Energy Research and Development Division
FINAL PROJECT REPORT

SAN LUIS OBISPO RENEWABLE ENERGY SECURE COMMUNITY

Prepared for: California Energy Commission
Prepared by: Local Power, Inc.

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Local Power.

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PREFACE

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

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

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

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

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- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

San Luis Obispo Renewable Energy Secure Community is the final report for the San Luis Obispo Renewable Energy Secure Community (SLO-RESCO) project (contract number PIR-08-032) conducted by Local Power Inc. The information from this project contributes to Energy Research and Development Division's Renewable Energy Technologies Program.

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

ABSTRACT

The Renewable Energy Secure Communities program is intended to advance the deployment and integration of renewable and distributed energy resources at the community level to provide local sources of power at competitive rates in line with statewide energy policy. The San Luis Obispo Renewable Energy Secure Communities project detailed in this report was intended to inform local decision makers, particularly government officials regarding the available pathways to achieve the program's goals. This report providesan overview of how the power sector is currently planned and operated, delineates options a local government has to influence or directly control its community's power supply, analyzes barriers to achieving Renewable Energy Secure Communities goals and proposes a commercialization strategy using Community Choice Aggregation with an innovative business model to deploy distributed energy resources. The business model proposeusing Community Choice Aggregation's access to customer electric meter and other data to (1) target the deployment of distributed energy resources in an integrated fashion, (2) streamline project financing, (3) use a performance-based contracting approach to deploying the technologies while managing performance risk, (4) capture retail bill savings through energy savings and power purchase agreements and to integrate the deployed technologies directly into the procurement planning and operations of Community Choice Aggregation.

Case studies of local distributed generation and "lessons learned," high-level surveys of local renewable and distributed energy resources, detailed studies of select end-uses of solar and biomass potential and the technical resource potential of select resources are also discussed in the report. Significant local outreach was undertaken by the project to form an advisory committee comprising local decision makers, educate the public and inform San Luis Obispo County's EnergyWise Action Plan. An Energy Atlas was created to summarize the findings of the resource survey and technical potential estimates as an outreach tool for the public.

Keywords: Renewable Energy Secure Community, RESCO, Community Choice Aggregation, CCA, distributed generation, DG, distributed energy resources, DERs, DER, renewables, greenhouse gas reductions, GHG, energy resiliency, energy security, Localization Portfolio Standard, LPS, energy localization, Big Data, meter data analysis, retail competition, municipalization, publicly owned utility, municipal utility, public utility district, municipal district, irrigation district, MU, PUD, MUD, ID, Direct Access, levelized cost, public power, PG&E, Pacific Gas and Electric, IOU, investor owned utility, resource inventory, Renewable Portfolio Standard, RPS, solar photovoltaic, solar thermal, combined heat and power, wind, advanced energy storage, energy efficiency, conservation, demand response, demand dispatch, OpenADR, AES, DSM, Energy Atlas, EnergyWise Action Plan, Climate Action Plan

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Introduction

The California Energy Commission's Renewable Energy Secure Communities (RESCO) program is intended to advance the deployment and integration of renewable energy resources at the community level to provide local sources of power and at competitive rates in line with statewide energy policy. The overarching goal is to increase reliance on local resources in order to lower greenhouse gas emissions and enhance local grid security by minimizing vulnerabilities to the interruption of electricity supply that can result from the over-reliance on remote generation resources and the transmission and distribution networks that supply this electricity to end users.

The deployment of distributed energy resources in California is currently left up to “the market to deliver. The power planning process provides subsidies to the direct installation of distributed generation and efficiency in the form of rebates, technical advice and limited procurement targets for the investor-owned utility. There is no widespread mechanism by which these technologies are targeted based on customer onsite economics or characteristics, despite the fact that the data and analytics to do so are available. There are also no funds to provide project financing so individual customers and installers must arrange it on a project-specific basis,although there is now a California Public Utility Commission (CPUC) initiative seeking to provide this service.

Renewable distributed generation and demand-side technologies, and the business models that deploy them, have become increasingly competitive over the last decade. The energy industry will continue to change fundamentally over the nearterm, as legacy infrastructure (transmission lines and large power plants) built to serve the centralized energy grid may become less competitive compared to “virtual power plants” composed of local distributed energy generation, storage and demand dispatch assets that are coordinated and optimized to serve customer power needs and to provide grid stability while lowering overall costs. The differences in reliability, power quality, local community development and long-term rate stability may be profound.

Project Purpose

The San Luis Obispo RESCO (SLO RESCO) project was intended to inform local decision makers and in particular government officials regarding the available pathways to achieve RESCO goals on a community-wide scale.

Project Results

This report provides an overview of how the power sector is currently planned and operated, delineates the options a local government has to influence or directly control their community’s power supply, analyzes gaps and barriers to achieving RESCO goals focused on San Luis Obispo County, and proposes a commercialization strategy and pathway that may overcome many barriers to achieve those goals in the near -term. The project performed case studies of local distributed generation facilities and lessons learned were derived from each. A high-level survey of local renewable resources is included in this report, with more detailed studies of select end uses of solar and biomass generation potential. Significant local outreach was undertaken to form an advisory committee composed of local elected officials, activists, educators and business owners to educate the general public and key stakeholders and to inform the county's EnergyWise Action Plan (formerly the Climate Action Plan). An Energy Atlas was created to summarize the findings of the resource inventory of San Luis Obispo County as an outreach tool for the general public.

California has strong policy support from the legislature and regulatory agencies as well as leadership in various local governments and from successive governors in advancing renewables, greenhouse gas reductions, and distributed generation. California's investor-owned utilities (IOUs) are mandated to procure 33 percent of their power from renewable resources by 2020 under the state's Renewables Portfolio Standard. California Assembly Bill 32 and the California Air Resources Board's subsequent Scoping Plan and actions to initiate a carbon market in California aim to reduce greenhouse gas emissions to 1990 levels by 2020.

Table 1 shows Governor Brown's goal for 12,000 megawatts (MW) of distributed generation by 2020, and the laws, programs, and regulatory proceedings in place to accomplish it.

Table 1: California Distributed Generation Programs and Goals (as of January 2013)

	Estimated Target MW	**Share of Governor's Goal**
Governor Brown's Goal	12,000	
Existing Programs		
California Solar Initiative	3,000	25%
IOU Qualifying Facility Settlement (CHP)	3,000	25%
CPUC Expanded Net Metering (May 2012)	2,800	23%
CPUC Investor Owned Utility (IOU) PV Program	700	6%
CPUC Renewable Auction Mechanism (RAM)	1,300	11%
Feed-In Tariff (SB 32)	750	6%
Biomass Feed-In Tariff (2012)	250	2%
Additional Voluntary Publicly Owned Utility (POU) Feed-In Tariffs	100	1%
Subtotal	11,900	99%
Proposed New Programs (2013)		
EJ Feed-In Tariff (AB 1990)	190	2%
Community Renewables	500	4%
Subtotal	690	6%
Existing & Proposed Programs		
Subtotal	12,590	105%

Source: Local Power Inc.

The ways in which the power system is planned, built, maintained and operated by various regulatory and state agencies carrying out state policy, utilities, merchant generators and other organizations could result in conflicting actions in implementing these policies. This lack of effective coordination stems from numerous factors but interrelated trends included:

- The conflicting ideologies of "command-and-control" of investor-owned utilities versus market design and competition among smaller entities.
- The after-effects of California's 2000-2001 energy crisis.
- The related institutional "drift" at the California Independent System Operator (CAISO) and the CPUC.
- The resulting disagreement over how to best to plan and implement California's energy policy mandates.

The interactions of these ideologies to influence the ways in which energy planning is implemented are summarized in this report to provide broader context for local governments seeking to further the penetration of renewables and distributed energy resources in line with RESCO goals.

Options available for local governments to influence or control their community's power planning are detailed in this report, along with summaries of potential implementation pathways. . Actions a local government could take to influence but not directly control how energy is used include:

- Applying to the CPUC to administer a portion of the energy efficiency funds collected from customers.
- Applying for grants from the incumbent investor-owned utility for local energy programs.
- Structuring programs to finance distributed energy resources (such as Property Assessed Clean Energy districts, or PACE).
- Streamlining permitting procedures and minimizing fees for distributed energy resources.
- Modifying local zoning to facilitate the siting of renewable generation.

Local governments in San Luis Obispo County are active in all of the options listed above.

Options for a local government to assume direct control over power planning include: municipalization of the distribution grid and the assumption of power planning and retail power service through one of the following entities' publicly owned utility (POU) structures: (1) municipal utility (MU); (2) municipal utility district (MUD); (3) public utility district (PUD); and (4) irrigation district (ID). The second option was implementing a community choice aggregation (CCA) to automatically enroll customers in a program wherein the local government would be responsible for power procurement (but not distribution service, which is provided by the incumbent utility), from which customers could voluntarily depart and return to their previous utility.

Table 2 compares the various forms of municipalizations and community choice aggregation by key considerations. In the table LAFCO refers to Local Agency Formation Commission and JPA refers to Joint Powers Authority.

Table 2: Comparison of Key Considerations for Municipalization and CCA

Type	Territory	Initiation Action(s)	LAFCO Review Required?	Popular Vote Required?
Community Choice Aggregation (CCA)	Single city or county, or multiple cities and/or counties under a JPA	Ordinance by local government(s)	No	No
Municipal Utility (MU)	Single city only, or multiple cities under a JPA (or county if authorized by state legislature)	Majority vote by city council(s)	No (unless county included)	Not for initiation (but required to issue bonds for distribution acquisition)
Municipal Utility District (MUD)	City and unincorporated territory up to the entire County or multi-county	Majority public agency resolution or petition by 10% of voters	Yes	Majority vote with 2/3rds turnout of registered voters
Public Utility District (PUD)	Unincorporated territories only	15% of last voter turnout total petition	Yes	Majority vote in each of the District's Unincorporated Territories
Irrigation District (ID)	Single city up to county or multi-county	Majority district landholder or 500 resident voter petition	Yes	Majority vote

Source: California Municipal Utilities Association and Local Power Inc.

Publicly owned utilities collectively supply approximately 25 percent of electricity in California and own significant transmission assets that together amount to more than 40 percent of the high voltage electricity transfer capacity in and out of the state. Retail competition has been largely suspended. Table 3 shows electricity consumption in California by the provider of the electrical service.

Table 3: California Electricity Consumption by Provider

Entity	GWh of Load Served	Percentage
IOU	187,516	69%
POU	68,375	25%
Federal	2,749	1%
Self-Generation	14,006	5%
Total	272,645	100%

Source: California Energy Commission

In addition, there are three CCAs in California:

- Marin Clean Energy work within Marin County and is managed by the Joint Powers Authority Marin Energy Authority (MEA), comprising the county and most cities within the county. In addition, the City of Richmond intends to join MEA to serve approximately 30,000 customers beginning in Q3 2013.
- Sonoma Clean Power, which intends to start serving customers in Sonoma County and participating cities beginning in December 2013.
- CleanPowerSF, which intends to start serving customers in the City and County of San Francisco in October 2013.

When all three CCAs listed above enroll all eligible customers in their territories their combined load (accounting for customers who choose to opt-out) will be approximately 7,021 gigawatt hours (GWh). This is approximately eight percent of the load served by Pacific Gas and Electric (PG&E), the distribution utility in the territory where the CCAs are located.

Table 4 provides a framework model to delineate key considerations to assist local governments in their discussions regarding the advancement of distributed energy resources in their communities, the following questions provide a 'framework model' to delineate key considerations. The answers for each pathway available to a local government in California are color-coded. Green denotes a desirable outcome, red denotes an undesirable outcome and orange denotes an outcome that is desirable but limited in scale.

Table 4: Framework Model and Pathways to Achieve RESCO Goals

Does the authority enable the local government to:	CCA	POU	Status-Quo
Influence local zoning, permitting, and land use considerations?	Yes	Yes	Yes
Provide technical and other assistance for deploying distributed energy resources?	Yes	Yes	Limited
Assume direct control over its community's power planning and operations?	Yes	Yes	No
Assume responsibility for the distribution grid?	No	Required	No
Issue revenue bonds to fund projects?	Yes	Yes	Limited
Fund generation projects cost-competitively (as compared to the incumbent utility)?	Yes	Yes	Limited
Integrate distributed energy resources into power planning and operations?	Yes	Yes	No
Access to customer-specific utility meter data?	Yes	Yes	No
Effectively implement without a referendum?	Yes	No	Yes
Implement in the near term (1-3 years)?	Yes	No	Yes

Source: Local Power Inc.

The commercialization strategy proposed to overcome as many barriers as possible to deploying distributed energy resources at scale while advancing RESCO goals shown in the framework model above employs CCA and is predicated on constructing local renewable and distributed energy resources in a targeted and scaled fashion. This strategy builds on the approach being taken by Sonoma Clean Power, while differing in regard to the strategies used to deploy distributed energy resources.

The Sonoma Clean Power CCA is a JPA comprising the Sonoma County Water Agency (SCWA), the County of Sonoma and several cities within the county. The SCWA is responsible for the implementation and management of the CCA and intends to begin serving customers in Q4 2013. This report includesd a brief history of the Sonoma Clean Power CCA as a case study for local governments of the studies and policies which formed and guided the CCA, the implementation pathway envisioned for the program and the current status of the implementation process.

Sonoma Clean Power is currently in the middle of a two-stage competitive bidding process to select an energy service provider to implement the CCA. The first stage of the request for proposals (RFP) process was a success and Sonoma Clean Power received 11 bids to supply the CCA with electricity services. Based on this preliminary pricing, Figure 1 compares example residential and commercial monthly electric bills for Sonoma Clean Power customers and Pacific Gas & Electric customers. While increasing the amount of renewable power to 33 percent (compared to PG&E’s 20 percent), the bids that the agency received resulted in rates between four percent below and 0.5 percent above the rates charged by PG&E.

Figure 1: Preliminary Comparison of Sonoma Clean Power and PG&E Rates

Example Residential Electric Fees Based on 500 kWh per month	SCP Low Estimate for 2014	SCP High Estimate for 2014	PG&E Estimated Rate for 2014
	33% Renewable Energy	33% Renewable Energy	20% Renewable Energy
Electric Generation Fees *(all customers)*	$35.71	$38.46	$40.76
PG&E Electric Delivery Fees *(all customers)*	$55.80	$55.80	$55.80
Additional PG&E Fees *(SCP customers only)*	$3.32	$3.32	$0.00
Last updated April 15, 2013	Total Cost **$94.83**	Total Cost **$97.58**	Total Cost **$96.56**

Example Commercial Electric Fees Based on 15,000 kWh per month	SCP Low Estimate for 2014	SCP High Estimate for 2014	PG&E Estimated Rate for 2014
	33% Renewable Energy	33% Renewable Energy	20% Renewable Energy
Electric Generation Fees *(all customers)*	$1,203	$1,296	$1,373
PG&E Electric Delivery Fees *(all customers)*	$1,169	$1,169	$1,169
Additional PG&E Fees *(SCP customers only)*	$90	$90	$0
Last updated April 15, 2013	Total Cost **$2,462**	Total Cost **$2,555**	Total Cost **$2,542**

Image Credit: Sonoma Clean Power.

The Sonoma Clean Power RFP also allowed bidders to propose local renewable generation and distributed energy resources. It is unknown at this writing to what extent the bids included these components. The Sonoma County Water Agency is prepared to develop local renewable and distributed energy resource projects regardless of whether the winning bidder proposed to or not.

In preparation for the expiration of the initial contract with the energy supplier in three years or more, the CCA is planning to take on the responsibility of running power procurement by contracting with multiple power plants and suppliers ahead of that date to assum direct control over the integration of local renewables and distributed energy resources.

The proposed strategy for achieving RESCO goals is similar to the process that Sonoma Clean Power is undertaking but differs in various key aspects regarding the methods employed to develop distributed energy resources. Sonoma Clean Power does not present a fully integrated approach and instead asks bidders to propose net energy metering and feed-in tariffs to stimulate the deployment of distributed generation while running separate efficiency programs. This approach is largely a continuation of the approach taken by the investor-owned utilities in California and does not overcome any further barriers to deploying distributed energy resources.

The proposed model provides an innovative deployment strategy that is commensurate with the scale of deploying distributed energy resources throughout an entire community. It proposes to use a CCA's access to customer meter and other data to target the deployment of distributed generation, advanced energy storage and demand-side measures (efficiency, conservation, and demand response) in an integrated fashion. The model's approach allows for streamlining the the financing of these projects, using a multi-stage performance-based contracting strategy to deploy the technologies while managing performance risk, and captures retail savings through energy savings and power purchase agreements and provides for the integration of these assets directly into procurement planning and operations of the CCA.

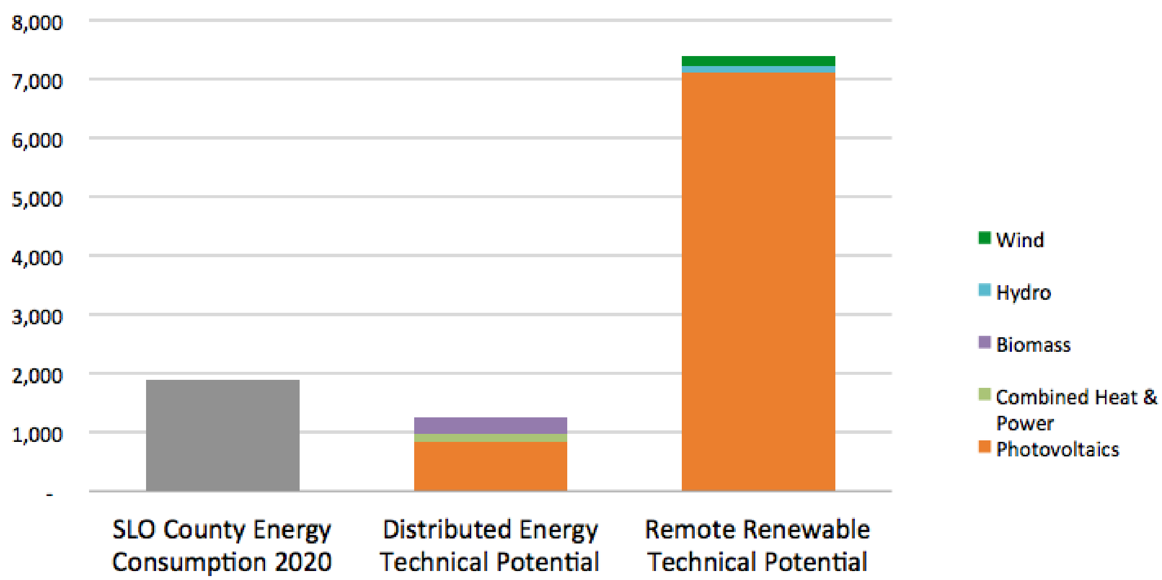
To initiate the RESCO commercialization strategy, interested local governments and agencies should form a Joint Powers Authority to manage the CCA. This may be accomplished relatively quickly , given political support at the board level. Each local government would adopt an ordinance to implement community choice aggregation, the Joint Powers Agreement would be drafted collaboratively and then the board of each agency and local government would adopt the agreement by majority vote. The JPA would then file a Notice of a Joint Powers Agreement with the Secretary of State. Efforts should be undertaken to identify staff in agencies or local governments that could take the lead in implementing and managing the program.

The local governments and agencies involved should adopt a goal and timeline for the deployment of local renewables and distributed energy resources. Policymakers should refrain from setting technology-specific targets, which could constrain the ability of staff and implementers to cost-effectively achieve the overall goal. Instead, a Localization Portfolio Standard should be set that specifies annual percentages of energy and capacity needs to be met by local resources comprising solar photovoltaic, solar thermal, combined heat and power, wind, advanced energy storage, energy efficiency, conservation and demand response technologies. Broader California Renewable Portfolio Standard targets could also be adopted specifying the percentage of power that meetthe definition of "renewable" under the policy to be procured in excess of minimum RPS targets mandated by law, although this may pose financial trade-offs for accelerating the Localization Portfolio Standard which should be fully considered. Finally, RESCO goals could also be adopted to provide clear policy direction to the CCA and the public.

Further outreach should be undertaken to other government agencies and interested organizations to identify sites with the potential to develop local renewable and distributed energy resources. For example, in preliminary discussions staff at the San Luis Obispo County Integrated Waste Management Authority identified several opportunities for combined heat and power, anaerobic digesters and landfill gas. Projects such as these may be able to be integrated into the CCA's initial program.

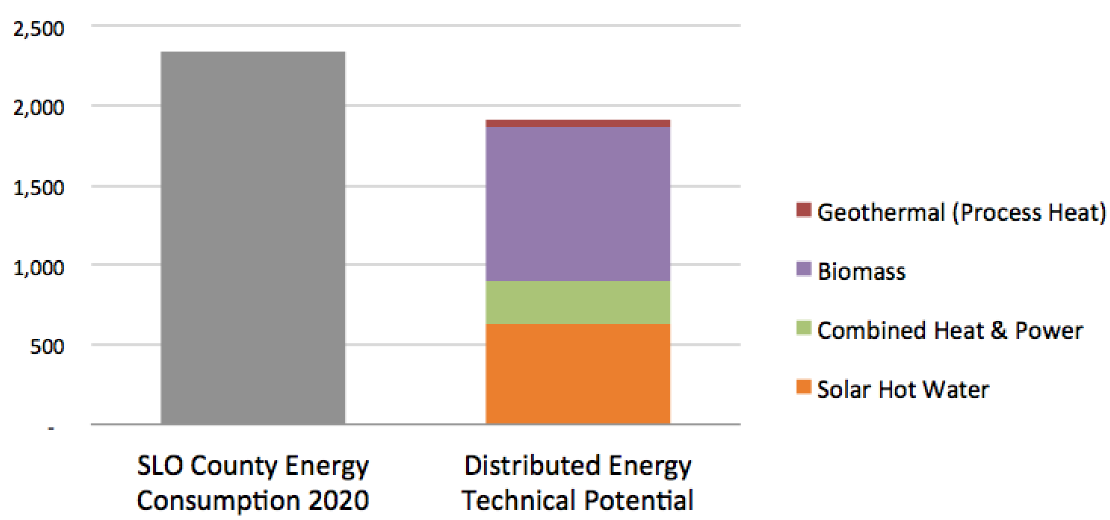
This project conducted a high-level survey of local renewable and certain distributed energy resources and more detailed studies of select end uses of solar and biomass resources were also performed. The data was used to calculate the technical generation potential. The technical generation potential is estimated to be sufficient to provide 66 percent of the county's electricity requirements and 82 percent of its thermal needs in the year 2020 with distributed energy resources, and the potential to build remote generation facilities to supply or export from the county electricity equal to 432 percent of the county's electricity consumption. Results of this analysis are shown in Figure 2 and Figure 3.

Figure 2: San Luis Obispo County Electricity Consumption and Resource Potential (GWh)



Source: SLO RESCO

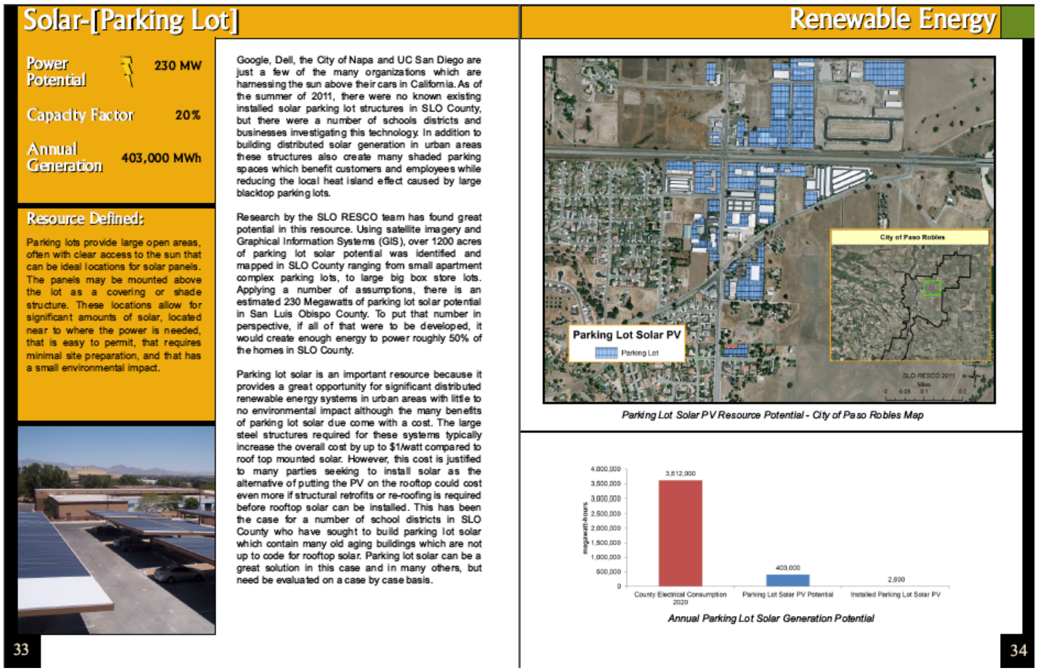
Figure 3: San Luis Obispo County Thermal Consumption and Resource Potential (GWh)



Source: SLO RESCO

Significant local outreach was undertaken to form an advisory committee composed of local elected officials, activists, educators, and business owners, to educate the general public and to inform the county's EnergyWise Action Plan. An Energy Atlas was created to summarize the findings of the resource inventory of San Luis Obispo County as one of several outreach tools to engage the general public. A screenshot from the Energy Atlas is shown in Figure 4.

Figure 4: Screenshot of the SLO RESCO Energy Atlas Publication



Solar-[Parking Lot]

Power Potential 230 MW

Capacity Factor 20%

Annual Generation 403,000 MWh

Resource Defined:

Parking lots provide large open areas, often with clear access to the sun that can be ideal locations for solar panels. The panels may be mounted above the lot as a covering or shade structure. These locations allow for significant amounts of solar, located near to where the power is needed, that is easy to permit, that requires minimal site preparation, and that has a small environmental impact.

Google, Dell, the City of Napa and UC San Diego are just a few of the many organizations which are harnessing the sun above their cars in California. As of the summer of 2011, there were no known existing installed solar parking lot structures in SLO County, but there were a number of schools districts and businesses investigating this technology. In addition to building distributed solar generation in urban areas these structures also create many shaded parking spaces which benefit customers and employees while reducing the local heat island effect caused by large blacktop parking lots.

Research by the SLO RESCO team has found great potential in this resource. Using satellite imagery and Graphical Information Systems (GIS), over 1200 acres of parking lot solar potential was identified and mapped in SLO County ranging from small apartment complex parking lots, to large big box store lots. Applying a number of assumptions, there is an estimated 230 Megawatts of parking lot solar potential in San Luis Obispo County. To put that number in perspective, if all of that were to be developed, it would create enough energy to power roughly 50% of the homes in SLO County.

Parking lot solar is an important resource because it provides a great opportunity for significant distributed renewable energy systems in urban areas with little to no environmental impact although the many benefits of parking lot solar due come with a cost. The large steel structures required for these systems typically increase the overall cost by up to $1/watt compared to roof top mounted solar. However, this cost is justified to many parties seeking to install solar as the alternative of putting the PV on the rooftop could cost even more if structural retrofits or re-roofing is required before rooftop solar can be installed. This has been the case for a number of school districts in SLO County who have sought to build parking lot solar which contain many old aging buildings which are not up to code for rooftop solar. Parking lot solar can be a great solution in this case and in many others, but need be evaluated on a case by case basis.

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Renewable Energy

Parking Lot Solar PV Resource Potential - City of Paso Robles Map

Annual Parking Lot Solar Generation Potential

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Source: SLO RESCO

Project Benefits

This project developed tools and methods to help meet the goals of the Renewable Energy Secure Communities program, which is focused on advancing the deployment and integration of renewable and distributed energy resources at the community level..

The project's results provide guidance and information that San Luis Obispo County may use in advancing its renewable energy and energy conservation goals, and potentially lead to ec onomic benefits for the County. The lessons learned and the ideas provided in this project are likely to be useful to other regions of California. Statewide, increased deployment of renewable and distributed energy as sources of electricity will reduce greenhouse gases that contribute to climate change and will also reduce other air emissions that cause air pollution

CHAPTER 1:
Overview of Power Planning and Deployment in California

1.1 Introduction

California has strong policy support from the legislature and regulatory agencies as well as leadership in various local governments and from successive governors in advancing renewables,[1] greenhouse gas reductions,[2] and distributed generation. The table below shows Governor Brown's goal for 12,000 MW of distributed generation by 2020, and the laws, programs, and regulatory proceedings in place to accomplish it:

Table 5: California Distributed Generation Programs and Goals (as of January 2013)

	Estimated Target MW	Share of Governor's Goal
Governor Brown's Goal	12,000	
Existing Programs		
California Solar Initiative	3,000	25%
IOU Qualifying Facility Settlement (CHP)	3,000	25%
CPUC Expanded Net Metering (May 2012)	2,800	23%
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Subtotal	11,900	99%
Proposed New Programs (2013)		
EJ Feed-In Tariff (AB 1990)	190	2%
Community Renewables	500	4%
Subtotal	690	6%
Existing & Proposed Programs		
Subtotal	12,590	105%

Source: Local Power Inc.

The broader context within which these policies are deployed warrants summarizing for local governments seeking to accelerate the penetration of renewables and distributed generation, in line with RESCO goals. An electrical system is a capital-intensive, technically complex, and economically vital component of infrastructure; because of this, the utility industry has for decades been referred to as a 'natural' monopoly, and been regulated heavily by government.

[1] The investor owned utilities in California are mandated to procure 33% of their power from renewable resources by 2020.

[2] AB 32 and the California Air Resources Board subsequent Scoping Plan and actions to initiate a carbon market in California aim to reduce greenhouse gas emissions to 1990 levels by 2020.

Competition was introduced to varying degrees of success during deregulation, which in California, infamously failed to produce the intended consequences. In this state, the investor-owned utilities (IOUs) continue to be vertically integrated[3] and have been partially deregulated, while retail competition remains largely suspended outside of community choice aggregation (CCA). The incumbent IOU serving the County of San Luis Obispo is Pacific Gas and Electric (PG&E).

The ways in which the power system is planned, built, maintained and operated by various regulatory and state agencies carrying out state policy, utilities, merchant generators, and other organizations can result in conflicting actions. This lack of effective coordination stems from numerous factors, but a few inter-related trends warrant summarizing:

- The conflicting ideologies of 'command-and-control' of investor owned utilities versus market design and competition among smaller entities;
- The after-effects of California's 2000-2001 energy crisis;
- The related institutional 'drift' at the CAISO and CPUC;
- The resulting disagreement over how to best to plan and implement California's energy policy mandates.

In principle, the aforementioned entities should, in the context of California's stated goals, work to ensure the success of renewables and distributed energy resources. Because of the aforementioned trends however, these efforts are being hindered.

1.2 Competing Ideologies

As stated at the beginning of this chapter, the electrical system is a capital-intensive, technically complex, and economically vital component of infrastructure; because of this, the utility industry has for decades been referred to as a 'natural' monopoly, and been regulated heavily by government. This is sometimes referred to as 'command and control', and the CPUC provides this service in California by regulating the IOUs. Competition was introduced to varying degrees of success during deregulation; the ideology behind those policy initiatives believes that a more economically efficient way to govern the energy sector depends on designing and overseeing market mechanisms, within which smaller firms compete to satisfy the goals of the market. The CAISO designs, implements, and oversees energy markets in California. Deregulation, the shifting from command-and-control to market mechanisms, infamously failed to produce the intended consequences in California, and instead led to extreme market manipulation and the destabilization of the electrical grid. The resulting energy crisis effectively halted the deregulation movement across the country, and produced an ad-hoc hybrid system of regulation in California.

[3] Vertically integrated refers to a utility that owns or operates generation, transmission, and distribution assets, and that offers retail electric service.

1.3 The Suspension of Deregulation

The California energy crisis resulted in the bankrupting and state-sanctioned ratepayer bailout of PG&E, the approval of 38 new power plants under fast-tracked permit processes (allowed by the Governor's state of emergency declaration) that may not have been needed, and the approval of relatively expensive long-term power contracts that burden California ratepayers to this day. The transfer of wealth from California ratepayers to power producers amounted to over $40 billion. Retail competition was suspended, making the IOUs *de facto* monopolies again, with a captive customer base. Deregulation, which had spread too many states, ceased to be politically tenable given public opinion regarding the energy crisis in California.

1.4 Institutional Impact of the Energy Crisis

Policy failures during deregulation preceded, and in many ways defined, California's current regulatory environment. During the energy crisis, many felt that the Federal Energy Regulatory Commission (FERC) did not respond to California's request to intervene to regulate market manipulation in a timely manner. As a consequence, the CPUC has since been extremely reluctant to cede any control over California's energy planning to the CAISO, which is regulated by the FERC. At the same time, the CAISO is responsible for balancing most of California's electricity grid using market mechanisms. Had deregulation worked in California, the CAISO would have a direct role in energy planning and resemble more comprehensive entities such as PJM and NE-ISO.[4] These entities oversee forward capacity markets in which merchant generators and demand-side management providers compete to satisfy projected future load needs: in exchange for a guarantee that they will be able to provide power or negawatts at a certain point in the future, they receive capacity payments, which are set by the market clearing price. California does not have a forward capacity market – the CPUC rejected the proposal. Instead, the CAISO is relegated to running short term markets (day ahead and real time energy markets, and ancillary service markets that ensure grid stability) while the CPUC regulates the IOUs long-term procurement and demand-side management programs and, by virtue of the IOUs size and their *de facto* monopoly status, is responsible for deciding much of California's energy future.

1.5 Energy Planning in California

Every two years, the CPUC holds a Long Term Procurement Plan (LTPP) proceeding, in which it examines the need for new generation and reviews the IOUs 10-year procurement plans. It additionally ensures that near-term reliability (i.e. that enough capacity is available to meet demand) is met through Resource Adequacy (RA) proceedings, in which IOUs, CCAs, and energy service providers demonstrate adequate capacity on a monthly basis for the coming year. As there is no capacity market at the CAISO, RA needs are met through the IOUs own generation capacity, demand response programs, and with bilateral contracts with generators. The CAISO provides the engineering studies that advise the CPUC on what levels of capacity are needed to meet reliability standards, and where that capacity must be built. The CEC

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[4] These entities balance the electricity grids of the mid-Atlantic seaboard and New England, respectively.

provides load-forecasting estimates, updates building and appliance efficiency codes, manages renewable incentive and R&D programs, and is responsible for permitting thermal power plants over 50 MW.

1.6 Evolving Policy Considerations

In recent years, there have been several policies that significantly affect and may require changes to this planning process. The first is the 33 percent by 2020 RPS. This will require the electricity grid to integrate significant amounts of variable renewable resources, such as wind and solar. To do so, it is necessary to ensure sufficient resources that can quickly respond to ramping events (the rapid rise and fall of generation or demand), which will in future occur at different times and in different magnitudes compared to previous years. At the same time, given the California State Water Resources Control Board's (SWRCB's) recent and more stringent environmental regulation of the use of ocean water for cooling, many of the existing fossil-fired coastal generating units will be forced to either retire over the next ten years or be retrofitted with costly upgrades that eliminate the use of the existing Once-Through Cooling (OTC) technology. Because much of the existing OTC units are flexible resources, their retirement could result in a deficiency of flexible generation that could otherwise be used to integrate increasing amounts of intermittent renewable generation.

1.7 CAISO and CPUC Jurisdictional Conflicts

The CAISO has voiced concerns that the CPUC's planning process is insufficient to ensure grid reliability in the near-term, given these policy considerations. The CAISO Board recently approved a 'backstop' procurement mechanism, giving the agency the authority to approve capacity at risk of retirement that is deemed necessary to provide flexible capacity within a five-year horizon. This was done over strong objection from all stakeholders, including the CPUC. It is an interim measure taken to ensure grid stability until a suitable planning framework can be agreed upon.

1.8 Concerns over CAISO Planning Assumptions

Some stakeholders have questioned the assumptions behind CAISO's engineering studies that examine the need for flexible capacity resources under the 33 percent RPS and OTC retirement policies. There are significant questions as to whether, when and how much new flexible generating capacity is needed to support the anticipated increase in intermittent renewable resources. Even assuming the retirement of the existing fossil-fired OTC units, there remains within the CAISO Balancing Authority area significant amounts of gas turbine capacity, storage-based hydroelectric generating capacity, pumped/storage/generation facilities and existing fossil-fired generation that does not use ocean water for cooling. Some of these resources may not have been appropriately modeled in the CAISO studies.[5] In addition, the ability of other Balancing Authorities within the WECC to supply the CAISO with flexibility services is potentially enormous. The Bonneville Power Authority (BPA), LADWP and BC

[5] For more details on these objections, see Sierra Club California *Stakeholder Comments to the Flexible Capacity Procurement Revised Draft Final Proposal* (28 August 2012)

Hydro by themselves have thousands of megawatts of hydroelectric generation resources including pumped storage facilities. Dynamic scheduling of these resources to the CAISO Balancing Authority would allow the CAISO to use these resources to accommodate the intermittency of wind and solar resources connected within the CAISO Balancing Authority area.

Finally, the ability of dispatchable load to satisfy a portion of the CAISO's flexibility requirements is only partially accommodated under the CAISO's existing market rules. Dispatchable load is permitted to supply non-spinning reserves in the CAISO's ancillary service markets and supplemental energy in the CAISO's imbalance energy market, but not spinning reserves or regulation services in the CAISO's ancillary service markets. Some loads, such as large pumping loads, would seem ideally suited for supplying regulation services where the pumping load could be varied on a second-to-second basis through Automatic Generation Control (AGC) signals. Similarly, it is difficult to understand how a dispatchable load could fail to supply spinning reserves where the requirement is that load must be dropped within a ten-minute period.

1.9 The 'Missing Market' Debate

Some stakeholders are again calling for the establishment of a forward capacity market. The Brattle Group recently published a study for Calpine detailing the lack of transparency and inherent economic inefficiency of the CPUC planning process, and advancing a forward capacity market as a solution. However, concerns remain that California's resource needs are unique, by virtue of its high penetration of renewables, and that no 'off the shelf' forward capacity market design would be appropriate; in response, it has been suggested that the CPUC define the capacity products needed, and the CAISO design markets to deliver them.

1.10 Anti-Competitive Procurement Practices

In contrast to embracing a more transparent and competitive process, the IOUs are instead advocating for simply extending the CPUC's mandated RA obligations from the current year-ahead out for three to five years. PG&E has also filed a motion requesting that the CPUC move its consideration of forward procurement from the LTPP proceeding to the RA proceeding, in order to hasten the approval of contracts. This approach would have the practical effect of suppressing competition by exposing future community choice aggregation (CCA) customers to increased exit fees[6], and because significant concerns have been raised that without a transparent forward market, energy service providers would find it difficult to adjust their positions (as they cannot predict their load years in advance).

[6] IOU 'exit fees' charged to departing CCA customers include the Power Charge Indifference Adjustment (PCIA) surcharge, designed such that generation costs incurred on behalf of a customer prior to their enrollment in a CCA are not borne by other IOU bundled service customers in the event that the IOU is only able to sell the excess power at a loss. Cost drivers of the PCIA include but are not limited to natural gas prices, wholesale power prices, and renewable energy costs. Broadly, the charge is inversely correlated with wholesale power prices, such that if prices go down, the PCIA increases.

In addition, the IOUs are using the CAISO's studies to provide support for their proposals at the CPUC to either enter into Purchase Power Agreements (PPAs) for new fossil-fired generation, or to build and own new fossil-fired generation. One stakeholder has claimed that PG&E is further attempting to bypass the LTPP process on misleading legal grounds.[7] PG&E has advanced a request to approve a contract with a fossil fuel plant outside of the LTPP, based on the supposition that the regulatory process is not fast enough to meet grid reliability targets in this case – but PG&E failed to demonstrate a need for the plant except by relying on the CAISO's Renewables Integration study "high load" scenario. This scenario was not, in fact, one of the CPUC-approved scenarios.

1.11 Alternative Providers of Retail Power Services

1.11.1 Direct Access

Direct Access (DA) refers to the provision of power (but not distribution service) by competitive third-party providers to individual customers. It is the way by which the market design and competition ideology intended to inject price signals down to retail customers, which would select their energy service providers (ESPs), that in turn would compete to contract for generation and capacity resources that were supposed to be operated and built by other competitive firms under the market mechanisms of the CAISO. When deregulation was suspended, so was direct access, although there are occasional incremental expansions to the cap on direct access activity.

1.11.2 Municipalization

Forming a publicly owned utility (POU) allows a local government to continue the 'command and control' ideology but at a smaller, and many would argue, more manageable level. Local governments may run the utility directly, or may hire a company to do so under contract (or both). Publicly-owned utilities are governed by a locally-elected Board of Directors, and not by the California Public Utilities Commission (CPUC), and so are more directly accountable to voters impacted by the utility. In addition, a publicly-owned utility may elect to become its own balancing authority so as to claim the authority to balance its own grid instead of relying upon the CAISO to do so.

1.11.3 Community Choice Aggregation

Community Choice Aggregation is a hybrid of both the 'command and control' and market deregulation ideologies. A CCA is a competitive entity, and under the business model proposed in this report to advance RESCO goals, offers market access to smaller firms to deliver distributed generation, storage, renewable, and demand-side (efficiency, conservation, and demand response) technologies and practices. At the same time, a CCA has access to customer meter data and, as detailed in this report, is small enough so that an approach to procurement planning and the deployment of local renewable and distributed energy resources based in part on 'command and control' (i.e. by hiring companies for services) is more effective than a purely

[7] More details on this may be found in the Western Power Trading Forum *Opening Testimony* (23 July 2012) available from: [https://www.pge.com/regulation/OakleyGeneratingStation/Hearing-Exhibits/WPTF/2012/OakleyGeneratingStation_Exh_WPTF_20120723_Exh010_246856.pdf]

market-based approach. As such, it is a poor fit for either regulatory regime: policies that have been designed around either tend not to properly accommodate CCA. Because of this, it is imperative that existing and potential CCAs engage at the CAISO and at the CPUC on numerous issues, to educate state regulators and to ensure that the evolving regulatory paradigm do not by design disadvantage CCAs. While the regulatory environment in California is complicated and at times contradictory, executive and legislative leadership are present and increasingly focused on CCA, and regulatory agencies are generally supportive.

CHAPTER 2:
Influencing or Controlling a Community's Power Planning

This section outlines the different authorities available to local governments to influence or assert direct control over their community's power planning and operations. There are a number of reasons why a local government would seek to control or influence power planning: control over rates, service reliability, tailored efficiency and conservation programs, increased renewable generation, and most importantly for the achievement of RESCO goals, increased local resilience and greenhouse gas reductions through the building of integrated distributed energy resources.

Local governments seeking to exercise direct control over power planning and operations for their community may do so through two different pathways. One is municipalization, where the local government forms an independent distribution utility and manages power planning and procurement to determine where its power comes from as well as build generation resources, and the other is community choice aggregation (CCA), where the local government controls power planning and procurement but does not own or operate the local distribution grid, as the power continues to be delivered to customer by the incumbent distribution utility. Also, Joint Powers Agencies or Authorities (JPAs) are an additional legal structure that can be formed and added to either a municipalization or a CCA as an overarching management agency.

Local governments that prefer to exercise influence but not control power planning may initiate various programs and actions that support their policy goals. Examples include acting as an enabler for energy efficiency and distributed generation in various ways, streamlining permitting procedures and minimizing fees for distributed energy resources, upgrading local building codes, and modifying local zoning to facilitate the siting of renewable generation.

Broadly, the above options may be distinguished by whether or not they:

- Allow the local government direct control over energy planning and operations;
- Require the local government to purchase and take control of the local distribution grid from the incumbent investor owned utility.

The ability of a local government to influence power planning and operations in their community without assuming direct control over these processes is relatively limited. Taking control of the distribution grid may serve to increase local grid reliability (refer to 'Potential Reliability Benefits of Municipalization' on page 24) but has two primary disadvantages in that it:

1. Almost certainly requires a costly and lengthy legal battle with the incumbent investor owned utility to negotiate the purchase of the assets;

2. Requires that the local government adopt a financial planning framework that cannot be easily reconciled with deploying distributed energy resources at scale. This is because distributed generation and energy efficiency lessen onsite energy consumption, diminishing revenue that is needed to service the debt payments for the capital required to purchase the distribution grid and for ongoing operation and maintenance of the grid. Power distribution rates and charges would have to be raised to compensate for this effect in proportion to the penetration of distributed energy resources, which may be challenging for a publicly-owned utility to accomplish and is a politically-contentious situation that many politicians and public servants would seek to avoid.

2.1 Average Rate and Cost of Generation Comparisons

To preface the discussion, many local governments enter the public power business to provide for lower rates for their community as compared to the investor owned utility over the long term. Publicly owned utilities, by virtue of their access to relatively low cost capital, broadly enjoy lower generation costs as compared to either investor owned utilities or merchant generators, as can be seen in the tables below. Note that a community choice aggregation would likely enjoy levelized costs comparable to those of publicly owned utilities.

The tables below summarize the levelized cost of generation for various renewable and fossil fuel generation plants, developed by publicly owned utilities, investor owned utilities, and private developers ('merchant plants'). High, low and average costs are estimated, both for 2009 and in 2018. Note that costs for several technologies are assumed to be available in 2018 that were not available in 2009 (offshore wind, ocean wave, and nuclear power). The estimates were developed by the California Energy Commission's Electricity Analysis Office using their Cost of Generation Model, and taking into account capital costs, technology characteristics and operations, financing arrangements, tax assumptions and other factors, several of which can vary depending upon the developer type.

