.* 2012b. http://hydrorelicensing.smud.org/IowaHill/default.htm (accessed 2012).

Saldana, Assemblywoman Lori. “California Assembly Bill 1103, Chapter 533.” State of California, Statues of 2007.

—. “California Assembly Bill 531, Chapter 323.” State of California, Statues of 2009.

Sanyal, Subir K. and Steven L. Enedy. “Fifty Years of Power Generation at The Geysers Geothermal Field, California -- The Lessons Learned.” *Thirty-Sixth Workshop on Geothermal Reservoir Engineering.* Stanford University SGP-TR-191, 2011.

Scheuermann, K., D. Boleyn, P. Lilly, and S. Miller. *Measured Performance of California Buydown Program Residential PV Systems.* http://www.energy.ca.gov/renewables/emerging_renewables/2004-11-04_PERFORMANCE_PV.PDF, California Energy Commission and Regional Economic Research, Inc., 2004.

Schroeder, R., B. Jackson, and S. Ashton. “Biomass Transportation and Delivery.” In *Sustainable Forestry for Bioenergy and Bio-based Products: Trainers Curriculum Notebook*, by W, L Biles, C Mayfield, S Ashton Hubbard, 145-148. Athens, GA: Southern Forest Research Partnerships, Inc., 2007.

Schwarzenegger, Govenor Arnold. “Executive Order S-06-06.” Governor of the State of California, 2006 *йил* 25-April.

—. “Executive Order S-3-05.” Govenor of the State of California, 2005.

Simon, A.J. and R.D. Belles. *Estimated State-Level Energy Flows in 2008.* https://flowcharts.llnl.gov/content/energy/energy_archive/energy_flow_2008/2008StateEnergy.pdf, Lawrence Livermore National Laboratory, 2011.

Skinner, Assemblywoman Nancy. “California Assembly Bill 758, Chapter 470.” State of California, Statues of 2009.

Solar Sonoma County. *Sonoma County Solar Implementation Plan.* http://www4.eere.energy.gov/solar/sunshot/resource_center/sites/default/files/solar_implementation_plan_final-05-10-10.pdf, Solar Sonoma County, 2012.

Sonoma County Office of the Agricultural Commissioner. “Sonoma County Crop Report 2010.” 2011.

Sonoma County Solid Waste Advisory Group: Research Committee. *Research Committee Report of Sonoma County Solide Waste Advisory Group.* Sonoma County Solid Waste Advisory Group, 2011.

Sonoma County Water Agency, County of Sonoma General Services, Dalessi Management Consulting LLC, MRW & Associates. *Report on the Feasibility of Community Choice Aggregation in Sonoma County.* Feasibility Study, http://www.scwa.ca.gov/files/docs/carbon-free-water//cca/CCA%20Feasibility%20Report%20101211.pdf : Sonoma County Water Agency, 2011.

Szyszlak-Barglowicz, J. and J. Zarajczyk. *Timber Waste as a Source of Energy.* http://www.pan-ol.lublin.pl/wydawnictwa/TMot9/Szyszlak.pdf, U.S. Environmental Protection Agency, Region IX (TEKA Kom Mot Energ Roln 9: 339-334), 2009.

Tellus Institute, Cascadia Consulting Group, Sound Resource Management. *Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review.* Massachusetts Department of Environmental Protection, 2008.

TSS Consultants. *Preliminary biomass fuel availability and feasibility review for siting biomass power facilities in Mendecino County, CA.* North Coast Resource Conservation and Development Council, 2006.

U.S. Department of Agriculture, Forest Service. *Heat Content of Bark, Twigs, and Foliage of Nine Species of Western Conifers.* http://digitalcommons.usu.edu/govdocs_forest/69/, U.S. Department of Agriculture, Forest Service, 1979.

U.S. Department of Energy EERE. *2008 Geothermal Technologies Market Report.* http://www.nrel.gov/analysis/pdfs/46022.pdf, U.S. Department of Energy EERE, 2009.

—. *Community Choice Aggregation.* 2012a. http://apps3.eere.energy.gov/greenpower/markets/community_choice.shtml (accessed 2012 *йил* November).

—. *Energy Basics: Ocean Thermal Energy Conversion.* August 12, 2011. http://www.eere.energy.gov/basics/renewable_energy/ocean_thermal_energy_conv.html (accessed 2013).

—. *Enhanced Geothermal Systems.* 2011 *йил* 29-November. http://www1.eere.energy.gov/geothermal/enhanced_geothermal_systems.html (accessed 2012 *йил* 30-November).