Figure 5: Levelized Cost of Generation by Developer Type and Technology (In-Service Year 2009)

In-Service Year = 2009 (Nominal 2009 $/MWh)	Merchant Plants			Investor Owned Utilities			Publically Owned Utilties		
	Average	High	Low	Average	High	Low	Average	High	Low
Small Simple Cycle	844.31	2865.75	268.81	655.69	2031.60	232.02	308.01	1372.61	179.80
Conventional Simple Cycle	794.67	2772.25	256.20	614.84	1970.52	221.86	291.10	1336.61	172.98
Advanced Simple Cycle	341.84	1021.12	139.66	281.03	761.50	125.20	190.29	562.13	104.98
Conventional Combined Cycle (CC)	123.84	223.18	69.50	114.76	193.44	66.43	107.91	171.70	62.20
Conventional CC - Duct Fired	127.38	235.40	71.01	117.64	202.67	67.79	110.25	178.67	63.35
Advanced Combined Cycle	114.36	204.21	66.38	106.23	177.82	63.45	100.14	158.58	59.42
Coal - IGCC	116.83	263.49	67.82	98.32	196.70	65.04	98.49	160.93	66.60
Biomass IGCC	109.99	289.58	69.67	111.65	233.16	79.17	117.58	192.56	83.92
Biomass Combustion - Fluidized Bed Boiler	104.02	292.34	39.66	100.75	235.12	57.66	106.42	193.68	59.49
Biomass Combustion - Stoker Boiler	108.25	248.11	49.46	105.87	207.59	66.65	110.42	178.60	68.85
Geothermal - Binary	83.11	310.02	53.89	93.52	260.81	78.55	106.91	194.68	65.74
Geothermal - Flash	78.91	254.34	61.84	88.51	215.60	86.47	100.59	163.31	72.37
Hydro - Small Scale & Developed Sites	86.47	892.76	27.02	95.54	702.88	28.02	103.50	490.16	31.07
Hydro - Capacity Upgrade of Existing Site	66.96	586.84	24.13	65.39	484.73	23.94	51.29	319.13	20.64
Solar - Parabolic Trough	224.70	638.77	138.18	238.27	494.13	184.48	271.52	379.75	214.92
Solar - Parabolic Trough with Storage	116.87	349.78	70.28	123.86	269.95	93.54	139.77	206.85	107.57
Solar - Photovoltaic (Single Axis)	262.21	795.79	154.42	278.71	609.30	209.65	320.00	461.76	246.31
Onshore Wind - Class 3/4	72.41	245.52	49.28	77.75	189.25	56.76	80.52	132.95	60.83
Onshore Wind - Class 5	65.47	251.25	43.45	70.19	193.57	46.84	72.44	135.85	49.65

Source: California Energy Commission, Electricity Analysis Office

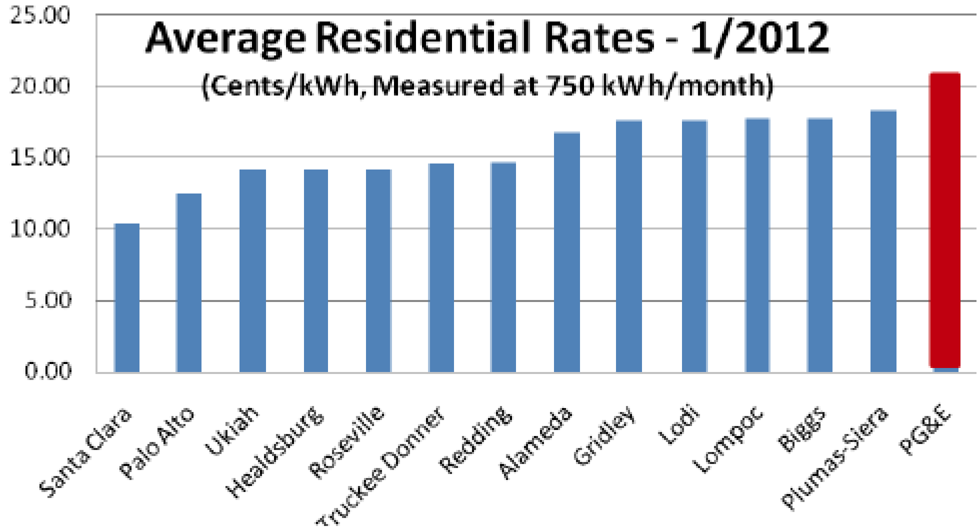
Figure 6: Levelized Cost of Generation by Developer Type and Technology (In-Service Year 2018)

In-Service Year = 2018 (Nominal 2018 $/MWh)	Merchant Plants			Investor Owned Utilities			Publically Owned Utilties		
	Average	High	Low	Average	High	Low	Average	High	Low
Small Simple Cycle	1009.57	3377.72	319.82	792.48	2417.45	277.61	389.97	1657.84	217.33
Conventional Simple Cycle	951.58	3270.16	305.32	744.57	2347.17	265.92	370.05	1616.40	209.48
Advanced Simple Cycle	426.62	1239.82	170.17	356.36	940.45	153.54	250.98	710.16	130.12
Conventional Combined Cycle (CC)	168.93	305.79	87.66	158.18	270.93	84.09	149.91	245.29	79.13
Conventional CC - Duct Fired	173.41	321.20	89.51	161.91	282.89	85.77	153.00	254.63	80.56
Advanced Combined Cycle	156.23	280.61	83.73	146.60	249.66	80.33	139.22	226.95	75.59
Coal - IGCC	178.14	357.96	76.24	142.48	258.42	73.36	113.17	189.96	75.03
Nuclear Westinghouse AP1000 (2018)	342.41	931.92	180.01	273.07	630.30	158.42	166.85	332.17	113.67
Biomass IGCC	168.48	351.53	81.90	161.86	290.05	92.78	140.97	224.61	98.32
Biomass Combustion - Fluidized Bed Boiler	160.43	355.02	46.94	148.32	292.89	67.57	127.60	225.65	69.74
Biomass Combustion - Stoker Boiler	158.22	299.83	62.53	148.82	255.80	91.00	132.88	208.84	76.55
Geothermal - Binary	129.42	374.85	71.69	136.73	324.82	100.15	124.98	224.57	84.25
Geothermal - Flash	120.72	307.50	71.69	127.66	268.21	100.15	117.99	188.76	84.25
Hydro - Small Scale & Developed Sites	164.59	1081.37	31.68	159.84	885.18	32.83	120.27	567.29	36.35
Hydro - Capacity Upgrade of Existing Site	77.80	677.66	28.25	76.09	560.88	28.07	59.88	370.31	24.29
Ocean Wave (2018)	261.71	551.98	106.75	249.02	448.86	123.36	189.33	300.68	134.46
Solar - Parabolic Trough	298.64	627.68	122.32	288.92	506.07	154.50	256.13	368.03	174.72
Solar - Parabolic Trough with Storage	159.61	352.27	64.37	154.30	282.96	81.54	136.60	204.38	90.96
Solar - Photovoltaic (Single Axis)	305.50	635.65	130.79	295.43	512.14	167.74	261.57	371.97	191.27
Onshore Wind - Class 3/4	127.19	293.22	63.20	120.59	234.75	62.12	90.69	152.36	66.27
Onshore Wind - Class 5	114.06	300.06	45.06	108.27	240.12	51.59	82.02	155.65	54.40
Offshore Wind - Class 5 (2018)	214.16	468.07	95.06	202.78	375.37	110.32	151.21	244.69	120.12

Source: California Energy Commission, Electricity Analysis Office

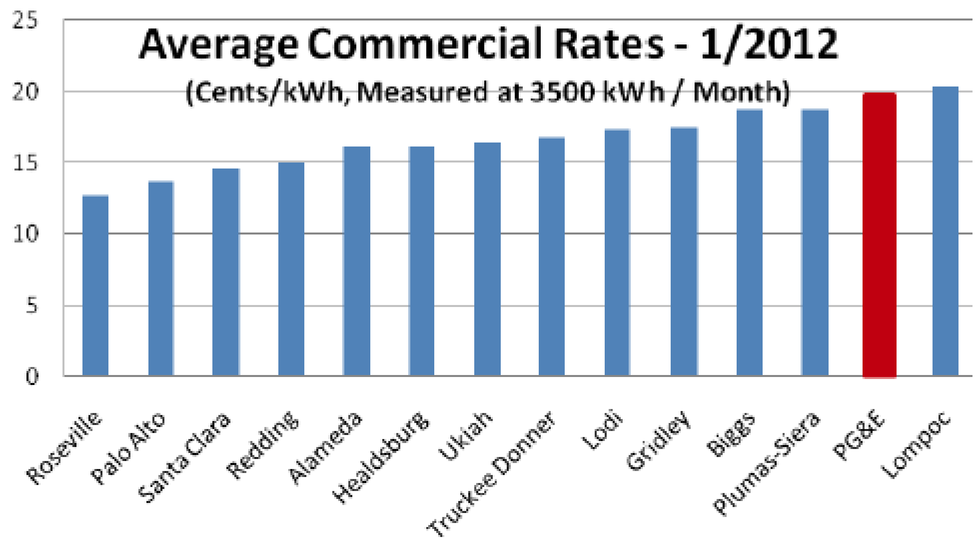
Over time, these and other advantages can lead to a lower average rate for the citizens and businesses of a local government that implements public power. The tables below compare publicly owned utility rates for members of the Northern California Power Authority against those of PG&E:

Figure 7: NCPA Member Residential Rate Comparison (Cents/kWh)



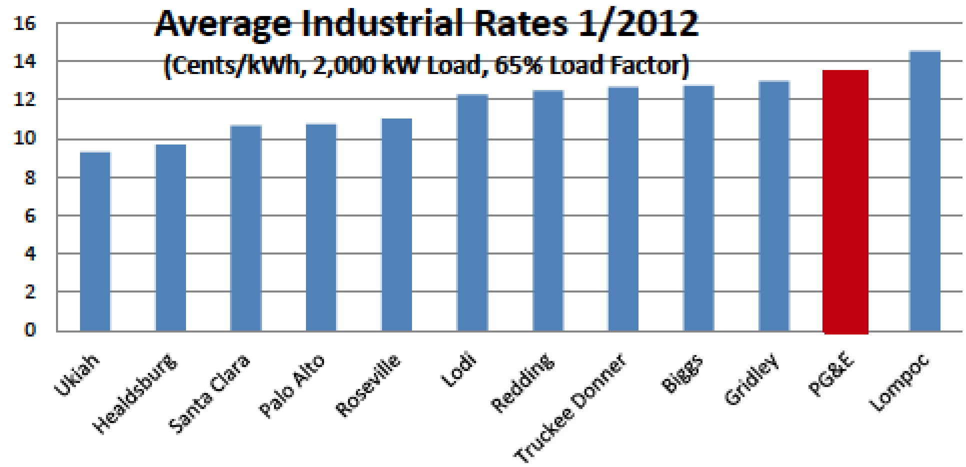
Source:Northern California Power Agency

Figure 8: NCPA Member Commercial Rate Comparison (Cents/kWh)



Source:Northern California Power Agency

Figure 9: NCPA Member Industrial Rate Comparison (Cents/kWh)



Source:Northern California Power Agency

2.2 Municipalization

2.2.1 Background

Municipalization is a public power option that has been successful in California in the past; communities have opted to municipalize and legally create completely separate electrical distribution utilities in order to serve their communities. The largest examples in California are:

- The Sacramento Municipal Utility District (SMUD, formed in 1923);
- The Los Angeles Department of Water and Power (LADWP, formed in 1902 as a municipal water utility and in 1917 started to deliver electricity);
- The Lassen Municipal Utility District (LMUD, formed in 1986).

2.2.1.1 Governance

Publicly-owned utilities are governed by a locally-elected Board of Directors, and not by the California Public Utilities Commission (CPUC). Among other authorities, the Directors may:

- Set rates and determine energy policies;
- Arrange for the maintenance and operation of the local electrical distribution grid;
- Arrange for power supply by constructing generation facilities and/or contracting with energy suppliers.

2.2.1.2 Distribution of Power in California

Collectively, POUs serve approximately 25 percent of the electric demand of California and own significant transmission assets that together amount to more than 40 percent of the high voltage electricity transfer capacity in and out of California.[8] The table below shows electricity consumption in California by the provider of the electrical service:

[8] California Municipal Utilities Association *Handbook on Public Agency Power Options Rev 1.0* (July, 2003) Pg. 2

Table 6: California Electricity Consumption by Provider

Entity	GWh of Load Served	Percentage
IOU	187,516	69%
POU	68,375	25%
Federal	2,749	1%
Self-Generation	14,006	5%
Total	272,645	100%

Source: California Energy Commission, Electricity Consumption by Planning Area (2011), available from: [http://ecdms.energy.ca.gov/elecbyplan.aspx]

2.2.1.3 Acquiring or Constructing a Distribution Grid

Opting to form a public distribution utility legally requires the local government to acquire the distribution grid assets (substations, wires, and poles) from the existing investor owned utility, or otherwise not use them (and to build an alternative system) for energy distribution purposes. In this regard, a municipalization has the following options:

1) Acquiring existing distribution wires and poles from the existing investor owned utility, by using a local agency's power of eminent domain or negotiating a purchase price for the distribution system;
2) Building a completely new distribution system to serve its customers;
3) Acquiring the distribution systems installed by developers only in new developments, by having the developer transfer the assets directly to the public utility;
4) Using a combination of the approaches described above.

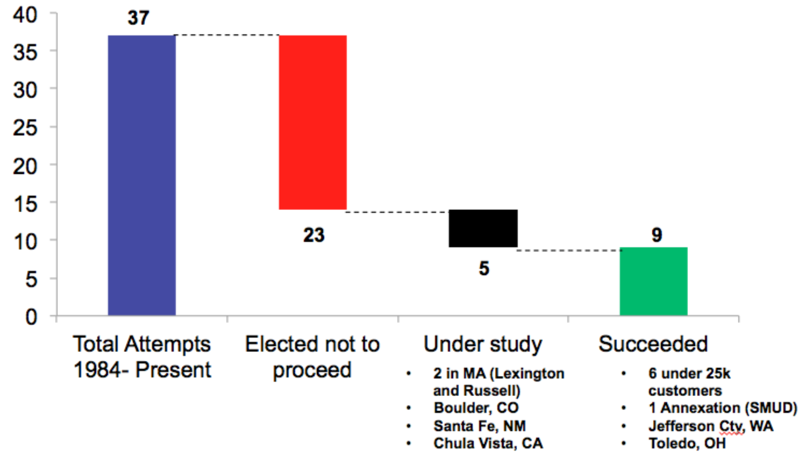
2.2.1.4 Barriers to Municipalization and Examples of Recent Successes

In recent years, municipalizations have been difficult to implement, and have several potential barriers to doing so:

- Relatively high startup cost for non-generation resources (required purchase of existing distribution grid, or construction of new separate poles and wires);
- The need for majority voter approval to implement (except for a MU, which can only serve a single city) and to finance the acquisition of the distribution grid, which can be difficult to obtain;
- An "all-in" commitment, in that once a municipalization is established, the customers in its service area do not have the ability to "opt-out" and go back to the previous utility (unless the enterprise fails and is sold back);
- Guaranteed vigorous political opposition from the existing distribution utility.

As a result, municipalizations often fail the approval process after a feasibility study is performed. The figure below shows the success rate of municipalization attempts nationwide over the past three decades:

Figure 10: U.S. Municipalization Attempts and Outcomes Since 1984

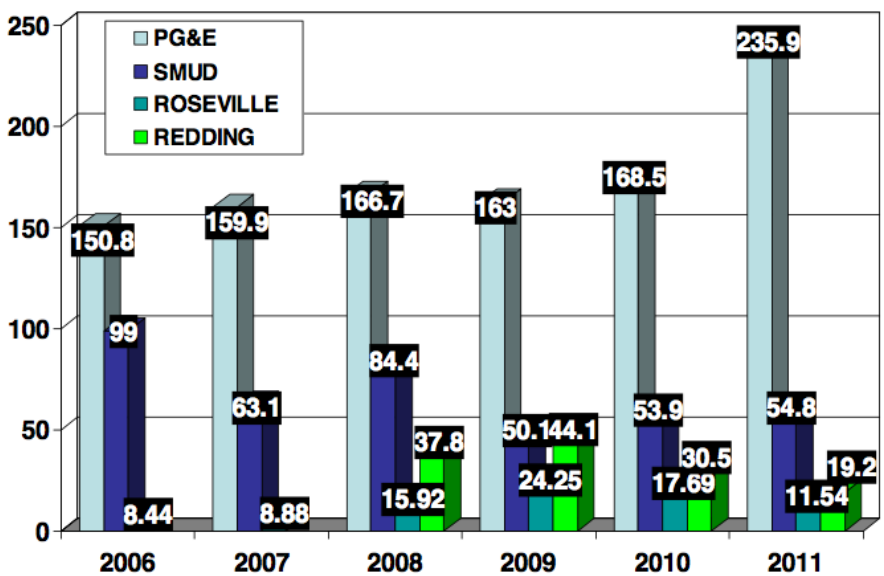


Source: Northeast Utilities System

2.2.1.5 Potential Reliability Benefits of Municipalization

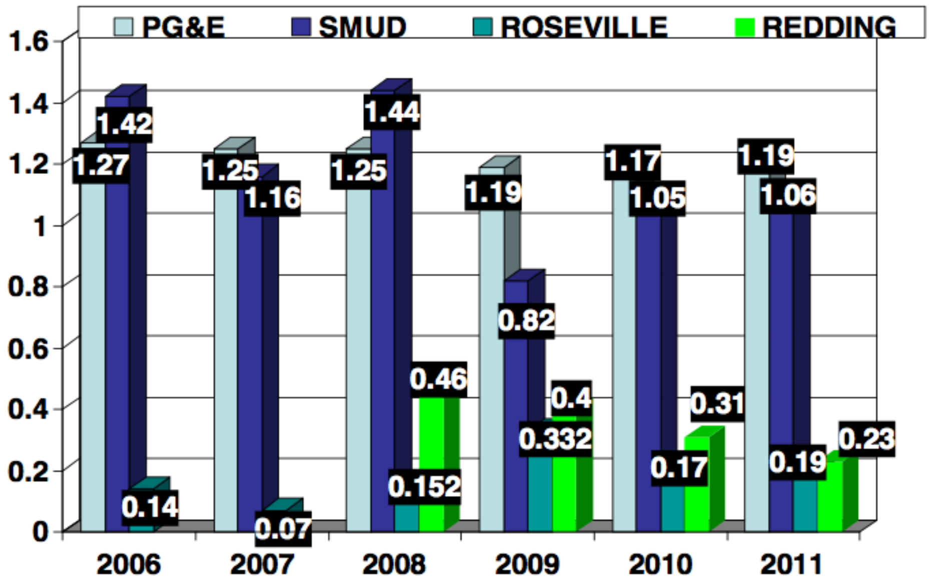
However, there can be distribution grid reliability benefits from municipalizing, as shown in the graphs below:

Figure 11: System Average Interruption Duration Index of PG&E and Select POUs



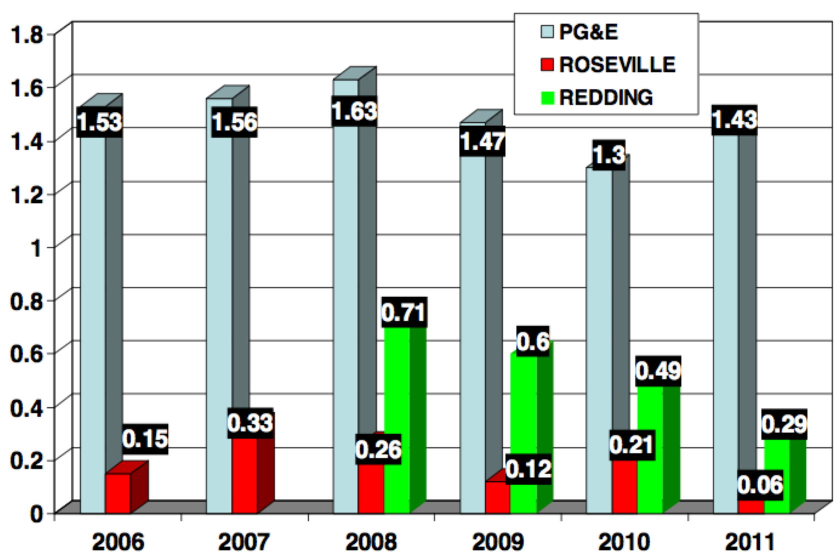
Source: Roseville Electric, available from: [http://www.roseville.ca.us/civicax/filebank/blobdload.aspx?blobid=16926]

Figure 12: System Average Interruption Frequency Index of PG&E and Select POUs



Source: Roseville Electric, available from: [http://www.roseville.ca.us/civicax/filebank/blobdload.aspx?blobid=16926]

Figure 13: Momentary Average Interruption Frequency Index of PG&E and Select POUs



Source: Roseville Electric, available from:
[http://www.roseville.ca.us/civicax/filebank/blobdload.aspx?blobid=16926]

The grid reliability metrics depicted in the graphs are SAIFI, SAIDI, and MAIFI:

> These are referred to as the System Interruption Frequency Index (SAIFI), (measures the average number of power interruptions lasting 5 minutes or more for each customer during a specified time period, calculated by dividing the total number of sustained customers interruptions by the total number of customers), System Average Interruption Duration Index (SAIDI) (measures the average duration of outages per customer calculated by dividing the total minutes of customer interruptions lasting five minutes or more by the

total number of customers), and Momentary Average Interruption Frequency Index (MAIFI), (measures the average number of momentary outages per customer calculated by dividing the total number of momentary interruptions by the total number of customers).[9]

2.2.1.6 Types of Publicly Owned Utilities

Municipalization can be used for a number of different purposes, and the term 'municipalization' can refer to four different types of publicly-owned utilities (POUs) that may provide electric distribution service to consumers:

1) Municipal Utilities (MUs)
2) Municipal Utility Districts (MUDs)
3) Public Utility Districts (PUDs)
4) Irrigation Districts (IDs)

The purpose, authority, capabilities and formation process of each type of publicly-owned utility is summarized in the following sections.

2.2.2 Municipal Utilities (MUs)

2.2.2.1 Purpose, Authority and Capabilities

A Municipal Utility (MU) is a municipalization adopted by an individual city that provides electrical service(s) to the city, including any combination of: light, water, power, heat, transportation, telephone and/or communications. The city council must pass a majority votes to form an MU, either as a department of the city or to add electricity as a service offered by their existing city water department and/or city sewer department.

While cities may establish their own MUs or join with other public agencies to form a Joint Power Agency (JPA) to provide electrical services, counties do not have the same rights. For more information about JPAs, refer to the proceeding section. Absent a law passed by the State Legislature allowing a specific county to form or join an MU, a county can either consider establishing a new MUD or PUD, or work in partnership with an existing MUD, PUD or ID.

2.2.2.2 Formation Process

To form an MU, processes vary depending upon the type of local government:

1) General law city[10]
    a. City council majority vote: establishment of the MU as a new city department or expansion of existing city department (such as the water department).
2) Charter law city[11]
    a. Legal review of city charter to ensure it does not restrict public power options.

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[9] Nixon Peabody LLP *City of Davis Energy Assessment* (October 2012)

[10] Incorporated cities in San Luis Obispo County that are general law cities include: Arroyo Grande, Atascadero, Grover Beach, Morro Bay, Paso Robles, and Pismo Beach.

[11] San Luis Obispo is the only charter law city in the county.

i. If the city charter restricts public power options, it may be changed with a voter approved Charter amendment.

ii. If the city charter does not restrict public power options, the MU may be established by one of two ways:

1. A city council majority vote to establish the MU as a new city department or expansion of existing city department (such as the water department);

2. A voter approved charter amendment to establish the MU as an agency separate from direct control of the City Council.

3) County

a. The California State Legislature must pass a law specifically allowing the county to provide electrical services through an MU.

2.2.3 Municipal Utility Districts (MUDs)

2.2.3.1 Purpose, Authority and Capabilities

A Municipal Utility District (MUD) is a form of municipalization that can provide electrical service(s) to a city and unincorporated territory, multiple cities, a county, or multiple counties. According to the California Public Utilities Code:

> Any public agency together with unincorporated territory, or two or more public agencies, with or without unincorporated territory, may organize and incorporate as a municipal utility district. Public agencies and unincorporated territory included within a district may be in the same or separate counties and need not be contiguous. No public agency shall be divided in the formation of a district.[12]

MUDs tend to cover larger service territories, and are more complex to initiate and ratify than MUs. However, MUDs have a greater authority and capacity to integrate multiple local agencies for the benefit of a larger territory of customers. MUD service territories are typically divided into five areas, or “wards” which are governed by the five members of the elected MUD Board of Directors.

2.2.3.2 Formation Process

1) Resolution to form a MUD from the legislative bodies of half or more of the agencies involved, or a petition to form a MUD signed by 10 percent of the registered voters in the proposed district.

2) The certified resolution or petition, complete with details of a MUD formation proposal, is presented to the Board of Supervisors of the County containing the largest number of voters in the proposed district.

[12] California Public Utilities Code section 11561-11562

3) The Board of Supervisors submits the official MUD formation proposal for review by the Local Area Formation Committee (LAFCO).
    a. The LAFCO sends a copy of the proposal to the California Public Utilities Commission (CPUC) for comment.
    b. The CPUC must respond to the LAFCO within 90 days stating whether the proposed service by the MUD would substantially impair the ability of the existing IOU to provide adequate services at reasonable rates within the remaining service territory of the IOU.
    c. The LAFCO conducts public hearings on the proposal.
    d. The LAFCO approves, denies, or modifies the proposal.
    e. When approved by the LAFCO, terms and conditions are adopted for the MUD; no changes can be made to them after LAFCO approval.
4) The Board of Supervisors calls an election on the LAFCO-approved MUD formation, including the candidates for the Board of Directors, applicable to voters within the proposed MUD boundary.
5) The proposition must be voted on by two-thirds of the registered voters within the proposed MUD boundary, and must pass by a majority vote.

2.2.4 Public Utility Districts (PUDs)

2.2.4.1 Purpose, Authority and Capabilities

Public Utility Districts (PUDs) are very similar to MUDs, except instead of covering at least one city and unincorporated territory, PUDs include only unincorporated areas.

PUD service territories are divided into territorial units, or "wards" which are each governed by a member of the elected PUD Board of Directors. Each unincorporated territory within the PUD boundary is regarded as a ward, and each unit having a population of at least 5,000 is entitled to one director. For voting purposes, the Board must be comprised of an odd number of Directors, and if the PUD is split up into an even number of wards, the voters will vote on three extra Directors to make the Board an odd number.[13] The Board collectively governs PUD operations, and has the authority to implement and modify taxes and fees applicable to the PUD service territory customers.

2.2.4.2 Formation Process

1) Petition to form a PUD signed by registered voters of the unincorporated territory equal to or greater than 15 percent of all votes cast for all candidates for Governor within the same territory at the last preceding general election at which a Governor was elected.[14]
2) The official petition, complete with details of a PUD formation proposal, is presented to the Board of Supervisors of the County containing the proposed PUD.
3) The Board of Supervisors publishes an official hearing on the PUD petition and proposal, and determines at the hearing if the PUD is feasible and lawful.

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[13] California Public Utilities Code section 15951

[14] California Public Utilities Code section 15702

4) If the Board rules in favor of the PUD, it submits the official PUD formation proposal for review by the Local Area Formation Committee (LAFCO).
    a. The LAFCO sends a copy of the proposal to the California Public Utilities Commission (CPUC) for comment.
    b. The CPUC must respond to the LAFCO within 90 days stating whether the proposed service by the PUD would substantially impair the ability of the existing IOU to provide adequate services at reasonable rates within the remaining service territory of the IOU.
    c. The LAFCO conducts public hearings on the proposal.
    d. The LAFCO approves, denies, or modifies the proposal.
    e. When approved by the LAFCO, terms and conditions are adopted for the PUD; no changes can be made to them after LAFCO approval.
5) The Board of Supervisors calls an election on the LAFCO-approved PUD formation, applicable to voters of the unincorporated territories within the proposed PUD boundary.
6) The proposition must pass by a majority vote in each of the unincorporated territories within the proposed PUD boundary.
7) On the next established election date, no less than 74 days after the successful passing of a PUD proposition, the voters of the unincorporated territories within the PUD boundary must vote on the candidates for the PUD Board of Directors.

2.2.5 Irrigation Districts (IDs)

2.2.5.1 Purpose, Authority and Capabilities

An Irrigation District is another option for communities looking to municipalize their energy. However, it is a more complex process than the other municipalization strategies because IDs primarily provide water to their constituents, but may legally provide electrical service(s) as well. The choice to form an ID would be best suited to a community that wants to municipalize both its water and energy distribution.

ID service territories can cover a city, multiple cities, a county, or multiple counties, and the land included in an ID need not be contiguous.[15] IDs, like MUDs, are generally divided into five territorial units, or "wards" that are represented by five Directors. The Board of Directors collectively governs ID operations.

2.2.5.2 Formation Process

1) Petition to form an ID signed by a majority of the number of holders of title to land eligible to be irrigated by a common source and by the same system of infrastructure, including pumping from subsurface or other water, who are also the holders of title to a majority in value of the land.[16] Alternatively, the petition to form an ID may be signed by 500 petitioners, each of whom is an elector residing in the proposed District or the

[15] California Water Code section 20701
[16] California Water Code section 20700

holder of title to land therein and which petitioners include the holders of title to not less than 20 per cent in value of the land included within the proposed district.[17]

2) The official petition, complete with details of an ID formation proposal, is presented for hearing to the Board of Supervisors of the County containing the largest number of voters in the proposed District, at a regular meeting of the Board.

3) The Board of Supervisors submits a copy of the petition to the Office of the Department on or before the day on which the petition is presented to the Board of Supervisors.[18]

4) At the hearing, the Board of Supervisors determines if the ID is feasible and lawful. If the Board rules in favor of the ID, it adopts a "preliminary formation resolution" which it sends to the Office of the Department.

5) The Office of the Department reviews the preliminary formation resolution, investigates the feasibility of the proposal, and responds to the Board of Supervisors within 90 days whether or not the project is feasible.[19]

    a. If the project is ruled not feasible, the Board of Supervisors can be petitioned in writing by three-fourths of the holders of title to land to continue the hearing, or the Board of Supervisors can modify the ID proposal to conform to the recommendations made by the Office of the Department.[20]

6) When the Office of the Department reports in favor of the ID proposal, the Board of Supervisors holds a final hearing on the proposal where it determines the details of the land to be formed into the proposed district, and reaffirms its conclusion that the proposal is sound.

7) When the Board rules in favor of the ID, it submits the official ID formation proposal for review by the Local Area Formation Committee (LAFCO).
    a. The LAFCO sends a copy of the proposal to the California Public Utilities Commission (CPUC) for comment.
    b. The CPUC must respond to the LAFCO within 90 days stating whether the proposed service by the ID would substantially impair the ability of the existing IOU to provide adequate services at reasonable rates within the remaining service territory of the IOU.
    c. The LAFCO conducts public hearings on the proposal.
    d. The LAFCO approves, denies, or modifies the proposal.
    e. When approved by the LAFCO, terms and conditions are adopted for the PUD; no changes can be made to them after LAFCO approval.

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[17] California Water Code section 20700
[18] California Water Code section 20820
[19] California Water Code section 20823
[20] California Water Code section 20824

8) The Board of Supervisors calls an election on the LAFCO-approved ID formation, including the candidates for the Board of Directors, applicable to voters within the proposed ID territory.
9) The proposition must pass by a majority vote within the proposed ID territory.

2.2.6 Municipalization through Expansions or Partnerships

Aside from a single community forming a new publicly owned utility on its own, there are several other ways for a community to municipalize its electricity distribution service:

- If the community is already served by an existing MUD, PUD or ID that provides services other than power, the agency's authority could be expanded to include it.
- The local government could request that an existing MUD, PUD or ID annex the local community in order to provide electricity supply services.
- The local government could partner with other cities, counties and agencies using a Joint Powers Agreement to expand an existing publicly owned utility or to form a new one. For more information on this option, see "Joint."

2.3 Community Choice Aggregation (CCA)

2.3.1 Background

Community Choice Aggregation (CCA) is a form of public power that is authorized in California by Assembly Bill AB 117 (Migden, Chapter 838, Statutes of 2002), which allows cities, counties, and/or groups of cities and counties to aggregate the electric load of all customers not already served by competitive third-party suppliers or publicly owned utilities within their jurisdictions, and arrange for the provision of electricity on their behalf.[21]

CCAs are similar to municipalizations in that they allow local governments to provide electricity generation services, control the content of the power supply, and set rates for the customers in their jurisdiction. A local government that implements a CCA program may procure electric power from power providers, may build its own generation facilities, and may deliver other services such as energy efficiency to its customers. However, CCAs are different from municipalizations in one key respect: they are not required purchase the existing transmission and distribution system from the incumbent utility or to manage the delivery of electricity over those facilities to end-use customers.

Currently there are three CCAs in California:

- Marin Clean Energy, which works within Marin County and is managed by the Joint Powers Authority (JPA) Marin Energy Authority, comprised of the county and most cities within the county. In addition, the City of Richmond intends to join MEA to serve approximately 30,000 customers beginning in Q3 2013.

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[21] Local Government Commission and Navigant Consulting, Inc. PIER Final Project Report CEC-500-2009-003, *Community Choice Aggregation Pilot Project Appendix G Guidebook* (September 2009) Pg. v

- Sonoma Clean Power, which intends to start serving customers in Sonoma County and participating cities beginning in December 2013.
- CleanPowerSF, which intends to start serving customers in the City and County of San Francisco in October 2013.

When all three CCAs listed above enroll all eligible customers in their territories, their combined load (account for customers who chose to opt-out) will be approximately 7,021 GWh. This is approximately 8 percent of the load served by Pacific Gas and Electric, the distribution utility in the territory of which the CCAs are located.

In addition, the San Joaquin Valley Power Authority (SJVPA) CCA, which was formed in 2006 to cover Kings County and some of its surrounding cities, never initiated service and has since been discontinued. After the CCA grew to include Tulare County, its board of directors unfortunately voted to "temporarily suspend" the SJVPA's operation in June 2009, citing market conditions. However, the SJVPA also faced sustained and intense political opposition from the incumbent investor-owned utility (PG&E). In 2013, the effort was abandoned.

2.3.2 Purpose, Authority and Capabilities

Cities and counties that establish community choice aggregations have the authority to pool together the electrical loads of all retail customers not already served by competitive third-party suppliers or publicly owned utilities in their jurisdiction in order to solicit bids, broker, and enter into contract agreements for electricity and related services for those customers.[22] A CCA also has the authority to build local electricity generation sources that would be integrated into its community energy mix, as well as design and implement tailored efficiency programs for its customers, and to apply to the CPUC to administer a portion of the energy efficiency funds collected from its customers through non-bypassable surcharges.[23]

Community Choice Aggregation affords a local government access to multiple years of customer end-use electrical meter and account data through the CCA INFO TARIFF. This data may be used to assess the cost for providing power to the local government's unique customer base, and may also be used to target the deployment of distributed energy resources on sites that offer the best economics to do so.

Once a CCA is established and the electricity service for its customers has been contracted for and/or built, the existing investor owned utility continues to provide all energy metering, billing, collection, and customer service, in addition to the distribution of the CCA's chosen electricity source(s) to the CCA's retail customers. Bills sent by the electrical corporation to retail customers identify the community choice aggregator as providing the electrical energy portion of the bill, while the investor-owned utility provides the distribution and service portion of the bill.[24]

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[22] California Assembly Bill AB 117, Chapter 838, Migden, Statutes of 2002, Section 4, 366.2 (c) (1)
[23] California Assembly Bill AB 117, Chapter 838, Migden, Statutes of 2002, Section 5, 381 (3) (c)
[24] California Assembly Bill AB 117, Chapter 838, Migden, Statutes of 2002, Section 4, 366.2 (c) (9)

Once a CCA initiates service, all eligible customers in the CCA's jurisdiction are automatically opted-in to the program,[25] although the CCA may choose to 'phase in' customers over time instead of all at once. However, if a CCA customer is dissatisfied with their service, they may opt-out of the program and return to investor owned utility service at any time. After a certain period of time, the CCA may impose a fee on customers that decide to opt-out, although this is typically set at a nominal level to cover administrative costs of processing the customer request.

2.3.3 Formation Process

1) The city or county adopts an ordinance to implement community choice aggregation. If one or more cities, counties, or cities and counties wish to form a CCA as a group, they must form a JPA (refer to proceeding section) in addition to adopting the ordinance to implement CCA.

2) The local government(s) draft an Implementation Plan for the CCA for submission to the CPUC that includes: [26]

    a. A Statement of Intent, that addresses:

        i. Universal access

        ii. Reliability

        iii. Equitable treatment of all classes of customers

        iv. Any requirements established by state law or by the CPUC concerning aggregated service

    b. An organizational structure of the program, its operations, and funding

    c. Rate-setting and other costs to participants

    d. Provisions for disclosure and due process in setting rates and allocating costs among participants

    e. The methods for entering and terminating agreements with other entities

    f. The rights and responsibilities of program participants, including consumer protection procedures, credit issues, and shutoff procedures

    g. Termination of the program

    h. A description of the third parties supplying electricity including financial, technical, and operational capabilities

[25] California Assembly Bill AB 117, Chapter 838, Migden, Statutes of 2002, Section 4, 366.2 (c) (2)

[26] See California Public Utilities Code 366.2; more detailed information is available from: Local Government Commission and Navigant Consulting, Inc. PIER Final Project Report CEC-500-2009-003, *Community Choice Aggregation Pilot Project Appendix G Guidebook* (September 2009) Pg. 6

3) The implementation plan, and any subsequent changes to it, is adopted at a duly noticed public hearing.

4) The adopted Implementation Plan is filed with the CPUC. The CPUC then takes the following actions:

    a. Within 10 days of the Implementation Plan filing, the CPUC notifies any electrical corporation serving the proposed CCA customers that an implementation plan for CCA has been filed.
    b. Within 90 days of the Implementation Plan filing, the CPUC certifies that it has received the implementation plan, and makes any requests for further information.
    c. With any requests for information fulfilled, the CPUC provides the CCA with a cost recovery mechanism, if applicable, that must be paid by CCA customers to prevent a shifting of costs to the existing utility's customers when the CCA begins operation.
    d. The CPUC submits a report certifying the CCA's compliance to the Senate Energy, Utilities and Communications Committee, or its successor, and the Assembly Committee on Utilities Commerce, or its successor.
    e. The CPUC sets a date when the CCA program can begin.

5) The CCA registers with the CPUC and posts a bond or provides evidence of insurance sufficient to cover reentry fees that would be imposed by the CPUC for customers involuntarily returned to IOU service in the event that the CCA fails to adequately arrange for the provision of power to its customers.
6) The CCA sends out notifications to customers that will be enrolled in the CCA, informing them of the terms of conditions of the service, that they will be automatically enrolled in the program, and that they may opt-out without penalty. These notifications may be ordered by the CPUC to be included in the regular monthly bills of the IOU, at the CCA's request. Potential customers must be served notice by the CCA:
    a. Twice in the 60 day period prior to their enrollment;
    b. For at least two consecutive billing cycles following their enrollment.
7) The CCA notifies the existing electrical utility that community choice service will commence within 30 days.
    a. The utility transfers all accounts applicable to the CCA to the new electricity supplier, as defined by the CCA, within a 30-day period from the date of the close of their normally scheduled monthly metering and billing process.
8) The CCA is then responsible for the provision of power for all customers transferred to its service.

2.4 Joint Powers Agencies or Authorities

2.4.1 Background

Two or more local governments and/or public agencies can create a Joint Powers Agency or Authority (JPA) while initiating a municipalization or a community choice aggregation. A JPA would be employed as the overarching management agency of the newly-formed public enterprise, though would not necessarily run the public power entity. For example, the Sonoma Clean Power JPA that is implementing CCA in Sonoma is comprised of the Sonoma County Water Agency (SCWA), the County of Sonoma, and cities within the county, but the SCWA is the agency charged with implementing and running the CCA.

A JPA is a common legal structure widely employed in California that allows local governments and/or public agencies to collaborate and exercise any of their specified common powers jointly. Individual public agencies often do not have the staff or funding to achieve all of their intended goals on their own, but may do so if they pool resources with other agencies. However, this sharing of authorities does not supersede state law governing which forms of public power are available to specific entities. For example, two or more cities may form a JPA to manage a municipal utility, but a county would not be able to join the JPA to extend this service to the customer base of the county, which must form a municipal or public utility district to do so (absent an act of the legislature allowing the county in question to form a municipal utility). If initiating a community choice aggregation program, the JPA could include both cities and counties, which individually have the authority to initiate a community choice aggregation program. The community choice aggregation programs Marin Clean Energy and Sonoma Clean Power are governed by JPAs, while San Francisco's CleanPowerSF program is not.

Because JPAs allow for the pooling of resources between the public agencies that form them, JPAs are a way for multiple jurisdictions to increase the scale and coordination of their public power effort. This provides an economy of scale for the enterprise in several ways, such as by spreading administrative costs over a broader customer base, and by allowing territories with complementary load profiles to combine, 'flattening' the resulting annual load profile and allowing the CCA to lower its overall cost of service by procuring a larger amount of baseload energy as opposed to peak and dispatchable products (which tend to be more expensive), and by sharing capacity reserves.

2.4.2 Legal Requirements and Authority

Local governments that are considering a public power implementation to be managed by a JPA would go through the same process as any potential municipalization or community choice aggregation, detailed in the proceeding sections. The formation of the JPA itself does not require a majority vote from the local electorate. Instead, the member agencies and local governments that wish to participate in the JPA need a majority vote by each of their governing boards to adopt the drafted Joint Powers Agreement document, and to form a JPA. It is important to note that the formation of a JPA is not subject to Local Area Formation Committee (LAFCO) review.[27] The governing board of a JPA can be made up of existing officials from the member agencies that establish or later join the JPA.[28]

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[27] California State Legislature, Senate Local Government Committee *Governments Working Together: A Citizen's Guide to Joint Powers Agreements* (August 2007) Pg. 21

[28] California Municipal Utilities Association *Handbook on Public Agency Power Options Rev 1.0* (July 2003) Pg. 20

2.4.3 Formation Process

1) Majority vote to adopt the mutually-edited Joint Powers Agreement document, and establish or join a Joint Powers Authority/Agency, by the elected officials in each of the public entities involved.

2) The JPA files a Notice of a Joint Powers Agreement with the Secretary of State. Until public officials file the JPA documents, the newly-formed JPA cannot incur any debts, liabilities, or obligations, or exercise any of its powers.[29]

2.5 Comparison of Key Considerations for Municipalization and Community Choice Aggregation

The table below compares the various forms of municipalizations and Community Choice Aggregation by key considerations, as detailed in the preceding sections:

Table 7: Comparison of Key Considerations for Municipalization and CCA

Type	Territory	Initiation Action(s)	LAFCO Review Required?	Popular Vote Required?
Community Choice Aggregation (CCA)	Single city or county, or multiple cities and/or counties under a JPA	Ordinance by local government(s)	No	No
Municipal Utility (MU)	Single city only, or multiple cities under a JPA (or county if authorized by state legislature)	Majority vote by city council(s)	No (unless county included)	Not for initiation (but majority vote required to issue revenue bonds for distribution acquisition)
Municipal Utility District (MUD)	City and unincorporated territory up to the entire County or multi-county	Majority public agency resolution or petition by 10% of voters	Yes	Majority vote with 2/3rds turnout of registered voters

[29] California State Legislature, Senate Local Government Committee *Governments Working Together: A Citizen's Guide to Joint Powers Agreements* (August 2007) Pg. 12

Type	Territory	Initiation Action(s)	LAFCO Review Required?	Popular Vote Required?
Public Utility District (PUD)	Unincorporated territories only	15% of last voter turnout total petition	Yes	Majority vote in each of the District's Unincorporated Territories
Irrigation District (ID)	Single city up to county or multi-county	Majority district landholder petition, or 500 resident voter petition	Yes	Majority vote

Source: California Municipal Utilities Association and Local Power Inc.

2.6 Other Actions that Enable Distributed Energy Resources and Renewable Generation

Local governments that prefer to exercise influence but not control power planning may initiate various actions that support their policy goals. Examples include applying to the CPUC to administer a portion of the energy efficiency funds collected from customers, applying for grants from the incumbent investor owned utility for energy programs, structuring programs to finance distributed energy resources, streamlining permitting procedures and minimizing fees for distributed energy resources, and modifying local zoning to facilitate the siting of renewable generation. Local governments in San Luis Obispo County are active in all of these categories, as summarized below.

2.6.1 Property Assessed Clean Energy (PACE) Financing

Property Assessed Clean Energy (PACE) financing allows for government issued revenue bonds to pay for the installation of distributed energy resources. The debt is paid back over time by property tax assessments. A lien is placed on the property to provide collateral to the lender in the event of default. The PACE model is available to commercial customers, and San Luis Obispo County and all cities except for Pismo Beach are participating in the CaliforniaFIRST PACE program to offer this service to local businesses.

2.6.2 EnergyWise Action Plan and General Plan

The EnergyWise Action Plan (formerly known as the Climate Action Plan) identifies how the County will achieve a GHG emissions reduction target of 15 percent below baseline (2006) levels by the year 2020 in addition to other energy efficiency, water conservation, and air quality goals identified in the Conservation and Open Space Element (COSE) of the County's General Plan. Both documents contain elements that further enable renewable energy, distributed generation, and energy efficiency by revising zoning, permitting, and building codes. The

EnergyWise Action Plan was drafted in 2010, approved by the Planning Commission and adopted by the County Board of Supervisors in 2011. Relevant sections (with emphasis added) may be found in the appendix.

2.6.3 Tailored Local Programs to Enable Distributed Energy Resources

San Luis Obispo County receives funding from the CPUC, collected from ratepayers through a non-bypassable surcharge, to run an Energy Watch Partnership program in conjunction with PG&E, SCE, the cities within the county, and the Economic Vitality Corporation, as well as a Small and Medium Business Energy Efficiency Pilot Program. The latter program offers information on broader rebate programs and preliminary energy analyses to medical, hospitality, and office businesses, and will perform detailed analyses on a total of 21 businesses. The Energy Watch Partnership program helps to tailor program design and outreach at a local level to increase participation in broader statewide and regional programs.

CHAPTER 3:
Pathways to Achieve RESCO Goals

3.1 Framework Model to Achieve RESCO Goals

To assist local governments in their discussions regarding the advancement of distributed energy resources in their community, the following questions together provide a 'framework model' to delineate key considerations. The answers for each pathway available to a local government in California (namely, community choice aggregation, publicly-owned utility, and the 'status quo' of current programs which influence but do not control power planning and operations) are color-coded: green denotes a desirable outcome, red denotes an undesirable outcome, and orange denotes an outcome which is desirable but limited in scale.

Table 8: Framework Model and Pathways to Achieve RESCO Goals

Does the authority enable the local government to:	CCA	POU	Status-Quo
Influence local zoning, permitting, and land use considerations?	Yes	Yes	Yes
Provide technical and other assistance for deploying distributed energy resources?	Yes	Yes	Limited
Assume direct control over its community's power planning & operations?	Yes	Yes	No
Assume responsibility for the distribution grid?	No	Required	No
Issue revenue bonds to fund projects?	Yes	Yes	Limited
Fund generation projects cost-competitively (as compared to the incumbent utility)?	Yes	Yes	Limited
Integrate distributed energy resources into power planning & operations?	Yes	Yes	No
Access to customer-specific utility meter data?	Yes	Yes	No
Effectively implement without a referendum?	Yes	No	Yes
Implement in the near term (1-3 years)?	Yes	No	Yes

Source: Local Power Inc.

The commercialization strategy proposed to overcome as many barriers as possible to deploying distributed energy resources at scale while advancing RESCO goals, as shown in the framework model above, employs community choice aggregation (CCA) and is predicated on constructing local renewable and distributed energy resources in a targeted and scaled fashion. This strategy builds off of the approach being taken by Sonoma Clean Power, while differing in regards to the strategies used to deploy distributed energy resources.

3.2 Sonoma Clean Power

The Sonoma Clean Power CCA is a JPA comprised of the Sonoma County Water Agency (SCWA), the County of Sonoma, and several cities within the county. The SCWA is responsible for the implementation and management of the CCA, and intends to begin serving customers in Q4 2013.

3.2.1 Background

The following documents and projects are available for review; summaries of each provide a brief history and timeline of the development of the program:

- 2008 - Sonoma Climate Action Plan[30]: the energy chapter of the plan identifies CCA as the best pathway to achieve the county's greenhouse gas reduction targets in the near-term.
- 2009 to 2011- Sonoma RESCO project[31]: delineates a framework for power planning predicated on distributed energy resources, and used utility meter and other data to conduct preliminary siting analyses for local renewable and distributed energy resources while paying particular attention to increasing energy resiliency at public safety and critical commercial facilities.
- 2011 - CCA Feasibility Study[32]: projects CCA rates for four different scenarios with local renewable generation, and compares this against incumbent utility rates. Includes a peer review of the study.
- 2012 - CCA Draft Implementation Plan and Statement of Intent[33]: delineates the organizational structure, implementation pathway and various other requirements (as summarized in the 2).
- 2012 – Request for Information: provided the Sonoma County Water Agency with an overview of the capabilities and products of companies interested in providing various services to Sonoma Clean Power, given the explicit goals of the program.
- 2013 - Request for Proposals: a two-stage RFP process in which bidders are first pre-qualified based on preliminary pricing and proposals (March 2013), before final electricity requirements are set by the JPA (based on which cities join the CCA after

[30] The Climate Protection Campaign *Sonoma County Community Climate Action Plan* (October 2008) available from: [http://www.coolplan.org/]
[31] Sonoma County Water Agency *Renewable Energy Secure Sonoma Community* available from: [http://resco.newmexicoconsortium.org]
[32] Sonoma County Water Agency *Report on the Feasibility of Community Choice Aggregation in Sonoma County* (10 October 2011) available from: [http://www.scwa.ca.gov/files/docs/carbon-free-water/cca/CCA%20Feasibility%20Report%20101211.pdf]
[33] Sonoma Clean Power *Draft Community Choice Aggregation Implementation Plan and Statement of Intent* (October 2012) available from: [http://www.scwa.ca.gov/files/docs/carbon-free-water/cca/SCP%20Draft%20Implementation%20Plan%20V4%2010-24-12.pdf]

reviewing the preliminary pricing estimates), and best-and-final offers are submitted by bidders (July 2013), upon which the winning bidder is selected (October 2013). The RFP:

- Requires bidders to supply full-services wholesale power and scheduling coordination for at least three years;
  - Respondents are given three different options for bidding supply; two are defined and at least one must be bid, while the third is undefined so that bidders may propose innovative approaches;
  - Respondents must allow the substitution of power produced by local projects to be integrated into the power supply for the CCA, so that the Sonoma County Water Agency and others may develop local projects regardless of whether the bidder proposes to or not.
- Allows bidders to integrate local renewable generation and distributed energy resources in their proposals and states that bidders which do so will receive preference in the evaluation process;
- Requests that bidders provide in-kind assistance or funding to cover up to $2.5 million in start-up costs and $6.5 million in bridge financing for power purchases (because of the time delay between paying for the power and collecting bills from customers), and states that preference will be given to bidders that do so;
- Allows for meter data management services to be bid integrated with supply or as a standalone service.

3.2.2 Current Status

The first stage of the RFP process was a success, and Sonoma Clean Power received eleven bids to supply the CCA with electricity services. Based on this preliminary pricing, the table below compares example residential and commercial monthly electric bills for Sonoma Clean Power customers and Pacific Gas and Electric customers. While increasing the amount of renewable power to 33 percent (as compared to PG&E's 20 percent), the bids that the agency has received result in rates between 4 percent below and 0.5 percent above the rates charged by PG&E.

Figure 14: Preliminary Comparison of Sonoma Clean Power and PG&E Rates

Example Residential Electric Fees (Based on 500 kWh per month)	SCP Low Estimate for 2014	SCP High Estimate for 2014	PG&E Estimated Rate for 2014
	33% Renewable Energy	33% Renewable Energy	20% Renewable Energy
Electric Generation Fees (all customers)	$35.71	$38.46	$40.76
PG&E Electric Delivery Fees (all customers)	$55.80	$55.80	$55.80
Additional PG&E Fees (SCP customers only)	$3.32	$3.32	$0.00
Last updated April 15, 2013	Total Cost **$94.83**	Total Cost **$97.58**	Total Cost **$96.56**

Example Commercial Electric Fees (Based on 15,000 kWh per month)	SCP Low Estimate for 2014	SCP High Estimate for 2014	PG&E Estimated Rate for 2014
	33% Renewable Energy	33% Renewable Energy	20% Renewable Energy
Electric Generation Fees (all customers)	$1,203	$1,296	$1,373
PG&E Electric Delivery Fees (all customers)	$1,169	$1,169	$1,169
Additional PG&E Fees (SCP customers only)	$90	$90	$0
Last updated April 15, 2013	Total Cost **$2,462**	Total Cost **$2,555**	Total Cost **$2,542**

Image Credit: Sonoma Clean Power.

3.2.3 Planning for Local Development of Renewables and Distributed Energy Resources

It is unknown at this time to what extent the bids included local renewable generation or distributed energy resources. The Sonoma County Water Agency is prepared to develop local renewable and distributed energy resource projects regardless of whether the winner bidder proposes to or not.

In preparation for the expiration of the initial with the energy supplier in three years or more, the CCA is planning to take on the responsibility of running power procurement by contracting with multiple power plants and suppliers ahead of that date, to assume direct control over the integration of local renewables and distributed energy resources.

3.3 Expanding upon The Sonoma Clean Power Approach to Accelerate Renewable and Distributed Energy Resources

The proposed strategy for achieving RESCO goals is similar to the process that Sonoma Clean Power is undertaking, but differs in various key aspects in regards to the methods employed to develop distributed energy resources. Sonoma Clean Power does not present a fully integrated approach, and instead asks bidders to propose net energy metering and feed-in tariffs to stimulate the deployment of distributed generation, while running separate efficiency programs. This approach is largely a continuation of that taken by the investor owned utilities in California, and does not overcome any further barriers to the spread of distributed energy resources.

The proposed model provides an innovative deployment strategy that is commensurate with the scale of deploying distributed energy resources throughout an entire community. It proposes to use a CCA's access to customer meter and other data to target the deployment of distributed generation, advanced energy storage, and demand-side measures (efficiency, conservation, and demand response) in an integrated fashion, streamlines the financing of these projects, uses a multi-stage performance-based contracting strategy to deploy the technologies and capture retail savings while managing performance risk, and provides for the integration of these assets more directly into procurement planning and operations of the CCA.

3.3.1 Using Data Analytics to Target The Deployment of Distributed Energy Resources

Community Choice Aggregation affords a local government access to customer end-use electrical meter and account data through the CCA INFO TARIFF. This data is not accessible to private developers of renewable and demand-side assets, and gives the CCA a strategic and commercial advantage relative to these firms that may be used to accelerate the deployment of distributed energy resources, given the proper analytics and program deployment processes. Over the last several years, a variety of companies have entered the 'big data' market for energy data management and analytics services, commensurate with the deployment of smart meters in many territories around the country, and the need to manage a large volume of data to derive operational insights. Several leading firms are also offering the ability to target distributed energy resources as a service.

The customer meter data available under the CCA INFO TARIFF may be combined with a variety of other datasets, in order to conduct a database and Geographic Information System (GIS) analysis of customer accounts. Based on the a variety of criteria, the most financially attractive sites for the near-term deployment of distributed generation, advanced energy storage, and demand-side assets may be targeted, detailed, further investigated, and ranked, in order to create a customer-targeting database that will guide the program's deployment.

The financial attractiveness of a deployment at a given site should be considered from a variety of perspectives. At a minimum, the value-proposition must be compelling to the site owner. The impact of the deployment opportunity for a given site on the program's overall portfolio and wholesale procurement activities should be considered, and used to select sites that further present a value-proposition to the CCA. Deployments should be ranked to provide the maximum benefit to both the host site and the program overall. As sites will be targeted with multiple technologies, the ranking of sites will depend on a variety of site evaluation criteria and expert judgment.

3.3.1.1 Targeting Public Safety and Critical Commercial Loads for Distributed Energy Resources

The data may also be used to further directly accelerate RESCO goals by targeting facilities that are deemed to be critical commercial or public safety facilities, including but not limited to:

- Public safety critical loads:
    - Healthcare
    - Police & Fire stations
    - Telecommunications
    - Water pumping
    - Rest homes
    - Grocery stores
    - Refrigerated warehouses
    - Fuel depot, delivery and filling stations
    - Natural gas lines
- Commercial critical loads:
    - Data Centers
    - High-Tech
    - Pharmaceutical

3.3.1.2 Qualitative Example of Initial Site Evaluation

A simplified example of this process will be instructive. Consider the behind-the-meter deployment of photovoltaics on a medium commercial customer site; the following are a sample of relevant site evaluation criteria, explained at length:

- The customer will have demand charges that are assessed on a monthly basis, set by the highest period of onsite demand within any 15-minute period. This is referred to as customer-coincident demand, and may be a substantial portion of the customer's total electricity bill. The ideal candidate site will have a customer-coincident demand period during the time of day when the photovoltaics are producing electricity, as this will lower both the customer's energy charges and demand charges.
- Avoiding the export of electricity from distributed generation to the grid is a key strategy for a CCA deploying distributed generation at scale, in order to minimize distribution upgrade costs and delays. The ideal candidate site would be a business that has demand sufficient to consume the output of the solar system all seven days of the week. An office, for example, would likely not have sufficient demand on the weekends.

However, if the office was adjacent to a property that did have sufficient load on the weekends or on holidays (such as a residential high-rise, or a grocery store), an over-the-fence transaction[34] could be arranged to directly supply the power from the solar array to the adjacent customer for periods when the host site was unable to fully consume the power generated.

To add some complexity to the example, consider the integration of demand-side management technologies for this deployment:

- Based on the customer's business type and energy usage intensity, the ideal candidate site would, in addition to the above criteria, also consume an above-average amount of energy (compared to similar business types), as this would indicate an above-average demand-side retrofit opportunity.
- The time of day when the customer is consuming this electricity, and the opportunity to reduce this consumption, may have implications for the program's finances overall:
    - The program is paying for resource adequacy each month, for the highest period of demand for the program overall within certain time periods (set by the California Independent System Operator at times when overall California peak demand is likely to occur); this is referred to as system-coincident demand. The system-coincident demand peak for a region is driven by the energy usage patterns of the customers within the territory, in the CAISO defined peak periods. These patterns are ultimately determined by what types of end-uses (lighting, heating, etc.) are being used by specific customer segments (single family homes, hospitals, etc.) during those time periods. The system peak in winter is likely to be driven by residential heating loads in the evening, and in the summer by afternoon air conditioning loads in the commercial sector. The photovoltaics array will offset peak consumption thus defined to a certain extent during summer months. However, the solar array will likely not offset the CCA's resource adequacy requirements during these winter months, as the peak may be in the evening.
    - If the customer is consuming an above-average amount of electricity during the system-coincident peak demand periods in both the winter and summer months, it would be an ideal retrofit candidate, as installing both a solar array and retrofitting the host site would drive down resource adequacy payments for the program overall in the summer months, and may result in the lessening of demand charges for the customer's retail bills throughout the year.
    - These demand periods also tend to coincide with the overall peak price pattern of energy, which is generally more expensive during periods of high demand. As

[34] Over the fence transactions permit the interconnection of distributed generation to two adjacent buildings other than the building on or in which the system is installed for the purposes of sharing the energy generated, with some restrictions. See California Public Utilities Code 218(b).

such, the program would also avoid paying for the more expensive on-peak electricity.

  - On the other hand, if the customer was consuming an above-average amount of electricity during the off-peak hours, it may still be a viable retrofit opportunity from the host site's perspective, but would be a less desirable retrofit candidate, as lowering the onsite consumption would result in less of a financial benefit to the program's procurement and resource adequacy revenue requirements. As compared to the above example, the site may be assigned a lower priority.

3.3.2 Initial Candidate Site Acquisition Process

In order to leverage a CCA's access to customer meter data to accelerate the deployment of distributed energy resources, the CCA must put in place a program structure which allows for sites to be pre-screened and acquired prior to soliciting bids from companies to install the technologies. This structure is summarized in the subsections below.

3.3.2.1 Host Site Customer Polling

Based on the selection of the most profitable sites from the initial data analysis, customers should be polled to gauge their willingness to participate in the program (customer contact details are included in the CCA INFO TARIFF data).

3.3.2.2 Detailed Modeling of Select Host Sites

More detailed technology configurations for specific sites that respond favorably to the customer poll should be conducted to provide estimates of site-specific onsite generation and demand-side potential. This analysis should result in customer-specific technology configurations and preliminary economic performance pro forma based upon site-specific:

- Load profiles;
- Technology configurations and performance parameters;
- The tariff which the customer is on prior to and after the installation of the selected technologies.

3.3.2.3 Onsite Audit of Candidate Sites to Refine Assumptions

To confirm and refine the assumptions of site-specific distributed energy resource potential and financial pro forma, the most promising candidate sites should be bundled and put out to bid for onsite audits using a competitive solicitation process. The audits should result in sufficient information to aggregate similar candidate sites and/or technologies in further competitive solicitation processes for the actual implementation of the distributed energy resources (refer to the 'Management and Contracting Structure for the Deployment of Distributed Energy Resources' below for more details).

3.3.2.4 Final Customer Targeting Database

The final customer targeting database should contain the results of the initial data analysis, customer poll, and detailed modeling and onsite audits of candidate sites. This data should be integrated into the project management database, described in the section below.

3.3.3 Project Portfolio Management Approach for The Deployment of Distributed Energy Resources at Scale

Monitoring and updating the projected online date and progress of each project must be a priority for the program. Doing so will allow cost-containment on a project-specific basis and overall, as:

- Problems are identified in real-time and prioritized for resolution;
- The impact of each project may be automatically integrated program power procurement and operations;
- Similar projects may be bundled and put out to bid using performance contracting structures, yielding increased competition and lower costs (as detailed in the proceeding section).

A single software platform should be used across all technologies and program areas; this is commonly referred to as project portfolio management (PPM) in project-intensive industries. Any off-the-shelf software will need some amount of customization for the CCA's purposes, but this will not be a significant expense. All program managers, including staff and subcontractors will need to use this system; as such, a web-based platform should be selected.

This database will use as inputs the results from the data analysis, which will identify key target sites and will pre-populate available site information and technology selections.

3.3.3.1 Document Generation

The PPM database should be customized to generate documents necessary for the negotiation, financing, construction, interconnection, operation and maintenance of each facility. Doing so will significantly drive down the transactional cost associated with document preparation, aid in quality control monitoring and trouble-shooting, and will act as a cost containment and risk mitigation measure.

3.3.4 Management and Contracting Structure for The Deployment of Renewable and Distributed Energy Resources

The CCA should hire a company that has expertise in managing multiple subcontractors using performance contracting to achieve cost-effective large-scale public works projects. This company would use the PPM database detailed above, and would be responsible for ensuring that the various subcontractors that actually implement the projects perform to expectations and fulfill their contractual obligations.

The types of contracts with the companies hired to install the distributed energy resources will vary, depending on the nature of the installations. There are three general types of contracting arrangements likely to be used by the CCA:

1) For complex, larger value, site-specific installations (such as microgrids and combined heat and power applications), one or more suppliers (technology manufacturers, installation contractors) would likely bid as a combined team for the supply and

installation (and possibly operation and/or maintenance) work on a project-by-project basis. These types of projects would likely be contracted using a 'turnkey' contracting approach; Design/Build, DBOM (design/build/operate/maintain) or Power Purchase Agreement (PPA) basis.

2) For more typical installations (such as distributed photovoltaic installations), or efficiency retrofits, suppliers/contractors could be pre-qualified to be part of a 'contractor pool'. The pool of participants could be required to work within standardized cost and pricing restrictions for the repeatable elements of their work. Any unique site-specific installation cost elements would be estimated and validated independently. This contracting approach is employed in many efficiency and solar deployment programs in California.
3) For lower cost, stand-alone small devices (such as thermostats or lighting components), suppliers could compete on a standing order price basis. These suppliers would quote unit pricing valid for a set time period. Products would be ordered on a pace that follows installation schedule, to avoid having to inventory any products. The goal of this approach would be to achieve savings through economies of scale. As customer orders are collected, purchase orders for devices are placed, and a separate local installation firm would perform the installation work on a fixed price arrangement.

3.3.4.1 Contracting Structures for Larger Projects

Larger projects (such as a large-scale solar or wind power installations, combined heat and power and microgrids) are well suited to various types of 'turnkey' contracting. These types of projects usually require some design and engineering work, a combination of components and installation hardware. In a turnkey contract the contractor is required to take responsibility for all aspects of the installation, and to deliver a completed project that meets functional and quality requirements, for a fixed price. Some of the turnkey variations that could apply to the CCA program include Design/Build, DBOM (design, build, operate, maintain) and PPA (power purchase agreement).

Design/Build

This type of fixed price contact combines the engineering and installation work under one contract. Usually, a combination of performance specifications and key technical requirements are used to define the contractor's scope of work. The contractor takes quality and schedule risk for meeting the functional requirements. A Design/Build contractor will typically be responsible for securing the some or all of the required construction permits. For applying for necessary permits, the contractors would work within any cooperative arrangements that have been made by the CCA and local permitting agencies to help expedite required approvals. Design/Build contracts can require a longer 'project-wide' warranty than likely to be available if components were to be sourced and installed under separate contracts. A major advantage in using a Design/Build approach for many of the customer based projects is that the contractor team can work directly with the site owners from the outset to design the installation locations, and resolve installation issues.

Under some circumstances[35], it may be desirable to complete a project on a Design/Build basis, and then have operations and maintenance services performed under a separate contract, without using the design, build, operate maintain (DBOM) contracting approach described below.

Design, Build, Operate & Maintain (DBOM)

Under this model, longer-term (15+ years) fixed price operations and maintenance obligations are added to a Design/Build contract. For projects with a greater degree of mechanical complexity, this model can be beneficial, because it requires the contractor to conduct the design and construction work in view of their long-term, fixed price obligation to keep the project functioning properly. This is especially applicable if a technology has not been thoroughly service-tested; using a fixed-price DBOM contract prevents the CCA from being exposed to cost overruns if additional work is required to achieve expected functionality, or if the installed equipment isn't sufficiently durable. Another benefit of the DBOM approach is that all inventory management and maintenance work for the contract term are included on a fixed price basis, and do not have to be addressed separately by the CCA after the projects have been completed.

Power Purchase Agreement

A Power Purchase Agreement (PPA) is similar to a DBOM contract, in that a single entity is responsible for completing the project, and making it function properly. However, instead of being paid for the work as the project advances, the PPA developer negotiates to sell the power from the project at a set price, and then secures financing for the project capital costs, and completes the project. The developer will be responsible for all permitting, final site acquisition agreements and the costs of implementation, operation and maintenance. The revenues secured from the power sales should be sufficient to repay the project capital cost, if the project developer has both correctly assessed the power output of the project, and kept the capital costs within budget.

3.3.4.2 Contracting Structures for Smaller Projects

Job Order Contracts

For the type of projects that are similar and will be conducted fairly regularly, the use of a Job Order contracting approach is recommended. This contracting method has been used successfully by efficiency and solar program throughout California. Projects that would likely use this approach include smaller solar installations and efficiency retrofits. The Job Order contracting approach is best suited to projects just requiring basic contracting work (basic electrical, plumbing, and construction, etc.) In contrast, Design/Build is better suited to projects

[35] This scenario is currently not anticipated, and therefore, not further addressed in the analysis.

with more complexity; difficult installation challenges, systems integration, technologies that require functional optimization tuning on site, and so on.

The Job Order contracting approach would involve a pre-selection process conducted by the CCA or a chosen subcontractor. Interested contractors would have to demonstrate that they had the required skills, experience and equipment to participate in the Job Order project work. They would also have to have required levels of liability insurance, and bonding, and have a good customer record. The Job Order contractors would have a performance and quality incentive from their interest in securing additional, ongoing work through the program.

The CCA would negotiate standard 'rate sheets' with installers, covering all general costs for each installation. When a project is ready for construction, the CCA manager or its chosen management subcontractor puts together a scope of work and asks for prices from the contractor pool; if the low price is within the acceptable cost range for the project, the CCA proceeds. The Job Order contractors price out of a catalogue and cannot increase pricing above the need a predetermined margin. If a measure is approved in the catalogue then the approval is done. Oversight and contract administration is the responsibility of the CCA or its chosen management subcontractor. The project is compared with previous base case of the project to determine actual savings.

The Job Order projects would typically be of smaller value, and relatively short installation duration. For the technology elements sourced through the CCA Program Suppliers, see Supply Contracting, below. Job Order Contractors would not be allowed to put markups on elements sourced through the Supply Contracts.

If there were unique elements for a particular installation, the Job Order Contractor would have to review the conditions with the CCA project management team in advance of performing the installation work, and have any additional costs approved. For all projects with customer site installations, the Job Order installers will provide a long-term installation integrity warranty, against leaks or other failures and damage.

The Job Order contracting method could also be used for any maintenance work that the CCA is responsible for, using a similar set of pre-negotiated costs for work assignments.

3.3.4.3 Supply Contracts

For small-scale devices and products that may be made available through the program, economies of scale may be possible through negotiated volume purchasing agreements. For example, efficient lighting technologies or advanced thermostats could be acquired this way. In many instances, it is expected that a customer installation would include a 'packaged solution', comprising a set of technologies and other efficiency measures appropriate for the location. It is expected that these types of installations would be conducted using the Job Order contracting approach described above.

The CCA could conduct a rolling procurement process as follows: supplier price bids would be requested for set price validity periods – for example, a six month period. Suppliers would be requested to provide quotes using a tiered, volume band discount mechanism. For example, if the actual number of orders placed during the pricing period were <500, the price would be $X, from 501 to 999, the price would be lower, and lower again if >1,000. A final price adjustment would be made at the end of the pricing term to reconcile accounts based on actual volume purchased.

The more effective the CCA program is in promoting the products and installations, and in processing orders and completing installations on a timely basis, the greater the savings that will be realized. Use of volume ordering would allow the products to be passed on to customers at the lowest cost. In instances where capital and financing costs affect the overall financial and economic performance of the program, the lower the base price for each unit, the better. To maintain optimal levels of competition, the pricing should be openly re-competed on a cycle of price validity periods.

3.3.5 Program Financing of Distributed Energy Resources

Currently, the financing of distributed energy resources is left up to the customer or installation company to arrange on a site-specific or company-specific basis. This serves to increase transactional costs, slow down the rate of deployment, and fragment the delivery of distributed energy resources. A CCA has a sufficient economy of scale to streamline this process for its customer base and contractors by structuring an investment fund to finance a variety of technologies across different customer types and project characteristics. The design of this fund is outside the scope of this report, and will be closely tied to the customer repayment mechanisms, contract structures, and collateral requirements summarized in the proceeding section. It should also be noted that the CPUC is overseeing a statewide initiative to streamline the financing of distributed energy resources (refer to 'The California Energy Efficiency Finance Project' in the proceeding section); it is well aligned with RESCO goals, and depending on the timeline for full implementation, may allow the CCA to achieve its financing goals while driving down startup and transactional costs. Project financing falls generally into the four categories below, which also list potential sources of project capital.

3.3.5.1 Bridge Finance

- Project developer equity
- Venture capital
- Development private equity
- Bond Anticipation Notes issues by the CCA
- Hedge funds

3.3.5.2 Debt Finance

- Local, regional and national banks
- Insurance companies
- Revenue bonds issued by the CCA
- Crowd-funding (with certain restrictions)

3.3.5.3 Equity Finance

- Project developer equity
- Venture capital
- Development & Infrastructure private equity
- Hedge funds

3.3.5.4 Tax Equity Finance

- Commercial and investment banks
- Select non-finance entities (Google, Chevron, etc.)

3.3.6 Customer Repayment Mechanisms, Contracts, and Collateral

Mechanisms to collect payments from customers for distributed energy resources include integrating the site-specific charges into the volumetric generation rate charged to an individual CCA customer, on-bill repayment (OBR) on either customer power or water meters, off-bill contracts, and commercial PACE assessments (property tax assessments).

Contracts in which the customer agrees to the specific terms of the installation and payment are referred to as a power purchase agreement (PPA) for distributed generation and an energy savings agreement (ESA) for an energy efficiency retrofit.

Offering a range of technology products and services to the full spectrum of customer types and profiles will require a system of diverse and flexible customer repayment mechanisms and contracts. Mechanisms and contracts that 'tie' repayment to the meter rather than the customer should significantly increase program participation as well as the average savings per retrofit, as the scale of the retrofit will be based on what makes the most long-term financial sense, instead of on what the customer can afford to implement at a given point in time.

Certain repayment mechanisms allow for greater or lesser collateral requirements for specific customer contracts. Repayment mechanisms that significantly diminish the potential for customer non-payment over time (for example, the threat of utility power and/or water meter shut-off in the event of non-payment, and/or the ability to 'tie' the repayment obligation to the meter or premise in the event that the original customer moves), typically require lower collateral requirements for specific customer contracts and enjoy relatively low interest rates and longer terms.

Loans that are unsecured either by the repayment mechanisms and/or customer contract will typically only be available to customers that meet certain underwriting criteria (such as a minimum FICO score), and at a higher interest rate.

However, it is worth noting here that evaluating the financial risk on a project specific basis, in which a default means the lender loses all of their investment, requires greater collateral than evaluating the same risk on a portfolio basis, in which a small number of customer defaults would not cause the lender significant losses. The program will likely have a surplus that may be used to mitigate or lessen the financial risk of non-payment at a small percentage of sites, because of the combined financial performance of the entire portfolio.

Therefore, the collateral requirements for a given contract under the program may be able to be less stringent in comparison to the requirements taken if every site were to require full collateral in the event of a default - providing that the overall performance of the portfolio was sufficient to make the lender whole. For example, if collateral requirements by lenders were to exclude a portion of low income or small business customers, the program could elect as a policy decision to set aside a portion of the program surplus to be used as a credit enhancement (such as a subordinated loan product) to negotiate with lenders or underwriters to extend financing to these customer segments.

Recommended Actions

The CCA should negotiate collateral requirements and contractual provisions for type-approved technology deployments and customer types with investors and underwriters, taking into consideration the use of repayment mechanisms and their impact on the perceived risk of customer non-payment, as well as the potential use of program surplus funds for making lenders whole in the event of individual customer defaults. Further risk mitigating actions the CCA may take in regards to specific repayment mechanisms and contractual terms are detailed in the subsections below.

These provisions should be further explored and negotiated as part of the program start-up process, so the necessary provisions may be incorporated into customer contracts prior to executing financed demand-side retrofits on customer homes and businesses. Program design should take into account contracting provisions and procedures that vary by customer type and technology.

3.3.6.1 CCA Generation Rates and Bill Ready Consolidated Billing

The CCA will have a variety of options for collecting payment from customers. First, CCAs enjoy a unique level of access to report data on each customer's monthly electric bills. The CCA designs and controls the rate schedule for each customer, and may report charges to the IOU for printing on its monthly bill on page space dedicated to the CCA. The program has the authority to directly 'roll in' the repayment charges for the asset into an individual customer's CCA generation rate on a volumetric basis, and to disaggregate these charges on the bill under the IOU's Bill Ready Consolidated Billing tariff. This approach will ensure that the repayment of assets is collected through the electricity bill, keeping transactional costs low in a similar manner to on-bill repayment (below). Also, the Bill Ready tariff would allow the CCA to include program website and customer log in information directly on the customer bill, to further explain charges and offer services to the customer.

Contract and Collateral Implications

The installation of major retrofits and appliances would require the approval of the property owner; as part of this process, the program should explore offering contracts contingent upon future tenant leases and rental agreements stipulating that the tenant must remain a customer of the CCA until the point in time that all assets are paid off, and that this provision be transferred to the subsequent property owner in the event of the sale of the property. As customer opt-outs are processed by the CCA, this would provide a measure of long-term guarantee of asset repayment.

Recommended Actions

The legality of using contracts which prohibit opt-out until the assets are paid off should be assessed. This would provide a measure of mitigation to the risk of customer non-payment, and would likely serve to relax the contractual collateral requirements demanded by lenders and underwriters. If this approach is deemed to be not legal or infeasible, the program design and bond issuance may still proceed with increased contractual collateral requirements, and the CCA may further consider implementing alternative payment mechanisms as appropriate (described below, some of which may face regulatory challenges or delays).

Increased collateral contractual requirements may include a lien on the property, which could serve to lower the risk of delinquency or default on repayment obligations, and the resulting risk profile and cost of capital to the program. Note that this mechanism remains viable and in use for the residential sector (by SMUD, for example) and not just the commercial sector in spite of the demise of Residential PACE programs for employing a similar mechanism. It would only apply for measures that exceed Title 20 equipment and appliance standards, which would practically result in needing to structure two loans for each comprehensive retrofit. This mechanism would drive up administration costs but remains viable nonetheless.

3.3.6.2 On Bill Repayment for Power Meters

On-bill repayment (OBR) is another potential repayment mechanism to service the debt on deployed assets, depending on CPUC and PG&E decisions to implement this approach. OBR as a tariff could offer the ability to tie repayment to the meter rather than the CCA customer. This approach is in-line with broader statewide programs: refer to "The California Energy Efficiency Finance Project" subsection below for more details. However, given the CPUC regulatory process and demonstrated reticence of IOUs to fully expand this mechanism, wide-spread implementation may take several years. It should also be noted that Marin Energy Authority has recently received approval for an on bill repayment pilot program in 2012.

The California Energy Efficiency Finance Project

The May 2012 CPUC Decision in Rulemaking 09-110-14 [36] ordered the continuation of IOU on–bill financing (OBF) and the expansion of energy efficiency financing mechanisms; Harcourt, Brown and Carey, under contract with San Diego Gas & Electric and Southern California Edison, has developed pilot proposals for various financing products, including OBR and various credit enhancements, under consideration by the CPUC to be piloted in 2013 and scaled up in 2014.[37] However, given the CPUC regulatory process and demonstrated reticence of IOUs

[36] California Public Utilities Commission *Decision in Rulemaking 09-110-14* (May 2012) available from: [http://www.calmac.org/events/EE_and_MEO_2103-14_decision_166830.pdf]

[37] For more details, refer to the California Energy Efficiency Finance Project available from: [http://www.caleefinance.com]

to fully expand this mechanism, wide-spread implementation may take several years. The financing proposals will be approved in rulings in R.09-110-14, as they were submitted too late to be considered in the October 2012 decision.

The proposals may be downloaded from the website of the California Energy Efficiency Finance Project.[38] The proposals call for the creation of the California Energy Efficiency Financing Hub (the Hub) to act as a 'one stop shop' for efficiency financing, in the near term to pilot OBR and credit enhancements in 2013, with an expanded implementation to follow in 2014, and eventually the expansion of the system to manage contractors and to integrate the analysis of utility and building data for targeted deployments and customer interfaces. Also, the CPUC has been explicit that while utility ratepayer funds for OBF must only support efficiency measures, private sector funds for OBR should also allow the financing of distributed generation.

The management and oversight of the Hub is proposed to be under the control of an IOU for the pilot phase; for full implementation, the appropriate entity to manage the Hub is under discussion, and may include:[39]

- State or quasi-state agencies such as entities managed under the State Treasurer's office;
- Utilities;
- New or Existing Not-for-Profit Organizations;
- For-Profit Entities.

This statewide process is well-aligned to the proposed RESCO commercialization strategy, and depending on the timeline for full implementation, may allow the CCA to achieve its deployment goals while driving down startup and transactional costs associated with site selection and financing.

Contract and Collateral Implications

The possibility that the OBR tariff will allow repayment obligations to be transferred to subsequent customers that occupy the premise, and the ability to turn off the customer meter for non-payment (for the commercial sector but likely not for the residential sector), represent notable risk mitigation measures for underwriters and lenders in regards to customer non-payment. This may drive down collateral obligations required for individual customer contracts, which would serve to increase the rate of customer adoption of behind-the-meter assets.

Recommended Actions

Regarding OBR in General: MEA's progress should be monitored and supported by CCSF in regulatory proceedings, if need be. The CCA should monitor the discussion of shut-off

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[38] For more details, refer to the California Energy Efficiency Finance Project available from: [http://www.caleefinance.com/category/all/]

[39] California EE Finance Project Team *California EE Financing Hub Pilot Proposal (*October 1, 2012) Pg. 6

provisions of utility power meters being considered under the OBR design process at the CPUC. The latter appears to be valid for nonresidential customers (~70 percent of the CCA's potential load) as it is a provision under PG&E's current OBF tariff, but faces legal challenges to implement for residential customer classes. Whether the corporation will cooperate with CCAs to offer this service to customers remains to be seen. Because of this, it is necessary to explore alternative repayment mechanisms in addition to on-bill options.

Regarding the California Energy Efficiency Finance Project: the CCA should support the implementation of an On-Bill Repayment mechanism and management program flexible enough to accommodate CCA innovations such as those described in this report. Particular attention should be given structuring OBR as a tariff to allow the obligation for repayment to be attached to the meter, even in the event of customer opt-out. The CCA should also intervene if possible to ensure that the eventual management of the Hub does not fall to an IOU, and that the CCA and not the IOU be the point of contact for any customer of the CCA's seeking services through the Hub, as a precaution against anti-competitive activities towards CCAs. The CCA should approach MEA and Sonoma Clean Energy to support intervention at the CPUC to ensure that the statewide activities result in a programmatic structure flexible enough to allow innovations that CCAs may want to develop within the statewide program to tailor it to local conditions. Examples of these innovations may include:

- The integration of a site selection process and contractor management system to be implemented more rapidly than the statewide version;
- Expanded repayment mechanisms available to a local government (i.e. water bill repayment and Rent Board efficiency expense pass-through allowances, etc.);
- Expanded collateral enhancements available to a CCA (i.e. using program surpluses to expand financing to hard to reach sectors);
- Tracking procedures to allow the integration of behind-the-meter assets into CCA procurement planning.

3.3.6.3 On Bill Repayment for Water Meters

The CCA could also have the option of transferring the repayment obligation from the electrical meter to the water meter, if controlled by a public utility, in the event that the IOU obstructs the collection of the charge and/or the customer opts out (and the contracting structure detailed under the "CCA Generation Rates and Bill Ready Consolidated Billing" subsection above have not been put in place).

Properties which have a single water meter but multiple electricity meters would pose barriers to deploy this mechanism easily, absent agreements between renters and owners that allow for it. This would likely only be a problem in dense urban environments.

Contract and Collateral Implications

The possibility that the OBR tariff will allow repayment obligations to be transferred to subsequent customers that occupy the premise, and the ability to turn off the customer meter for non-payment, represent notable risk mitigation measures for underwriters and lenders in regards to customer non-payment. This may drive down collateral obligations required for individual customer contracts, which would serve to increase the rate of customer adoption of behind-the-meter assets.

Recommended Actions

The CCA should explore the feasibility of this mechanism in cooperation with the local water utility, if publicly owned. This may require regulatory or legal actions to implement, and should be explored prior to program start-up activities. Provisions allowing for the discontinuation of service in the event of customer non-payment would have to be explored. As the ease of use of this mechanism various by customer type, the benefits of this approach would have to be weighed against the increased transactional costs for certain customer types, and accounted for in service charges.

3.3.6.4 Off Bill Contracts

Alternatively, the program could structure off-bill contracts with customers. The Sacramento Municipal Utility District (SMUD) has successfully run an off-bill residential efficiency financing program for the last two decades. The utility has invested over $500 million through the program, which at one point reportedly made them one of the largest community banks in the country.

Contract and Collateral Implications

This would impose an added cost to the program in terms of staff and/or contractor expertise, processing and paperwork, and would require the customer to refer to multiple documents to understand their cost of energy. This approach would also tie the debt repayment to the customer rather than the meter, which would lessen the achievable investment opportunity on many sites unless sufficient collateral were required (for example, though a lien on the property - see mitigations under "CCA Generation Rates and Bill Ready Consolidated Billing" above).

Recommended Actions

The CCA could further explore this mechanism, and request further information and guidance from SMUD's program administrators.

3.3.6.5 Property Assessed Clean Energy

Property Assessed Clean Energy (PACE) financing is an option for the commercial sector. The ability of PACE financing and collateralization practices to offer service to many commercial customers is limited. Nonetheless, this program should be integrated into the CCA's program design where appropriate.

Contract and Collateral Implications

PACE loans are by definition collateralized by a senior lien on the property. This poses high transactional costs in negotiating with other lien-holders, which drives up the cost of financing. It is not in practice not a valid repayment mechanism for the residential sector, as Fannie Mae and Freddie Mac object to the senior lien position given to the lender. For the commercial sector, given the performance of the real estate market post Great Recession, this financing tends to be extended to Class A commercial properties and may not be able to be extended to the majority of CCA customers.

Recommended Actions

San Luis Obispo County and all incorporated cities (except for Pismo Beach) participate in the CaliforniaFIRST PACE program, which should be utilized by the CCA operations where appropriate.

3.3.7 Integration with Scheduling Coordination and CAISO

Broadly, the CCA's Scheduling Coordinator will interact with the California Independent System Operator (CAISO) for two general purposes: 1) arranging for the delivery of energy through the electrical grid, and 2) direct participation in ancillary service markets run by the CAISO, by aggregating and dispatching certain distributed energy resources.

3.3.7.1 Forecasting and Settlement

The CCA will need to calculate its own load shapes and estimates of the impact of installed distributed energy resources internally, and for the purposes of forecasting and settlement, submit to the CAISO estimates of the net load shape to be satisfied through wholesale procurement (either self-scheduled or market purchases). The CCA should hire a schedule coordinator or outside consultants to provide these estimates. The installation of smart meters throughout the IOU territories in California has simplified this exercise: the CCA will be able to base a majority of its estimates on hourly or 15-minute interval meter data, instead of extrapolating monthly usage data into hourly usage estimates by rate class and climate zone (which can introduce inaccuracies in the forecast). Similarly, project impacts may be monitored on an on-going basis using smart meter data.

3.3.7.2 Ancillary Services

For the purposes of aggregating distributed energy resources to bid into ancillary service markets, the CAISO must first update its market rules and requirements, which were developed for large power plants. For this purpose, the CAISO has convened a stakeholder group[40] that has met since October 2012; an issues paper will be forthcoming in Q1 2013, summarizing progress made to date regarding the metering and telemetry requirements for the participation of distributed energy resource in ancillary service markets. The group has so far reviewed and catalogued 932 requirements from 25 documents. The stakeholder process is projected to conclude by Q2 2014, [41] with certain options for the participation of distributed energy resource coming online within that time frame; however, other options will require the revision of CAISO tariffs and FERC Business Process Manual revisions, with a projected (but tentative) online date of Q4 2014.

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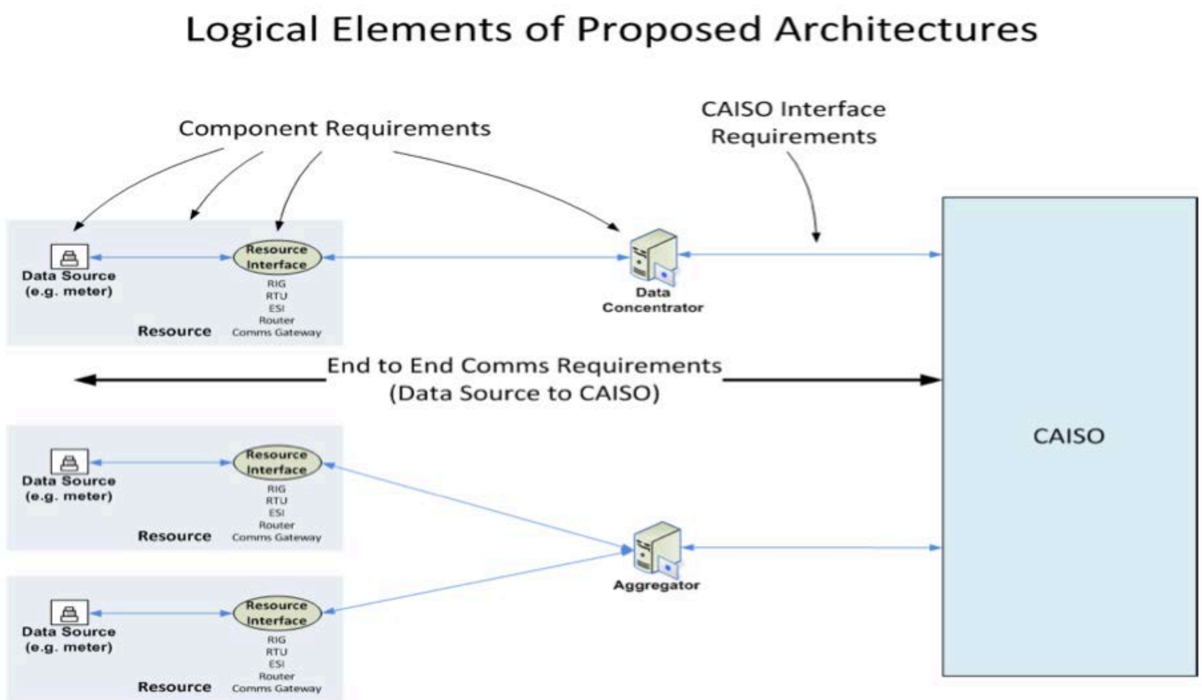
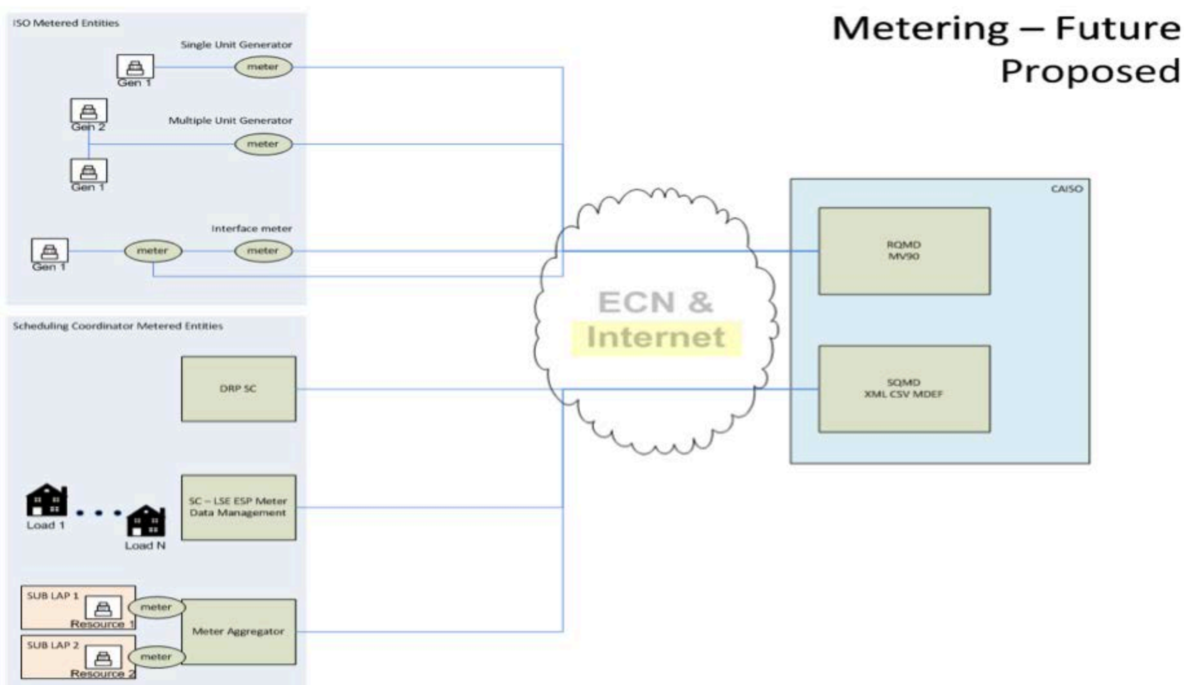
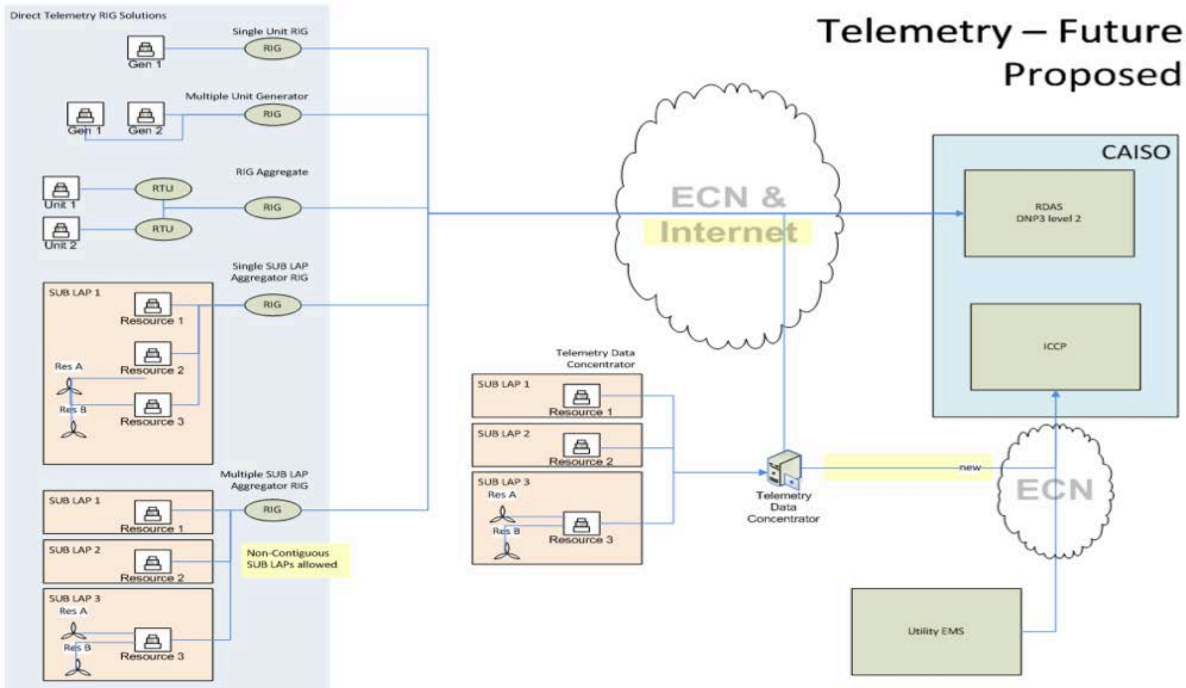
[40] Refer to CAISO *Expanding Metering and Telemetry Options* available from:
[http://www.caiso.com/informed/Pages/StakeholderProcesses/ExpandingMetering-TelemetryOptions.aspx]
41 CAISO *Expanding Metering and Telemetry Options* (7 February 2013) available from:
[http://www.caiso.com/Documents/Presentation-ExpandingMetering-TelemetryOptionsFeb6_2013.pdf]

Current and proposed telemetry and metering architectures for the participation of aggregated distributed energy resources in CAISO ancillary service markets are shown below:







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3.3.7.3 Integration into Grid Modeling

The CAISO has recently initiated information exchanges with the IOUs to track distributed generation installations at a zip code level of geographic granularity, for the purposes of integrating this information into their grid analyses. They will provide the CCA with forms to use in reporting these installations to the CAISO upon request.

3.3.8 Operational Integration

The operational integration of dispatchable distributed energy resources (see the proceeding section for a summary of these resources by technology) requires 1) a Scheduling Coordinator capable of aggregating and controlling the technologies, or a third-party aggregator of distributed energy resources that is able to communicate with the Scheduling Coordinator and directly with CAISO markets, and 2) appropriate control systems and communications for each technology.

Assets which are not dispatchable (i.e. solar photovoltaics, energy efficiency retrofits, and most CHP technologies) do not have to be integrated into daily procurement operations, but may be monitored for billing and O&M purposes, and the load impacts of each asset must be factored into procurement planning.

[42] CAISO *Metering and Telemetry Workshop Agenda* (9 October 2012) available from: [http://www.caiso.com/Documents/Presentation-MeteringTelemetryWorkshop.pdf]

3.3.8.1 Distributed Energy Resources Aggregator: Capabilities and Services

The distributed energy resource aggregator will provide a range of services to the program to aggregate, control, and integrate the technologies operationally into schedule coordination and CAISO markets:

- Needs assessment
    - Assessment of customer base and potential capacity
    - Special conditions due to regulatory, geographic and climatological environment
- Program design services
    - Knowledge of existing programs
- Program rules
- Baseline design
- Financial incentive/penalty rules
    - Ability to design custom programs
    - Metering and telemetry requirements for distributed energy resources
    - Wholesale bidding strategies
    - Retail engagement and contracting strategies
- Enrollment process management
    - Enrolling customers and registering assets with CAISO (eligibility, meter requirements, approvals, etc.)
- Active management of distributed energy resource operations
    - Capacity nominations, event dispatch, outage management, etc.
- Retail rate and tariff impact and optimization
- Wholesale market participation
    - Maximize investment by bidding resources in applicable markets
- Day-ahead
- Real-time energy
- Non-spinning reserve
- Regulation products
    - Resource and bid optimization
    - Demand Response Provider (DRP) and Scheduling Coordinator (SC) services
- Resource registration
- Bidding
- Award management
- Dispatch
- Telemetry
- Revenue quality meter data
- Settlement verification
- Performance measurement, validation and settlements
- Integration with other systems (MDMS, etc.)