—. *Geothermal FAQs.* 2012c *йил* 26-September. http://www1.eere.energy.gov/geothermal/faqs.html#geothermal_energy_cost (accessed 2012).

—. *Low-Temperature and Co-produced Geothermal Resources.* 2012d *йил* 22-March. http://www1.eere.energy.gov/geothermal/low_temperature_resources.html (accessed 2012 *йил* 30-November).

U.S. Department of Energy. *SmartGrid.gov.* 2012a. http://www.smartgrid.gov/ (accessed 2012).

—. *Solar America Communities.* 2012b. http://solaramericacommunities.energy.gov/ (accessed 2012).

U.S. Energy Information Administration. *2005 RECS Survey Data (Residential Energy Consumption Survey).* 2008. http://205.254.135.7/consumption/residential/data/2005/ (accessed 2012).

—. *High Rates and Low Bills -- Comparing California Residential Electricity Rates and Bills to Other U.S. States in 2009.* 2009. (accessed 2012).

U.S. Environmental Protection Agency. *Combined Heat and Power Partnership: Efficiency Benefits.* 2012a. http://www.epa.gov/chp/basic/efficiency.html (accessed 2012).

—. *Efficiency Benefits.* 2012b. http://www.epa.gov/chp/basic/efficiency.html (accessed 2012).

URS. *Tidal Power Feasibility Study.* http://sfwater.org/ftp/large-documents/SFPUC-587377v.pdf, San Francisco: San Francisco Public Utilities Commission, 2008.

Varshney and Associates. *Cost of State Regulations on California Small Business.* http://arc.asm.ca.gov/member/3/pdf/CostofRegulationStudyFinal.pdf, El Dorado Hills: California State University -- Sacramento, 2009.

Western Governors Association. *Energy Efficiency Task Force Report.* Page vi, Western Govenors Association, 2006.

Williams, R.B. *Draft: An Assessment of Biomass Resources in California 2007.* http://biomass.ucdavis.edu/files/reports/2008-cbc-resource-assessment.pdf, Davis: California Biomass Collaborative At University of California -- Davis, 2008.

Wiser, Ryan, Eric Lantz, Mark Bolinger, and and Maureen Hand. "Recent Developments in the Levelized Cost of Energy from U.S. Wind Power Projects." http://eetd.lbl.gov/ea/ems/reports/wind-energy-costs-2-2012.pdf: National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory, 2012.

Wright, Tasha. "Santa Rosa and Solar Sonoma County Market Transformation." *Solar Technologies Program Pier Review.* City of Santa Rosa, California: http://www1.eere.energy.gov/solar/review_meeting/pdfs/prm2010_santarosa.pdf, 2010 *йил* 25-May.

GLOSSARY, ACRONYMS, AND ABBREVIATIONS

Glossary of Terms

Anaerobic Digestion	Process in which microorganisms break down biodegradable material in the absence of oxygen and release chemical energy (potential fuel) in the form of methane gas.
ArcGIS	A computer-based mapping and geospatial analytical tool developed by Esri. (http://www.esri.com/software/arcgis/arcgis10)
Baseload	The minimum amount of stable energy service (natural gas or electricity) needed to supply a given service area over an extended period of time, such as a day, a month, or a year.
Behind the Meter	Energy resources or efficiency measures that are physically located, and financially valued, on the customer, not utility, side of the electric meter.
Betz Limit	Theoretical physical limit that no wind turbine can convert more than 16/27 (59.3 percent) of the kinetic energy of the wind into mechanical energy turning a rotor.
Biogas or Biomethane	Methane gas (CH_4) that is ordinarily produced by the anaerobic digestion of organic material.
Biomass	Biological material — from plant or animal sources — that may be used as a feedstock in anaerobic digestion.
Bone Dry Ton	A volume of biomass that would weigh one ton (2000 pounds, or 0.9072 metric tons) if all the moisture content was removed.
"Bottom Up" Approach	The methodological approach where local characteristics are used as the primary information for investigation or deriving conclusions; this approach can analyze local demand data, the character of location-specific renewable energy resources, or the distribution grid at neighborhood scale, and using the information to investigate applicability of types of projects, financing, and program goals.
Bundling	The combining of different services provided by a utility or energy service provider, or combining of features of a financial mechanism.
Capacity Factor	The ratio of the actual output of a power plant over a period of time compared to its potential output if it had operated at full capacity the entire time.