- Program management reporting ('lessons learned', etc.)

3.3.9 Dispatchable Distributed Energy Resource Technologies Overview

3.3.9.1 Demand Response and Dispatch

Demand response falls into two categories: traditionally, it has meant turning off appliances in response to periods of peak electricity demand (i.e. hot summer afternoons or cold winter nights), and may only be done at certain times, for a limited number of times per year; the more recent definition is referred to as Demand Dispatch or Automated Demand Response, which is the practice of turning assets on or off to mitigate grid instability (for example, from renewable energy intermittency) and instead of relying on combustion turbines burning natural gas. Demand dispatch is an expanded form of demand response, involves the full automation of assets.

3.3.9.2 Smart Buildings

Smart Buildings are equipped with a communication and control system that allows the monitoring, optimization, and control of end-use appliances and circuits. In the commercial sector, Smart Building systems may have one of several configurations, depending on whether the building has existing controls or not. Many medium and large commercial buildings are already equipped with Building Automation Systems (BAS), which monitor, record, and control end-use appliances and circuits. Depending on the vintage and type, the BAS may use a variety of protocols. A Java Application Control Engine (a 'JACE box') may be installed to translate these legacy protocols into a universal format, which will communicate with a 'gateway' device that communicates with the aggregator for demand dispatch signals, or with a third party for various purposes (such as data analytics). The gateway device may have additional local control intelligence. Circuits and large appliances may be further monitored with current transformers, to enhance the insight into energy use patterns within the building and to refine operational control strategies.

3.3.9.3 Home Area Networks

Home Area Networks (HAN) refers to smart-grid enabled products and services at a residential customer's home. For dispatchable assets, the HAN enables demand dispatch by receiving electricity price and/or grid reliability signals from the service provider through a local 'gateway' device, which then communicates with radio controlled appliances within the home to turn them on or off in response to the signals. The point at which the signals are translated into appliance specific actions may be hosted remotely (i.e. on a cloud server), locally (in the gateway device), at the appliance itself, or across all three locations. HAN are still under development, with several promising test pilots and nationwide action across all parts of the value chain to deliver these products, standards, and services in the medium-term. Smart thermostats that act as gateways for the HAN and also directly control heating and cooling loads within the home (the most readily controllable and large residential loads, on average), are commercially available.

In March of 2013, the Electric Power Research Institute (EPRI), USNAP Alliance, and CEA implemented a testing and certification program for the ANSI/CEA-2045 Modular

Communication Interface (MCI) Standard from the Consumer Electronics Association. This standard addresses a significant gap in enabling residential appliances to be used for smart grid purposes. The essential problem has been that manufacturers have not been able to produce smart-grid enabled appliances cost-effectively on a widespread basis, because of a lack of agreement between utilities regarding which communication protocol to use for the purposes of monitoring and dispatching price and grid reliability signals to the appliances over the HAN. The standard allows manufacturers to produce appliances with the communication interface, into which a range of different communication radios may be inserted at a later date, depending on which utility territory the appliances ends up being installed.

This development should accelerate the availability and affordability of residential smart grid enabled appliances. The program should monitor appliances on the market for integration into CCA deployment programs and scheduling coordinator activities.

3.3.9.4 Electric Vehicle Managed Charging

Electric Vehicle (EV) managed charging refers to the practice of turning the EV charger on or off in response to price or grid stability signals. The customer specifies what the desired level of charge is for a certain time in the future, and it is left up to the aggregator to ensure that the vehicle arrives at the desired state of charge at the right time, while optimizing the charge pattern to take advantage of the lowest prices for electricity. EV managed charging aggregators must also take into account the impact on the additional load from charging the vehicles on the customer's retail bill, such that the charge schedule does not increase the demand charges for the customer unduly.

3.3.9.5 Electric Vehicle to Building

Electric Vehicle to Building refers to the practice of using the vehicle's battery to supply onsite power to the customer by discharging the battery. The chargers which enable this are available on the market today, but due to the uncertain impact of this practice on the life of the vehicle battery and the related warranty concerns that manufacturers have, there are no vehicles on the market in the USA today that offer this capability. However, there are two manufacturers that produce and market vehicles with this capability outside of the country, and the CCA should monitor the development of this market while ensuring that any chargers deployed by the program have this capability.

3.3.9.6 Advanced Energy Storage

Distributed Advanced Energy Storage (AES) is a rapidly evolving technology space, not only in the battery technologies at the core of the technology, but also in the hardware and software that controls the battery for both onsite and offsite uses, and the business models to deploy the technology. The versatility AES of is such that the California Energy Storage Alliance (CESA), as part of the CPUC's workshop to implement AB2514, has commenced modeling the energy and financial impacts of energy storage under fourteen different use cases. The modeling for the first use case, ancillary services, was recently released, showing that energy storage has a payback of 2 to 3 years when used to supply ancillary services. Many of these potential revenue streams for distributed storage applications are not available currently, but are in development at the CPUC and CAISO. The CCA should monitor the distributed AES market, and take into account the CESA's use case modeling during the distributed energy resource aggregator program design process.

3.3.9.7 Combined Heat and Power Peak Boosting

Combined heat and power (CHP) is typically run to satisfy onsite thermal usage and is not dispatchable. However, it is worth noting that at least one CHP technology (Tecogen) is capable of boosting its power output by ~25 percent for a limited number (~300) of hours per year. As many installations do not produce all the onsite electrical requirements, the distributed energy resource aggregator may be able to dispatch the peak boosting capability of these units without even back-feeding electricity into the distribution grid.

3.3.10 Impacts of The Proposed RESCO Commercialization Strategy

The approach recommended for advancing RESCO goals builds off of Sonoma's pioneering efforts to implement a CCA focused on renewables and local development, and proposes mechanisms that would substantially accelerate the deployment of distributed energy resources as well. In summary, among other achievements, this business model would:

- Design and construct a maximum of cost-effective distributed energy resources by focusing limited resources on achieving a community-scale approach to power planning, as opposed to pursuing a small number of projects (on government facilities, for example).
- Provide for an economy of scale and standardization to the financing of distributed energy resources, and allows the entity sufficient revenue to receive a credit rating and to issue revenue bonds for fund projects.
- Allow the local government to make energy policy and investment decisions regardless of the revenue conflicts that occur when distributed energy resources diminish revenue used to pay for the transmission and distribution infrastructure (as onsite generation and savings lessens revenue collected by the distribution utility, but the community choice aggregation program is only responsible for power planning and not for the distribution system).
- Use utility meter and other data to target the deployment of distributed energy resources in order to:
    - Pre-screen customer host sites in find locations where technology combinations result in retail savings;
    - Target sites and technology configurations which also benefit the community choice aggregation program's wider customer base by lowering wholesale energy and capacity supply requirements;
    - Increase energy resiliency on critical public and commercial facilities.

- Utilize performance contracting where appropriate to design, build, operate and maintain distributed energy resource installations and allocate performance risk to commercial parties that are able to take mitigating actions.
- Lower overall transactional costs associated with customer outreach, site acquisition, and ongoing payments by using pre-existing customer data and billing systems.
- Allow for the integration of distributed energy resources directly into power planning and procurement operations to lower the overall cost of service by:
    - Monitoring the online date of each project, so power is not procured in excess of what is needed (defined as retail load minus onsite generation and efficiency savings);
    - Operationally dispatch distributed energy resources such as demand response, advanced energy storage, and combined heat and power 'peak boosting'.

Corollary impacts of this business model would include:

- Reduced capital flight from the region, as funds that previously paid for remote generation are used instead to deploy local assets that produce revenue streams;
- Increased local and regional clean energy jobs;
- Increased community and customer ownership of energy resources;
- Lower customer bills;
- Reduced cost of providing electricity balancing and back-up services, from deploying assets that can dynamically balance intermittent renewable sources of power.
- Reduce greenhouse gas emissions.

3.4 Implementation Pathway

When a local government decides it is interested in forming a community choice aggregation program, it should first consider how it would like to structure the enterprise. To do so, a third-party energy consultant is usually hired to help the government and citizenry understand how to best design the enterprise to fit their particular needs. A feasibility study is typically commissioned to address the technical, legal and financial issues regarding the establishment of the CCA, though this may become unnecessary as the market continues to succeed in multiple counties. In particular, given the success of the Sonoma Clean Power RFP to date, it is unlikely that a local government interested in initiating a CCA to achieve RESCO goals would require a feasibility study to be performed.

Feasibility studies regarding community choice aggregation for the following cities and counties should be available upon request to interested citizen groups and local governments:

- The County of Sonoma
- The City and County of San Francisco
- The County of Marin

- The East Bay Municipal Utility District (EBMUD)

In addition, the California Energy Commission Public Interest Research Program (PIER) commissioned a Community Choice Aggregation Pilot Project to develop a number of reports, tools and analytical models to assist local governments.[43] Over the course of the project, twelve local governments evaluated the feasibility of implementing CCA programs to procure a minimum of 40 percent renewable energy. Three cities and counties further developed business plans for CCAs to achieve a minimum of 50 percent renewable energy.

Provided that a feasibility study is deemed to be unnecessary, the local government should:

- If possible, form a JPA to oversee the CCA with other interested local governments and/or agencies to increase the scale and impact of the program;
- Assess which entity is best positioned to take the lead in managing the implementation and management of the CCA;
- Closely monitor the Sonoma Clean Power RFP process and have staff contact the Sonoma County Water Agency staff involved in the RFP process directly, in order to assess the ability of bidders active in the California CCA market to integrate the development of local renewables and distributed energy resources.
    - If bidders are not prepared to do so at this time, an RFI should be drafted and released to interested companies to assess their ability to achieve the goals of the program closer to the date of the implementation of the CCA.
    - If potential bidders are still not well positioned to achieve all program goals, the CCA should be prepared to
        - Unbundle the program into multiple RFPs and plan for the CCA to assume more management responsibility to coordinate the various implementing firms;
        - Develop certain programs and contracting structures in-house, as necessary.
- File a draft Implementation Plan and Statement of Intent with the CPUC that reflects the above considerations and includes specific targets for renewable content, local generation, and distributed energy resources based upon the experience or goals of other CCAs;
- Select an energy supplier (and additional service providers, if necessary) to initiate the program through a competitive RFP process;
- If deemed to be desirable or prudent, plan to provide some or all of the CCA's operational services in-house over the medium- to long-term. Doing so would allow the development of staff expertise, and would likely serve to minimize costs over the medium to long term.

[43] Stoner, G. Patrick, PIER Final Report CEC-500-2008-091, *Community Choice Aggregation Pilot Project Final Report* (2008)

3.4.1 Initial Steps Recommended

To initiate the RESCO commercialization strategy, interested local governments and agencies should form a JPA to manage the CCA. This may be accomplished relatively quickly, given political support at the board level. Each local government would adopt an ordinance to implement community choice aggregation, the Joint Powers Agreement would be drafted collaboratively, and then the board of each agency and local government would adopt the agreement by majority vote. The JPA would then file a Notice of a Joint Powers Agreement with the Secretary of State. Efforts should be undertaken to identify staff in agencies or local governments that could take the lead in the implementation and management of the program.

The local governments and agencies involved should adopt a goal and timeline for the deployment of local renewables and distributed energy resources. Policymakers should refrain from setting technology-specific targets, which could constrain the ability of staff and implementers to cost-effectively achieve the overall goal. Instead, a 'Localization Portfolio Standard' should be set, specifying annual percentages of energy and capacity needs to be met by local resources comprised of solar photovoltaic, solar thermal, combined heat and power, wind, advanced energy storage, energy efficiency, conservation, and demand response technologies. Broader California Renewable Portfolio Standard targets could also be adopted, specifying the percentage of power that meets the definition of renewable under the policy to be procured in excess of minimum RPS targets mandated by law – though this may pose financial trade-offs for accelerating the Localization Portfolio Standard, which should be fully considered. Finally, RESCO goals could also be adopted to provide clear policy direction to the CCA and the public.

Further outreach should be undertaken to other government agencies and interested organizations to identify sites with the potential to develop local renewable and distributed energy resources. For example, in preliminary discussions, staff at the San Luis Obispo County Integrated Waste Management Authority identified several opportunities for combined heat and power, anaerobic digesters, and landfill gas. Projects such as these may be able to be integrated into the CCA's initial program.

CHAPTER 4:
Energy Deployments in San Luis Obispo County

4.1 Distributed Generation and The Green Economy in San Luis Obispo County

San Luis Obispo County is host to approximately 1,795 distributed energy installations, comprising 23.9 MW of installed capacity.

Table 9: Count and Capacity of Distributed Generation in San Luis Obispo

Distributed Generation in SLO	Locations	Capacity (kW)
Photovoltaics		
Residential	1,678	7,361
Commercial	77	7,086
Government	16	5,942
Non-Profit	6	32
Unknown	4	269
Subtotal	1,781	20,690
Advanced Energy Storage		
Residential	2	10
Commercial	4	110
Subtotal	6	120
Combined Heat and Power		
Gas Turbine	1	1,383
Internal Combustion Engine	3	1,230
Microturbine	4	478
Subtotal	8	3,091
Total Distributed Generation	**1,795**	**23,901**

Source: California Energy Commission & California Public Utilities Commission, California Solar Initiative database, available from:[http://www.californiasolarstatistics.ca.gov/current_data_files/]; California Public Utilities Commission, Self-Generation Incentive Program database (projects that are reserved, advancing, or completed), available upon request.

In addition, there are 23 fuel stations that sell alternative fuels, including 16 that offer electric vehicle chargers. While it is unknown whether a portion of these are located at stations that also sell gasoline and diesel, approximately 17 percent-21 percent of the fuel stations in the county offer some type of alternative fuel:

Table 10: Count of Fuel Stations by Type in San Luis Obispo

Fuel Station Type	County Total
Electric Charging	16
Biodiesel	1

Fuel Station Type	County Total
Compressed Natural Gas	2
Liquefied Petroleum Gas	4
Gasoline and/or Diesel	109
Total	**132**

Source: United States Department of Energy, Alternative Fuels Data Center, available from: [http://www.afdc.energy.gov/data_download/]; California Energy Commission, Retail Fuel Stations - Survey Responses and Estimated Totals by County, available from: [http://www.energyalmanac.ca.gov/gasoline/retail_fuel_outlet_survey/reporting_stations.html].

4.1.1 Local Case Studies and Lessons Learned

The following case studies examine the current business-as-usual practices for producing energy and fostering the development of a green economy throughout County of San Luis Obispo. Lessons learned are detailed for each case study across five categories, which serve to inform the broader gap analysis that examines barriers to the near-term realization of RESCO solutions:

1. Policies, laws and governmental structures that have been enacted at the federal, state and local levels;
2. Technology applications and integration;
3. Financial tools and systems;
4. Commercial development and market readiness;
5. Environmental constraints on resources and needs.

The table below shows which case studies correspond to the above categories of barriers:

Table 11: SLO RESCO Case Studies: Barriers by Category

Case Study	Policy	Finance	Technology	Markets	Environment
Geothermal Heat Pump, City of SLO	x	x	x	x	
CHP Microturbines, City of SLO WWTP	x	x	x	x	
Solar PPAs, Cal Poly and Atascadero Unified School District	x	x		x	
Green Corridor, Arroyo Grande	x	x		x	
Clean Energy Workforce Training Program, Cuesta College	x			x	
Solar Parking Lot, San Luis Coastal Unified School District		x			x

Source: Local Power Inc.

4.1.1.1 919 Palm Street Office Complex, City of San Luis Obispo

In 2003, the City of San Luis Obispo acquired the 919 Palm Street lot to develop a parking garage and an office complex for city staff, and decided to install a ground-source heat pump (GSHP). The City hired an engineering firm to conduct a feasibility study comparing a GSHP system to a conventional closed-circuit evaporative cooler and boiler system.

The feasibility study showed that the 919 Palm Street location was ideal for a GSHP with re-circulating ground loops. While installing the GSHP system would require a larger initial investment, the study showed that it would be more cost-effective over the life of the system. The initial installed cost for the GSHP was $483,000, compared to $265,000 for the conventional system. The GSHP was calculated to have a lifecycle payback of 16 years, and would save $113,000 over a 20 year, due to the higher projected maintenance and utility costs for the conventional system. Annually, the GSHP system would save nearly 17,000 kWh of electricity, 300 therms of natural gas, and 10,000 gallons of water. The system would also reduce annual CO2 and SO2 emissions by approximately 20,000 and 18,500 pounds, respectively.

In January of 2004, construction began on the four-story office complex, parking garage and GSHP system. Five separate 300 foot deep ground loops and twenty-five sub loops were installed by a private contractor prior to being cemented over by the bottom floor of the parking garage. The main loops were plumbed to a utility room where two 5-horsepower pumps were installed to pump water through eighteen heat pumps located throughout the office building. Construction was completed in August of 2006.

The system currently circulates 130 gallons of water per minute through the ground loops, which yields a temperature of 68 degrees year-round. This constant temperature allows the office complex to meet all of its heating and cooling needs without a closed-circuit evaporative cooler or boiler. The development won an Energy Champion Award from the Southern California Gas Company in recognition of the system's innovative energy-efficiency technologies.

The GSHP system initially operated as designed. In 2008 however, maintenance workers noticed a significant water loss in the closed loop system, an inferred the existence of a leak in one of the loops. Because the geometry of the plumbing was both relatively complex and poorly-documented during construction, snaking tools or cameras through the loops to identify the location of the leaks was not feasible. Using trial and error, SLO City maintenance workers were able to determine which of the five loops were leaking and turn that loop off. Because the sub loops were inaccessible, a leak in one of them necessitated shutting down the main loop to which it was attached. Months later, a second loop began leaking and was turned off. As the loops had been cemented over during construction, there was no way to fix the leaks.

The leaks had occurred approximately two years after the system had been commissioned, but the installer was only responsible for guaranteeing their work for a single year. The designer and the installer of the system recommended adding a sealant to the loop to fix the leaks, but the City determined it was not worth the risk of the sealant settling at the bottom of the loops, which would block the flow for the whole system.

While the cause of the leaks will likely never be known, the maintenance manager of the complex speculated that the loops may have been compromised as the foundation settled. Since 2008, the three remaining ground loops have continued to operate without any leaks or maintenance issues, and have provided adequate capacity to meet all heating and cooling needs for the building. However, if more ground loops spring leaks in the future, the system may not be able to meet the building's heating and cooling demands.

Figure 15: Inside the GSHP Ground Loop Mechanical Room at 919 Palm Street

Image Credit: SLO RESCO

Lessons Learned:

'Turnkey' Performance Agreement Approach to Development. While the GSHP system remains sufficiently functional for the City to consider it a success, the technical failures of this project were avoidable. They did not result from the limitations of the technology, but from an improper allocation of risk between the City and the firms which constructed the building and GSHP system. The settling of the foundation should have been anticipated, the links between the control room valves and each of the loops should have been properly documented, and the loops should not have been sealed beneath the cement foundation. Regardless of which company was responsible for these errors, the City should have made either the developer or the GSHP installer contractually responsible for the performance of the system. This performance guarantee should have been over a period of time sufficient to encourage the maximum diligence in ensuring the project was built properly. Because the maintenance guarantee ended after only one year, at which point all liability was transferred to the City, too much risk was borne by the City and too little by the developer of the system. A 'turnkey' performance contracting approach would have both minimized risk to the City and likely resulted in a properly-designed and installed system. This might have raised the project cost as well, but would more accurately inform decision-makers on the objective commercial value of the project and choice of technology.

Maintenance Accessibility: While maintenance in theory should be very low for a GSHP system, as it is a relatively passive system, designing for maintenance, troubleshooting and repairs should have been included in the initial engineering of the system. The system at 919 Palm Street could have been designed to that the heads of the main loops and sub-loops were easily accessible, instead of under several feet of concrete.

Well Documented 'As-Builts': During the construction of the GSHP loop system, there was no documentation of which loops corresponded to the valves in the mechanical room. The leaking loops had to be inferred, and their precise location remains unknown. Proper labeling during construction, and especially for 'as-builts', is essential.

Over-Sizing a GSHP System: The installed system was significantly oversized for the anticipated heating and cooling load of the building. While this increased the installed cost of the system, it was a smart design consideration given the permanence of a GSHP system. Adding another loop after the system was plumbed would be cost-prohibitive. This design allows for additional heating and cooling growth in the future and adds a 'safety buffer' if leaks or other problems were to occur – as they did at 919 Palm Street.

GSHP are a Cost-Effective Heating and Cooling Solution: Conducting the life-cycle cost analysis of the GSHP system demonstrated that it was more cost-effective than a traditional heating and cooling system. With minimal maintenance requirements, little electricity and water consumption and no natural gas inputs, operational costs are predictable and low.

4.1.1.2 Combined Heat & Power Micro-turbines at the City of San Luis Obispo Waste Water Treatment Plant

In 2002, in an effort to save money and "green" its power supply, the San Luis Obispo City Council directed the city's Water Reclamation Facility (WaRF) to install energy generating micro-turbines from a developer called Kinetics. These micro-turbines would burn the waste methane gas from the digesting bio-solids at the WaRF to generate electricity and heat for the WaRF to use. Eight 30 kW micro-turbines were installed in July of 2005, totaling 240 kW worth of capacity. To help maintain the turbines, a three-year warranty and maintenance plan was purchased from a separate company for approximately $50,000.

The WaRF only generates enough waste methane to run four of the turbines, but the developer convinced the City to install an additional four turbines because natural gas was relatively inexpensive at the time. According to the developer, running a blend of natural gas and waste methane fuel would make the project more cost-effective. The City received a $312,000 rebate through the PG&E Self Generation Incentive Program (SGIP), reducing the project cost from roughly $1.5 million to $1.2 million dollars. The developer estimated the project would have a ten year payback period.

The turbines initially ran as expected until four months into operation, when one of the turbines broke down. With the parts under warranty, the turbine was replaced, though the WaRF had to pay for the cost of the labor. A few months later another turbine broke down, and two others malfunctioned shortly thereafter. The operators at the WaRF and the maintenance and warranty company began an investigation, and discovered significant levels of siloxanes in the methane gas being fed into the turbines. When combusted in the micro-turbines under high temperatures, siloxanes form small beads of glass on the turbine blades. This build-up leads to an imbalance in the rotating motion of the turbines, which eventually causes them to malfunction. Siloxanes are common in methane gas from waste water and result mainly from petrochemical products such as cosmetics. The filtration system was supposed to remove the compound; however, when the filter mediums become saturated, the ability to remove the siloxanes decreases and rapidly allows unacceptable levels of the compound to pass through. The proper rate of replacement was estimated to be every 15 to 30 days, but the maintenance company was under contract to replace the filters only every 360 days.

The cost of the filter replacements was not appropriately factored into the project financial analysis, and the WaRF was unable to satisfactorily renegotiate the maintenance contract to allow for the necessary replacements. Seven of the eight micro-turbines had been replaced once, and two micro-turbines had been replaced twice, at significant cost to the WaRF. The operation of the turbines was suspended and has not resumed.

Currently, the methane gas is being flared off. The WaRF is considering installing a reciprocating engine to harness the methane gas along with other energy saving projects throughout the plant.

Figure 16: Broken CHP Microturbines at the SLO Wastewater Treatment Plant

Image Credit: SLO RESCO

Lessons Learned

Competitive Bidding: The San Luis Obispo City Council directed the WaRF to install micro-turbines using a specific developer (Kinetics). This developer made several poor decisions which exposed the City to unacceptable financial risk and ultimately resulted in the suspension of the project after great public expense. This specific developer has subsequently gone out of business. Had the WaRF utilized a transparent competitive bidding process to develop the project, it would likely have resulted in more informed decision-making and ultimately a financially-viable project.

Risk Allocation - Performance Contracting: In this project the manufacturer, the developer and the maintenance companies were all separate entities. This led to unnecessary, inappropriate and significant risk being held by the City after the project was built, and also caused confusion among WaRF staff responsible for overseeing the project. The developer was separated from responsibility for the project's performance by the warranty and maintenance plan, and the firm awarded this contract did not have the experience or incentive necessary to provide appropriate project maintenance. The City's unbundling of its project into separately liable parties placed unnecessary performance risk on the city government of San Luis Obispo, resulting in several critical errors. The situation could have been avoided through a performance contracting structure such as a Power Purchase Agreement (PPA) or Design-Build-Operate-Maintain (DBOM) contract, or through a broader Community Choice Aggregation program. Alternatively the City could have had the maintenance entity assume the risk of nonperformance, and post a bond or demonstrate financial backing commensurate with that risk.

Hire Expert Consultants: The City invested in eight micro-turbines in spite of the fact that the WaRF produced only enough methane gas to power four of them. The developer made this recommendation to the City on the basis of then-current attractive natural gas prices. An independent expert would have flagged this as a high-risk assumption, given the historic volatility and upward trends in the price of natural gas, and would likely have further ensured that the issue of siloxanes in the methane gas was handled appropriately. Municipal staff often have inadequate experience in energy projects compared to the knowledge of a specialized company. To minimize implementation risk, it is important to draw upon independent expertise from a qualified consultant experienced in the transactions and technologies in question, and not have staff directly negotiate with suppliers or developers until and unless substantial staff experience has been funded and established.

Involve Local Staff: This project was essentially a directive of the City Council to work with a specific developer to install a specific technology. This decision was made with very little feedback from staff at the WaRF. Because of this, and the confusion caused by the City's unbundling of its project into three separately liable parties, staff had very little ownership or technical familiarity with the project. While leadership needs to be demonstrated at all levels, engaging staff in a public process while focusing consultants in the behind the scenes process from the beginning of future projects will allow for better design and increase the chances of a successful project.

Combined Heat and Power Micro-Turbines are Cost-Effective: The technical failures of this project were avoidable and resulted from an inappropriate approach to contracting; the project should have been a success. The siloxanes pose a common problem; thorough testing of the gas should have been performed before the system was designed. Throughout the life of the facility, regular filter maintenance and gas testing at the appropriate time intervals to ensure that the filtering system was removing contaminants prior to combustion should have been anticipated and conducted. Had basic due diligence been performed, the project's economic performance should have been excellent.

4.1.1.3 Solar Power Purchase Agreements (PPAs) at Cal Poly and Atascadero Unified School District

Background: Atascadero USD

In late 2009, the Atascadero Unified School District (AUSD) announced their intention to generate 70 percent of the school district's energy from alternative resources, primarily solar power. Budgetary constraints prompted the district to examine power purchase agreements as a financing tool. A PPA was attractive due to zero initial capital expenses and the convenience provided by the installers in maintaining the system. Additionally, these agreements are of special interest to public institutions which cannot take advantage of the 30 percent federal tax credit for renewable energy projects, as the third-party can. The district then issued a Request for Qualifications (RFQ), and after evaluating the potential bidders which responded, a local provider was selected to submit a proposal. The local provider's PPA proposal proposed the rates of electricity at $0.1690 per kWh with a 3.5 percent annual escalator. The proposal also predicted the extant utility rates from PG&E ($0.1580 per kWh in 2009) would escalate at 6.0 percent annually. Given these assumptions, AUSD would see an estimated savings of $1.1 million over the course of the 25 year contract.

The school's facilities manager hired an independent energy consulting company to examine the assumptions within the proposal. The consultant found that the school's utility bills over the past several decades had historically increased an average of 3 percent per year. Using this lower annual escalator in extant electric rates yielded a loss of $1.6 million over the course of the contract. There were additional concerns regarding various "hidden costs" within the PPA, such as the delegation for the responsibility of construction costs between the provider and the school district. These uncertainties led to the rejection of the proposed solar PPA.

In the November 2010 election, the residents of Atascadero approved a bond measure which granted AUSD a $117 million bond for capital improvements on its various campuses. With the ability to finance the solar facility at an estimated 4 percent municipal bond interest rate, AUSD plans to solicit proposals for buying the system outright as well as for a PPA. The facilities manager is planning on hiring a third party to assist in the creation of the RFP and to review the proposals to make the most informed and financially responsible decision.

Background: Cal Poly SLO

On 2 August 2006, California State University (CSU) Chancellor Charles Reed signed CSU Executive Order 987 establishing a variety of sustainability and renewable energy goals for the 23 CSU campuses, including a goal of 50 megawatts of on-site renewable generation. One strategy to facilitate this on-site renewable energy development was to leverage the CSU's buying power and negotiate prices with solar providers to put solar PV on a number of campuses. In the first round of solar PV development, the CSU Chancellor's Office, which oversees facilities on all 23 CSU campuses, solicited interest from the different CSUs and issued a Request for Proposals (RFP) to develop facilities on multiple campuses. They also hired expert consultants to evaluate the proposals and negotiate prices and terms with the selected provider on behalf of the participating campuses.

All of the campuses involved were then offered a rate of 14.5 cents per kWh, with a 1.85 percent annual escalader from the selected solar provider, Sun Edison. It was left to each campus to determine if the contract made financial sense given their electricity rate structure, site availability, solar resource, campus goals, and other variables.

Cal Poly evaluated a number of rooftop sites on its campus and eventually settled on Building 21, Engineering West. This site was selected because it had a new roof and very few obstructions which would cast shading on the solar array. Given the roof space, the size of the solar array was determined to be 135 kW with an installed cost of $1.1 million, the largest solar PV array in SLO County at the time.

At the time, Cal Poly did not have the metering technology to perform an hour-by-hour analysis of their electricity consumption, so they used a blended average cost per kWh for their financial analysis. As the solar array would be producing energy when electricity is more expensive, this method produced a conservative estimate of the financial benefits of the installation. The campus energy manager was able to demonstrate to the Cal Poly administration that, based on a historical escalator rate of 3.5 percent from PG&E, the solar array would have a 12-14 year payback period, and would save approximately $100,000 in energy costs over a 20 year period. Additionally, the solar array would help Cal Poly reduce their greenhouse gas emissions, and would be a positive public relations symbol for Cal Poly as a university which is environmentally conscious and forward-looking.

Figure 17: Cal Poly Energy Manager Dennis Elliot Giving a Tour of the Engineering West 135kW Solar PV Array

Image Credit: SLO RESCO

Lessons Learned

Consider Public Financing Options: Atascadero's authority to issue $117 million of revenue bonds for capital improvements, and its decision to use this authority to finance and lower the cost of capital for its photovoltaic development, were critical to make solar power sufficiently cost-effective to pursue under current market conditions. The ability to use public financing to capitalize photovoltaic arrays is a high-priority for local governments and districts. Prior to the credit crisis of 2007-8 or 'Great Recession', private financing was popular and convenient, and plentiful credit and investment capital filled the gap with debt-averse local governments. Since 2008 however, the availability of third-party capital to support developments has declined steadily, and the cost of private capital to support PPAs has increased, as was the case in Atascadero's RFP process.

Hire Expert Consultants: for a public institution to take on a large, multi-million dollar energy project with little to no experience in renewable energy development is a challenging and potentially risky task. Having the Chancellor's Office and expert consultants create the RFQ and thoroughly vet the proposals from various solar providers was a substantial benefit to Cal Poly. This process allowed for an informed selection of the solar provider and a financially attractive rate structure for Cal Poly.

AUSD had no independent expert review of their RFP or proposals, or assistance during the subsequent negotiations. This created a great deal of uncertainty which led to eventual inaction. Hiring an independent expert consultant who is experienced with the technology and related financing structures would allow informed decision-making through the entire PPA process.

Utility Rate Escalation Assumptions: Cal Poly was able to provide some insight into their expected rates by examining their historical energy data. However, forecasting utility rates is an inherently uncertain process. Rate forecasts may or may not be made available by the IOU, and may be difficult to locate. For example, PG&E has published a range of rate forecasts in the 2012 Long Term Procurement Proceeding at the CPUC, while SDG&E has not. Additionally, government agencies such as the California Energy Commission and the Division of Ratepayer Advocates could provide further assumptions regarding the most likely utility escalation rate, but may be even more uncertain than utility provided forecasts.

If the local government implements a CCA or municipal utility, it would have direct control over energy planning. Before implementing a CCA, end-use meter data and regional aggregate data may be collected using the CCA-Info tariff data request procedures. This would enable the local government to gain a comprehensive understanding of energy use within their jurisdictional boundaries to the individual meter level, as well as to analyze the cost basis for local service in specific resource and market scenarios. Once a CCA has commenced service, the local government may choose to publish rate forecasts in a transparent manner, and could also choose to offer its customers an optional guaranteed generation rate escalator over a multi-year period as a value-added service to its customers. A municipal utility would also be able to forecast rates in a more transparent manner, and to offer such a rate structure for the full retail rate.

Setting PPA Parameters in the RFP: Institutions should structure their RFPs to encourage competitive bidding. In Cal Poly's case, the RFP set a maximum escalator rate of 2.0 percent; the final bid came in at 1.85 percent. By comparison, AUSD did not set an escalator in their RFP and was offered a 3.0 percent escalator.

Group Purchasing: The CSU Chancellor's Office solicited an RFP on behalf of many campuses in the CSU system, giving them the power to negotiate lower prices than would otherwise be possible had each campus solicited solar PPA bids on their own. Opportunities for greater aggregations of electricity end-users for both the public and private sectors, such as through Community Choice Aggregation (CCA), exist to achieve economies of scale for both government and private sector customers.

4.1.1.4 Arroyo Grande Green Corridor: New Business Incentive Program

In August of 2009, the Arroyo Grande City Council approved an innovative program to provide economic incentives to attract new "green" businesses and create a "green corridor" in the city, qualifying green businesses with products and/or services in air quality, energy conservation, alternative fuels, and non-fossil transportation technologies. Developed by Arroyo Grande's city staff from redevelopment funds, the Green Corridor and New Business Incentive Program (NBIP) was created to promote local economic development and make Arroyo Grande a leader in the green economy.

As part of the green corridor, City staff worked with various owners of four specific property areas which were identified along the El Camino Real from East Grande Avenue to Oak Park Boulevard. This concentrated area is meant to attract businesses that will support each other and attract similar customers to a one-stop area for green products and services.

Under the program, qualifying businesses are eligible during their first year of operation to receive a 90 percent rebate of their business license fee, sales tax generated by their business and tax increment generated by their property. This incentive is then reduced to 60 percent during the second and third year of business and 30 percent during the fourth and fifth year of business. As the intent of the program is to assist start-up businesses, the incentives would be eliminated after five years.

In order to qualify, green businesses must devote a minimum of 65 percent of their operation and sales to products and/or services specializing in:

- Alternative fuels and alternative fuel vehicles or other non-fossil fuel powered modes of transportation.
- Equipment, supplies, or services related to the production of renewable energy sources including, but not limited to, solar, wind, compressed natural gas, battery electric, tidal and biofuels.
- Recycling or recycled products.
- Energy and/or water conservation.
- Water and/ or air quality.
- Organic, pesticide-free, or bio-dynamic farming.
- Green building equipment, supplies, materials or services.

City staff estimates that the financial incentive for a typical business during their first year of operation would be approximately $10,000. City staff also set an established target for the program to bring in $100,000 in annual revenue to the city at the end of the five-year period due to overall net increase in tax revenues from the new green businesses.

After the program was approved by the Arroyo Grande City Council in August of 2009, marketing materials were designed for outreach to new green businesses, chambers of commerce, and similar entities. A colorful two-page brochure was created and strategically mailed to certain businesses. Initial seed funding to develop the program was provided by state redevelopment funds, but when it came time to actually to implement and market the program, the redevelopment funding was no longer available. This has caused the program to have a slower start than anticipated, as advertising is limited to the city website and 'word-of-mouth'. City staff estimates that $15,000 to $20,000 is needed to conduct sufficient outreach for the program to be a success. The program awaits some new source of funding or revenue to be fully implemented.

As of May 2011, the City is in discussions with a green business which would be the first to take advantage of the NBIP. Additionally, the city is working with a new green building-oriented hotel development which is looking to locate in the green corridor. While the hotel would not qualify for the NBIP, they are planning to incorporate green building standards into the design and construction of the new hotel to contribute to Arroyo Grande green corridor.

The City had also planned to build an alternative fueling station along the Green Corridor, but was unable to do so because of budget cuts. The City initially had hoped to budget $100,000 to create a public/private partnership to build the fueling station which was to include biodiesel and ethanol.

Figure 18: Map of the Green Corridor in Arroyo Grande, CA

Image Credit: Arroyo Grande Green Corridor

Lessons Learned

Pursue Non-Tax Sources of Revenue: Given the economic recession and decrease in local government revenues, funding projects such as the Green Corridor have not been a top priority. Arroyo Grande, and other cities which have struggled to finance green energy projects, should explore options to bring in non-tax revenue to fund their programs.

Apart from establishing municipal bond authorities for financing green investments, revenues are needed outside of tax increases in order to both finance and securely repay resulting investments. Absent unanticipated revenue increases or state and federal aid, Community Choice Aggregation is a tool presently available to local governments. It allows for innovative, locally-designed energy programs to be capitalized by revenue from participating customers rather than by state funding. As California's local governments continue to face increasing uncertainty regarding federal and state funding and local tax revenues, many are starting to look at new ways to meet their green goals while spurring local economic development using Community Choice Aggregation.

4.1.1.5 Clean Energy Workforce Training Program, Cuesta College

In the summer of 2009, a community group called the San Luis Obispo Green Job Corps was awarded a $610,055 Clean Energy Workforce Training Program (CEWTP) grant, made possible from the American Recovery and Re-Investment Act and the State of California. Partners in the grant included Cuesta College, Shoreline Workforce Development, the San Luis Obispo One Stop Center, the Workforce Investment Board, the County of San Luis Obispo, the International Brotherhood of Electrical Workers #639, the California Conservation Corps and the Community Action Partnership of San Luis Obispo County.

The Workforce Investment Board of San Luis Obispo County is one of forty-nine local boards in California that together comprise the statewide workforce investment system. Each is responsible for a 'One Stop Career Center' and may partner with a variety of local, state, and federal agencies and nongovernmental development and education organizations to deliver job training and business services. This system was devised in response to the federal Workforce Investment Act of 1998 (Public Law 105-220), which required the consolidation of approximately sixty state and federal employment and job training programs under the supervision of the local Workforce Investment Boards. The state also established the California Workforce Investment Board, which advises the governor on compliance with the federal law and publishes annual strategic plans to guide the statewide system.

The San Luis Obispo Clean Energy Workforce Training Program officially launched in January of 2010, offering an 18-week training program at Cuesta College. Students applied, interviewed and were enrolled in the program with the help of Goodwill Industries and Shoreline Workforce Development Services, the operator of the San Luis Obispo One Stop Center.

The program was structured to give students from a variety of different backgrounds the opportunity to look through a new "green lens" and build upon their existing skill sets. Course topics were diverse, as indicated by the CEWTP grant. During the environmental literacy portion of the course, students learned about large environmental issues such as climate change and indoor air quality. Next, students learned about units of energy, how to read utility bills and how to do energy calculations. This prepared them for three weeks of training in home energy auditing where students learned to use tools such as blower doors, duct blasters and infrared cameras. With the help of the local IBEW training center, students had four weeks of solar PV and hot water installation training which included building a 3.2kW solar array and a solar hot water system on campus. Lastly, students learned the basics of water efficiency and sustainable landscaping while retrofitting an existing campus structure to include a green roof.

While Cuesta College took the lead with instruction, the program would not have been a success without the support of over 25 local businesses and organizations who donated time, materials and expertise to the program through guest lectures, tours and labs.

Throughout the program students had the opportunity to earn a number of certifications including Green Advantage, OSHA 10, First Aid and CPR. At the end of the semester students had the opportunity to choose specialized training and certification to become either a photovoltaics installer, irrigation auditor, wind turbine technician, or building analyst (as certified by the Building Performance Institute). With the help of their case manager and instructors, students chose a specialized training which built upon their existing skills to make them the most competitive for employment.

As of May 2011, dozens of student had found gainful employment, many of them in 'green' fields. Graduates from the program are now working as solar salespersons, solar PV installers, solar hot water installers, home energy retrofitters, sustainable landscapers, wind turbine technicians and more.

Figure 19: Funded by the State of California and the American Recovery and Reinvestment Act

Image Credit: Cuesta College and the Federal Government

Lessons Learned:

Green Jobs Programs: one general limiting factor for communities and businesses interested in deploying new renewable energy and demand-side resources may be the availability of trained laborers for the evaluation, installation, rehabilitation, and maintenance of renewable facilities and efficiency retrofits. The statewide Workforce Investment Board system provides local communities and businesses with a 'One Stop Career Center' for their region, and a focal point to engage further agencies and local organizations in green job training program planning and deployment.

4.1.1.6 Instructional Program Design

- Performing local labor market research early on will help design appropriate course content and business partners.
- A semester-long course is beneficial, but can be very challenging for students who are unemployed. Concentrated programs can allow for better student focus and will be accessible to a greater population.

- Hands-on training with local businesses is important, as it allows for real-world experiences and introduces students directly to potential employers.
- Giving students the opportunity to choose more specialized training at the end of the program gives students focus and direction regarding their career path throughout the course.
- Integrating soft skills (communication, resume development, interviewing, etc.) is critical for preparing students for assuming the responsibility of a job.

Case Management and Student Support

- Strong collaboration between instructors and case managers allows for effective communication and increases student accountability.
- Supportive service funds for students - such as providing gas reimbursement, new work clothes and basic tools - removes barriers and increases their chances of completing the program.
- 'On the Job Training' funds, which pay up to half of a new employee's wages for up to six months while they train, give graduates a powerful advantage in a competitive and emerging job market.
- Students with criminal backgrounds face barriers with many companies as employers seek to minimize risk, particularly with high-value products such as photovoltaic panels.

4.1.1.7 Solar Parking Lots, San Luis Coastal Unified School District

In 2007, in an effort to make their school district a leader in green energy, the San Luis Coastal Unified School District (the District) began exploring options to harness solar power on many of their campuses from San Luis Obispo to Los Osos to Morro Bay. Not wanting to divert funding from educational activities, it was imperative that the solar energy systems be at least cost-neutral to the school district from year one, with a high probability of increased savings year over year. This led the school district to explore financing the projects using power purchase agreements (PPAs). A power purchase agreement would allow the District to lease their land or rooftops to a third party that installs and maintains the renewable energy system and sells the power back to the District at a contracted rate.

During the process, the District also explored using Recovery Zone Bonds (provided by the American Recovery and Re-Investment Act) in conjunction with a power purchase agreement. These are taxable bonds available to local governments, in which the federal government provides a direct payment equal to 45 percent of the interest payable on the bonds - thus providing a significant subsidy to the power purchase agreement partner. However, due to the short-term nature of the ARRA funding, these bonds required the projects to move expediently in order to take advantage of them.

In 2008, the District solicited and accepted requests for proposals (RFPs) for solar photovoltaics (PV) on a number of campuses throughout the school district. SunEdison, a large solar energy services company, was selected by the District and began working with them to design a solar energy solution on a number of their campuses. After examining the proposed sites, it was determined that parking lot solar structures would be the most expedient and economical option for solar energy at nine of the campuses. Rooftop solar was determined not to be expedient or economical because of the potential for roof leaks, the long-term liability for increased re-roofing costs and the potential that many of the projects would require buildings to undergo a detailed Division of the State Architect structural review. With major structural retrofits likely to ensure the buildings would comply with current code, it was determined that rooftops solar systems were too expensive.

As the plans were finalized, the bundled 3 MW project encountered several hurdles as it went through the permitting process, and four of the projects were appealed for various reasons. These included planned tree removal, concerns regarding the impact on endangered snail and butterfly populations, potential Indian burial ground disruption, and interruptions of scenic view sheds.

While the appeals were eventually resolved at the local level (SLO County and the City of Morro Bay), local opponents were able to file appeals to the California Coastal Commission based on a rarely used regulation relating to energy generation facilities due to the fact that these schools were in the "Coastal Zone". According to the Coastal Act Section 30603 and Local Coastal Program (LCP) Section 23.01.043(c)(5), "any development that constitutes a Major Public Works Project or Major Energy Facility… exceeding $100,000 in estimated construction cost" is appealable.

The four project appeals were eventually all denied by the Coastal Commission in the spring of 2011. The lengthy permitting process came at a cost to the District, the developer and ultimately to the project itself.

Not only did the District incur many costs in retaining specialized biologists and consultants, but the prolonged timeline caused by the appeals resulted in the District missing the opportunity to take advantage of the attractive Recovery Zone Bond financing and contributed to reduced project rebates from the California Solar Initiative. Due to these reasons and other changes in the project economics, SunEdison ended up withdrawing the five smallest project sites; Monarch Grove Elementary, Baywood Elementary, Bishop Peak/Teach Elementary, Pacheco Elementary and the San Luis Coastal Corporation Yard.

The District moved forward with installations on four campuses: San Luis High, Morro Bay High, Los Osos Middle School and Laguna Middle School. The projects came online in the spring of 2012 and totaled 1.6 MW (approximately half the original size proposed). The first year savings for the District is estimated at $40,000 to $60,000.

Lessons Learned:

Throughout the development of this project the San Luis Coastal School District learned many lessons which should be of use to other school districts and organizations looking into solar energy. Below some of the key lessons learned are discussed.

Perform a Cost/Benefit Analysis of Tree Removal: the Morro Bay High School parking lot solar project was significantly delayed due to tree removal issues along the scenic corridor of Highway 1, because the trees at certain times of the day would shade the solar array, decreasing production. While the trees would certainly decrease production, it was not until late into the project that the District's consultant requested a detailed shading analysis from the developer to quantify the actual production loss. According to the consultant, this analysis revealed an "insignificant production loss due to early morning shading" and it was then determined that the trees could stay and the project could move forward without disrupting the scenic corridor. Future projects in which trees are barriers in a projects permit or design should undergo detailed shading analysis to compare cost/benefit of energy production losses with potential extended permitting timelines. 11 trees were ultimately removed, with 22 planted as mitigation on the site of Los Osos Middle School.

Modify Coastal Zone Regulations to Support Distributed Generation: the Coastal Act regulation (Coastal Act Section 30603 and Local Coastal Program Section 23.01.043(c)(5)) which allows for appeals for "Major Energy Facilities" over $100,000 was likely designed with good intent to allow for critical review of large fossil fuel power plants in coastal areas. However, with the emergence of distributed renewable energy systems, this dated regulation creates an unnecessary barrier. As the regulations are currently written, a 15 kW solar array (a small commercial or large residential system) in the Coastal Zone (assuming ~ $7/ watt) could be appealed to the Coastal Commission adding significant costs to small energy systems with tight economics. This regulation should be reviewed and revised to encourage responsible development of solar and other renewable energy resources in coastal areas.

4.2 Large Scale Power Plants and Formative Events in San Luis Obispo's Energy History

San Luis Obispo County has long been host to several large scale power plants, to the extent that the county exports more power than it consumes. Power plants built or under construction in the county are listed in the table below:

Table 12: Large Scale Generation Plants Active or Under Construction in San Luis Obispo

PLANT NAME	MW	FACILITY	ONLINE	OWNER
Stunner Canyon	0.8	Hydroelectric	1985	City Of San Luis Obispo
San Luis Obispo	0.7	Hydroelectric	1985	City Of San Luis Obispo
Lopez WWTP	0.1	Hydroelectric	1984	San Luis Obispo County And Water Control District
Diablo Canyon	2,202	Nuclear	1985	Pacific Gas And Electric Company
Morro Bay	912	Natural Gas	1955	Dynergy Power And NRG Energy, Inc.

PLANT NAME	MW	FACILITY	ONLINE	OWNER
Koch California Ltd.	0.3	Natural Gas (CHP)	1985	[Blank]
Meridian	1.1	Solar	2010	Paso Robles Solar, LLC
Topaz Solar Farm	550	Solar	2015	MidAmerican Energy Holdings
California Valley Solar Ranch	250	Solar	2012	NRG Energy
TOTAL	**3,917**			

Source: California Energy Commission - California Operational Power Plants, .1MW and above - November 6, 2012 and Local Power Inc.

While impressive in scale, these plants do not make San Luis Obispo more secure. Environmental degradation, both realized from land use and environmental contamination, and the threat of nuclear contamination in the event of a natural or man-made disaster, are examples of the health and quality of life impacts of large scale generation. To provide more context to the history of energy in San Luis Obispo, the stories behind two power plants and several notable events have been detailed in depth below.

4.2.1 Pacific Gas and Electric Company Forms

At the turn of the 20th century, Midlands Counties Gas and Electric Company was the foremost energy supplier in the county. However, in 1912, this business was absorbed, along with Paso Robles Light and Water Company as well as the Russell Robison Water and Electric Company. The consolidating company was Coalinga, an enterprise that supplied electric motors to cut back on manual labor and increase oil production in the fields. The following year, Coalinga Water and Electric Company changed its name to Midland Counties Public Service Cooperation and continued to exercise great influence all along the coast. The Cooperation was led by its major shareholders, The North American Co. in 1925, before it was consolidated into Pacific Gas and Electric holdings in 1930. Although a part of PG&E, Midlands was not completely liquidated until 1936, at which point the Cooperation had officially merged.

4.2.2 The Morro Bay Power Plant

During the 1950's in California, a growing population and economy was driving the need for more energy. In Morro Bay, the site of an old World War II Navy base was selected by Pacific Gas and Electric Company as an ideal location to build a new power plant. Bechtel Corporation of San Francisco was chosen to build the power plant and in 1953 began construction on the $44.3 million, 300 megawatt project. In 1955, the power plant was complete and was operating delivering energy via a transmission line to the San Joaquin Valley. Ten years later the plant was expanded to 1,003 Megawatts.

The power plant operates using a simple cycle steam generator system. Fuel is burned in the boiler, which creates steam. This high-energy steam turns a turbine that in turn drives a generator making electricity. This process operates at about 30 percent efficiency; meaning 70 percent of the energy from the fuel is lost to mostly heat. The Morro Bay power plant cools its components by drawing in ocean water from an intake structure in Morro Bay and discharging water by the north end of Morro rock. The power plant also employed the first evaporator to desalinate sea water and create fresh water for the cooling system.

Originally designed to run on fuel oil, the power plant at full capacity would consumed 500,000 gallons a day from four seven million gallon storage tanks adjacent to the plant. This fuel oil was brought in by tankers and transported to the plant by an underwater pipeline, which has a port located a short distance offshore from the plant. In the 1970s, PG&E built a natural gas pipeline to the power plant giving it another fuel source. For a number of years, the plant could run on either fuel oil or natural. Eventually, due to stringent air quality standards, fuel oil was phased out and natural gas became the sole fuel for the Morro Bay power plant in 1995. In 2003, piping to the tanks was removed, and they were industrially cleaned to remove residual oil.

Morro Bay was initially used as a base load power plant for the PG&E service territory. Over the years, as new, more efficient combined cycle power plants came online, operating Morro Bay's simple cycle generators became less cost-effective to run. Eventually, Morro Bay Power Plant was reduced to being used only in times of peak power demand.

In 2006, Units 1 and 2 shut down due to air pollution regulations. Later that year, the power plant applied for a relicensing to build a high-efficiency combined cycle natural gas power plant. Due to push back from the local community and environmental groups, it seemed that relicensing would be a struggle. In 2010, the California State Water Resources Control Board adopted a policy to phase out or retrofit power plants such as the one at Morro Bay that depended on 'once through cooling' systems, because of the environmental impact on coastal marine life of the increased temperature of the discharged water. In an effort to meet this requirement, new proposals were put forward to retrofit the power plant to a high-efficiency combined cycle power plant, which would use cooling towers to reject waste heat from the power plant rather than ocean water, but these plans were rejected by the California Energy Commission.

Over the years, the Morro Bay Power Plant has had many owners. During the deregulation of the energy markets in California, PG&E sold off many of their power plants, including the Morro Bay power plant. The plant was first sold to Duke Energy, then to LS Power, which then transferred the plant to Dynegy as part of a joint venture.

Morro Bay Power Plant now operates with a contract with Southern California Edison for standby power powering on only a few times typically during the summer months. As of 2011, it appears the plant is due to close in five years in 2016 ending a nearly 60-year life in Morro Bay. Proposals for how the coastal land will be used are being discussed between various local groups. Community organizations and student design teams propose a variety of uses, which range from high-end condominiums to a green technology research institute.

4.2.3 The World's Largest Solar Power Plant Comes to San Luis Obispo

On August 8, 1977, in response to the 1973 oil crisis, the Carter Administration created the Department of Energy with a large focus on energy independence for America. In 1978 the U.S. Congress passed the Public Utility Regulatory Policy Act (PURPA), which essentially required monopoly utilities to purchase renewable energy from non-utility generators at the "avoided cost" of building new fossil fuel generation. This created the beginning of a renewable energy boom in the United States.

In 1979, the Atlantic Richfield Company (ARCO), an oil company, entered the solar energy business by building the world's largest photovoltaic manufacturing facility in Camarillo, California and establishing the company a forerunner of solar technology. In this leadership position, ARCO became the first solar company to exceed an annual photovoltaic manufacturing capacity greater than 1 megawatt.

In San Luis Obispo County, the Carrizo Plains' was quickly identified for its vast solar resource and in near proximity to transmission lines. In 1983, ARCO Solar built a 6-megawatt solar facility in the Carrizo Plains just north of highway 58 and the California Valley community. The power was sold to PG&E. This gained national attention, making headlines in the business section of the New York Times. The ARCO solar power plant was constructed with nearly 800 concentrating photovoltaic tracking towers and covered more than 177 acres, making the Carrizo Plains ARCO solar plant the largest solar power plant in the world.

In 1990, the Carrizo Solar Corporation, based in Albuquerque, New Mexico, bought the Carrizo Plains solar power plant and a similar 1 Megawatt facility from ARCO Solar. However, the cost of operating the ARCO solar power plant was too high to operate profitably, leading to the plant to suspend operation in 1994. By April of 1995, the last of the 6 MW power plants was being dismantled. The PV panels were then sold and distributed all over the world, with many still reportedly in operation today.

4.2.4 The Diablo Canyon Nuclear Power Plant

In the wake of Cold War, Americans both favored and feared nuclear energy. In 1953, President Eisenhower ushered in the U.S. Atomic Energy Act, allowing private utilities to develop "peaceful atoms." Ten years later, PG&E joined the "Atom Rush" and strategically bought 1,100 acres Nipomo Dunes from Union Oil. Despite optimism, the endeavor to build a plant in the area was met with open opposition from local conservation groups, most notably the Sierra Club. Working to mitigate public concern, PG&E opened discussions with the Sierra Club Board of Directors, which eventually led to an alternative project site: Diablo Canyon.

In 1966, PG&E leased approximately 600 acres of land in Diablo Canyon from the Marre family. By June of 1967, *PG&E Life*, the company's promotional magazine, began to advertise the stretch of coastline as the secured area for a new power plant. The energy company attached promises of tax revenues, job opportunities, and new schools to its imminent plan to build.

Yet, the Sierra Club was still not satisfied; they had averted environmental destruction in one site in an exchange for another. Different sides emerged within the Club itself, with those who favored compromise and those who favored conservation against each other. By 1967, Diablo Canyon began to attract a great deal of controversy as well as media attention. The "save-Diablo" coalition was constructed. This campaign centered on capturing the unique environmental intricacies only found in Diablo Canyon. The Sierra Club commissioned a committee of ecologists to investigate the ecology of Diablo Canyon. The committee decided that the land was ecologically important and diverse, but it was not enough to sway the majority in the Sierra Club against the plant's establishment. After bulletins and campaigns, the decision was put to a referendum within the Sierra Club. The results yielded about 11,000 in favor of the construction of the power plant at Diablo Canyon in order to protect the Nipomo Dunes, and approximately 5,000 opposed. Though the controversy was still afoot when new board directors entered the Club, the battle was lost due to organizational disputes.

Despite its shift from strictly conservationist to environmentalist, the Sierra Club remained heavily entangled with Diablo Canyon. Rather than fighting nuclear energy itself, as many of the alternate energy's faults were unknown, the Club fought the environmental degradation that the power plant would bring. As far as many saw it, nuclear energy was a welcome substitute to unsightly environmentally harmful dams. By the 1969 Sierra Club Board elections, two opposing platforms had emerged surrounding Diablo: an Active Bold Constructive (ABC Coalition) that promoted an internationalist and confrontational style and the Concerned Members for Conservation (CMC coalition) that upheld a traditional and organized regime. Along with the board elections, the save-Diablo petition was put to a vote. Both the ABC Coalition and the petition were defeated, which demarcated the goals of the Sierra Club and the future of Diablo Canyon.

The first few years of the 1970s boded well for Pacific Gas and Electric as it seemed that the controversy had subsided, and the power plant was welcomed into the county. 1973 proved to be a milestone for PG&E when, in March, Unit I of the reactor had been installed and began to physically redefine Diablo Canyon. PG&E marketed nuclear energy as a part of the environmental movement, and a move towards U.S. energy independence. San Luis Obispo County was receptive to this image, as it was even commonly referred to in the *Telegram Tribune* as "our nuclear neighbor." Yet, the tension once more began to bubble up within the community. In a 1966 legal agreement with the California Resource Agency, PG&E vowed that the plant would aesthetically meld with the landscape. Despite the implosion of the opposition of the Sierra Club, smaller yet equally passionate groups rose up to argue that PG&E's actions were not in line with its legal agreements. One such group came from Cal Poly: Ecology Action. Ecology Action intervened in nuclear licensing hearings and picketed the California Public Utilities Commission on power line issues. Likewise, The Mothers for Peace, an anti-war group, petitioned to gain access to nuclear licensing hearings and raised skepticism about the corporation within the County. This skepticism was only encouraged when it was publicized that a major fault, the Hosgri Fault, was located only three miles away from the plant's location. Although the fault was discovered in 1969, it took four years for this information to become widespread. After this, the *Telegram Tribune* withdrew its unconditional support for the plant, and public opposition for the Diablo Canyon nuclear plant began to increase.

However fervent, anti-nuclear sentiments were directly countered by the oil price shocks of the 1970s. In a 1975 poll, about 75 percent of the 1,046 asked strongly or somewhat favored nuclear energy. The Mothers for Peace organized a forum of professionals to describe the advantages and disadvantages of building the plant. However, this further dichotomized the groups as many only took from its support for their respective sides. The Mothers for Peace were not ultimately successful in halting the construction.

During the controversy, PG&E was suffering internal problems. During 1974 alone, an estimated one million man-hours of labor were lost due to labor disputes. In 1976, the Hosgri Fault forced the Company to acquire another licensing agreement, and even became entwined in a legal battle over a property dispute with the family from which the corporation had leased the land. PG&E was also challenged by the passage of the National Environmental Policy Act (NEPA) in 1970. Providing an Environmental Impact Statement on a half-finished nuclear power plant proved to be difficult for the utility, which fought to delay the report and continue construction.

Other concerns surrounding marine life, notably abalone, emerged. This spurred the creation of the aptly named Abalone Alliance in opposition to PG&E's plans. However, the Alliance was not only a defender of marine life, but also a collection of anti-nuclear groups. The Alliance gained momentum in 1976 during a Continental Walk for Disarmament and Social Justice. A year later in June of 1977, the group had established a headquarters where it gained much of its opposing power. On August 6, 1977, the Abalone Alliance held its first civil disobedience action against Diablo Canyon. A rally was also held at Avila Beach.

Following the crisis at Three Mile Island in 1979, in which Metropolitan Edison's plant accidentally released a large amount of radioactive nuclear reactor coolant, national support for nuclear technology continued to plummet. Paired with angst from the popular film, *The China Syndrome*, a fictional film publicizing dangers of nuclear power, many locals took to increased activism.

The Abalone Alliance formed at blockade at the worksite in order to block workers form hulling in construction materials. By 1981, this blockade was able to end on a high note for the activists as news had been released that there was an error in the blueprints, which caused Unit I reactor to be installed backwards, but construction proceeded at significant costs to PG&E ratepayers. Despite various protests and pleas, in 1984, the NRC granted PG&E licensing for their Unit I reactor. By May of 1985, full capacity was achieved, and the Alliance was over.

4.2.5 Creation of The San Luis Obispo County Energy Division

With energy becoming a mainstay of the San Luis Obispo economy and in response to a proposed offshore oil project, the SLO Energy Division was created as part of the County's General Plan in an effort to gain more control over local energy development. Though typically the federal Mineral Management Service superseded local jurisdictions pertaining to off-shore development, the County of San Luis Obispo challenged the federal services with legal precedent, establishing SLO County's jurisdiction over coastal planning. Against the efforts of major oil companies such as Unocal and Shell, SLO County officials began to exert a significant role in offshore oil development, oil spills and remediation of existing oil sites such as Avila, Guadalupe and Cayucos.

Throughout the 20th century, the County developed many ties to the oil industry. In SLO County alone, there were three different points of offshore oil loading. One was located in Morro bay, primarily for jet fuel loading, another for the use of PG&E and Chevron, as well as a pipeline supplied by Mobil Oil. During the mid to late 1990s, the creation of a new pipeline was afoot: the Pacific Pipeline. This pipeline was originally planned to go down the coast, but the direction changed. The pipeline actually went through Midway Sunset oilfield, located near Bakersfield, which was at one time the biggest oil field in the world.

Chevron had a heated pipeline in the area that was frequently pumping oil out of the region. Due to the viscous nature of the oil taken out of the County, the heated pipe increased productivity. However, aside from the pipeline, Chevron began to run into problems during the 1990s. In order to use what is regarded as communal pieces of land such as ocean floor, a lease renewal and a permit was required from the County, as Chevron's existing lease was coming an end. The intended project was an expansive oil project in Cayucos, which would utilize ocean bottom lying pipeline in San Luis Obispo County. The County was involved in the process through the new founded power of the SLO Energy Division.

Before Chevron could attempt to renew their lease, the County mandated that the State Lands Commission form a Joint Task Group. This group brought together California Fish and Game, US Fish and Wildlife, SLO County organizations and a consultant from the State Lands Commission. Pouring over the Environmental Impact Report, this group monitored every proposed action that Chevron would make and the project was eventually suspended. Additionally, with the installment of the Pacific Pipeline which ran inland through the valley, there was no longer a necessity for the Cayucos Project. Cleanup of the site was begun, and is still in progress today. Because of these efforts, there are no longer any marine oil terminals on the San Luis Obispo County coastline.

4.2.6 Oil in Avila Beach

In 1995 a man digging a footing in downtown Avila Beach struck oil. News of the oil seepage beneath the quite coastal town quickly spread. Though Unocal, the oil company that had been working in Avila for decades and operated an oil tank farm in the community, did a large part in keeping the travesty well-hidden, those who either visited the site or researched the damage knew the truth. According to Thomas D. Beamish, a researcher on the subject used his work and first-hand accounts to broadcast what had really happened: "The estimates quoted most often by government personnel put the spill at 20 million gallons or more, which would make it the largest petroleum spill ever recorded in the United States." Beamish also describes how Unocal took measures to clean up the spill. Although it aided their public image, Beamish questions why the spill ever happened at all, and why measures were not taken sooner to prevent it. During mean-high tide, the top layer of sand would rinse off of the beach, exposing the mass amounts of spilled oil lying beneath. This oil would be carried into the ocean. The Coast Guard informed Unocal that this had to be stopped. Rather than attempting to extract it, Unocal pounded 40-foot sheets of steal into the ground, making a barricade of sorts. However, the oil was extremely thick. Using Kerosene diluid, Unocal attempted to dilute the crude oil in the wells, yet this is what caused the great oil spill. The half-hearted attempts at preventing the spills and clumsy efforts to clean it up nearly destroyed Avila. Although the cleanup has officially ended, oil still remains in the ground today.

CHAPTER 5:
Survey and Technical Resource Potential of Renewable and Distributed Energy in San Luis Obispo County

5.1 Summary

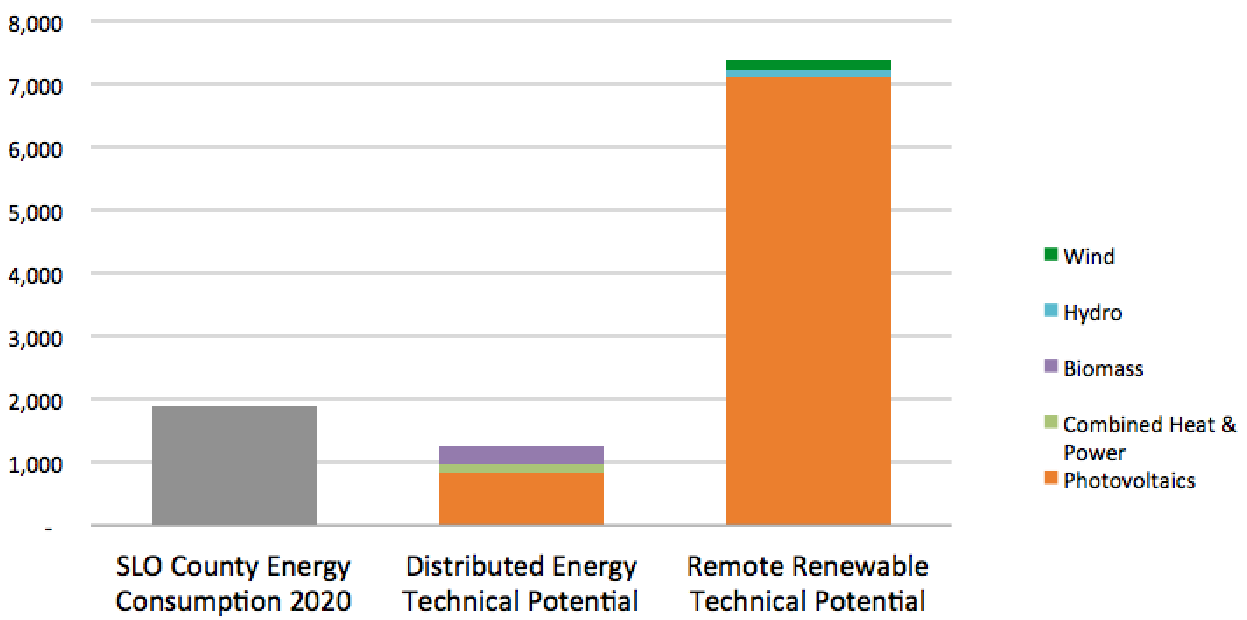
As part of the broader effort to start discussions within the local communities in San Luis Obispo County regarding the use and supply of energy, the local SLO RESCO team members identified and characterized potential local and distributed energy resources and conducted a high-level survey of select resources to inform an estimate of the gross resource and technical generation potential available in the county. In addition, more detailed studies of select end-uses of solar and biomass generation potential were also undertaken by the local team members (which are detailed in the preceding three "Site Specific Resources" chapters of this report), and this data was used to refine the technical potential estimate. Data was gathered through a variety of methods, including literature surveys, the use of geographic information system (GIS) analytics, expert interviews, and further local research.

The results of this effort comprise the remainder of this report and informed the previous report chapter 'Energy Deployments in San Luis Obispo,' as well as two outreach tools intended for the general public: the Resource Inventory Tool (the spreadsheet tool used to estimate resource potential) and the Energy Atlas (a summary publication); refer to 'SLO RESCO Outreach and Education Activities' on page 297 for more information.

The gross resource potential is the theoretical physical potential of the resource, while the technical potential lowers the gross estimate by taking into account system and land use constraints. Technical availability conversion factors are assigned in the Resource Inventory Tool. The economic and market potential of deploying the resources were beyond the scope of the analysis. It should be noted that this report in general and the Energy Atlas focuses more on the technical potential availability of resources, as gross resource potential can be easily misconstrued by the general public.

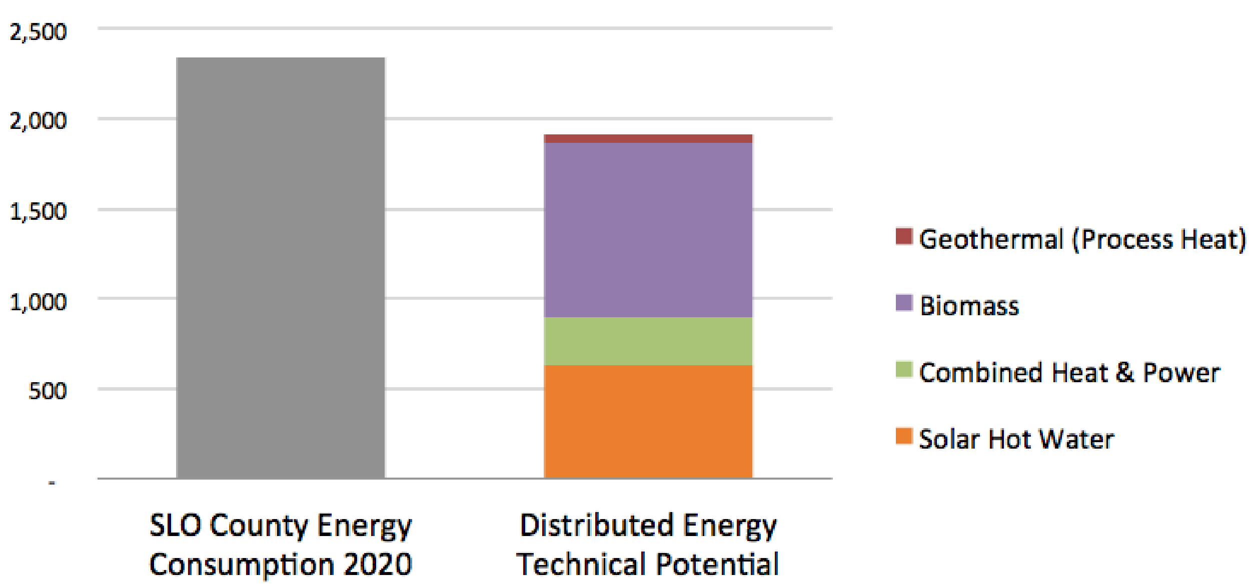
The analysis identified a technical resource potential sufficient to provide 66 percent of the county's electricity requirements and 82 percent of its thermal needs (assuming a base year of 2020) with distributed energy resources, and the potential to build remote generation facilities to supply electricity equal to 432 percent of the county's electricity consumption, as can be seen in the graphs below:

Figure 20: San Luis Obispo County Electricity Consumption and Resource Potential (GWh)



Source: SLO RESCO

Figure 21: San Luis Obispo County Thermal Consumption and Resource Potential (GWh)



Source: SLO RESCO

The manner in which the resources were construed in this report and in the Energy Atlas was designed to engage citizens in novel approaches to thinking about how energy is created and used. For example, the report includes a number of technologies such as solar hot water and ground source heat pumps under the designation of 'ambient' energy resources, which may supply energy directly for use without it needing to be converted into another form of energy such as electricity. Similarly, 'regenerative' energy refers applications such as combined heat and power and in-conduit (pipeline) hydroelectric generation, in which energy that would otherwise go to waste is captured and used. 'Negawatts' refer to the technologies and practices that avoid or lessen energy usage.

Each category is comprised of multiple types of technologies, each of which are explained and given local context by the following six subsections (though some categories have additional subsections as well, and the local resource potential was not quantified for all technologies)::

- Characterization of the General Resource
- Local Resource Potential
- Maps and Charts
- Technology and Applications
- Investigation Process and Methodology
- References

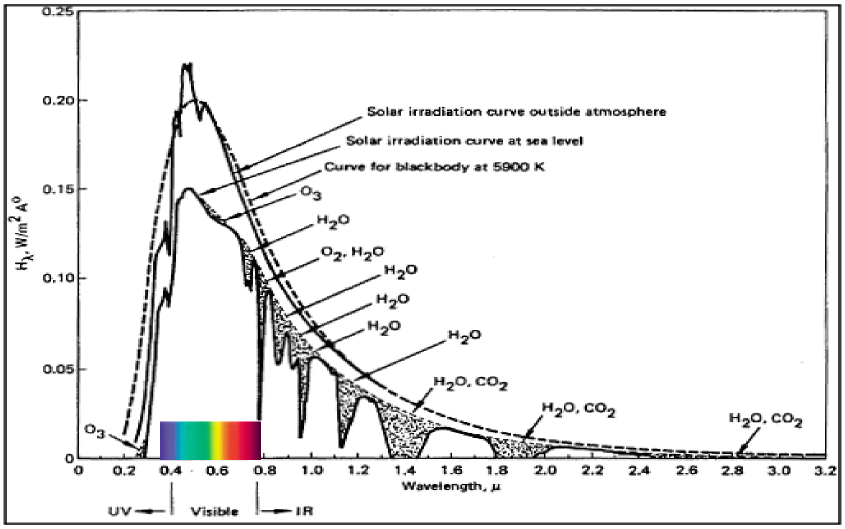
5.2 Renewable Energy: Solar Power

5.2.1 Characterization of Solar Energy Resource

At the top of the earth's atmosphere the amount of energy in solar radiation is about 1,300 watts falling on every square meter directly facing the sun, but not all of this energy reaches earth's surface. The white light of the sun is composed of a spectrum of colors that in turn correspond to various frequencies of electromagnetic waves. The higher frequencies have longer wavelengths and appear to us as red, while the shorter and faster vibrating waves appear as blue. The electromagnetic spectrum extends far beyond the range we can see, to shorter waves than blue light in the ultraviolet (UV) range, while longer waves with slower vibrations than red light are in the infrared (IR). The greatest amount of energy from sunlight is in the middle range of visible wavelengths that appear as yellow and green light. The sensitivity of the human eye to various colors corresponds quite closely to relative amount of light emitted by the sun in each color range.

Most ultraviolet light is absorbed by the ozone layer, while carbon dioxide and water vapor absorb part of the infrared. Much of the sunlight is reflected back to space by small water droplets or clouds which normally cover 50 percent of the earth's surface. Light also interacts with certain gases and dust particles, scattering uniformly in all directions; some is redirected away from earth and back into space. This type of scattering affects blue light the most, giving the sky its characteristic color.

Figure 22: Solar Radiation Spectral Curve



Source: NREL

Figure 22 shows intensity of sunlight over a range of wavelengths; the energy is strongest in the portion visible to the human eye. Shaded areas are wavelengths absorbed by water vapor and carbon dioxide in the infrared range (right), while ozone (O3) blocks ultraviolet light (left). Absorption and scattering of light result in less light reaching the surface that is at the top of the atmosphere.

To quantify solar energy, a few standard units are used. On a clear day with the sun directly overhead, about 1,000 Watts per square meter reaches the earth's surface. This amount of sunlight at 25 degrees centigrade is referred to as "Standard Test Conditions" or "One Sun." (Refer to Brinkworth.)

Kilowatts per square meter (KW/m^2) is a measurement of the amount of "power" per unit of area, either continuously or in a given instant. A given amount of power applied over time is often referred to as "energy", and is measured in kilowatt-hours (KWh). A kilowatt-hour is 1,000 watts of power delivered for 1 hour, or any mathematical equivalent. For example, it can also be 500 watts of power for 2 hours, or 2,000 watts for half an hour.

The amount of power delivered by the sun over time on a flat square meter surface is measured in kilowatt-hours per square meter (KWh/m^2); this can be over any named period of time—typically a day, a month or a year. Most of the regions of the earth inhabited by human beings receive an average of 3 to 7 kilowatt-hours of energy per square meter (KWh/m^2) in a day. This energy can be tapped in a variety of ways to provide light, heat and electric power.

5.2.2 Local Resource Potential

San Luis Obispo County is located at 34.9° North Latitude, along a west ocean coast. This creates a mild Mediterranean microclimate providing the County with an average 315 days of sunshine per year. (See SLO County Facts and Figures under 'References'.)

As defined by the California Energy Commission, SLO County has two climate zones—Zone 4 and Zone 5— which are used for energy planning and green building analysis. Climate Zone 4 covers a majority of the county, including Paso Robles and Atascadero, which are inland from the coast but have some ocean influence which keeps temperatures from hitting more extreme highs and lows. Climate Zone 5 includes the coastal cities of Morro Bay and Pismo Beach, and has warm summers with afternoon winds until sunset, which cools the region. The air is usually moist. Fog and cloud-cover commonly block the sun in the morning and evening.

The solar energy potential in SLO County relative to the rest of the U.S. is very good, as can be seen from in Figure 2. In order to find the theoretical potential of the local solar energy resource it is important to understand how solar energy is collected.

According to the National Renewable Energy Laboratory, a fixed collector in Santa Maria, CA pointing due south and tilted to match the latitude (34.90 N) will collect an average of 5.9 $kWh/m^2/day$ of solar radiation resource. (Refer to Figure 32.) To put this number in perspective, in 2008 the average household in SLO County consumed roughly 20 kWh/day (~$66/ month electricity bill). This amount of energy falls on a roughly 3.4 m^2 (tilted at latitude) on average every day in SLO County. Theoretically, if 100 percent of this solar radiation could be captured and converted to electricity with no losses, each home would only need a roughly 6 foot x 6 foot area (tilted at latitude) to provide all the energy for their home.

Solar collectors can also be arranged to track the sun to produce significantly more energy. A one-axis tracking system (pivoting on a North-South axis), fixed at latitude (34.90N), can collect an average of 7.6 $kWh/m^2/day$. Additionally, a two-axis tracking system (North-South and East-West) can collect an average of 7.8 $kWh/m^2/day$ which is roughly 30 percent greater than a collector fixed at latitude. Looking at a slightly different technology, parabolic collectors can focus the light of the sun to collect heat or to generate electricity. A two axis tracking system (North-South and East-West) can collect an average of 5.7 $kWh/m^2/day$. This study was conducted over 30 years from 1961 to 1990 with a year to year variation of 8-9 percent. (Refer to NREL/ Santa Maria.)

A 2005 California Energy Commission study of the potential solar energy resource in the state showed an average of 5.84 $kWh/m^2/day$ of gross solar radiation (using flat plate collectors angled at latitude) for SLO County. The study calculated the technical resource potential for the county at 418,263 MW, which assumes 10 percent efficient solar PV panels, and excludes north facing slopes greater than 5 percent, forests, and environmentally sensitive areas. (Refer to CEC/ McCabe/Simon.) While it is unrealistic to assume that this potential would be fully developed, the technical solar resource of SLO County is 65 percent of the total U.S. peak electricity demand of 630,000 MW.

In 2007, Navigant Consulting performed a "California Rooftop PV Resource Assessment and Growth Potential by County" for the California Energy Commission which examined residential and commercial rooftop potential by county, and considered factors such as shading, roof pitch, orientation, material compatibility, and climate. Rooftop potentials were estimated for 2006, 2010 and 2016 assuming efficiency gains in PV technology and energy demand growth within each county. For SLO County in 2010, this study estimates a technical rooftop potential of 284 MW (residential) and 110 MW (commercial), for a total of 394 MW. (Refer to CEC/ Navigant.) This is larger than the current peak electricity demand of the county.

While the Navigant study used a layered screening methodology to calculate the rooftop solar potential, the results are surprisingly similar to the Simons/McCabe report. The Simons/McCabe study simply assumed that a 2.5 kW system would be placed on every home in a given region. Assuming 116,767 housing units in the county (U.S. Census 2008), the residential potential would be 292 MW (2.5kW x 116,767 housing units). This is very close to Navigant's prediction of 284MW by 2010. While the assumptions and methodologies of both of these rooftop studies can be critiqued (refer to Investigation and Methodologies Section), the results confirm that there is large technical solar PV rooftop potential within SLO County.

The SLO RESCO analysis used slightly more conservative numbers for rooftop potential throughout SLO County and estimated potentials of 189 MW (AC) for residential buildings and 72 MW (AC) for commercial buildings.

In addition to rooftop solar, there is also potential for substation scale and utility-scale solar power plants in SLO County. This potential has been explored by the Renewable Energy Transmission Initiative (RETI), a stakeholder group composed of utilities, renewable energy industry representatives, regulatory agencies and environmental organizations. The goal of RETI's work is to identify major upgrades to California's electric transmission system needed to access areas with concentrations of renewable energy, designated Competitive Renewable Energy Zones (CREZs), to meet the state's renewable energy target of 33 percent by 2020. These CREZs typically have multiple sites with potential for projects of hundreds to thousands of megawatts, and are selected based on a variety of resource, economic and environmental screening criteria.

Within SLO County there are 22 identified sites that RETI considers suitable for solar thermal steam generation, located within the North and South Carrizo Plains and the Cuyama Valley. RETI assumes each site can deliver at least 200MW, for a total of up to 4,400MW of potential solar thermal peak power. (Refer to RETI.) Although the RETI study considers solar thermal power plants as the preferred technology, it should be noted that technology was not the focus of this study and does not consider the recent large price drops in solar photovoltaics. What this does show is that there is a significant solar resource in the eastern part of the county which can be harnessed by a variety of solar collectors and tracking technologies. The SLO RESCO analysis found there to be a more conservative 3,310 MW of central station solar PV potential. (Refer to Figure 29.)

In addition to the CREZs, the RETI study also identifies locations where smaller 20 MW renewable energy systems (referred to as "non-CREZ resources") can be put online without large transmission upgrades. While 20MW is used as a generic figure in the RETI report, a more refined estimate created by the SLO RESCO team found that between the 17 identified substations (refer to RETI) there was 343 MW (AC) of capacity. (Refer to Figure 28.) While this is much smaller than the CREZ potential within SLO County, it is likely that non-CREZ resources can be more quickly permitted, constructed and connected to the grid due to the much smaller project sizes. A map of the CREZ and the non-CREZ solar resources found by RETI within SLO County is shown in Figure 28 and Figure 29 in the Maps and Charts section.

The SLO RESCO team also evaluated the potential for parking lot solar canopies. (Refer to Figure 27.) Using GIS mapping and a number of assumptions the SLO RESCO team found there to be 235 MW (AC) of solar potential throughout the County's parking lots.

State and national studies show that San Luis Obispo County has a very large solar energy resource potential and infrastructure to support its development. Integrating the resource estimates yields an estimated solar electric power potential for SLO County of 4,071 MW at peak as shown in Figure 23.

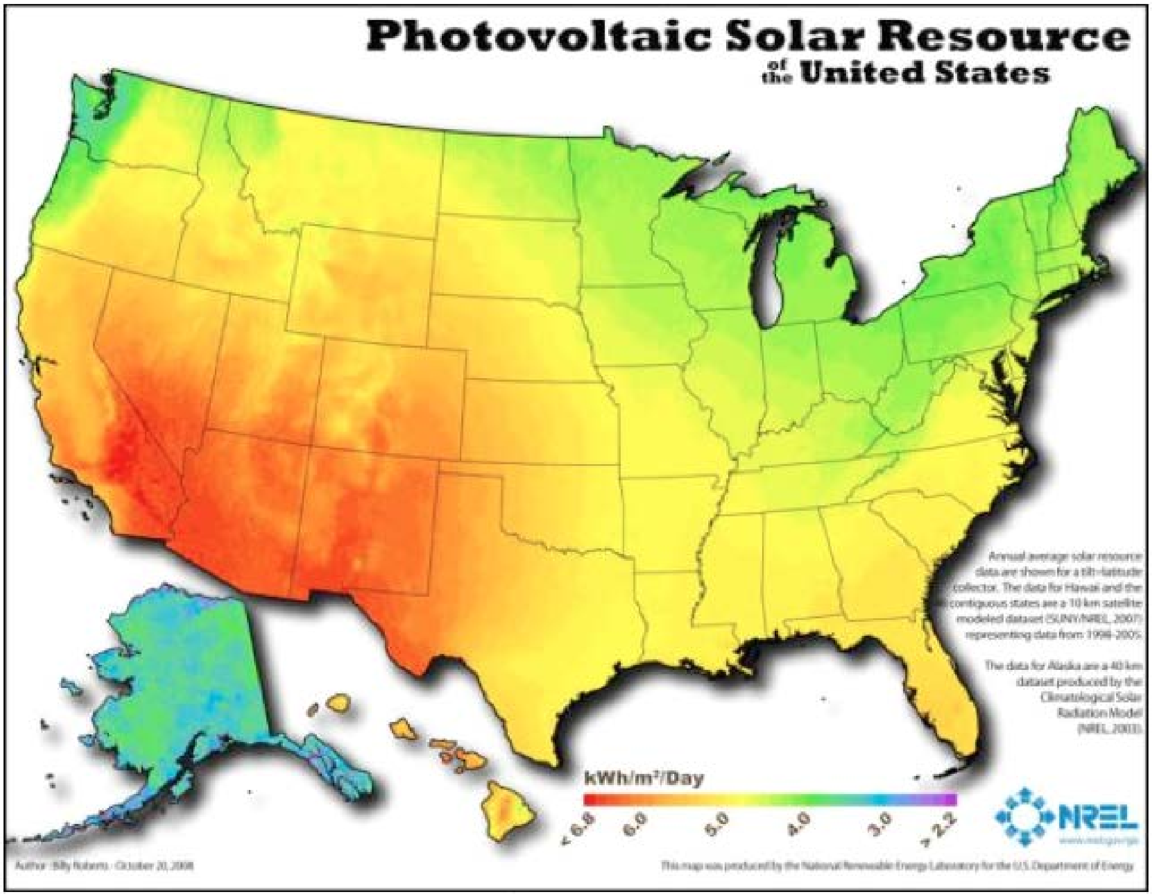
Figure 23: Summary of Solar Electric Technical Potential in SLO County

Type	**Project Size**	**Potential MW (AC)**
Rooftop (Residential)	Less than 10 KW	189
Rooftop (Commercial)	10 to 1,000 KW	72
Parking Lot Solar	<5MW	230
Substation Solar	1 to 20MW	336
Central Station Solar	Over 200 MW	3,244
Total	**n/a**	**4,071**

Source: SLO RESCO

5.2.3 Maps and Charts

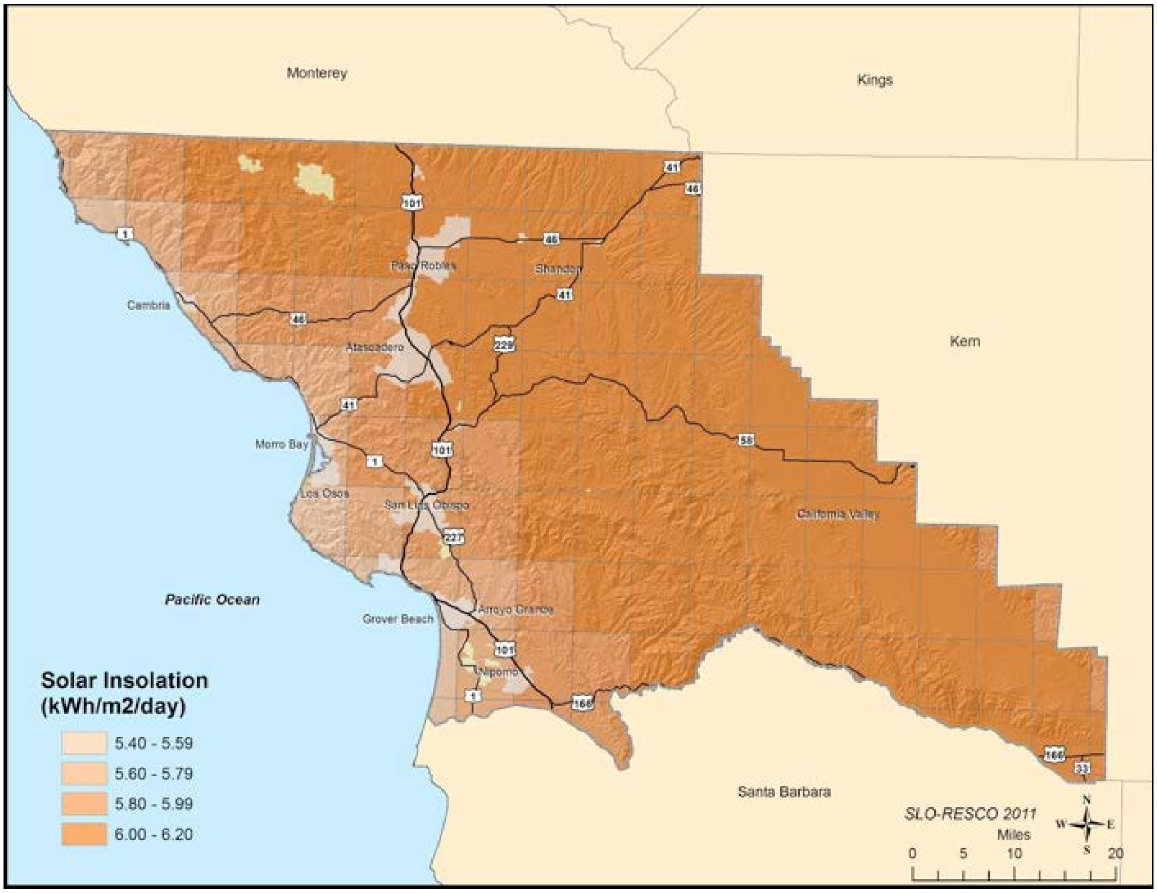
Figure 24: Solar Insolation Map of the United States



Source: NREL

The National Renewable Energy Laboratory’s map of solar resources in the United States shows the highest amount of solar energy in orange and red. California is one of the most solar-rich states in the nation, with between 5.5 to over 6.5 kilowatt-hours per day falling on every square meter of fixed and un-shaded surface angled toward the south.

Figure 25: Solar Insolation Map of San Luis Obispo County

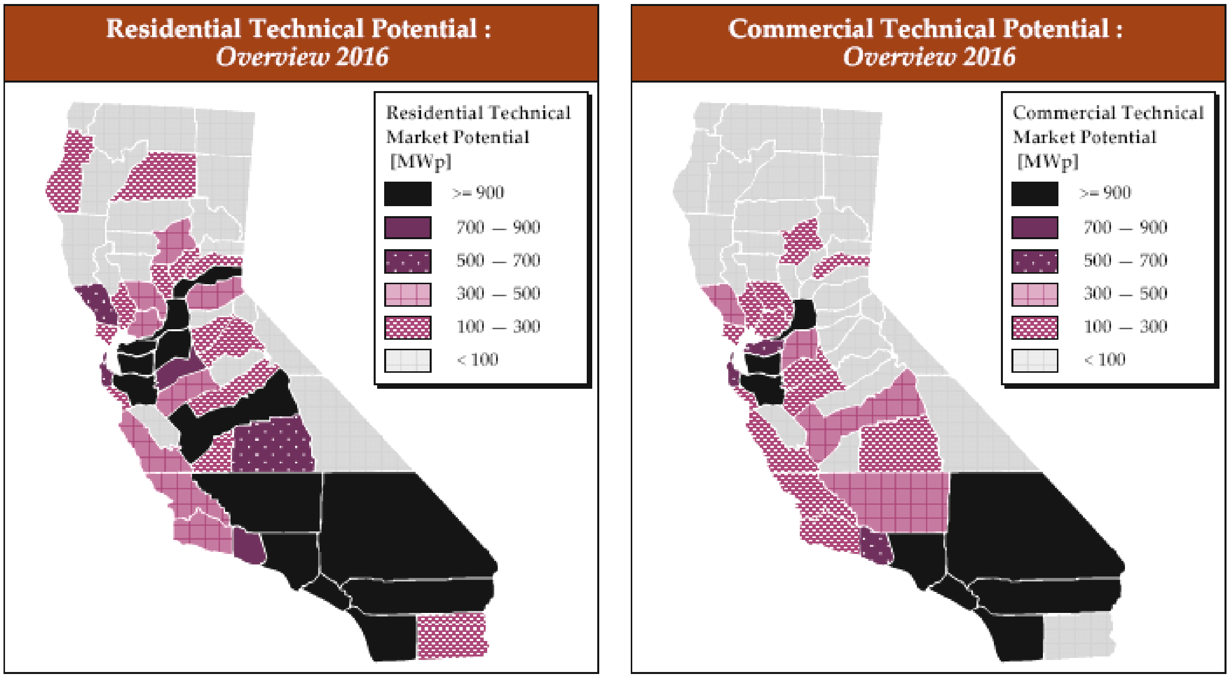


Source: NREL and SLO RESCO

Here is an additional solar radiation map from the National Renewable Energy Labs' PV Watts Calculator, which shows a closer view of SLO County. As can be seen the northern and eastern parts of the County have an exceptional solar resource.

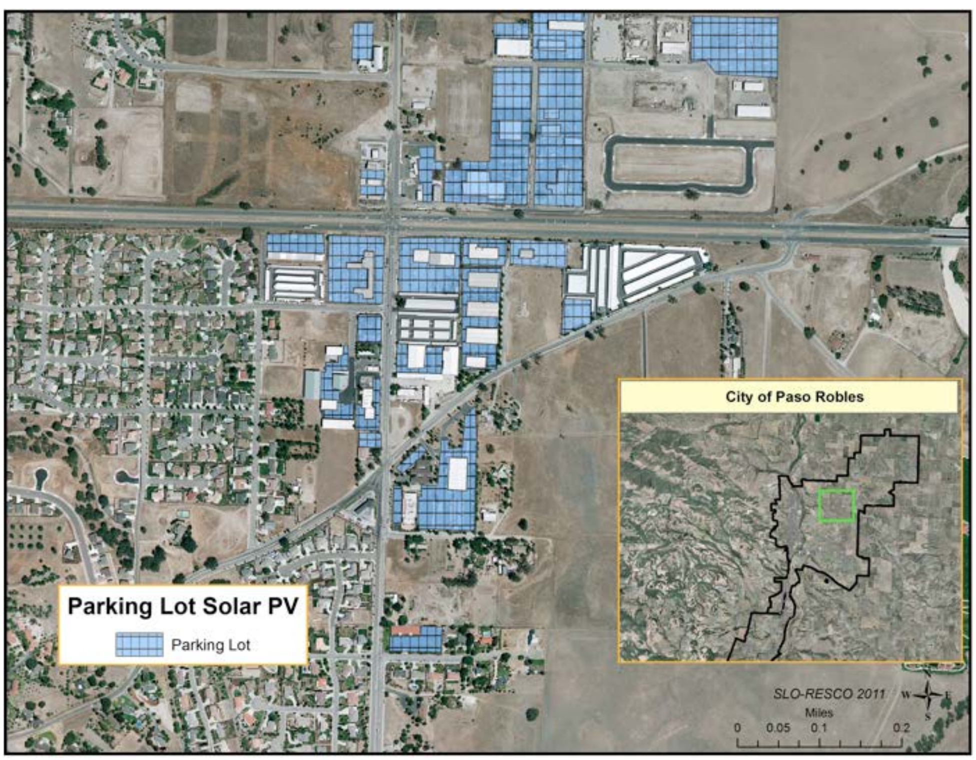
Figure 26 is a map of California solar potential by county, measured in peak megawatts, from a California Energy Commission report: "California Rooftop PV Resource Assessment and Growth Potential by County: CEC-500-2007-048." San Luis Obispo County is shown to have between 300 to 500 MW of residential and 100 to 300 MW of commercial Technical Market Potential by 2016. Research performed by SLO RESCO found similar, but slightly more conservative rooftop solar potentials. (The SLO RESCO analysis assumed that of the available suitable roof space for solar energy 75 percent was available for solar PV and 25 percent was available for solar hot water.) The SLO RESCO analysis found there to be 192 MW (AC) of residential roof top solar PV potential and 74 MW (AC) of commercial rooftop potential. The analysis also determined that as of March 2013 there was roughly 7.4 MW (AC) and 7 MW (AC) of residential and commercial PV respectively (rooftop and ground mount combined) installed in San Luis Obispo.