Chunking	Partitioning an energy load to allow a localized analysis of energy supply; chunking treats the energy demand of the region as a set of quasi-independent "campuses," and can be applied to local energy networks that integrate combined heat and power and other small scale energy services.
Cogeneration	Also referred to as combined heat and power or CHP, cogeneration is the use of a heat engine or a power station to simultaneously generate both electricity and useful heat.
Community Choice Aggregation	A local governmental program that buys, and may generate, electrical power for residents and businesses within the jurisdiction of the local government.
Community Wind	Wind power generation at a scale commensurate with the sensibilities of a given community.
Conventional Resources	The primary energy sources that have up to the present time been used to generate electricity, such as coal, natural gas, nuclear, and hydropower.
Coupling	In system dynamics modeling, refers to the degree to which two elements of a system are related to each other and how the interactions of the coupled elements affect the overall system.
Conversion	The process of changing one form of energy to another.
Data Dictionary	A centralized repository of information about data such as meaning, relationships to other data, origin, usage, and format
Deferrable Load	An electrical load which needs to be supplied for a part of day and can be deferred in time
Demand	The amount of electricity required to serve a given electrical load.
Demand Management	The modification of consumer demand for energy through various methods such as financial incentives, efficiency measures, education, and technological controls.
Demand Response	Demand response mechanisms respond to explicit requests, or automated controls, to reduce or shut off energy usage, usually during times of stress on energy supplies.
Deployment	The process of financing, building, and operating new renewable energy or energy efficiency.

Distributed Generation	Electrical generators, smaller than 20 megawatts, connected to electrical distribution circuits (rather than high voltage transmission), and that is intended to serve primarily local energy demand.
Distribution	The final stage of transporting energy to large numbers of end users. An electric power distribution network carries electricity from the bulk transmission system and delivers it to consumers, and typically includes medium-voltage (less than 50 kV) power lines, substations and pole-mounted transformers.
District Heat	A system for distributing heat generated in a centralized location for commercial and/or residential heating requirements such as space heating and water heating.
E-CCAINFO	A PG&E "tariff" or customer class through which certain data, such as electrical load data, may be obtained by local governments investigating, pursuing, or implementing community choice aggregation.
Energy 10 Software	ENERGY-10™ is a software tool that helps architects, builders, and engineers quickly identify the most cost-effective, energy-saving measures to take in designing a low-energy building.
Energy Efficiency	A technology, measure, or practice that delivers comparable or superior service or performance output, using less energy input.
Energy Security	The relationship between security, including personal and public health, safety, and welfare, and the availability of natural resources for energy consumption.
Energy Storage	A device or system that stores electrical or other forms of energy for use at a later time.
Exergy	The energy that is available to be used from a system.
Feed-in Tariff	A policy mechanism whereby an energy utility is required to purchase energy supplies, normally from renewable sources, at a pre-established, administratively set price or schedule of prices.

Feedstock	The raw material used to fuel a machine or industrial process.
Feedbacks	In system dynamics, feedbacks are internal loops in a system that may have a range of effects on the whole system or parts of it.
Gasification	A process that converts organic materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures without combustion. The resulting gas mixture is itself a fuel. The power derived from gasification of biomass and combustion of the resultant gas is considered to be a source of renewable energy
Geocoding	The process of finding associated geographic coordinates (often expressed as latitude and longitude) from other geographic data, such as street addresses, or postal codes. With geographic coordinates the features can be mapped and entered into Geographic Information Systems, or the coordinates can be embedded into media such as digital photographs.
Geospatial Analysis	An approach to applying statistical analysis and other informational techniques to geographically based data.
Geothermal	Thermal energy generated and stored in the Earth that can be used to generate electricity, or to provide heat for buildings or industrial processes.
Geysers	A complex of geothermal power plants drawing steam from more than 350 wells, located in the Mayacamas Mountains in Sonoma and Lake Counties.
Grid	The interconnected physical network for delivering electricity from suppliers to consumers.
Grid Parity	Grid parity is where the cost of a renewable energy source, such as electricity from solar photovoltaics, is equal to conventional grid power.
HOMER Software	A computer model that is used for designing distributed generation systems — both on and off-grid.
Hot Spot	An area of high electrical demand coinciding with favorable distribution grid characteristics and renewable energy deployment prospects.