Figure 26: Residential and Commercial Rooftop Photovoltaic Technical Potential by County (in 2016)



Source: Navigant Consulting

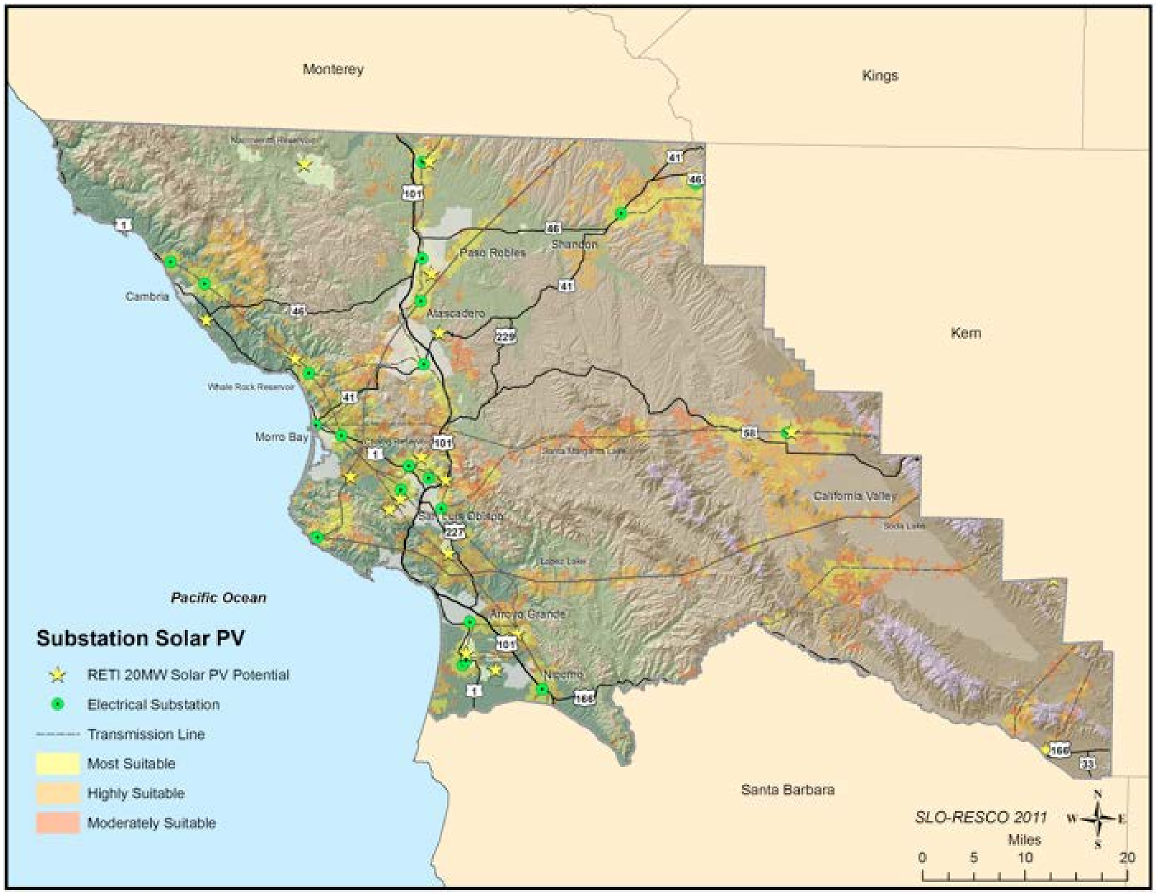
Figure 27: Parking Lot Solar Photovoltaic Mapping Screenshot



Source: Google Earth and SLO RESCO

Research performed found there to be a significant resource in solar canopies over parking lots. GIS mapping of parking lots throughout the County showed there to be 235MW (AC) of parking lot solar potential throughout SLO County. More information about the Solar Parking Lot analysis can be found in a proceeding section of this report.

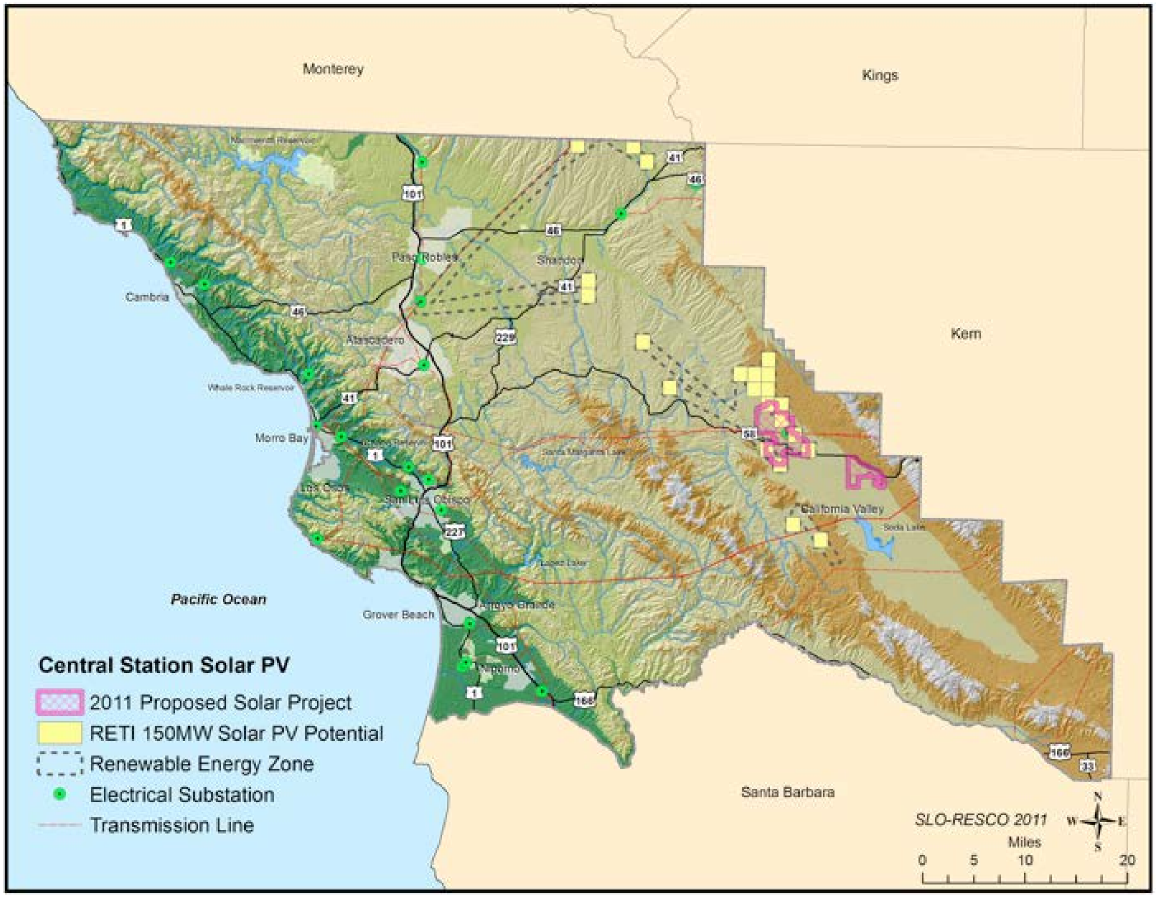
Figure 28: Substation Solar Photovoltaic Potential in SLO County



Source: RETI and SLO RESCO

Figure 28 examines the most suitable places in the County for the potential development of substation scale solar power plants (<20MW). Using a variety of inputs such as terrain, solar resource and proximity to substations or transmission lines lands were ranked from most suitable to least suitable. Layered upon this are the substation scale power plant locations identified in the RETI report. The analysis estimates that there are 343 MW (AC) of substation solar potential in SLO County. More information about this solar suitability study can be found in a proceeding section of this report.

Figure 29: Central Station Solar Photovoltaic Potential in San Luis Obispo County



Source: RETI and SLO RESCO

The RETI Phase 1B report identified 22 large scale solar PV power plants throughout San Luis Obispo County. Using this data and other information, the analysis estimated there to be 3,310 MW (AC) of central station solar power throughout the county.

Figure 30: Residential Rooftop Solar Photovoltaic Potential

Source: Navigant Consulting & SLO RESCO

The analysis found there to be very significant rooftop solar potential throughout SLO County. Using the methodology of the Navigant Consulting report (explained further in the Investigation and Methodologies section below) and a number of different assumptions, the analysis determined there to be approximately 189 MW of rooftop potential throughout SLO County. Additionally, through analyzing the three different solar program databases (Emerging Renewables Program, Self-Generation Incentive Program and California Solar Initiative) it was determined that as of August 2011 there were 1,458 grid-tied solar PV systems (rooftop and ground mount) throughout the county with an average system size of 4.0kW (AC) for a total of 5.8MW. It should also be noted that in the Emerging Renewables Program which ended in 2006 there was differentiation between residential or commercial systems. The analysis therefore estimated that all systems 10kW or smaller were residential and all systems 10kW or larger were commercial.

Figure 31: Commercial Rooftop Solar Photovoltaic Potential

Source: Navigant Consulting & SLO RESCO

The analysis found there to be very significant commercial rooftop solar potential throughout SLO County. Using the methodology of the Navigant Consulting report (explained further in the Investigation and Methodologies section below) and a number of different assumptions, the analysis estimated there to be 72 MW of rooftop potential throughout SLO County. Additionally, through analyzing the three different solar program databases (Emerging Renewables Program, Self-Generation Incentive Program and California Solar Initiative) it was determined that as of August 2011 there were 112 grid-tied solar PV systems (rooftop and ground mount) throughout the county with an average system size of 60kW (AC) for a total of 6.7MW. It should also be noted that in the Emerging Renewables Program which ended in 2006 there was differentiation between residential or commercial systems. The analysis therefore estimated that all systems 10kW or smaller were residential and all systems 10kW or larger were commercial.

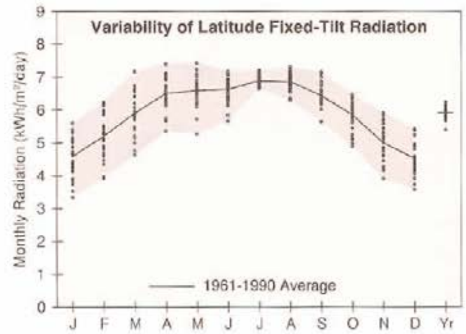
Figure 32: Summarized NREL Solar Radiation Data from Santa Maria, CA (1961 to 1990)

Santa Maria, CA

WBAN NO. 23273

LATITUDE: 34.90° N
LONGITUDE: 120.45° W
ELEVATION: 72 meters
MEAN PRESSURE: 1008 millibars

STATION TYPE: Primary



Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.8	3.7	4.9	6.2	7.0	7.4	7.5	6.8	5.6	4.4	3.2	2.7	5.2
	Min/Max	2.3/3.3	3.0/4.2	4.0/5.8	5.3/6.9	5.6/7.9	6.3/8.0	7.1/7.9	6.3/7.2	5.0/6.1	3.8/4.7	2.7/3.6	2.3/3.0	4.8/5.4
Latitude -15	Average	4.0	4.7	5.7	6.6	7.0	7.2	7.4	7.1	6.3	5.4	4.4	3.9	5.8
	Min/Max	3.0/4.8	3.7/5.6	4.5/6.8	5.5/7.5	5.6/7.9	6.2/7.8	7.1/7.8	6.5/7.5	5.6/7.0	4.6/5.9	3.5/5.1	3.1/4.6	5.3/6.1
Latitude	Average	4.6	5.2	5.9	6.5	6.6	6.6	6.9	6.9	6.4	5.8	5.0	4.5	5.9
	Min/Max	3.3/5.6	3.9/6.2	4.6/7.2	5.3/7.4	5.3/7.4	5.7/7.2	6.6/7.2	6.3/7.3	5.6/7.1	4.9/6.5	3.9/5.9	3.6/5.4	5.4/6.2
Latitude +15	Average	4.9	5.4	5.8	6.0	5.8	5.7	6.0	6.2	6.2	6.0	5.3	4.9	5.7
	Min/Max	3.5/6.1	4.0/6.5	4.5/7.1	4.9/6.9	4.7/6.5	4.9/6.1	5.8/6.2	5.7/6.6	5.4/6.9	4.9/6.6	4.1/6.3	3.8/5.9	5.2/6.0
90	Average	4.4	4.4	4.0	3.4	2.7	2.3	2.5	3.2	3.9	4.6	4.6	4.5	3.7
	Min/Max	3.0/5.5	3.2/5.4	3.1/4.9	2.8/3.8	2.4/2.9	2.2/2.4	2.4/2.6	3.0/3.3	3.5/4.4	3.7/5.1	3.5/5.6	3.5/5.5	3.3/4.0

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	4.2	5.2	6.7	8.3	9.0	9.4	9.6	8.8	7.5	6.1	4.7	4.0	7.0
	Min/Max	3.0/5.1	3.8/6.3	5.1/8.4	6.7/9.7	6.8/10.6	7.7/10.8	8.8/10.6	7.9/9.6	6.3/8.7	5.0/7.0	3.7/5.7	3.2/4.8	6.3/7.4
Latitude -15	Average	5.0	6.0	7.3	8.7	9.1	9.4	9.6	9.1	8.1	6.9	5.6	4.9	7.5
	Min/Max	3.5/6.2	4.3/7.3	5.5/9.2	6.9/10.2	6.9/10.8	7.6/10.7	8.8/10.6	8.1/9.9	6.7/9.4	5.6/7.9	4.3/6.7	3.8/5.9	6.7/7.9
Latitude	Average	5.5	6.4	7.5	8.6	8.8	9.0	9.2	8.9	8.2	7.3	6.0	5.4	7.6
	Min/Max	3.8/6.8	4.5/7.8	5.6/9.5	6.8/10.1	6.7/10.4	7.3/10.2	8.5/10.2	8.0/9.7	6.8/9.5	5.9/8.3	4.6/7.3	4.2/6.6	6.8/8.1
Latitude +15	Average	5.7	6.5	7.4	8.3	8.3	8.3	8.6	8.5	8.0	7.3	6.3	5.7	7.4
	Min/Max	4.0/7.2	4.5/8.0	5.5/9.4	6.4/9.8	6.3/9.8	6.8/9.5	7.9/9.5	7.6/9.2	6.6/9.3	5.9/8.4	4.7/7.7	4.4/7.0	6.6/7.9

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	5.8	6.5	7.5	8.7	9.2	9.6	9.7	9.1	8.2	7.4	6.3	5.8	7.8
	Min/Max	4.0/7.3	4.6/8.0	5.6/9.5	6.9/10.2	6.9/10.9	7.8/10.9	8.9/10.8	8.1/9.9	6.8/9.5	5.9/8.4	4.8/7.7	4.4/7.2	7.0/8.4

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	3.6	3.8	4.0	4.5	4.9	5.3	5.6	5.2	4.6	4.3	3.9	3.7	4.5
	Min/Max	2.1/4.9	2.1/5.0	2.3/5.7	3.0/5.7	2.9/6.2	3.6/6.4	4.6/6.4	4.1/5.9	3.2/5.6	3.2/5.2	2.6/5.2	2.6/5.0	3.6/5.0
1-Axis, N-S Horiz Axis	Average	2.9	3.6	4.6	5.9	6.4	6.8	7.1	6.5	5.5	4.5	3.4	2.8	5.0
	Min/Max	1.6/3.9	2.0/4.8	2.7/6.7	4.0/7.5	3.8/8.2	4.5/8.3	5.7/8.3	5.0/7.5	3.7/7.0	3.3/5.5	2.2/4.5	2.0/3.8	4.1/5.5
1-Axis, N-S Tilt=Latitude	Average	4.0	4.6	5.3	6.1	6.2	6.3	6.7	6.6	6.0	5.4	4.5	4.0	5.5
	Min/Max	2.3/5.4	2.5/6.1	3.0/7.6	4.1/7.8	3.7/7.9	4.2/7.8	5.4/7.8	5.1/7.5	4.0/7.6	4.0/6.6	3.0/6.0	2.8/5.4	4.4/6.1
2-Axis	Average	4.3	4.7	5.3	6.2	6.5	6.9	7.2	6.8	6.1	5.5	4.8	4.4	5.7
	Min/Max	2.5/5.8	2.6/6.3	3.0/7.7	4.1/7.9	3.9/8.4	4.6/8.4	5.8/8.4	5.2/7.7	4.0/7.6	4.1/6.7	3.1/6.3	3.1/5.8	4.6/6.4

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	10.6	11.4	11.6	12.7	13.9	15.9	17.3	17.8	17.6	16.1	13.1	10.6	14.1
Daily Minimum Temp	3.5	4.7	5.2	5.8	8.0	10.2	11.6	12.2	11.3	8.9	5.7	3.2	7.5
Daily Maximum Temp	17.7	18.2	17.9	19.4	19.9	21.7	22.9	23.4	23.8	23.3	20.4	17.9	20.6
Record Minimum Temp	-6.7	-5.6	-4.4	-0.6	-0.6	2.2	6.1	6.1	2.2	-3.3	-3.9	-6.7	-6.7
Record Maximum Temp	30.0	30.6	35.0	39.4	37.8	38.9	40.0	39.4	39.4	42.2	33.9	32.2	42.2
HDD, Base 18.3°C	239	193	210	173	138	77	53	40	56	79	161	239	1658
CDD, Base 18.3°C	0	0	0	3	0	5	21	23	32	11	0	0	94
Relative Humidity (%)	70	73	76	75	76	76	77	78	78	73	71	70	75
Wind Speed (m/s)	2.8	3.2	3.7	3.8	4.0	3.7	3.2	3.0	2.8	2.8	3.0	2.8	3.2

Source: NREL

Figure 32 shows the National Renewable Energy Laboratory 30-year data for Santa Maria, California, the nearest station to San Luis Obispo County. The top right chart shows variation in solar output over the course of 30 years sorted by months. Solar energy at this site can vary significantly from year to year, especially during the non-summer months. While tracking systems can increase solar energy production by nearly 30 percent, using concentrators that focus the light can erase these benefits.

Figure 33: Solar Energy Production of Different Technologies

RETI Stakeholder Steering Committee
RETI Phase 1B – Economic Analysis of CREZ

6.0 Project Identification and Characterization

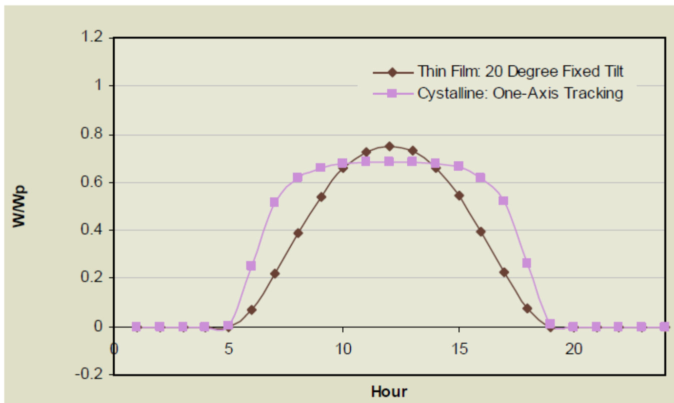


Figure 6-1. Example Energy Output from Tracking Crystalline and Fixed Tilt Thin Film (July).

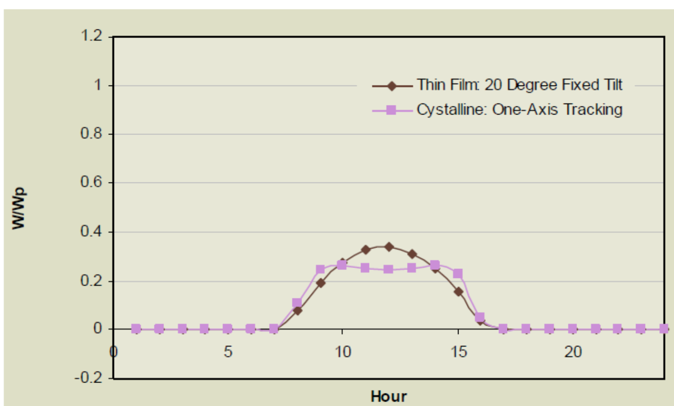


Figure 6-2. Example Energy Output from Tracking Crystalline and Fixed Tilt Thin Film (December).

Source: RETI

Figure 33, from the Phase 1B Report by California's Renewable Energy Transmission Initiative (RETI) shows energy produced by tracking and non-tracking photovoltaic systems over the course of a day in the summer and a day in the winter. Using a tracking system to allow the solar panels to follow the sun creates up to 30 percent more cumulative energy as well as more level production. Also important is the fact that the tracking system maintains much higher capacity after 3 pm, which better coincides with California's peak demand.

5.2.4 Technologies and Applications

The processes in which solar energy can be used for human benefit include growing food and biofuels, electricity generation, heating and cooling, cooking, and more. This section of the study considers technologies and applications in SLO County for solar electricity generation.

5.2.4.1 Solar Electricity Generation (Photovoltaic)

There are several ways in which solar energy can be converted into electricity. Using photovoltaic cells is the most common. How solar radiation is converted to electricity with a photovoltaic cell can be explained in four simple steps.

1. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.

2. Electrons are then knocked loose from their atoms, allowing them to flow through the material to produce electricity. Due to the composition of solar cells, the electrons can only move in a single direction.

3. An array of solar cells (solar module) then creates a usable amount of direct current (DC) power.

4. This DC power can then be converted to alternating current (AC) power by an inverter, and if it is given the right voltage, current and frequency the power can be delivered to the electrical grid.

5.2.4.2 Solar cells

There are many types of solar cells; here are the four most common.

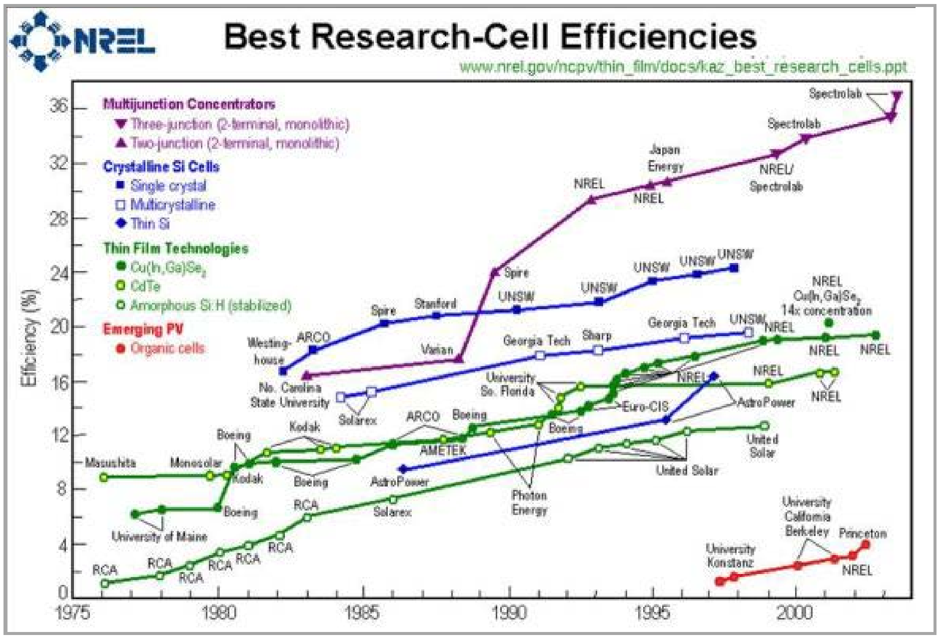
- Monocrystalline cells are the highest grade of crystalline silicon (c-Si) which is used as the light absorbing semiconductor in solar cells. Monocrystalline cells are sliced into thin wafers from high purity single crystal silicon ingots (boule). Monocrystalline panels are considered very durable, with estimated potential useful life of 80 years or longer.

- Polycrystalline wafers are less efficient than the more perfect monocrystalline cells, but are cheaper and faster to manufacture. Polycrystalline cells have a flaky looking surface where monocrystalline cells appear much smoother.

- Amorphous silicon cells are the most developed of the “thin film” solar technologies. Although the cost of manufacturing amorphous cells is cheaper than crystalline cells, the energy conversion efficiencies are lower and they may be less durable. However, nearly all commercial panels today come with long-term warranties that assure at least 80 percent of initial rated production after 20 years.

- Multi-Junction cells have multiple layers, where each layer is designed to capture a certain color of the spectrum. This design increases efficiency, but is costly. Sunlight is focused onto small multi-junction cells to minimize use of the expensive material.

Figure 34: Solar PV Research Efficiency Trends



Source: NREL

5.2.4.3 Solar Cell Efficiency

A solar cell's energy conversion efficiency is the percentage of power from incoming solar radiation which is converted to electrical energy produced out of the solar cell. Advances in technology have significantly increased the efficiency of solar cells, leading to several benefits:

- Less material needed for cells and modules
- Lower cost
- Reduced time to pay back the energy it takes to manufacture components
- Much less area needed for solar energy systems

5.2.4.4 Solar Modules

Solar cells are connected and encapsulated in a "module". Within the module solar cells are wired in series creating an additive voltage. Module efficiencies are typically lower than cell efficiency because of reflection from the glass cover plate, and the fact that efficiencies are measured over the full area of the module, including the frame and any space between cells, neither of which produce any power. While current leading commercial solar cells have efficiencies of 20 percent to 22 percent, the top module efficiency ranges from 17 percent to 20 percent due to these various deductions. (Refer to SunPower.)

5.2.4.5 Energy Production of Solar Photovoltaic Arrays

Time & Intermittency of Solar Power

Solar radiation is an intermittent resource due to seasonal differences in the amount of sunlight (i.e. the sun sets much later in the winter than in the summer) and more instantaneous variations day to day and minute to minute due to cloud cover. For example, in the NREL Santa Maria study, solar radiation in the winter months is roughly 40 percent less than in the summer months. (Refer to NREL/ Santa Maria.) And while this variation can be forecasted, an energy resource dependent on the weather does present challenges for electricity grid operators who must keep the grid energized at all times. As solar energy becomes a greater and greater percentage of the energy portfolio, technologies must be developed to account for and to mitigate this intermittency. Some technologies include solar photovoltaic cells which can harness more energy even when light is scattered from clouds. Solar tracking systems provide a more even distribution of energy output throughout the day as seen in Figure 33. Energy storage in the form of pumped storage, flywheels or batteries will enhance reliability and balance fluctuations in solar generation.

Solar Geometry
The orientation of the solar array is important to the amount of energy that can be produced and will be discussed further in the Applications section below.

Shading
"Solar shading" refers to shadows which are cast upon photovoltaic modules when nearby structures or natural features. Because the solar cells in each module are wired in series, if one cell is shaded then the entire module's electricity production is reduced proportionally. This is why it is important to use tools which calculate shading from buildings, roofs, trees, or other objects for the entire year of sun travel.

Heat
When solar cells become hot, their efficiency drops significantly. It is important in solar design to ensure adequate space for air to flow around the back of the panels to dissipate the heat generated from each module. According the California Energy Commission's EPBB calculator, it is best to leave at least six inches of spacing between the roof and the solar module. Also, some modules are more "heat tolerant" than others and will lose less electricity production in hot climates.

Tracking
One way to capture more solar energy with a solar module is to pivot it throughout the day to track the sun. This is done using a one or two axis tracking system, allowing for up to 30 percent more solar radiation to be captured by the modules. Tracking systems may be installed for homes with adequate yard space and clear access sun, but it is more common in large arrays where economies of scale can help make the tracking technology more affordable.

Inverters
Inverters convert direct current (DC) power produced by the solar panels into alternating current (AC) power that is useful for standard appliances. High quality "grid-intertie" inverters are designed so that the power can be delivered to the electricity grid. Advances in technology have allowed even residential-scale inverters to be mass produced with efficiencies that can reach 95 percent or higher.

5.2.5 Applications and Scales

Due in part to its ability to be scaled for almost any size application, from portable cell phone chargers to large power plants, solar photovoltaics is the most versatile renewable energy technology on the market. Although a climate with good solar radiation is important; the application and scale also help determine the benefits and cost-effectiveness. As mentioned previously, orientation and tracking capabilities affects how much energy is produced from a solar system and the economic feasibility of a project. For example, for a ground mount solar system panels could be mounted flat on the ground, which reduces racking costs, but also reduces energy output. Contrast this to a two axis tracking system mounting system, which is more expensive, but captures direct sunlight over the full course of the day therefore generating more energy.

Determining the proper scale for solar photovoltaic projects is based on the site (i.e. amount of solar radiation, available area, access to power grid, on-site energy consumption, etc.) policy (Feed in tariffs, net metering, etc.) and cost (technology, land, permitting, etc.)

5.2.6 Peak Shaving

One of greatest advantages of solar energy technologies is their ability to generate electricity when demand for electricity is highest. In California the demand for electricity is the greatest on hot summer days when the sun is shining the brightest. Traditionally, this is when fossil fuel "peaker" plants and back-up generators are brought online— at a relatively high cost— to ensure grid stability. Fossil fuel peaking generation is often inefficient, polluting and expensive. Solar energy technologies have the ability to greatly reduce the use of these generators. According to a NREL California Peak Shaving study for on June 15th, 2000 "an installed dependable PV capacity of 5,000MW reduces the peak load for that day by about 3000 MW— thereby cutting in half the number of equivalently sized gas peakers needed to ensure capacity reserve." (Refer to NREL/ Herig.)

5.2.7 Photovoltaic Scale

Typically, solar energy generation is divided into four size categories: residential, commercial, community and utility scale. These markets can be developed by policies, financial incentives and technologies, which are appropriate to each scale. The sizes below are estimates based on market data and language used within the solar industry.

Figure 35: Photovoltaic Scales

Scale	Size
Residential	1kW -10kW
Commercial	10kW- 1MW
Sub-Station	1MW- 20MW
Utility	> 20MW

Source: SLO RESCO

5.2.8 Solar Thermal Electricity Generation

Solar thermal energy—heat that is produced by sunlight— can be used in a number of processes and technology applications are divided into three categories of collectors: low, medium and high temperatures. Low and medium temperature collectors are used for industrial process heat, domestic hot water, cooking, etc. and are further explained in the Ambient Energy sections.

High temperature collectors are used to generate electricity. Also known as Concentrated Solar Power (CSP) this technology uses reflective materials or lenses to concentrate sunlight onto a thermal receiver in which a fluid absorbs the solar radiation in the form of heat. This heated fluid boils water to create steam, which runs a generator to produce electricity. CSP technologies include parabolic troughs, molten-salt power towers, and parabolic dishes with Sterling engines. The scale and application of Concentrated Solar Power is typically limited to larger installations due to cost factors and the need for optimal siting.

5.2.9 Investigation Process and Methodology

There are a variety of investigation processes and methodologies, which have been used to study the solar energy resource potential in SLO County. Four solar studies which have been mentioned previously are discussed below.

5.2.9.1 NREL Solar Data 1961-1990 for Santa Maria, California

This study provides solar radiation data collected over 30 years with +/- 8 percent levels of certainty, but no feasibility analysis. While the data site was outside of SLO County, the data is likely very similar for SLO County since it is from only a few miles south of the county line and is within the same climate zone. The data is presented in four sets, showing the resource for fixed and tracking surfaces. Each set also shows different angle of tilt and output for each month and for the year as a whole, which make it easy to apply the data to different technologies and for performing further data analysis.

5.2.9.2 CEC: California Solar Resources (Simons & McCabe, 2005)

This study performs a very macro level solar analysis across the state of California and translates raw solar data into different technical potentials by county for rooftops and all other areas excluding north facing slopes greater than 5 percent, forests, and environmentally sensitive areas. The result for SLO County of this report’s simple methodology of determining residential technical solar potential by assuming a 2.5kW system on each home was remarkably close to Navigant’s 2007 report.

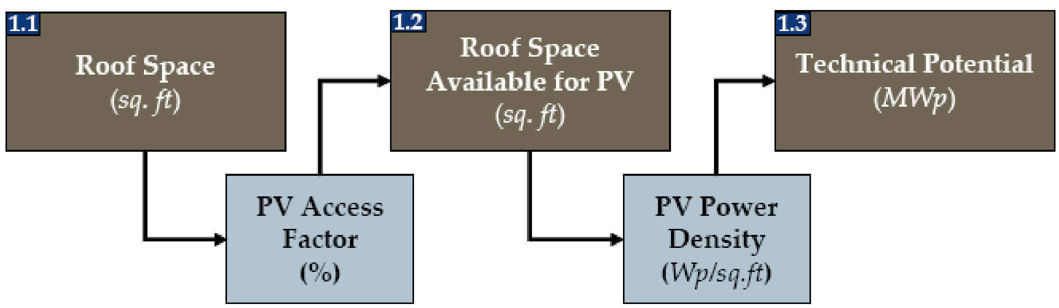
5.2.9.3 Renewable Energy Transportation Initiative: Phase 1B (2009)

The RETI report is a long and extensive study focusing on meeting California’s requirement for obtaining 33 percent of electricity from renewable energy by 2020. RETI identifies different areas which have high renewable energy potential. This study, while primarily focusing primarily on the need for transmission, also shows areas around the state where renewable energy could be developed with no transmission upgrades. SLO County has both types of resources and this is important when evaluating the local need for and viability of large centralized energy systems. Utility companies have stated that RETI over-estimated that capacity of substations to host sites for photovoltaics, and these critiques are being considered in our evaluation of resource potential for SLO County.

5.2.9.4 CEC: California Rooftop PV Resources Assessment and Growth Potential By County (Navigant Consulting, 2007)

This study performs a technical resource potential analysis by county using the methodology shown in Figure 36, below:

Figure 36: Navigant Consulting Rooftop Technical Potential Methodology



First the potential total roof space potential was calculated, then a PV Access Factor was applied which took into consideration pitched vs. flat roofs, material compatibility, cool vs. warm climates, shading, and orientation which yields a percentage of roof space of total roof space which is suitable for PV systems both for residential and commercial sectors. The results from this analysis are shown below in Figure 37.

Figure 37: PV Access Factor Summary

	Summary of PV Access Factors	
	Residential	Commercial
Warmer Climates (zones 4 through 15)	27%	60%
Cooler Climates (zones 1, 2, 3 and 16)	22%	65%

Source: Navigant Consulting

To determine the technical resource potential, the power density of solar PV was analyzed using the following equation: System Power Density = Module Efficiency X 1000 (W/m2) / Packing Factor. For this study, a module efficiency of 19 percent was assumed for the year 2016. Additionally, a packing factor of 1.25 was used to account for racking, wiring, etc. Navigant then used an online tool, “Clean Power Estimator”, which accounts for county capacity factors and recommended tilt angles, to derive the maps of the technical resource potential.

According to this study, SLO County's technical resource potential by the year 2016 is 404 MW peak for the residential sector and 154 MW peak for the commercial sector. Using these projections and removing the assumptions regarding solar PV efficiencies and packing factors the theoretical rooftop potential in SLO County in 2016 is 2,658 MW for the residential sector and 1,013 MW for the commercial sector.

This study is very useful, but there may be ways in which it could be further improved. The study is limited to rooftops, and this does not capture the full residential and commercial solar potential. SLO County is a relatively rural county with a great deal of large open space ideal for ground mount systems. The commercial potential could also be greater if parking lots are considered.

5.2.10 References

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5.3 Renewable Energy: Wind Power

5.3.1 Characterization of Wind Resource

Wind is most easily understood through the principle that since hot air is lighter than cold air, it rises. Unequal pressure areas in the atmosphere are caused by uneven heating and cooling of the earth. Warm, lighter bodies of air rise and cooler, heavier bodies rush in to fill their place. Air can be heated directly by the sun and by heat rising from the earth's surface.

5.3.1.1 Prevailing Winds

Besides the sun, other factors influencing the creation of wind include local weather conditions and the rotation of the earth. If the globe did not rotate, hot air that has raised high into the atmosphere near the equator (approximately 6 miles before spreading North and South) would travel to the North and South Poles, sink down, and return to the equator. Rotation of the earth creates the Coriolis Effect which causes winds to blow from a prevailing direction based on latitude, pressure zones, and geographic features. This is called the prevailing wind direction. Wind turbines should be sited so that they are placed into the prevailing wind, ahead of obstructions. Local winds can also be affected by geographic features and local climatic events.

5.3.1.2 Energy in the Wind

Moving masses of air contain kinetic energy that can be harnessed to generate electricity. Winds are measured according to the direction from which they are blowing as well as their speed. Since power is related to the cube of wind speed, speed is the most important factor in determining the value of a wind resource. This relationship is described by the Power Equation:

Figure 38: Power Equation

Power in the Wind

$$P = .5\rho AV^3$$

where:

P = power in watts (746 watts = 1 hp) (1,000 watts = 1 kilowatt)
ρ (rho) = air density (about 1.225 kg/m^3 at sea level, less higher up)
A = rotor swept area, exposed to the wind (m^2)
V = wind speed in meters/sec (20 mph = 9 m/s) (mph/2.24 = m/s)

Source: SLO RESCO

Wind resource maps show wind class, average wind speed, or average wind power. This information, while useful, does not characterize the resource completely. Since wind is variable, there is a distribution of wind speeds over time. The power at each wind speed is multiplied by the frequency in the wind speed distribution to derive the Wind Power Density. From the Power Density it is possible to calculate the amount of energy available in the wind over time.

The tool used to measure the wind speed is called an anemometer. It is standard to mount these devices on 33 foot masts, existing wind turbines, or other tall towers. (Refer to Gipe) It is also common to install devices to measure wind direction alongside the anemometer. Wind speed is most often measured in meters per second (m/s) or miles per hour (mph).

5.3.1.3 Wind Power Classes

The "Battelle" Classes of Wind Power Density assists in communicating the quality of a wind resource. It assigns a rating between one and seven based on defined ranges of average wind speed and power densities. The rating is accompanied by a descriptive word such as "good", "excellent", and "outstanding'. It is important to clarify that the descriptive names such as poor, marginal, and fair do not definitely mean that the resource is unsuitable for generation, it simply describes the resource as being less suitable than others and will most likely produce more expensive energy. The classes are associated with power density ranges based on the elevation of the wind resource. For example, at 10 meters (33ft), a power density of 400 W/m2 has a wind power class of six, while it has only a wind power class of three at 50m (164ft). The 50 meter wind power classification in Figure 39, below, illustrates this system.

Figure 39: Wind Power Classification at 50m

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
1	Poor	0 - 200	0.0 - 6.0	0.0 - 13.4
2	Marginal	200 - 300	6.0 - 6.8	13.4 - 15.2
3	Fair	300 - 400	6.8 - 7.5	15.2 - 16.8
4	Good	400 - 500	7.5 - 8.1	16.8 - 18.1
5	Excellent	500 - 600	8.1 - 8.6	18.1 - 19.3
6	Outstanding	600 - 800	8.6 - 9.5	19.3 - 21.3
7	Superb	> 800	> 9.5	> 21.3

[a] Wind speeds are based on a Weibull k of 2.4 at 500 m elevation.

Source: NREL

5.3.1.4 Factors Influencing Wind

An important characteristic to understand about wind is that its behavior is variable and ever changing. Factors influencing wind behavior can be observed in both space and time.

5.3.2 Temporal

Temporal variability of wind resource appears on several different timescales

Instantaneous: Wind strength can vary significantly over a timescale measured in minutes and even seconds. Modern wind turbines possess technologies to "smooth out" the effects of gusting winds and lulls using pitchable blade control and advanced blade shape to automatically stall in high winds.

Diurnal: Wind strength undergoes daily cycles. In San Luis Obispo County, wind strength usually picks up in the afternoon, peaks at night and fades in the morning. The increased wind is earlier in the afternoon when closer to the sea and later in the evening if further inland.

Seasonal: Changes in season affect wind strength over an annual cycle. In San Luis Obispo County, wind is strongest near to the winter months and weakest near to the summer months.

5.3.3 Spatial

Air Density: Air density (indicated by the Greek letter rho— "ρ") affects the energy capacity of the wind. It varies with temperature and elevation. Since warm air is less dense than cold air, wind turbines will produce less energy in summer than in the winter. Additionally, air density at lower elevation is greater than at higher elevation. San Luis Obispo possesses a moderately high air density having a near sea level elevation and cool prevailing winds from the northwest.

Surface Characteristics: Surface characteristics are a key factor influencing wind speed. Smoother terrain around a wind turbine, allows winds to flow more smoothly and at higher speed. Wind Table 1 describes different types of terrain and their associated wind shear exponent, used when calculating wind speed at different heights. Figure 40 accounts for a majority of terrain characteristics.

Figure 40: Terrain Wind Shear Exponent

Terrain Wind Shear Exponent	**t**
Open water	0.1
Smooth, level, grass-covered	0.15
Row crops	0.2
Low bushes with a few trees	0.2
Heavy trees	0.25
Several buildings	0.25
Hilly, mountainous	0.25

Source: NREL

Height: Height above the ground has a significant impact on available wind and wind speed. Since obstructions near the surface slow the flow of wind, wind speed increases with height. Using the equation below, wind speed can be determined for any height as long as initial wind speed, height, and surface characteristics are known.

Figure 41: Power Law of Wind Speed

Power Law (wind speed at any height)

$$V_2 = (H_2/H_1)^t V_1$$

where:

V_1 = initial wind speed

V_2 = final wind speed

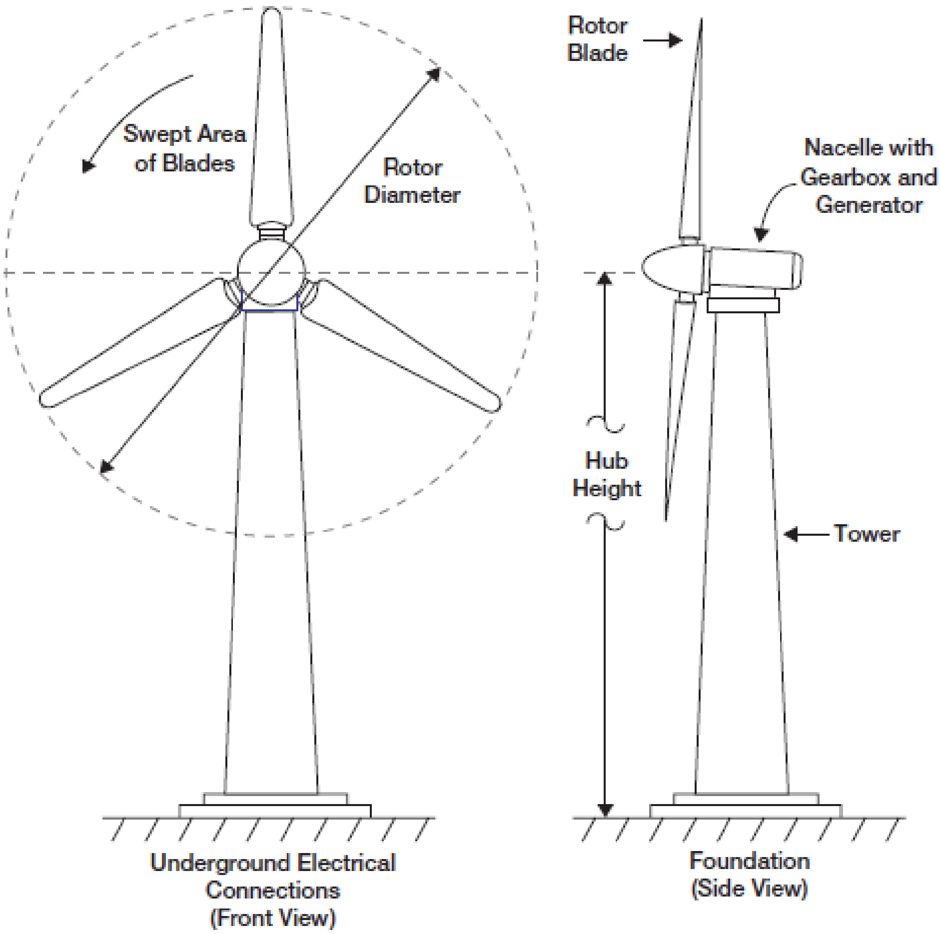
H_1 = initial height

Source: SLO RESCO

5.3.4 Technologies and Applications

Although there have been a variety of wind turbine designs developed and installed throughout the world, the 3-blade horizontal-axis wind turbine (HAWT), pictured below, has emerged as the leading technology.

Figure 42: 3-Blade Horizontal-Axis Wind Turbine (HAWT)



Source: RETScreen Engineering Handbook

When the wind blows, the blades of the 3-blade horizontal-axis turbine experience a lift similar to an airplane wing. The rotor, which connects the blades to the nacelle, starts spinning. The nacelle is a housing at the top of the tower that contains power generation equipment. The nacelle can turn in different directions to keep the rotor blades facing the wind. Inside the nacelle is a gearbox that ensures the generator turns at the proper speed. The generator produces electricity that is passed through equipment that prepares the electricity to enter the grid. The larger the swept area of the blades and the higher the hub height, the more energy the turbine is capable of capturing from the wind to convert into electricity.

5.3.4.1 Manufacturers of Wind Turbines

There are several hundred manufacturers of wind turbines in the world, the key players in the U.S Market are:

- GE Energy

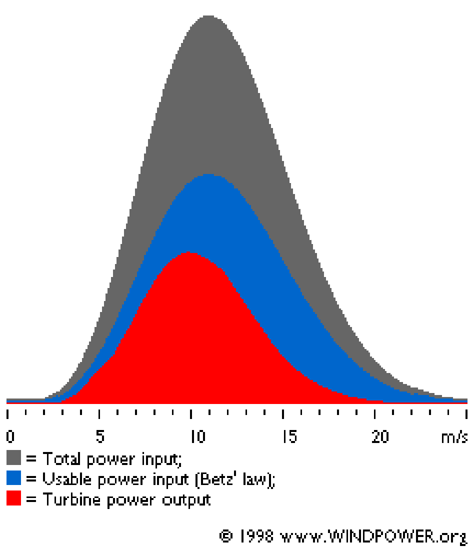
- Vestas
- Siemens
- Mitsubishi Heavy Industries
- Suzlon
- Clipper Windpower
- Nordex
- Northern Power Systems

Enercon, a German turbine manufacturer, holds the record for the world's largest wind turbine. (Refer to Enercon.) Introduced in 2011, the Enercon E-126 generated power at a rated 7.5MW, has an overall height of 650 feet and has a blade diameter of 413 feet. At least five companies are working on the development of a 10MW turbine.

5.3.4.2 Resource Efficiencies and Losses

Converting energy in the wind to electrical energy is a bit more complicated than just connecting spinning turbine blades to an electrical generator. There are physical laws, turbine design optimizations, and energy conversion losses that limit the ability of a wind turbine to convert 100 percent of the wind resource to electricity.

Figure 43: Betz' Law: Wind Energy Conversion Losses



Source: www.windpower.org

5.3.5 Betz' Law

When extracting energy from the wind using a turbine, due to the laws of physics, it is impossible to convert all of the kinetic energy in the wind into mechanical energy. Betz' law states that a maximum of 59 percent of the kinetic energy in the wind can be converted into mechanical energy. This means that at least 41 percent of the wind power potential described by the power density equation for a given wind speed is lost due to Betz' law. The usable power input described by Betz' law (the blue curve in Figure 43) compared to the total power input from the wind (the grey curve in Figure 43).

5.3.6 Wind to Electricity Conversion Efficiency

The measurement of how efficiently a turbine converts wind into electrical energy is called the power coefficient. It is the ratio of the electrical output (the red curve in Figure 43) divided by the wind power input (the grey curve in Figure 43). Designers assign turbines a rated wind speed at which a turbine generates at maximum efficiency. In the sample figure above, the rated wind speed for the wind turbine would be approximately 9.5 m/s. Depending on a wind turbine's design, efficiency of power conversion can reach upwards of 40 percent at its rated wind speed.

5.3.6.1 Siting Considerations

Wind turbines are large rotating energy generating machines mounted on steel towers often hundreds of feet in the air. That being said, a variety of factors affect the siting of large wind turbines.