Hydropower or Hydroelectric Power	The generation of electrical power using the gravitational force of falling water, and engineered structures, such as dams, that constrain or divert bodies of water.
Hydrokinetic Power	The generation of electrical power using the energy of natural movements of water, including ocean wave, current, or tidal power.
Incremental Cost	The overall cost of an increase of one additional unit of output
Insolation	A measure of solar radiation energy received on a given surface area and recorded during a given time.
Interconnection	The physical electrical interface between a utility and a renewable energy resource.
Interoperability	Deploying renewable energy and load balancing resources in such a way that they work together to improve efficiency and optimize the use of each resource.
Levelized Cost of Energy	All the costs of an energy resource over its financial life divided by the total number of kilowatt-hours or megawatt-hours of electricity generated over the same period; normally adjusted on a net-present value basis.
Load	An amount of electrical power demanded or consumed by an electricity user or customer.
Load Balancing Resources	Measures or systems such as energy efficiency, demand management, and energy storage that help to balance energy supply with energy demand.
Load Factor	The average power divided by the peak power over a period of time.
Load Profile or Shape	A graphic representation of the variation in the electrical load over time. A load profile or shape will vary according to customer type, time of day, temperature, season, and other variable factors.
Loading Order	A policy that establishes the priority ranking for preferred deployment of energy services; in California, energy efficiency is prioritized over renewable energy, and natural gas power generation is lowest in rank.

Methodology	A system for solving a problem, with specific components such as phases, tasks, methods, techniques, tools, and documentation.
Microgrid	Small-scale electricity network, usually designed to achieve specific local goals, such as diversification of energy sources, GHG emission reduction, reliability, and cost reduction.
Minnesota Flip	A hybrid financial structure for renewable energy development in which a third party developer owns a project in the initial years to take advantage of the tax benefit, and then sells the project at a minimal cost to customers.
Model and Modeling	A collection of logical and mathematical relationships that represents aspects of a situation under study. Models describe important relationships between variables, include an objective function with which alternative solutions are evaluated, and often have constraints that restrict solutions to certain values.
Natural Gas	A naturally occurring hydrocarbon gas mixture consisting primarily of methane, with up to 20 percent of other hydrocarbons as well as impurities in varying amounts; extracted from geological reservoirs of natural gas or petroleum.
Net Metering or Net Energy Metering	An electric rate structure that allows a customer-generator to receive a financial credit for power generated by their onsite system and fed back to the utility. The credit is used to offset all, or a portion, of the customer's electricity bill.
Off Grid	A system that is not interconnected to the electrical grid.
Peak, or Peak Power	The highest amount of electricity demand in an electricity load profile.
Peaker Plant	Power plants that generally run only when there is a high demand, or peak demand, for electricity.
Point to Raster Conversion	A type of geospatial analytical tool that allows the user to select a conversion that is specific to a selected data set.
Portfolio	A combination of energy supplies and services that are designed to achieve strategic objectives, such financial, environmental, or performance goals.

Power Purchase Agreements	A contract between two parties, one who generates electricity for the purpose of sale (the seller) and one who is looking to purchase electricity (the buyer), who does not own the electrical generation equipment.
Property Assessed Clean Energy	Loans for energy efficiency measures or renewable energy that are repaid over a fixed term via a voluntary assessment on property tax bills.
Pumped Storage	Storage of energy in the form of water, pumped from a lower elevation to a higher elevation reservoir. Low-cost off-peak electric power is used to run the pumps. During periods of high electrical demand, the stored water is released through turbines to produce electric power.
Pyrolysis	The thermochemical decomposition of organic material at high temperatures with an absence of oxygen.
Rankine Cycle	A cycle that converts heat into work. The heat is supplied externally to a closed loop, which usually uses water. This cycle generates about 90 percent of all electric power used throughout the world including virtually all solar thermal, biomass, coal and nuclear power plants.
Raster Data	A structure based on a (usually rectangular) rendering of data cells into a two dimensional plane.
Rate	The amount of money charged for a specific unit of good or service, such as a kilowatt-hour of electricity.
Rate Class	A category of customer, usually sharing a similar structure of rate charges.
Ratepayer	A customer who pays for utility services, such as electricity or natural gas, based upon an established schedule of service rates.
Renewable Energy	Energy resources, such as solar and wind energy, that can be practically used at a rate that does not deplete the resource; national and state governments often define by law which renewable energy resources are eligible for specific programs.
Rule 21 (CPUC)	The CPUC Rule that governs interconnection of distributed generation to the electric grid. http://www.cpuc.ca.gov/PUC/energy/Procurement/LTPP/rule21.htm