5.3.6.2 Wind Resource Potential

The most important factor to consider when siting a wind turbine is whether there is a wind resource worth developing. Using wind resource maps are a good way to conduct preliminary surveys, but local mast-mounted anemometer studies are usually essential to prove the resource potential and to convince funders that the project could be profitable.

5.3.7 Site Geography

The local geography surrounding a wind turbine will dramatically affect its ability to generate energy efficiently. Terrain features, ground cover, and obstructions to prevailing wind are a few geographical elements to consider when siting wind turbines.

5.3.8 Exclusion Areas

Land use classifications may exclude an area from wind resource development. Protected, cultural and environmentally sensitive lands, urban areas, and certain strategic military flight paths are excluded from development regardless of their wind resource potential.

5.3.9 Road Access

Wind turbine blades are sometimes longer than 150 ft. Transportation of heavy equipment and large and often fragile turbine components require road infrastructure that can accommodate these special requirements. On the west coast of the United States, usable wind resources are often times located in mountainous areas. This creates logistical challenges for wind turbine installation and may exclude a resource from being developed.

5.3.10 Transmission Access

Access to electrical transmission can be a determining factor for development of a wind resource. Installation of new infrastructure, especially over rough terrain or over long distances, can have adverse effects on the economics of wind generation. It is best to prioritize wind resources that offer easiest access to the electrical grid. A variety of issues affect the possibility to connect wind generators to the grid, such as local grid capacity, voltage, and grid stability.

5.3.10.1 Turbine Packing Density and Setback Requirements

Factors such as safety, noise, and effective electricity generation influence the appropriate packing density and setback requirements when siting a single wind turbine or designing an entire wind farm. Figure 44 describes two possible packing arrangements based off of two industry leading wind turbine designs, detailed in the table. California requirements suggest a setback distance of at least 3 times the overall height of the turbine from impacted developments (refer to CEC). Overall height is the tower height plus one-half of the rotor's diameter. To avoid wind shade interference and insure safety in case of turbine collapse, turbine spacing requirements suggest three times rotor diameter row spacing and ten times rotor diameter column spacing.

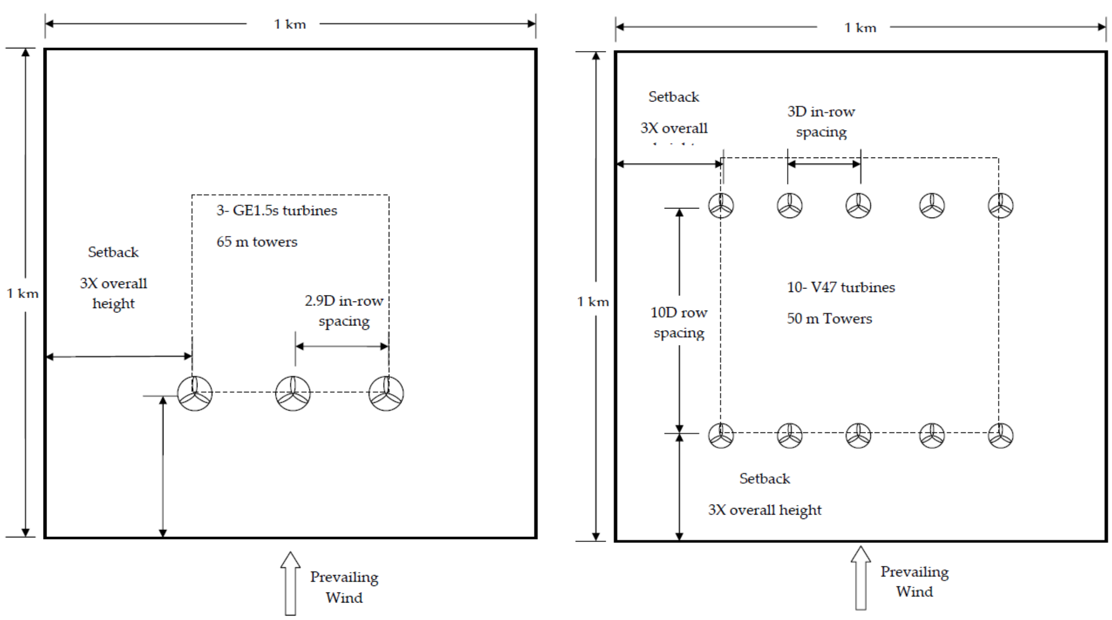
General Electric GE 1.5a

- 1500 kW full rating
- 230ft | 70.5m rotor diameter
- 210ft | 65m tower height

Vestas V47

- 600 kW full rating
- 150ft | 47m rotor diameter
- 165ft | 50m tower height

Figure 44: Packing Orientations for General Electric GE1.5a and Vestas V47 turbines.



Source: General Electric

5.3.10.2 Scales of Wind Power Projects

Wind resources can be developed at a variety of scales. The scale of a project helps to indicate a variety of factors including: energy generation potential, technologies, zoning rules, involved parties, funding methods, capital, and investment requirements, and project risk. Figure 45 describes generating capacity, wind resource requirements, and size of turbines at each scale.

Figure 45: Scales of Wind Potential

Scales of Wind Potential					
Turbine Scale	**Power Rating**	**Minimum Wind Power Class Requirement**	**Average Wind Speed**	**Physical Dimensions (ft. ǀ m)**	
	(MW)	(at 230 ft. ǀ 70m)	(mph ǀ m/s)	Hub Height	Rotor Diameter
Residential	Less than .015	Fair (3) (at 100 ft. ǀ 30m)	13+ ǀ 6.0+	30 to 140ǀ 10 to 40	10 to 30 ǀ 3 to 10
Metered (Urban / Commercial)	.3 to 1	Good (4)	16+ ǀ 7.2+	200 to 300 ǀ 60 to 90	100 to 250 ǀ 30 to 75
Community	1 to 2	Good (4)	16+ ǀ 7.2+	250 to 300 ǀ 75 to 90	200 to 300 ǀ 60 to 90
Utility	1.5 to 2.5	Excellent (5)	17+ ǀ 7.6+	250 to 330 ǀ 75 to 100	230 to 330 ǀ 70 to 100
Off-shore	Up to 3.6	Excellent (5)	17+ ǀ 7.6+	Up to 330 ǀ 100	Up to 365 ǀ 110

Source: Combined by SLO RESCO from turbine literature for leading manufacturers

5.3.11 Residential

Residential scale wind can take several forms. Technologies that attach to the building can include both roof mounted and building integrated wind turbines. According to Paul Gipe, a California wind expert, these sorts of wind generators are generally considered ineffective, uneconomical, and sometimes dangerous. Tower mounted wind turbines with proper siting are preferred for residential scale wind. For safety reasons, this size of wind turbine, referred to as mini or micro, are best suited for very low density residential or rural residential zones.

Although smaller wind turbines require a smaller wind resource, small-scale wind development may create higher risk for a homeowner or project developer. Due to the cost of tower mounted anemometric wind studies, residential scale projects normally use less than perfect wind data to assess a resource and more often rely on personal experience and local whether monitoring stations.

5.3.12 Metered (Urban / Commercial)

Metered urban or commercial scale wind development often involves medium sized wind turbines between 300 kW and 1.5MW. Turbines at this scale may be installed by local governments or businesses at developed and grid connected sites that have a wind resource, significant electrical demand and available space. Excess energy that isn't used "behind" the meter can be sold back to the power utility in states—such as California— with net-metering policies.

5.3.13 Community Scale

Community scale wind development is characterized by individual or small clusters of wind turbines in the vicinity of urban, suburban and rural communities. These sites, similar to utility scale wind projects, have their own meters and grid connection equipment. They also require consideration of zoning, finance, and other factors. Community scale wind projects are considered to be distributed renewable energy systems.

5.3.14 Utility Scale

Large wind farms designed to contribute significant capacity to the central grid are normally considered to operate at the utility scale. Utility Scale wind developments most often take place where the wind resource is greatest. Sometimes, the greatest wind resource potential is located in highly remote areas far from the large energy-use centers. This creates the possibility for both significant benefits and challenges. While wind energy potential and inexpensive, easily developable land in these areas is abundant, the remoteness of the locations require costly and sometimes highly political transmission infrastructure to be built in order to connect the energy from where it is generated to the far off areas where the energy will be used.

5.3.15 Off-Shore

Developing wind resources offshore also has significant benefits and challenges. The vast, smooth, unobstructed ocean surface offers the potential to generate huge amounts of energy. However, the ocean is a harsh corrosive environment that imposes additional design constraints, costs, and risks when installing and maintaining large mechanical structures such as wind turbines. Water depth is the current major factor limiting the development of ocean wind resources.

5.3.16 Local Resource Potential

5.3.16.1 Local Wind Patterns

In San Luis Obispo County, prevailing winds throughout the year come from the West-Northwest. Local wind patterns overlay onto prevailing winds. Geographic features such as mountains and large bodies of water have significant impact on local wind behavior caused by the uneven cyclical heating and cooling of these features. In the daytime the land mass warms more quickly than the ocean does. The warm air rises over the land causing a breeze to blow inland. In the evening as the land cools faster than the ocean, the warmer air over the ocean continues to rise causing a breeze to blow out to sea.

There are also special local winds that often effect seasonal wind patterns. In Southern San Luis Obispo County, the Sundowner winds blow warm fast moving air from the eastern Sierras to the Pacific Ocean. A link to other local winds is available in the resources section below.

Based upon initial evaluations of meso- and micro-scale wind models of San Luis Obispo County provided by the California Energy Commission, there appear to be wind resource pockets scattered throughout the County with sufficient wind for generating electric power. However, there are environmental and geographic constraints to development of this resource, mainly difficult and steep access. There is evidence of good wind strength offshore in waters that are too deep for development today. New technologies may open up the possibility to tap this resource in the future.

5.3.16.2 Existing Wind Generation

There are currently two wind turbines installed in San Luis Obispo County, described in Figure 46. These turbines were documented by a California Energy Commission report and have not been physically verified. Based on the report, the turbines are small residential scale with a generating capacity of less than 100 kW each. Interestingly, the map within which these turbines are identified indicates that there is a useable wind resource area of between 11 and 14 mph (5 – 6.3 m/s) at the site of turbine 1. This resource area is not shown by any of the CEC AWS Truewind wind speed datasets. This finding may call for additional resource investigation and verification of maps made from modeled wind speed data using local measurement stations.

Figure 46: San Luis Obispo County Existing Wind Turbines

San Luis Obispo County Existing Wind Turbines				
Turbine Number	**Location**	**Scale**	**Generating Capacity**	**Verified**
1	Los Osos Valley Rd.	Residential	< 100 kW	No
2	Near Grover Beach coast	Residential	< 100 kW	No

Source: CEC WPRS00-01

5.3.16.3 Offshore Potential

Compared to other areas along the California Coast, San Luis Obispo has a relatively low wind resource potential in the near-offshore region (within 12 nautical miles of the shore.) From analysis of CEC statewide wind power maps, there may be higher wind potential further off shore, but there is a gap in the data that needs to be better understood.

The offshore wind map in Figure 52 offers additional information. In this map, the western coast has three distinct gaps, either in the data or in the resource. Unfortunately, San Luis Obispo County is contained within the second of these three gaps. This data is consistent with the California Energy Commission 30, 70, and 100 meter wind speed maps, which show only up to Class 4 wind potential at any height up to 15 miles offshore. However, like the CEC wind speed maps, there may be a data gap that needs further investigation. Even if a developable wind resource exists near offshore, water depth off the coast is so great that current technology would prohibit the resource development.

It is important to note that offshore wind technology is currently being developed and tested that allows for deep water turbine installation using floating platforms that are tethered to the ocean floor. According to the leading developer of this technology, these turbines could be installed in water depths ranging from 400 ft. to nearly 2400 feet.

5.3.16.4 Land-Based Potential

Based upon analysis of wind map data for areas with Class 3 and above, San Luis Obispo County has a wind resource potential of 150MW, assuming use of the standard turbine described in the methodology section. After considering developmental constraints, San Luis Obispo County may have a developable land-based wind resource potential of less than 30MW.

Maps below offer insight into resource locations, developmental constraints, and methodology. For clarity, the maps only include Class 3 and greater wind resources which are capable of development using conventional technologies. A Class 3 wind may be suited for small or residential scale wind turbines while Class 4 and above may be suitable for larger turbines. Analysis of wind speeds at 30, 70, and 100 meters shows that wind classification is generally consistent over these elevations. It can be seen in Figure 47 that Good (4) to Outstanding (6) wind resources are found in small pockets in the west-central, northwest and south-central portions of the County. Wind speeds at the lower 30 meter elevation suited for residential scale wind development would normally be expected. Surprisingly, this is generally not the case.

Figure 47 describes the wind resource site locations, identified wind classes, and potential capacity* throughout the County. The potential power capacity shown here is based solely on the availability of a wind resource and does not consider constraints on development.

Figure 47: San Luis Obispo County Wind Resource Sites

Site Number	**Site Name**	**Site Description**	**Wind Classes Identified at 230 ft. | 70m**
1	San Luis Obispo City South-East	Resource located on a ridge east of the intersection of Orcutt Rd. and Johnson Rd. in San Luis Obispo	3,4,5,6

Site Number	Site Name	Site Description	Wind Classes Identified at 230 ft. | 70m
		City.	
2	West Cuesta Ridge TV Towers	Resource located along West Cuesta ridge off of TV Tower Road.	3,4
3	La Panza Range	Resource located in South Eastern San Luis Obispo County along the La Panza Range.	3,4,5,6
4	Diablo Canyon	Resource located on hillsides in the near vicinity of Diablo Canyon Nuclear Power Plant.	3,4
5	Hearst Castle	Resource located East of Hearst Caste .5 miles West of the Rocky Butte Truck Trail.	3,4,5
6	Santa Lucia Wilderness	Resource located West of the Hi Mountain Lookout in the Santa Lucia Wilderness.	3,4,5,6

Source: SLO RESCO

Figure 48 characterizes each wind resource site based on initial analysis of road access, transmission access, coverage by an exclusion area, and visibility. Unfortunately, a majority of San Luis Obispo County's wind capacity faces a variety of development constraints.

Figure 48: San Luis Obispo Wind Resource Sites with Developmental Constraints

Site Number	Site Name	Road Access	Transmission Access	Exclusion Areas	Visibility
1	San Luis Obispo City South-East	Yes	Yes	Slope > 20%	High
2	West Cuesta Ridge TV	Uncertain	Yes	Enviro Yellow, Slope > 20%	High

Site Number	Site Name	Road Access	Transmission Access	Exclusion Areas	Visibility
	Towers				
3	La Panza Range	No	Yes	Enviro Black, Slope > 20%	Low
4	Diablo Canyon	Uncertain	Yes	Slope > 20%	Moderate
5	Hearst Castle	Uncertain	No	Slope > 20%	Moderate
6	Santa Lucia Wilderness	Uncertain	Yes	Enviro Black, Enviro Yellow, Slope > 20%	Moderate

Source: SLO RESCO

5.3.16.5 Local Resource Summary

Potential energy capacity was adjusted downwards from the capacity potential listed in figure Figure 47 based on the evaluation of each site's development constraints listed in Figure 48, and taking into consideration various factors described in the 'Investigation Process and Methodology' section below. It was determined that there is the technical resource potential to provide approximately 8.9 percent of the county's electricity requirements with utility-scale wind turbines, as can be seen in the table below:

Figure 49: San Luis Obispo County Utility Scale Wind Technical Potential

	Capacity	MWh	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Wind (24% Average Capacity Factor)	30	61,000	3.2%	15,982
Wind (15% Average Capacity Factor)	82	107,000	5.7%	28,034
Total	112	168,000	8.9%	44,016

Results are presented by separating the potential into two classes of average capacity factor. Sites 2 and 4 on West Cuesta Ridge and near Diablo Canyon respectively may have the potential to develop up to 24 MW of wind capacity. Ultimately each site will require further investigation to determine actual developable capacity. Additionally, with further investigation it may be possible to develop up to roughly 200 kW of residential scale wind throughout the County. At the community scale, specifically at site 1 near the south-east side of San Luis Obispo City, it may be possible to develop up to 3MW of wind.

5.3.17 Maps and Charts

Figure 50 describes wind resource potential based on the 70m elevation annual average wind speed data layer provided by the California Energy Commission. The legend provides wind speed ranges in miles per hour along with their associated wind Class number and descriptor. Within the map, the brighter colors (look closely) represent increasing wind resource potential ranging from blue to red to green. Figure 50 has been updated from the original map to now reflect both wind resource potential and the resource zones described further below.

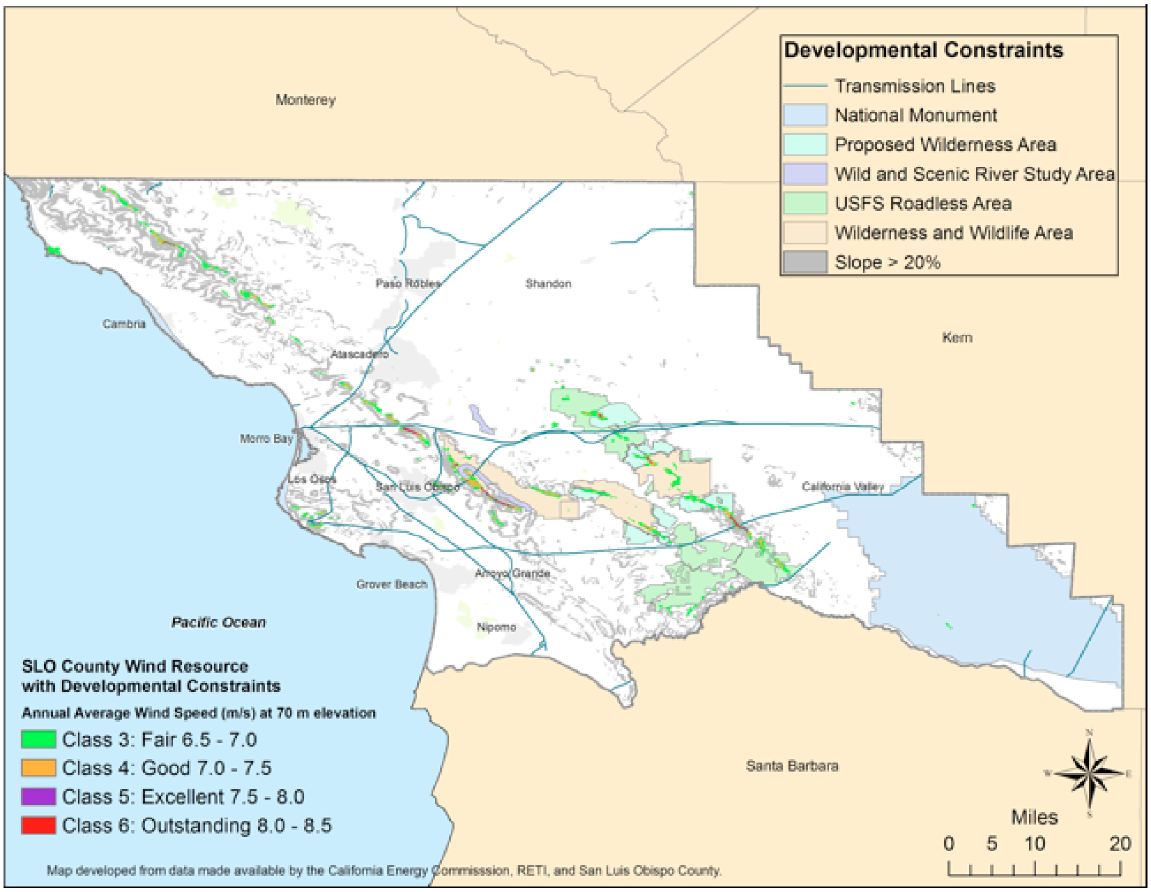
Figure 50: San Luis Obispo County Wind Resources Map

Source: SLO RESCO

Figure 50, the "pockets" of wind resource have been organized into discrete sites to simplify reference and resource characterization. The site's number relates to entries in Figure 47 and Figure 48 above.

The map in Figure 51 defines all of the areas within the County that would be excluded from wind resource development due to slope and environmental black zone constraints. The key explains the variety of developmental constraint criteria that have been applied. Additionally, it shows the relationship between identified resource sites, exclusion areas, and existing transmission infrastructure. This map was created using RETI Phase 1B western United States exclusion area data layers, the CEC 70 meter annual wind resource layer and San Luis Obispo County Transmission and base layers.

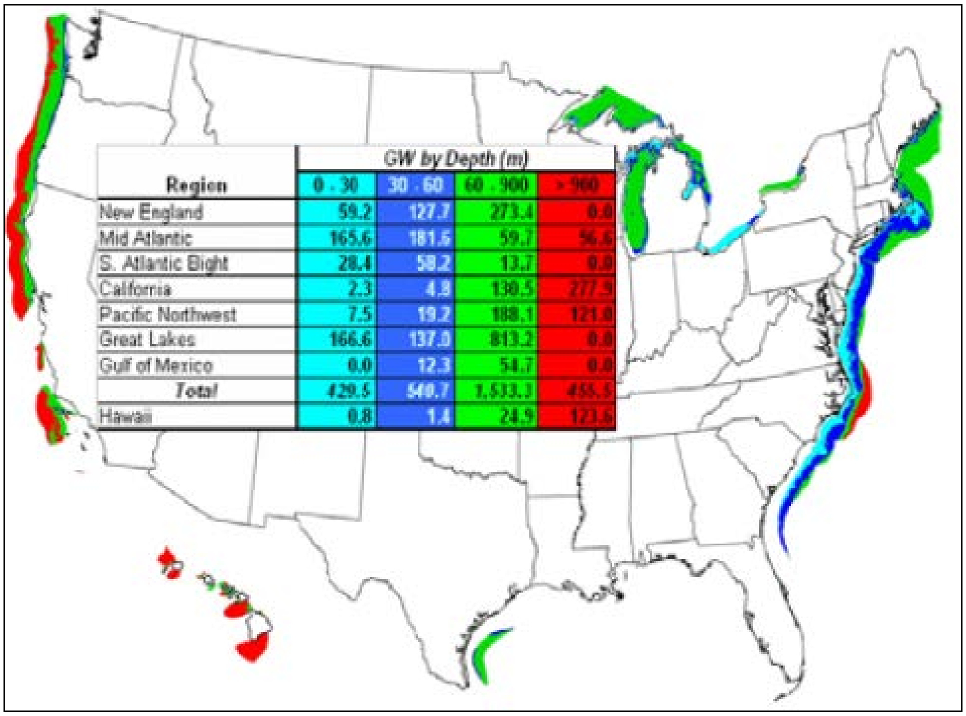
Figure 51: San Luis Obispo County Wind Resource Map with Developmental Constraints



Source: SLO RESCO

The offshore wind resource map below, Figure 52, was included as part of a 2009 report by the U.S. Offshore Wind Collaborative (refer to Offshore). It describes Class 5 and above wind potential by depth along the U.S coastline.

Figure 52: United States Offshore Wind Resource Map - Class 5 and Greater by Depth



Source: USOWC

5.3.18 Investigation Process and Methodology

5.3.18.1 Aggregation of relevant data, maps and literature

Government

The CEC, RETI, and NREL are all very good sources for macro scale wind resource maps, exclusion area layers, and detailed resource potential layers. San Luis Obispo County and other RESCO partners provided a wealth of local GIS data layers including political boundaries, natural features, high resolution aerial photography, and terrain data.

Private

Private companies, such as AWS Truewind, offer high quality wind data products. However, their most current higher resolution wind data products must be purchased. As a point of reference, the wind product for a resource map the size of San Luis Obispo County from AWS costs about $3,000. This data was not acquired for the analysis. However, the CEC offer local governments access to 2006 seasonal and annual wind GIS data layers at a variety of appropriate heights from AWS Truewind at no cost. These GIS layers have been valuable in providing additional site-specific detail of the County's wind resource.

Local

Local wind data is available through a variety of air quality (APCD), meteorological (NOAA), and co-op weather stations throughout San Luis Obispo County. These stations usually measure wind data 30 feet (10m) above the ground. They offer the opportunity to identify additional wind resources and also help to validate the resource wind models using actual local wind data.

5.3.18.2 Identification of Wind Resource Areas

Understanding the Methodology behind Datasets

Once resource data has been collected, in order to evaluate this data and its limitations, it is important to understand the methodologies used to create it. For example, the CEC and NREL resource maps and GIS layers were created using AWS Truewind's meso/micro scale modeling technique. This technique uses computer models that incorporate meteorological and local wind data, fluid dynamics, and terrain models to estimate wind speed or power potential at a usable resolution over large areas without the need for widespread wind anemometry. The standard error of the AWS Truewind mean wind speed is less than 0.8 mph. The standard error applies to 68 percent of the mapped area. However, the error may increase depending on terrain complexity, surface conditions, and the quality of the wind-monitoring stations.

Defining a Usable Resource

The current capabilities of technology require at least Class 4 wind at 50m and above to be considered a commercially developable resource. Class 3 wind was also included in this study to account for smaller, potentially developable wind resources at lower elevations.

Resource Site Identification

Specific locations of usable wind potential are identified using graphical information systems (GIS) tools and data collected from the variety of different sources above. The CEC wind speed data layers are classified using the wind speed ranges defined by the Battelle Wind Resource Classification system also described above. Unusable resource classes are excluded while the usable resource classes are color coded to assist resource analysis. Discrete resource sites are then identified and labeled in preparation for the specific site analysis.

5.3.18.3 Specific Resource Site Analysis

Analyzing Site Potential

Having defined sites with usable wind resource, a methodology is required to systematically evaluate site potential. This is initially calculated based off of the raw resource without consideration of possible developmental constraints. The methodology employed involves determining a reasonable packing density using a standardized turbine design. In this case, the General Electric GE1.5a, a 1.5MW turbine described in the Turbine Packing Density section above was selected. This turbine design has a 230ft (70m) rotor diameter and 210ft (65m) hub height. Since the wind maps used for analysis contained 650ft x 650ft resolution blocks, a single turbine could be placed safely at the intersection of four blocks.

To approximate the number of turbines, and thus potential generation capacity that could be installed in an area, the number of usable wind resource blocks at a site were counted and divided by four (the number of blocks per turbine.) To determine generating potential, the number of possible turbines at each site is multiplied by the rated power of the standard turbine, in this case 1.5MW. This method results in a reasonable description of potential generating capacity for each resource site.

It is not implied that 1.5MW turbines are the optimal size turbines for each site. This size and methodology was simply used to approximate potential capacity in a consistent way. Different sized turbines which may be better suited for each site would affect possible packing densities and generating capacity.

Developmental Constraints

The next step for analysis of wind site potential is to overlay the RETI exclusion GIS layers onto the wind resource to determine how much of the resource is undevelopable, and for what reason. It is important to understand the types of exclusions and the methodology used to determine the exclusion zones in order to minimize the excluded resources. In the case of San Luis Obispo County, steep slopes and several environmental black zones are significant exclusion types affecting wind resource development.

Access to transmission infrastructure, road access, and visibility are other potential development constraints needing analysis which were not covered by the RETI exclusion layers. Basic transmission infrastructure layers provided by San Luis Obispo County were used for the initial evaluation. The CEC has more detailed transmission maps that should help refine this aspect of the analysis. Google Earth was used to investigate road access, terrain, and area visibility from nearby roads and urban areas.

Adjusted Site Potential

Sites with useable wind resource blocks that had not been excluded were reevaluated using the site potential analysis criteria described above.

5.3.19 Next Steps

5.3.19.1 Include Red Military Flight Path Exclusion Areas in Site Analysis

Adding the Red Military Flight path exclusion areas may affect potential wind resource development. This task involves contacting RETI to acquire the GIS layer. Then potential wind resource sites should be reevaluated to determine if they have been affected by the additional exclusion areas.

5.3.19.2 Conduct Detailed Site Characterization and Evaluation

Site characterization up to this point has been preliminary. Additional research on turbine transportation and installation processes should be carried out. Additional site evaluation criteria must be developed and applied to each potential wind resource site. Recommendations for how to maximize potential wind development based on findings should be developed.

5.3.19.3 Conduct Seasonal Wind Data Analysis

Seasonal wind speed data was provided by the California Energy Commission. This data will be used to evaluate the effect of seasonal changes on the identified wind resource sites.

Findings from this investigation could affect the potential capacity factor for wind resource sites.

5.3.19.4 Verify Wind Models and Conduct Additional Site Identification from Local Wind Data Analysis

Local wind data should be collected from a variety of different local sources to help verify the findings from using the meso / micro scale wind speed datasets. It will also be used to find additional potential sites for development that may have been missed by the wind models.

5.3.19.5 Further Investigate Offshore Water Depths and Wind Potential

Gaps in the offshore wind data should be evaluated, and either the federal, state or local government may decide that it is worthwhile to measure this resource. Evaluation of potential for future use of this resource should be pursued, including contacting companies that are developing new technologies.

5.3.20 References and Resources

5.3.20.1 References

- **AWEA 4th quarter 2011 Public Market Report**
  American Wind Energy Association
  http://www.awea.org/learnabout/publications/reports/upload/4Q-2011-AWEA-Public-Market-Report-2.pdf
- **AWST Mesomap System Description**
  AWSTruewind
  http://navigator.awstruewind.com/support_faq.cfm
- **Enercon E-126**
  Enercon
  http://www.enercon.de/de-de/66.htm
- **Wind Energy Basics**
  Gipe, Paul. Chelsea Green Publishing Company, 2009
- **Renewable and efficient electric power systems**
  Masters, Gilbert. Wiley-IEEE Press, 2004
- **Permitting Setback Requirements for Wind Turbines in California**
  CEC-500-2005-184. California Energy Commission, 2006
  http://www.energy.ca.gov/2005publications/CEC-500-2005-184/CEC-500-2005-184.PDF
- **Phase 1B Final Report RETI-1000-2008-003-F**
  Renewable Energy Transmission Initiative, 2009
  http://www.energy.ca.gov/2008publications/RETI-1000-2008-003/RETI-1000-2008-003-F.PDF
- **U.S. Offshore Wind Energy: A Path Forward**

US Offshore Wind Collaborative, 2009

http://www.usowc.org/pdfs/PathForwardfinal.pdf

5.3.20.2 Resources

Sources for Wind Data and Resources

Federal

- National Renewable Energy Laboratory (NREL)
  http://www.nrel.gov
  - 50 Meter Elevation Wind Resource Maps
  - Western US Wind Integration Dataset
- US Offshore Wind Collaborative
  http://www.usowc.org
- National Oceanic and Atmospheric Administration (NOAA)
  http://www.noaa.gov
  - Surface Weather Data

State

- California Energy Commission (CEC)
  http://www.energy.ca.gov/wind/
  - 50 Meter Elevation Wind Power Map
  - 100 Meter Elevation Wind Speed Map
  - AWS Truewind 2006 200 Meter Resolution GIS Dataset
    - 30, 70, 100 meter wind speed data
    - Seasonal wind speed data
- Renewable Energy Transmission Initiative (RETI)
  http://www.energy.ca.gov/reti/
  - Wind Exclusion Areas GIS Dataset
  - PV substation GIS Dataset
  - Potential Wind Project GIS Dataset
  - Additional RETI GIS Datasets

Local

- San Luis Obispo County Air Pollution Control District (SLOAPCD)
  http://www.slocleanair.org
- Local Weather Station Data
  San Luis Obispo Co-op Weather Stations
  Weatherunderground.com

Private

- AWS Truewind
  - WindNavigator Tool at awstruewind.com
  - 200 Meter Resolution Wind Dataset

- Contact: Anna Caban 518.213.0044 x 1053 acaban@awstruewind.com

Online resources for wind data

- List of local winds -- Wikipedia
  http://en.wikipedia.org/wiki/List_of_local_winds
- Prevailing Wind Direction
  http://www.wrcc.dri.edu/htmlfiles/westwinddir.html#CALIFORNIA

Other Online Resources

- Danish Wind Energy Association Guided Tour
  http://www.talentfactory.dk/en/tour.htm
- Windustry.org
- Wind-works.org by Wind expert Paul Gipe
- American Wind Energy Association
  http://www.awea.org

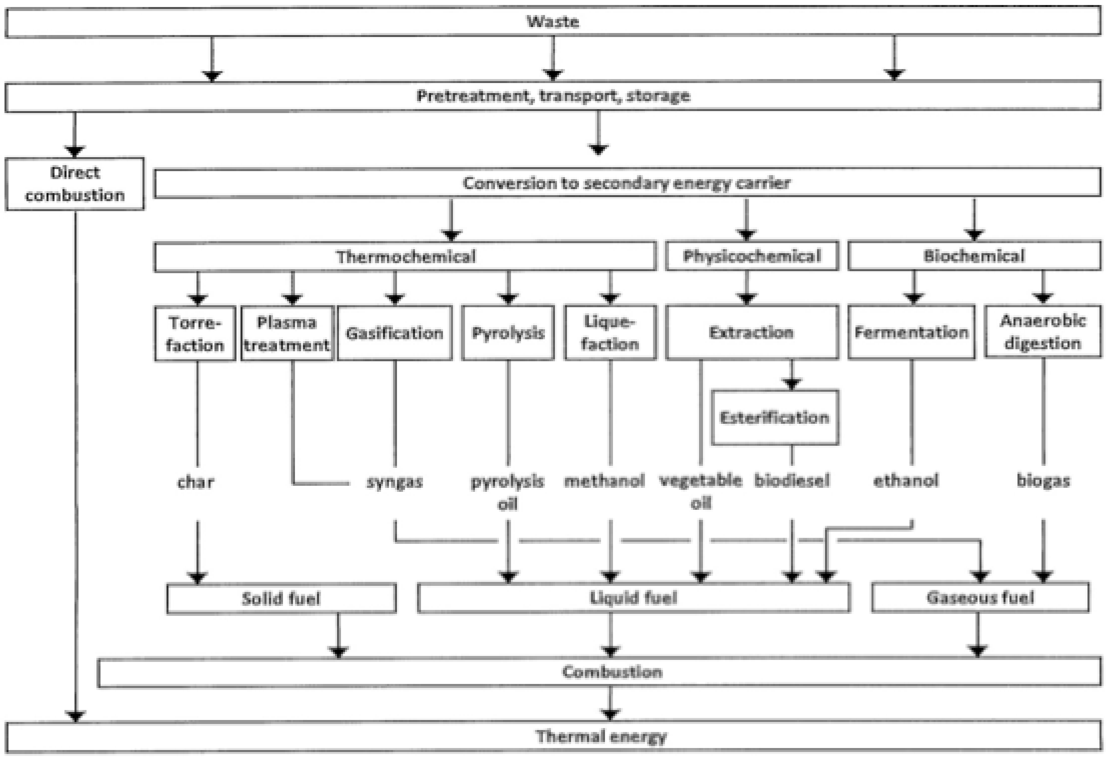
5.4 Renewable Energy: Biofuels

5.4.1 Characterization of Biomass Resource

Life on earth has survived because it long ago solved the problem of how to store solar energy. Plant cells contain small factory-like chloroplasts that conduct photosynthesis, using solar energy to bind carbon dioxide and water in order to manufacture a range of compounds. These compounds include sugars, starches and cellulose – collectively called carbohydrates. Solar energy is stored in the chemical bonds of these and other organic substances. This stored energy is passed on to animals when they eat plants (or eat other animals); thus, plants, animals and even their waste function as a sort of natural battery for storing solar energy.

Biomass is a general term for living material – plants, animals, fungi, bacteria etc. Solid, liquid, or gas fuels directly made or derived from biomass are called *biofuels*, all of which can be stored and used on demand to provide controllable energy, unlike wind and solar power that have the problem of intermittency. Today, biomass resources are widely used to generate electricity and power, and to produce liquid transportation fuels, such as ethanol and biodiesel. Recent technological advances have shown that biomass energy can be captured efficiently and has great potential to reduce pollution and revitalize local economies. The figure below depicts various waste to energy and waste to liquid conversion technologies and processes:

Figure 53: Waste to Energy and Waste to Liquid Conversion Technologies and Processes



Source: Zhen Fang, et al. *Biofuels - Economy, Environment and Sustainability* (2013), originally from Anouk Bosmans.

5.4.2 Sources of Biomass

While biomass can be found from many different sources, they are considered here in three categories: waste, dedicated energy crops, and ocean resources. Forestry and agriculture residuals, as well as municipal solid wastes (MSW), sewage, and landfill gas, can be used sustainably if proper practices are followed. Furthermore, plants grown for energy can be produced in large quantities, just like food crops. However, biofuels that don't displace food crops, that require minimal water, that take less energy to produce than they contain, and that have high yield per acre, are generally superior from an environmental perspective. It is also more efficient to use locally available biofuels due to the energy required for transporting them. The best approach to producing biofuels varies from region to region according to climate, soils, geography, and population.

Waste

One of the cheapest and most available sources of biofuel is to convert a portion of our waste into energy. This fuel is commonly used either by burning solid biomass or by capturing methane gas emitted from solid or liquid waste.

Forestry: Forestry wastes, in the form of pulping liquor, sawdust, and shavings, are the largest source of biofuel heat and electricity today. They are used predominantly by lumber, pulp, and paper mills to power their factories in Combined Heat and Power (CHP) facilities. CHP, is the practice of producing both electricity and useful heat to improve industrial efficiency. Another large source of wood waste is treetops and branches normally left behind in the forest after timber-harvesting operations. Some of these must be left behind to recycle necessary nutrients to the forest and to provide habitat for birds and mammals, but some could be collected for energy production.

Agriculture: As with the forestry industry, most crop residues are left in the field. Some should be left there to maintain cover against erosion and to recycle nutrients, but some could be collected for fuel. For example, some crop stover, leftover leaves and stalks from corn, sorghum or soybean plants after harvest may potentially be a source for cellulosic ethanol. Moreover, wastes such as whey from cheese, wastewater from wineries and breweries, and manure from livestock operations can also be used to produce energy while reducing disposal costs and pollution.

Municipal: People generate wastes in many forms that can potentially be used as fuel, including "urban wood waste" (such as leftover construction wood, street & park maintenance, and shipping pallets), the biodegradable portion of garbage (paper, food, leather, yard waste) and the methane gas given off by landfills when waste decomposes. Even our sewage can be used as energy.

Dedicated Energy Crops

Making better use of our waste is important, but only likely to make a relatively small contribution to our energy needs. In some cases biomass is grown specifically for energy production, primarily to produce liquid biofuels. While corn is currently the most widely used energy crop used to create ethanol, food-base biofuels have aroused some controversy. Corn ethanol is frequently processed using coal power, and can take about as much energy to produce as it yields. Corn is water intensive, depletes soil, and may be grown with intensive use of fertilizers and other chemicals that pollutes ground and surface water. Some people also believe that corn ethanol can increase food prices, though others have argued that this effect is less than what has been claimed.

Another important factor in growing fuel crops is the large amount of land that may be required. It is unlikely that we could replace more than a fraction of our current fossil fuel supply with biofuel, especially if they are grown using conventional crops. Increasing yields, as well as increasing the efficiency of our energy systems, are important tools for maximizing the benefit of biofuels. There are proposals to use the cellulose material in plants as a source of ethanol (see Biomass Figure 8). This would provide higher yield of fuel and not require using food crops for fuel. Furthermore, alternative biocrops of the future may be local perennials, which can be grown on marginal land. These crops tend to improve soil quality and wildlife habitats, and require less maintenance than do annual row crops, so they are cheaper, more sustainable, have also have high yields (see Union of Concerned Scientists).

Trees: Some fast growing trees make excellent energy crops, since they grow back repeatedly after being cut down near ground level, a feature called "coppicing". Coppicing trees, also called "short-rotation woody crops" can grow to 40 feet in less than 8 years and can be harvested for 10 to 20 years before replanting (see Union of Concerned Scientists). In cool, wet regions, varieties of poplar, maple, black locust, and willow are the best choice. In warmer areas, sycamore, sweetgum, and cottonwood are ideal, and eucalyptus is most effective in the warmest parts of California and Florida.

Grasses: Thin-stemmed, tall, perennial grasses used to blanket the Great Plains and parts of the South before the settlers replaced them with corn and beans. Switchgrass appears to be the most promising native bioenergy feedstock in the country; however other fast growing varieties such as miscanthus, big bluestem, reed, canarygrass, and wheat grass also have the potential to be profitable (see Union of Concerned Scientists). Thick-stemmed perennials like sugar cane and elephant grass can be grown in hot, wet climates like those of Florida and Hawaii.

Food Crops: Annuals commonly grown for food, such as corn, sorghum, and wheat, just to name a few, can be used to create bioenergy. Since these must be replanted every year, they require much closer management. Food crops also often use more water, fertilizers, pesticides, and energy. For these and other reasons, significant controversy surrounds the use of food crops for energy. There are a number of ways to address these challenges. For example, crops can be grown using organic methods; and crop rotation can reduce the need for fertilizer while protecting soils. Crops that are less water intensive, have higher energy yield per acre, and use renewable energy to supply process heat, improve the environmental profile of all crop fuels.

Oil Plants: Plants such as soybeans, rapeseed, sunflowers, oil palm, and peanuts produce oil, which can be used to make fuels. Unfortunately, like corn these crops are energy-intensive and may not be sustainable in the long term. However, a different type of oil crop with great promise for the future is algae. These tiny aquatic plants have high population growth rates and do not need to consume fresh water nor need to compete with food crops for land as they can be grown in either a pond or in the ocean.

Ocean Resource

Kelps along with all seaweeds are algae. The National Renewable Energy Laboratory (NREL) estimates that algae can produce up to 10,000 times more oil per acre then other biofuel crops (see Pond Scum)]. Most importantly, algae are oily. About half the mass of algae is fat which can be chemically converted into diesel, gasoline, and aviation fuels. A jet has already been flown using algae fuel. The Carbon Trust estimates that algae biofuels could displace 12 percent of annual global jet-fuel by 2030, if aggressively developed (see Pond Scum). The other half of the algae is a mixture of protein and sugars that can be used in many different products including animal feed, bio-plastics, and pharmaceuticals; or it could be burned to generate electricity from steam.

Biomass production at sea is a potential solution to the current biofuel battle over the use of cropland to produce fuel rather than food, as well as concerns about limits on freshwater resources. San Luis Obispo County has kelp forests off its coast, the most notable located in Cayucos. There are about 10,000 different kinds of "seaweeds" worldwide, divided into three main groups: red, green and brown (see Kelly). About 600-700 seaweeds can be found in California. Of the brown seaweeds about 20 of the largest are referred to as kelps; these are perennials that can live up to 7 years and grow to over 100 feet. Giant Kelp (Macrocystis) has become the dominant species on the central coast by out-competing other seaweeds for available sunlight. However, the environmental conditions in SLO County seem optimum for seaweed growth.

Ricardo Radulovich, a professor and director of the Sea Gardens Project at the University of Costa Rica, claims that if proper yields were met, the area needed to replace the world's fossil fuel use would require less than 3 percent of the world's oceans—equivalent to approximately 20 percent of the land currently being farmed (see Austin). Radulovich's also calculated the expected energy yield from a seaweed farm. A species of brown seaweed called Sargassum produced 49 tons of dry biomass per hectare (2.5 acres) with 2 percent recoverable oil content on a dry-weight basis. The Sargassum produces about 264 gallons of oil per hectare per year. After the oil is extracted, the seaweed biomass may be used to produce alcohol. Ethanol yield is expected at about 40 percent of the biomass yield on a dry-weight basis. About 53,000 gallons of ethanol per hectare per year can be obtained (see Austin). Even after ethanol production, a considerable amount of residue is left, which can be burned to generate electricity or used as fertilizer as it has been used for centuries.

5.4.2.1 Biofuel

Biomass can be used as or converted into a fuel in the form of solid, liquid or gas. Biomass contains significant water content, and must be dried in order to be used for direct combustion. The method of expressing moister content of biomass by dry weight after a standardized drying process is referred to as the *dry basis* measure. Fuel quantities are calculated according to weight after drying, in units called "Bone-Dry Tons" (BDT), with yield rates given annually (BDT/y). Gross energy content of a fuel is measured in British Thermal Units (BTUs) produced when a given quantity, conventionally per pound, of fuel is combusted. BTU/lb. is defined as the Higher Heating Value (HHV) when the entire water component of the fuel is in liquid form at the end of combustion, whereas Lower Heating Value (LHV) assumes a final vapor state. For historical reasons the U.S. generally calculates the efficiency of power plants based on the HHV, which varies with different biomass fuels as shown in the table below:

Table 13: Energy Content of Select Organic Materials

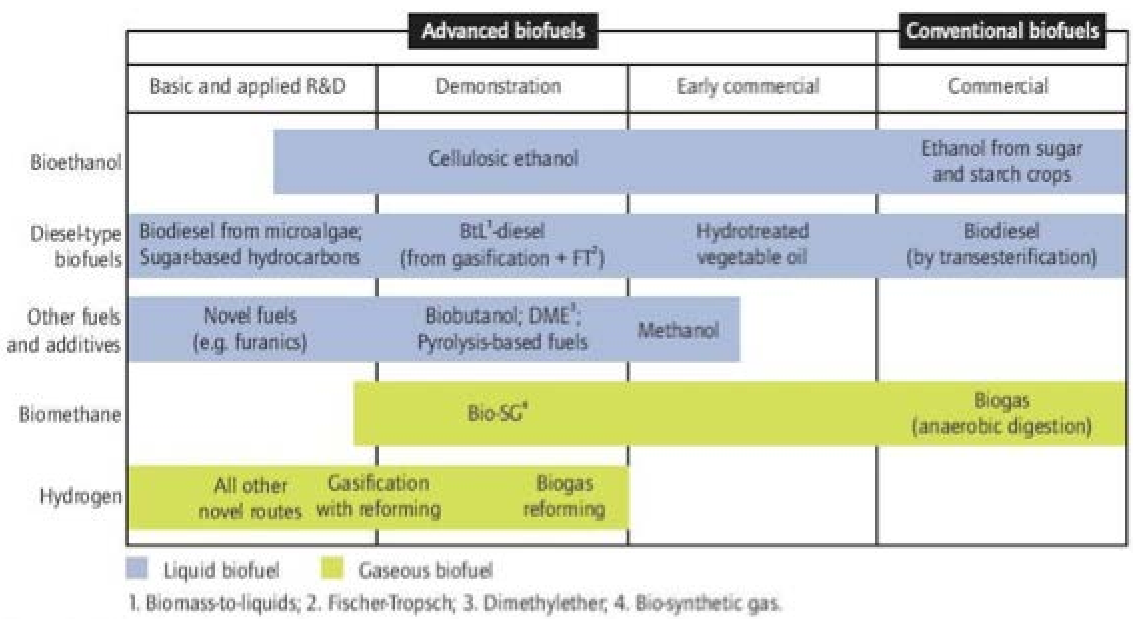
Biofuel Type	Higher Heating Value (BTU/lb., dry basis)
Majority of Orchard & Vineyard Crop Residuals	8597
Grape Residuals	8168
Corn Residuals	7587
Wheat Residuals	7527

Biofuel Type	Higher Heating Value (BTU/lb., dry basis)
Sorghum Residuals	6620
Potato Residuals	7738
Vegetable Crop Residuals	7738
Olive Processing Residuals	9195
Beef Cow Manure	7414
Horse Manure	6018
Forest Thinnings	9027
Paper/Cardboard Landfilled	7642
Food Waste Landfilled	6018
Dedicated Biomass Crops	8168

Source: SLO RESCO

Solid biomass can also be processed and converted into liquids such as ethanol or biodiesel, while decomposing organic materials will under certain conditions produce bio-methane, the same substance that is the main constituent of natural gas fossil fuel. The commercialization status of various solid and gaseous biofuels by production process is shown in the figure below:

Figure 54: Commercial Status of Solid and Gaseous Biofuels by Production Process



Source: OECD/EIA, modified from Bauen et al., 2009

Cellulosic ethanol produced biochemically or thermochemically has the potential to become a competitive energy resource, but currently is not a commercially-viable technology.