Shapefile	A geospatial vector data format for geographic information systems software.
Smart Grid	A digitally enabled electrical grid that gathers, distributes, and acts on information about the behavior of all participants (suppliers and consumers) in order to improve the efficiency, reliability, economics, and sustainability of electricity services.
Solar Photovoltaics	A method of generating electrical power by converting solar radiation directly into electricity using semiconductors that exhibit the photovoltaic effect.
Spinning Generator	An electrical generation system that can be ramped up to meet increased demand.
Substation	A part of an electrical grid that connects major elements of the grid, such as large generation, transmission and distribution systems, and performs several important functions, including transforming voltage and controlling power flow.
System Dynamics Model	A model used to understand the behavior of complex systems over time including internal feedback loops and time delays that affect the behavior of an entire system.
Systems Ecology	An application of general systems theory that takes a holistic approach and focuses on interactions within and between given systems.
Therm	A unit of heat energy equal to 100,000 British thermal units. It is approximately the energy equivalent of burning 100 cubic feet of natural gas.
"Top Down" Approach	A methodological approach where policies, goals, programs, generally available renewable energy resources, larger scale demand characterization, and general financial features are the main factors for evaluating deployment of elements of a renewable energy portfolio.
Transmission	The bulk transfer of electrical energy, on high voltage power lines, from large power plants to electrical substations located near demand centers.

Upfront Cost	A fee paid before a good is produced or a service is performed. The upfront fee is generally a portion of the total fee that the buyer must pay.
Utility Scale	Large scale energy systems suitable for use by electrical utilities.
Virtual Power Plant	A system of distributed generation resources that are collectively controlled by a single entity.
Wind Turbine	A device that converts kinetic energy from the wind into mechanical energy used to power a generator to produce electricity.

Glossary of Acronyms and Abbreviations

8760	Refers to the 8,760 hours in a year
AB 32	Assembly Bill 32
AC	Alternating Current
ARRA	American Recovery and Reinvestment Act
ARB	Air Resources Board
AWS Truewind	Mapping tools produced by the company AWS Truewind, used for analyzing wind power potential
BAU	Business as Usual
BDT	Bone Dry Tons
Btu	British Thermal Unit
C&D	Construction & Demolition
CAISO	California Independent System Operator
CARE	California Alternative Rates for Energy
CCA	Community Choice Aggregation
CCAP	Community Climate Action Plan
CF	Capacity Factor
CFL	Compact Fluorescent Light
CLEAR Model	Climate-Energy Assessment for Resiliency
CO_2	Carbon Dioxide
CPC	Climate Protection Campaign
CPUC	California Public Utilities Commission
CREB	Community Renewable Energy Bond
CSI	California Solar Initiative
DA	Direct Access
DC	Direct Current
DG	Distributed Generation
EE	Energy Efficiency

EEM	Energy Efficient Mortgage
EERE	Energy's Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EPBB	Expected Performance Based Buydown
ERP	Emerging Renewables Program
ESCO	Energy Service Company
ESP	Energy or Electricity Service Provider
EV	Electric Vehicle
FERC	Federal Energy Regulatory Commission
FiT	Feed-in Tariff
GHG	Greenhouse Gas
GIS	Geographic Information System
GW	Gigawatt
GWh	Gigawatt-hour
HOMER	Hybrid Optimization Model for Electric Renewable
HVAC	Heating, Ventilation, and Air Conditioning
IOU	Investor Owned Utility
IP	Implementation Plan
JPA	Joint Powers Authority
kW	Kilowatt
kWh	Kilowatt-hour
LANL	Los Alamos National Laboratory
LCOE	Levelized Cost of Energy
LED	Light Emitting Diode
LTPP	Long Term Procurement Plan
MEA	Marin Energy Authority
MMBTU	Million British Thermal Units
MMSCF	Million Standard Cubic Feet

MSW	Municipal Solid Waste
MW	Megawatt
MWe	Megawatt-electric
MWh	Megawatt-hour
NCPA	Northern California Power Authority
NG	Natural Gas
NREL	National Renewable Energy Laboratory
O&M	Operations & Maintenance
PACE	Property Assessed Clean Energy
PBI	Performance Based Incentive
PGC	Public Goods Charge
PG&E	Pacific Gas & Electric
PIER	Public Interest Energy Research
POU	Publicly Owned Utility
PPA	Power Purchase Agreement
PWRPA	Power and Water Resources Pooling Authority
RAM	Renewable Auction Mechanism
RCPA	Regional Climate Protection Authority
RD&D	Research Development & Demonstration
RDG	Renewable Distributed Generation
REC	Renewable Energy Credit or Certificate
RESCO	Renewable-based Energy Secure Community
RPS	Renewable Portfolio Standard
SCADA	Supervisory Control and Data Acquisition
SCE	Southern California Edison
SCWA	Sonoma County Water Agency
SGIP	Small Generator Incentive Program (may also refer to Self-Generation Incentive Program, a different program)

SMUD	Sacramento Municipal Utility District
SSA	Substation Service Area

APPENDICES: A through B

Appendix A	Sonoma County RESCO Portfolio Resource Spreadsheets Description	APA
Appendix B	Cost of Electrical Generation in Sonoma RESCO Portfolio	APB