5.4.3 Local Resource Potential

Refer to section Site Specific Resources: Biomass Potential on page 256 for a detailed explanation of the technical resource potential for certain biomass end uses in San Luis Obispo based on extended research undertaken by the project. Biomass within the county has the technical resource potential to provide 14 percent of electrical energy demand and meet 18 percent of thermal energy demand (2020 consumption levels:

Table 14: San Luis Obispo Biomass Technical Potential (Electric)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Agricultural Residuals	10	-	-	72,000	3.8%	18,864
Forestry Residuals	16	-	-	118,000	6.3%	30,916
Municipal Waste	11	-	-	79,000	4.2%	20,698
Total	37	-	-	269,000	14.3%	70,478

Source: SLO RESCO

Table 15: San Luis Obispo Biomass Technical Potential (Thermal)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Agricultural Residuals	15	-	-	111,000	4.7%	29,082
Forestry Residuals	24	-	-	181,000	7.7%	47,422
Municipal Waste	17	3	22,338	123,000	5.3%	32,226
Total	56	3	22,338	415,000	17.7%	108,730

Source: SLO RESCO

In addition, a quantification of the energy potential that would result from dedicating 5 percent of agricultural land to dedicated biocrops is shown below:

Table 16: San Luis Obispo Dedicated Crop Biomass Representative Potential (Electric)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Biomass (Dedicated Crop)	49	-	-	364,000	19.4%	95,368

Source: SLO RESCO

Table 17: San Luis Obispo Dedicated Crop Biomass Representative Potential (Thermal)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Dedicated Crops	75	-	-	558,000	23.9%	146,196

Source: SLO RESCO

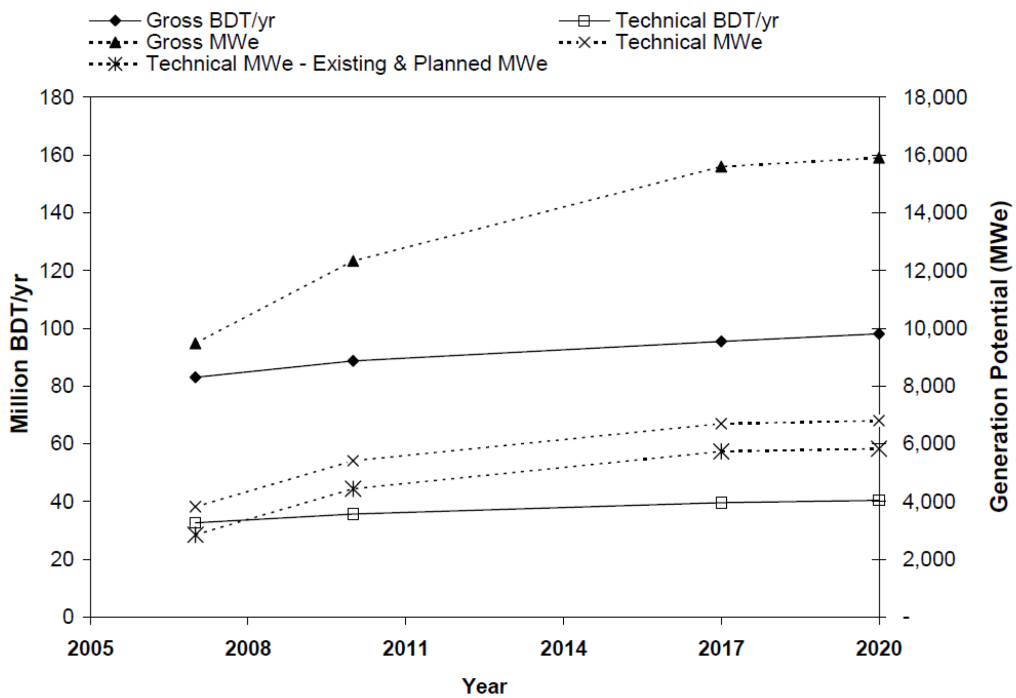
5.4.4 Maps and Charts

Figure 55: Estimated Total Biomass (gross BDT/yr.) in California (2007)

Source: California Energy Commission

Resource estimates were derived for agricultural (2007 NASS data) and forestry biomass (2004 CDFFP data), municipal wastes (primarily 2006 disposal data), and forecast future dedicated biomass crops. Biomass in the state totals 83 million gross Bone-Dry Tons per year (BDT/y) at present and is projected to increase to 98 million BDT/y by 2020. Biomass considered to be available on a technically sustainable basis totals 32 million BDT/y in 2007, increasing to 40 million BDT/y in 2020.

Figure 56: Resource and Generation Potentials from Biomass in California, 2007-2020



Source: California Energy Commission

Existing biomass and biogas power generation capacity in the state is (as of March 2013) 1,459.44 MW including solid-fueled combustion power plants and engines, boilers, and turbines operating on landfill gas, sewage digester gas, and biogas from animal manures.

5.4.5 Technologies and Applications

The simplest and most common way of extracting energy from biomass is by direct combustion. This is still how most biomass is put to use to generate energy in the United States and elsewhere. However, burning can be inefficient and polluting if not carefully controlled. An approach that may increase the use of biomass energy in the short term is co-firing in coal power plants, which can substitute up to 20 percent of the coal with biomass.

A number of less polluting non-combustion methods are available that convert raw biomass into gaseous and liquid fuels. This conversion can be done in three ways: thermochemically (through gasification and pyrolysis), biochemically (by means of anaerobic digestion and fermentation), or chemically (producing biodiesel).

5.4.5.1 Thermochemical

When plant matter is heated but not burned through gasification and pyrolysis, it breaks down into various gases, liquids, and solids. These products can then be further processed and refined into useful fuels such as methane and alcohol. Another approach is to take the hydrogen-rich fuels and run them through fuel cells, converting them into electricity and water, with few or no emissions.

Gasification is a process that exposes a solid fuel to high temperatures and limited oxygen to produce a gaseous fuel. One of the resultant gases is methane, which can be treated similar to natural gas, and used for the same purposes. Under suitable circumstance, the gaseous byproducts can also be used to produce syngas, a mixture of carbon monoxide and hydrogen. Syngas can be used to make almost any hydrocarbon, such as methane and methanol.

Pyrolysis is an old technology that involves heating the biomass to drive off volatile matter, leaving behind charcoal or 'biochar'. More sophisticated pyrolysis techniques have been developed recently to collect the volatiles that are otherwise lost to the system to produce a gas rich in hydrogen ad carbon monoxide. These compounds, if desired, can be synthesized into methane, methanol and other hydrocarbons.

5.4.5.2 Biochemical

Bacteria, yeasts, and enzymes also break down carbohydrates. Fermentation uses yeast and other microorganisms to change the sugar of various plants into alcohol, a combustible fuel. A similar process is used to turn sugar and corn into ethyl alcohol, or ethanol. More environmentally-friendly ethanol made from cellulosic feedstocks (non-edible parts of plants, wood, grasses, and MSW) is currently being developed and not yet commercially available.

Biomass digestion is a biological process in which biodegradable organic matters are broken-down by anaerobic (requiring an absence of oxygen) bacteria. When these microorganism feed on organic matter such as animal dung or human sewage in tanks (called digesters), a mixture of methane and carbon dioxide ('biogas') is produced. A related technique collects gas from landfill sites. Over a period of several decades, anaerobic bacteria steadily decompose the organic material in landfills and emit methane. The gas can be extracted and used by 'capping' a landfill site with an impervious layer of clay and then inserting perforated pipes that collect the gas and bring it to the surface. This method is often less efficient at capturing methane than using sealed digester tanks. In addition, landfills may contaminate the remaining solid organic materials and make them less useable for other purposes such as organic fertilizer. Water may be injected into the landfill to increase anaerobic bacteria activity and biogas production, but environmental concerns have been raised that the increased fugitive emissions (unintended gas leaks into the atmosphere) of biogas that result negates the greenhouse gas savings of the process. Utilizations of digester gas include:

- Generation of electric power using reciprocating engines, gas turbines, steam turbines, microturbine, and fuel cells;
- Medium-BTU gas uses;

- Injection into an existing natural gas pipeline after being upgraded into high-BTU gas;
- Conversion to other chemical forms, such as methanol, ammonia, or urea.

5.4.5.3 Chemical

Biomass oils, like soybean and canola oil, can be chemically converted by esterification into a liquid fuel similar to diesel fuel. Cooking oil from restaurants, for example, has been used to make biodiesel for cars and trucks. Biofuel produced from algae is a promising source of potential, as it may be produced in ocean or waste water is environmentally benign, and relatively fuel-dense on a per unit weight basis, but the processes to do so at scale are still in the research and development phase.

5.4.6 Investigation Process and Methodology

Supporting data was collected from several sources, such as the California Energy Commission, EPA, San Luis Obispo County Department of Agriculture, Scottish Association for Marine Science, and other academic and public documents listed in the References section below. Refer to section Site Specific Resources: Biomass Potential on page 256 for a detailed explanation of the methodology behind the gross resource and technical resource potential generation estimate for biomass in San Luis Obispo County, based on additional research undertaken by the project.

5.4.7 Next Steps

5.4.7.1 Site Specific Analyses

More detailed site specific analysis will be required for any proposed project than what was provided in the CEC assessment. The CEC recognized a number of limitations within their inventory data, which should be systematically investigated in the future with local organizations to provide more accurate data, calculations, and recommendations. Technical availability estimates are largely experiential and are often not supported by qualified field studies. Physical constraints and limitations associated with agricultural and municipal waste resources in particular need to be evaluated in more detail. The 'Site Specific Resources: Biomass Potential' section of this report summarizes certain end uses and assumptions that were further refined over the course of this project.

5.4.7.2 Yield Factors

Yield factors, used to calculate gross BDT/y for biomass from agricultural crops, have not been systematically updated for years, although data from commercial biomass fuel suppliers for commonly used crop residues exist. An effort to compile and update yield factors for agricultural crop biomass should be made.

5.4.7.3 Animal Manure Factors

Animal manure production estimates and biodegradability factors are based on national data standards developed from a wide range of sources. Comprehensive study of the California Polytechnic State University's micro-turbine operation with biogas from a covered dairy manure lagoon may better characterize production rates and material properties.

5.4.7.4 Food Processing Operation Factors

Food processing operations generate waste water and other waste streams that have not been fully characterized in the CEC assessment. Better characterizations of food and fiber processing wastes in SLO County would be important for local and regional biomass development and waste management efforts.

5.4.7.5 Transportation Fuel Estimates

The report considered biomass solely as a source of electricity and not as a potential source of transportation fuel. Future projects could help clarify this option.

5.4.8 References

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  http://www.energy.ca.gov/research/renewable/biomass/anaerobic_digestion/data.html
- **Landfill Gas-To-Energy Potential in California**
  California Energy Commission, September 2002
  http://www.energy.ca.gov/research/renewable/biomass/landfill/reports.html
- **A Roadmap for the Development of Biomass in California**
  California Energy Commission, November 2006

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- **Renewable Energy Cost of Generation Update**
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  California Energy Commission, March 2008
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  SB Community Environment Council, November 2007
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5.5 Renewable Energy: Ocean Power

5.5.1 Characterization of Ocean Wave Resource

Waves are created by the force of the wind blowing over many miles of water surface. However, waves are a far more concentrated form of energy than wind, primarily due to the fact that water is 832 times denser than air. In fact one can say that waves are concentrated wind energy. Unlike the wind, waves do not represent an actual flow of water, but a propagation of energy that goes through the water. As a wave moves through a body of water, the water rises and falls in a circular motion parallel to the direction of the wave's movement.

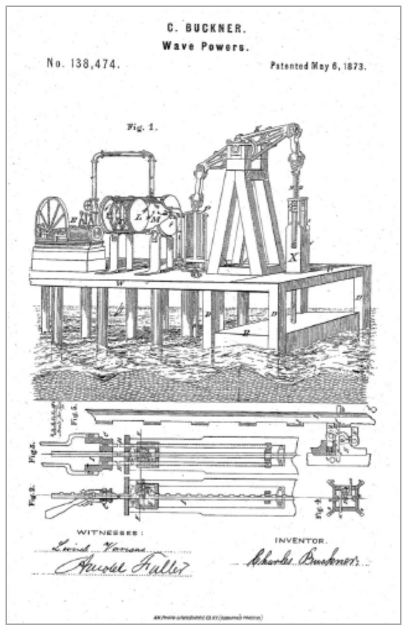
Water waves are defined by their height and frequency; higher waves will contain more energy, as will those with greater frequency. The average height of waves in a given location that are capable of producing power is called the "significant wave height". Locations with significant wave heights of less than less than 3 to 4 feet may be inadequate to produce enough power to be worthwhile using present technology, and the best waves for electric power generation range from 6 to 15 feet. Energy from a wave is proportional to the square of its height, so a wave 6 feet high will generate four times the energy of a three foot high wave.

Frequency is measured in seconds, which is also called the "power period". Waves might come in as frequently as every 5 or 6 seconds, or as far apart as 15 to 20 seconds. The power period is dependent on the distance between two waves, called the "wavelength", and the speed at which the wave is travelling, which in turn depends on the speed of the wind. As long as the wind is moving faster than the wave, the wind will continue to impart force and accelerate the wave.

The combination of significant wave height and power period can be used to calculate the available wave resource. This is measured in kilowatts per meter of wave front. Globally, wave resource can range from 5 to 10 kilowatts per meter on the low side, to over 70 kilowatts in some areas far off the western coast of North America, off the southern coasts of South America and Australia, and in the North Atlantic between the UK and Greenland. High storm waves—towering up to 30 feet— can carry a megawatt or more per meter of wavefront, equivalent to the electric power consumption of over 1000 homes.

While ocean waves vary over time, especially during different seasons, they tend to be more regular and predictable than the wind, particularly further out to sea. Areas with deeper water avoid various disturbances caused near coastlines. For these reasons, wave power can be a more reliable source of energy for electric generation than wind power.

Figure 57: 19th-Century Wave Power Machine



Source: Public Domain

5.5.2 Technologies and Applications

Ocean wave power, like other renewable energy sources, is a new technology with a long history. Wave energy conversion systems have been available for centuries, but wide use of the wave resource has not yet emerged. Several technologies have been under development for decades, with increasing commercialization projected by 2020.

The most advanced technology to date is the Pelamis Wave Converter, which was the first wave energy machine to sell power to the electric grid, and the first to achieve a scale of over 1 megawatt. The Pelamis units float on the ocean surface, and are anchored to the sea floor. They are composed of tubular segments joined together by flexible hinges that make a long snakelike device that undulates as the waves pass by. The rocking of the tubes causes a fluid to flow by gravity back and forth, and the device captures the force and flow of this fluid to generate electricity inside each segment. The electricity is sent out through a wire, and the power from multiple floating converters are gathered and delivered by cable to the shore.

The first Pelamis project was offshore at Agucadoura, Portugal. Four power units, each 450 feet long and rated at 750 kilowatts, were deployed to make a small 3 megawatt wave farm. Power was sold through a standardized, long-term contract, called a feed-in tariff, whereby the utility pays a generous guaranteed price of 25 cents Euro per kilowatt-hour for the electricity. The feed-in tariff reduces key risks that would otherwise make novel technologies like the Pelamis much more difficult to deploy. Due to financing and commercial problems, the Portuguese wave project was taken offline and is not operating today. The company indicates that they are planning to deploy a larger project at the same site in the future, and that other commercial projects are in the works.

At this point, the Pelamis is the only product with at least some commercial track record, and other devices would have to be categorized as either conceptual or experimental, although some wave technology developers claim that they are close to early commercial development. The challenges are quite large, since the machines have to stand up to the harsh conditions at sea that include corrosive salt, storms, moderate to violent waves, as well as repeated mechanical stress.

Figure 58: Pelamis Wave Converter, Portugal

Source: Pelamis

Wave technology is mainly designed to produce electricity, but some devices are specifically made to desalt sea water and make it fit for human uses. Wave machines can produce electricity and/or pressurized water to facilitate reverse osmosis which requires pumps to move water through very fine filtration systems that remove the salt and produce fresh water.

While commercial wave energy is at a very early stage, there are a number of companies and technology approaches.

Figure 59: Selected Wave Energy Technologies

Company	Product	Technology	Rated Power	Deployment
Pelamis Wave Power, Ltd.	Pelamis P 1-A	Jointed snakelike float with hydraulic fluid falling through turbines.	750 KW	2008, Agoucadoura, Portugal
Ocean Power	PB150	Float rises and falls on pillar with foundation on	150 KW	2010, Orkney Islands, Scotland

Company	Product	Technology	Rated Power	Deployment
Technologies	Power Buoy	ocean floor		& Reedsport, OR.
Finavera Renewables	AquaBuOY	Float pumps sea water through hose driving turbine.		Macah Bay, WA & Humboldt Bay, CA Projects dropped
AWS Ocean Energy		Archimedes Wave Swing, floater buoy on vertical cylinder compresses air; hydraulic pressure		Under development

Source: SLO RESCO

In addition to the technical challenges, wave energy also faces significant financial and regulatory hurdles. A few projects have been proposed for the West Coast of the United States. Finavera Renewables secured approval from the Federal Energy Regulatory Commission (FERC) to deploy its AquaBuOY in Macah Bay, Washington, and off the Northern California coast. PG&E signed a power purchase agreement with Finavera for its proposed 2 megawatt wave farm offshore from Humboldt County. This deal was rejected by the CPUC for not being economical.

5.5.3 Local Resource Potential

The west coast of California has good potential for developing ocean wave power, with two main resource areas. To the south of Point Conception the coast turns far toward the east, providing a measure of protection of the open ocean waves that come in from the west to northwest direction. The Channel Islands off the south coast further shield the coast. This results in a rather poor wave resource from Santa Barbara to Los Angeles and San Diego; to access better wave energy would require going quite far off the coast in this part of the state. Going north from Point Conception, the coast is directly exposed to the open ocean waves arriving primarily from the west to northwest, and the resource is good.

California Energy Commission data shows relatively level wave period of near 12 seconds along the entire coast of the state, but mean significant wave height increases from only about half a meter (1½ feet) near San Diego, to over 2 meters (7 feet) north of Point Conception. The power in the wavefront (called Mean Energy Flux Density), is about 7 kilowatts per meter of wavefront at San Diego, rapidly rising as one moves toward the north, and reaching about 27 kilowatts per meter by the time it reaches the ocean west of San Luis Obispo County.

A due north-south line offshore, the full length of the county, would run about 90 kilometers (56 miles). One practical limit to a wave capture technology might be the length of cables required to anchor the machines to the seafloor. If the edge of the continental shelf is considered the furthest boundary, rather than just the south county border, then the practical wave front might extend as far as 100 kilometers. Calculating the full energy potential of this wavefront line is partly a function of the direction from which the waves are moving. However, with the simplifying assumption that they generally come from the west, the total power equals:

27 kilowatts/meter x 1000 meters /kilometer x 100 kilometers = 2,700,000 kilowatts

This is equivalent to 2700 megawatts of average continuous power, though the actual amount of power will vary considerably over the course of a year. This amount of resource would never be fully available due to environmental and other practical limitations. In addition, practical wave conversion systems are far from 100 percent efficient. However, even taking all such factors into account, the amount of energy from the local waves would be more than enough to supply the county will electricity. The annual electricity consumption for San Luis Obispo County was 1.7 million megawatt-hours in 2007. This is equivalent to an average capacity of:

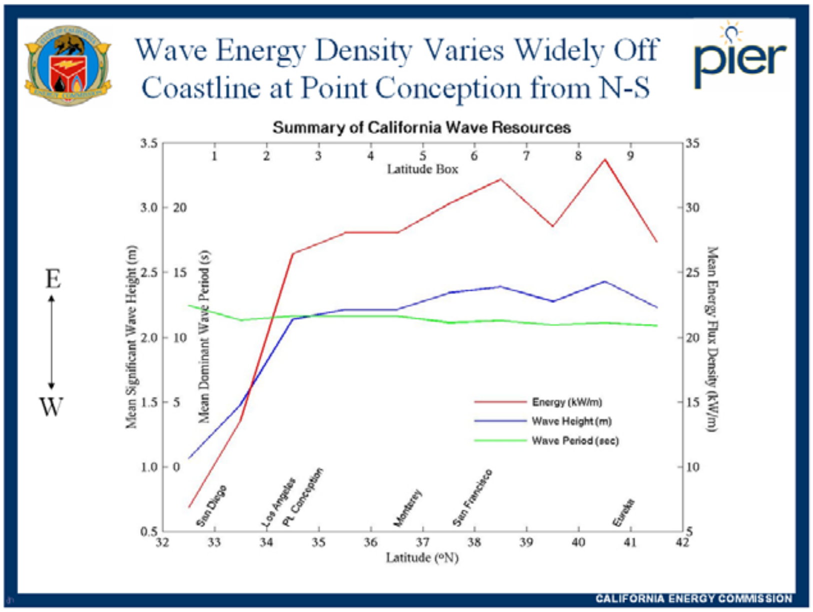
1,713,969 megawatt-hours / 8760 hours/year = 195.6 megawatts

In other words, the county consumes about 7 percent of the total available wave resource, equivalent to the energy delivered over 7 kilometers (about 4 miles) of wave front. However, an actual wave project would likely need to be much wider to capture this much power, due in part to the imperfect efficiency of wave energy conversion machines mentioned above, but also to the fact that space would be needed between them. One benefit of spacing between generators is that it limits the impact on the wave motions and shoreline. Estimates of practical limits to capturing wave energy run from 3 percent to 15 percent of the total potential, with the county's electricity demand falling toward the lower side of this range.

Two large power plants are located at the ocean shore, Diablo Canyon Nuclear Plant and Morro Bay natural gas power plant. Both of these have large substations with access to transmission. Diablo currently generates over 2000 megawatts of power, while Morro Bay has a capacity of over 1000 megawatts but has only been used intermittently during the summer when demand for electricity in California reaches a peak. The Morro Bay plant is slated for closure, primarily due to its cooling system that harms sea life. This will leave a major access point to the grid on the shoreline for marine energy resources.

5.5.4 Maps and Charts

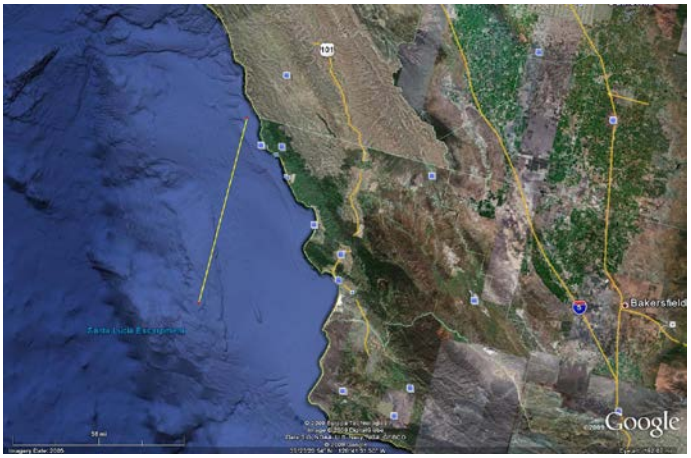
Figure 60: Wave Energy Density Varies Widely Off of Point Conception from N-S



Source: California Energy Commission

The chart above shows wave height in meters, wave period in seconds, and wave power in kilowatts per meter of wave-front. San Luis Obispo County, at about 35 degrees North latitude, has a wave resource averaging 27 kilowatts per meter. A section of water only 1 ½ inches wide has enough wave power passing though it to power a house continuously, if 100 percent of the energy in that width could be tapped.

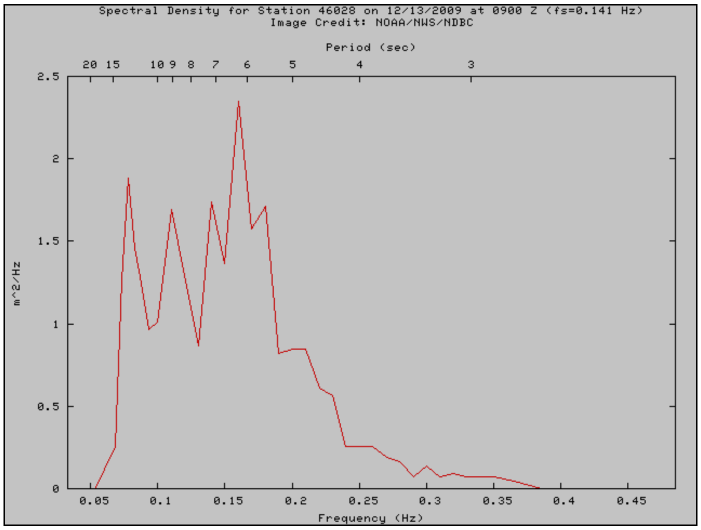
Figure 61: San Luis Obispo County Potential Wavefront



Source: SLO RESCO and Google Maps

The line on the map shows 62 miles (100 kilometers) of potential wavefront directly off the Coast of San Luis Obispo County. At 27 kilowatts per meter of wavefront, this line represents 2700 megawatts of total theoretical power resource. The resource is so large that only 7 percent of its energy would be sufficient to generate 100 percent of the County's electricity supply; this amount falls within the range of feasible capture.

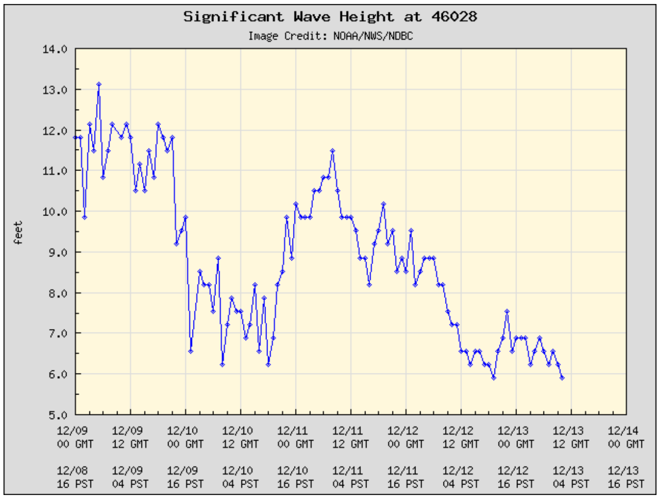
Figure 62: Buoy 56 Single Day Activity Distribution



Source: National Oceanic and Atmospheric Association (NOAA)

Figure 62 above shows the distribution of properties over the course of a day for waves from a buoy 56 nautical miles West-Northwest of Morro Bay. The scale on the top of the chart shows the wave period in seconds, while the bottom of the graph shows the frequency in Hertz, or wave cycles per second. The left, vertical scale shows the square of the wave height, which is how the power of a wave is determined. The larger, more powerful waves have a period ranging from 5 to 15 seconds. Figure 63 below shows significant wave height at the same buoy over 5 days, ranging from 6 to 13 feet. Both charts give a good idea of the variability of this resource; 12 foot waves have four times as much energy as six foot waves.

Figure 63: Buoy 56 5-day Activity Distribution



Source: NOAA

5.5.5 Investigation and Methodology

Offshore wave resource for San Luis Obispo County, California is determined using the map reference shown above that gives the three principle parameters of waves along the full length of California's shoreline. This is correlated to a map showing the available offshore area for placing wave farms. The most likely siting would be partly defined by the angle of approach of the normal wavefront. This needs to be determined.

5.5.6 Next Steps

Further research could involve the following:

- Offshore buoy data, results of other offshore wave potential studies, and potential limitations on siting.
- Plotting of resource with GIS system.
- Further examination of literature on technology & development potential, especially fraction of resource that is feasible to use.

5.5.7 References and Resources

5.5.7.1 References

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- **PG&E to ride the waves with Finavera**
  Ehrlich, David, Cleantech Group, 18 December 2007
  http://cleantech.com/news/2215/pg-e-to-ride-the-waves-with-finavera
- **Wave Energy Density**
  Image file, California Energy Commission
- **Map of the Ocean off San Luis Obispo County**
  Google Maps.
- **National Oceanic and Atmospheric Administration (NOAA), National Data Buoy Center**
  Data is from Station 46028 (LLNR 275)—Cape San Martin – 55NM West Northwest of Morro Bay, CA.; 35° 44' 29" N 121° 53' 3" W.
  http://www.ndbc.noaa.gov/station_page.php?station=46028

5.5.7.2 Resources

- **National Oceanic and Atmospheric Administration**
  National Data Buoy Center
  1007 Balch Blvd.

Stennis Space Center, MS 39529
228-688-2805
http://www.ndbc.noaa.gov

- **Ocean Renewable Energy Council (OREC)**
  12909 Scarlet Oak Drive, Darnestown, MD 20878.
  Sean O'Neill, President (301-869-3790)
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  http://www.oceanrenewable.com/
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  http://www.oceanpowertechnologies.com

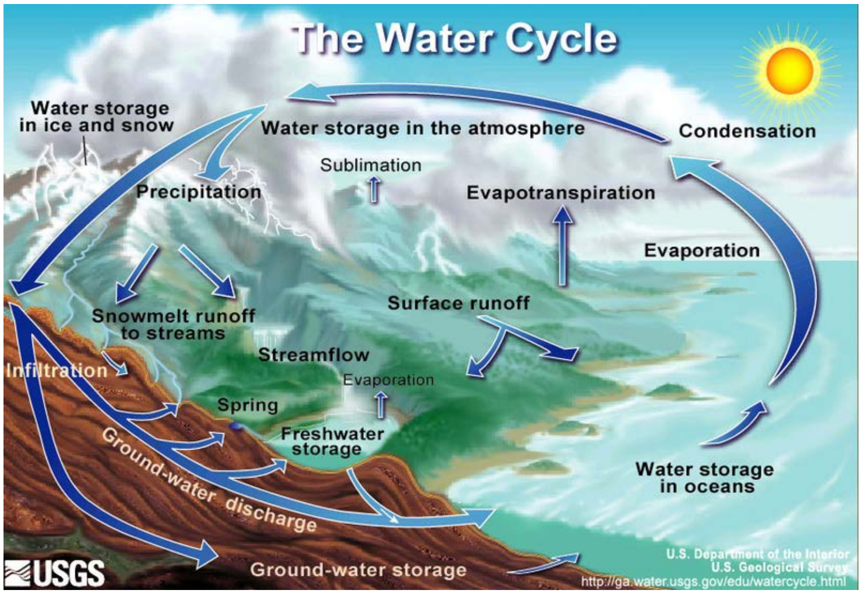
5.6 Renewable Energy: Hydropower

5.6.1 Characterization of Hydropower Resource

5.6.1.1 Water cycle

Water is recycled into many forms as it constantly moves around the globe. This movement of water between the atmosphere, the surface of the earth and the ground is called the hydrologic cycle or water cycle. The water cycle is driven by energy from the sun through numerous processes such as condensation, evaporation and precipitation. Water evaporates from oceans and lakes, condenses into clouds and then precipitates (falls) as rain and snow. Water then flows downhill returning back to oceans and lakes. Hydro Figure 1 illustrates the complex and ongoing process of the water cycle.

Figure 64: The Water Cycle



Source: USGS

5.6.1.2 Energy in water

Once water has fallen back to earth, the force of gravity drives surface water from a higher to a lower state of potential energy. As water moves downwards the gravitational potential energy of the water is converted to kinetic energy. The force of the water flowing downwards can be utilized in order to spin a turbine or water wheel. The amount of energy that can be obtained from a potential micro hydropower site is dependent on the distance the water falls and the volume of water available to do work. These factors are called head and flow respectively.

5.6.1.3 Head

The head is defined as the vertical distance that the water falls. This distance can be measured in feet or units of pressure (usually psi). For any type of hydropower system the gross head and net head have to be considered. The gross head is the change in vertical height between the intake pipe of the system and the water turbine. The net head takes into account losses of energy due to friction. In general, the higher the head, the more potential power the site will have and more economical the hydropower will be to develop. Potential hydropower sites are usually evaluated as either high or low head. High head is considered any change in height greater than 10 feet. Likewise, low head is considered any change in height less that 10 ft. Any change in height less than 2 feet makes hydropower impractical.

5.6.1.4 Flow

The flow is the volume of water over time moving through a hydro system. It is often measured in either cubic feet per second (cfs) or gallons per minute (gpm). There are several factors influencing the flow of a stream or river. The size of the watershed, meaning the number of streams at higher elevation feeding water into the river, has a big impact. Seasonal temperature variations also have a big impact. If it is a really long, dry summer or a cold, snowy winter, the different amounts of rain, snowpack or glacier melt will affect the flow downstream.

5.6.1.5 Power Potential Calculation

The United States Department of Energy (DOE) gives the following equation to calculate the potential power of a micro hydropower source. The equation is based on a system with 53 percent efficiency, which is considered standard for micro hydro systems. The equation uses the net head (feet) and the flow (gallons per minute) giving an answer in watts.

Figure 65: Hydropower Equation

$$Power = [Net\ head\ (ft) \times flow\ (gpm)] \div 10$$

Source: US DOE

5.6.1.6 Factors impacting regional hydropower potential

The most influential factor regarding hydropower is the annual precipitation. Areas with large amounts of precipitation will have larger flows and lots of potential sites to implement hydropower. The distribution of precipitation throughout the year must also be considered. Many areas such as San Luis Obispo receive the majority of their rainfall during only a few months out of the year. There may not be sufficient rain during dry months to make hydropower viable in some spots. Another vital factor is topography. In general mountainous areas are more likely to have ideal sites for hydropower because of steeper changes in elevation.

5.6.2 Local Resource Potential

San Luis Obispo County includes both coastal and inland segments of the Santa Lucia mountain range which crosses into nine major watersheds. This natural character creates a multitude of drainages with small creeks, streams, and a few rivers that have the potential for hydropower development. Additionally, San Luis Obispo County has a long history of water resource development with four large man-made reservoirs delivering water throughout the County.

5.6.2.1 Existing Hydropower Resources

Lopez WTP located east of Arroyo Grande is the only active small-low power hydropower plant in the County. The hydropower facility, which is described in Figure 66, is an impoundment type system with its power station located on the southern bank of the outlet stream below the earthen dam at Lopez Lake (reservoir). It is rated to produce 130kW of power.

There are at least two known off-grid mini-hydro sites in the San Luis Obispo's north county. Both located on the same property, they are run-of-the-stream type systems in adjacent small creeks. The systems have high head, low flow characteristics. One system has over 200ft of head through a 900 ft. penstock creating almost 90 psi of pressure at the inlet of the 4-nozzel Pelton wheel type turbine. Flow in the creek is low and seasonal. The creeks are dry during the summer but provide enough flow in wetter seasons to generate enough energy to offset the reduction in solar energy produced onsite during the low winter sun. Both systems have a rated power of 1kW but on average produce only a fraction of that.

Figure 66: San Luis Obispo County Existing Hydro Generators

San Luis Obispo County Existing Hydro Generators					
Name	Description	Size (kW)	Type	Scale	Status
Lopez WWTP	Below Lopez Lake Dam	130	Impoundment	Small-low power	Online
North County	Seasonal - Pelton wheel	1	Run-of-the-stream	Mini	Online

Source: SLO RESCO

5.6.2.2 Potential New Hydropower

According to results from a sophisticated watershed flow model (refer to DOE) used in the development of the Idaho National Labs Hydropower Prospector, San Luis Obispo County has a total of 187 potential hydropower project sites with over 20 MW of power potential. This model initially used average rainfall, a digital terrain model, the National Hydrographic Dataset, and other data to identify sites with sufficient elevation change and water flow to qualify for potential hydropower development. Additionally, sites considered for potential were evaluated using criteria such as grid access, road access and environmental sensitivity.

Figure 67: San Luis Obispo County Hydro Potential by Scale

Power Class	**Number of Sites**	**Total Power Potential (MW)**
Small – Conventional	1	3
Small – Low Power Turbine	18	8
Micro-Hydro	168	10
Total	187	21

Source: SLO RESCO

From preliminary site-specific analyses, a significant number of sites identified by the INL Hydropower Prospector tool may not be able to be developed, and/or the locations should be refined and adjusted to local conditions. As an example, the 3 MW small hydro–high power project site included in Figure 67 is located in a normally dry riverbed on the Santa Maria River downstream from the Twitchell Reservoir; this specific site is not developable, though it is possible that the resource could be developed upriver of the dam. Also, many of the potential project sites in the 'Micro-Hydro' class are located along the same stretch of waterway and likely cannot all be developed.

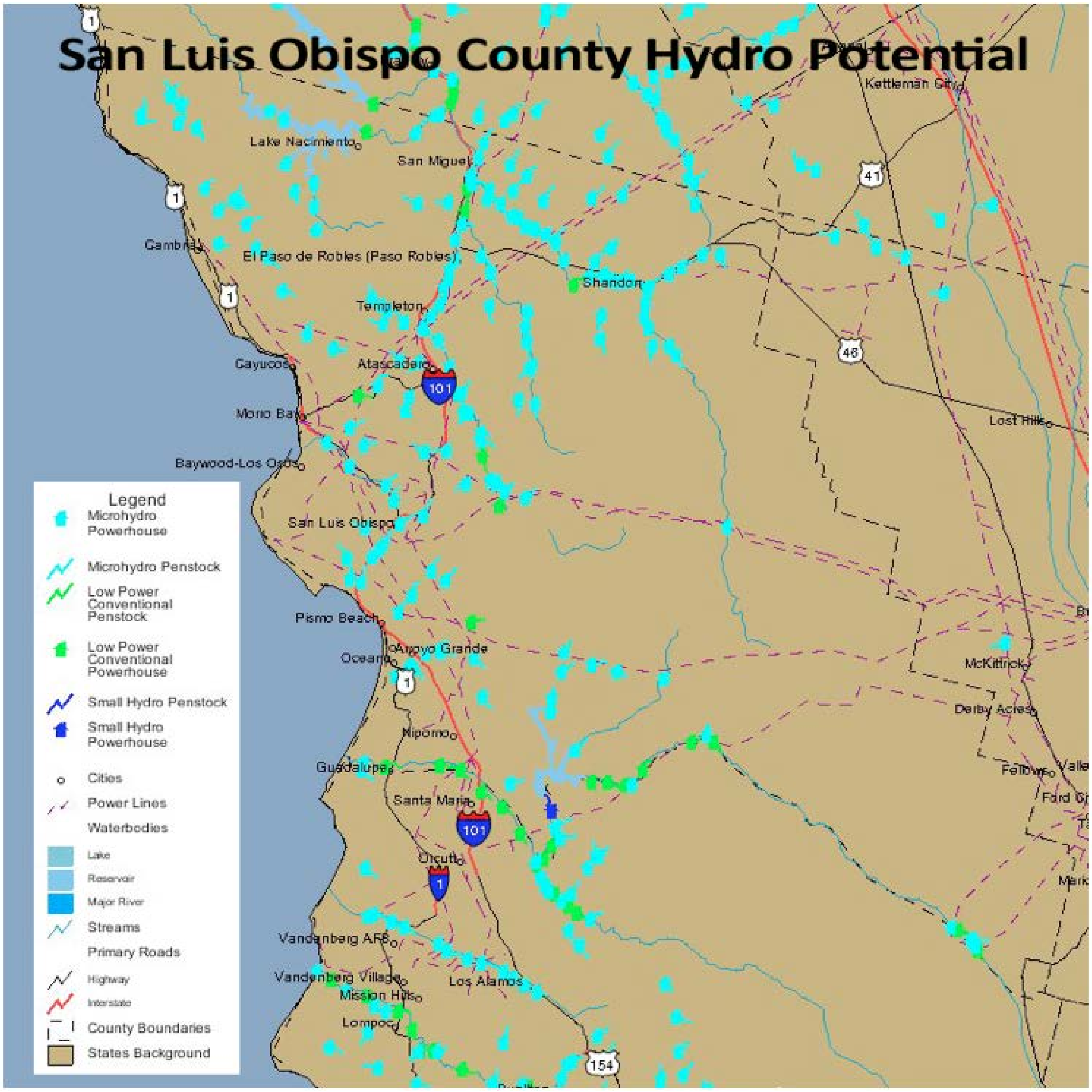
5.6.3 Maps and Charts

Figure 68: San Luis Obispo County Existing Hydro Power

Source: SLO RESCO and INL Hydropower Prospector Tool

Figure 68 shows both the conventional hydro and the in-conduit hydro resources that have been developed in San Luis Obispo County. In total, there are three existing systems but of those only two are in operation including Whale Rock and Lopez WTP. The San Luis Obispo WTP system is no longer in operation and has been decommissioned. The in-conduit systems are discussed in greater detail in the Regenerative Energy section under In-conduit hydro power.

Figure 69: San Luis Obispo County Existing Hydro Potential



Source: SLO RESCO and INL Hydropower Prospector Tool

A total of 187 potential hydropower project sites identified by the INL Hydropower Prospector tool are shown in Figure 69 (refer to Virtual). A majority of the projects, shown in light blue, are micro or mini scale and are scattered throughout the western side of San Luis Obispo County often times along the same waterway. There are 18 potential low power conventional project sites, shown in green, and one small hydro project site at the southern edge of the County near Twitchell Reservoir which is shown in dark blue.

5.6.4 Hydropower Applications

Hydropower is classified by law as either large (greater than 30 MW) or small (less than 30MW). Large hydropower is not a resource being evaluated in this report. Small hydropower is commonly divided into four scales: small-high power (1000 to 30,000 kW), small-low power (100 to 1,000 kW), micro (5 to 100 kW) and mini (up to 5 kW).

Figure 70: Scales of Hydropower

Scales of Hydropower	
Scale	Size (kW)
Small – High power	1000 to 30000
Small – Low power	100 to 1000
Micro	5 to 100
Mini	Up to 5

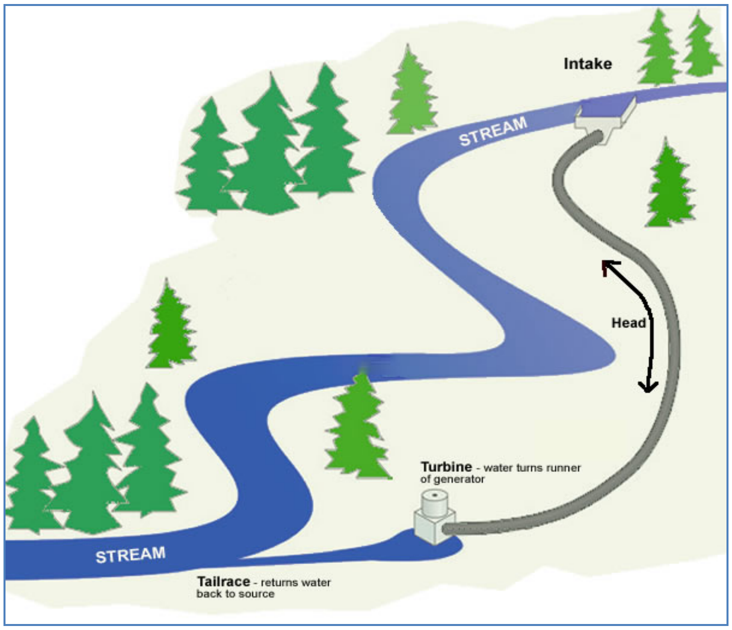
Source: SLO RESCO

There are several configurations of hydropower systems. These are detailed below.

5.6.4.1 Impoundment

Impoundment hydropower makes use of a dam or a canal to achieve the necessary head (change in elevation) for a viable hydropower system. The scale of impoundment hydropower can vary from the largest of dams to micro hydropower systems that only produce a few kilowatts. There are many existing impoundments that do not yet utilize their hydropower potential. Since impoundments dramatically change the flow of water within a water-shed, there is the potential for significant environmental impacts on the surrounding ecosystem.

Figure 71: Run-of-the-Stream Hydropower System



Source: http://www.peakprosperity.com

5.6.4.2 Run-Of-The-Stream

In run-of-the-stream or run-of-river hydropower the water is not stored held behind a dam, or in a reservoir. Instead, a portion of the water is diverted from a canal or piped out of the water source. Run-of-the-stream is by far the most common type of micro hydropower.

At the entrance to the hydropower system, water is diverted from the stream through a filtration system, which prevents clogging into a pipe known as the penstock. Water flows through the penstock down elevation to the turbine. The water flows through the turbine, generating energy and then exits the system through the tailrace back into the stream. The distance that the water must flow through a pipe depends on the desired head. Some systems may require a head of over 100ft requiring an extensive lay of pipe.

The head and flow of the stream will determine the appropriate turbine to use. Each turbine will come with specifications of head, flow and power potential. As an example the ES&D LH1000 Low-Head turbine is capable of taking 1000 gallons per minute falling a maximum of 10ft to produce a rated power of 1kW (refer to ES&D). Other turbines are better adapted to higher head and do not require as significant a flow of water. The two general types or turbines are reaction turbines and impulse turbines.

5.6.5 Types of Turbines

5.6.5.1 Impulse turbine

Within an impulse turbine, a jet of water exiting the penstock impacts a paddle wheel inside the turbine causing the wheel to rotate. Impulse turbines are generally best for high head low flow water sources. This makes them particularly useful in micro hydropower systems which often have a low flow. Common types of impulse turbines include the Pelton, Turgo, and Crossflow.

5.6.5.2 Reaction turbine

Within a reaction turbine, the change in pressure resulting from the water flowing through the turbine causes the blade to rotate. Although these turbines are usually used for larger scale impoundment hydropower, one type of reaction turbine useful for micro hydropower is a kinetic energy or free flow turbine. This turbine is placed directly in the rivers natural path forcing the water to flow through it. Kinetic energy turbines avoid the need to divert water out of the water source (refer to Reaction).

5.6.6 Developmental Considerations

Developmental considerations of hydropower depend on the type of hydropower used. Impoundment hydropower will usually have the most negative environmental impacts associated with it because it drastically changes the natural flow of the stream. Impoundment hydropower can potentially also impede the movement of fish and impact areas behind the dam.

Run-of-the-stream hydropower systems often have less impact on the environment. It is important to consider how much of the stream's normal flow will be removed. Diverting an entire stream over hundreds of feet may have significant impact on the surrounding ecosystem.

Identifying a suitable site for a micro hydropower system may be difficult and consideration of site access, the distance to electrical connection, and permitting should be made. Difficult access to the site for construction and maintenance may not make power produced feasible. Also, depending on state and local regulations, permitting construction of a hydropower system around local creeks and rivers could be difficult.

5.6.7 Investigation Process and Methodology

5.6.7.1 Literature Review

In the last several decades, there have been a variety of studies done on US hydropower potential. These studies were conducted at both the national and state level. The first task was to identify existing knowledge of hydropower potential by performing a literature review to understand what had been studied and what information had been created.

5.6.7.2 Visit Sites

Site visits to several existing facilities were made to better understand scale and application of different technologies. Visits were made to both a conventional small – low power impoundment system and to an unpermitted run-of-the-stream mini hydro system.

5.6.7.3 Explore Hydropower Prospector

Discovery of this tool during the literature review greatly expanded knowledge about San Luis Obispo's hydropower potential. Idaho National Lab (INL) has been the nation's leader in hydropower resource assessments over the last decade. Findings from numerous Department of Energy and California Energy Commission studies along with sophisticated analysis using watershed modeling were used in the development of the INL's Hydropower Prospector. This online, graphical information system (GIS) based tool can be used to research and analyze San Luis Obispo County's hydropower potential. This tool provides access to information including existing facilities and other power infrastructure, sites with resource potential, sites that qualify for potential projects based off of specific criteria, and other relevant developmental information. Data tables containing site specific information can be generated and exported.

5.6.7.4 Perform Graphical Analysis using GIS Tools

Specific sites were investigated using information from the INL hydropower prospector, National Hydrographic dataset, aerial photos, and other GIS data.

5.6.8 Next Steps

5.6.8.1 Qualify Small Hydro Sites

In order to refine the INL Hydropower Prospector database extract, a site-specific verification of small hydro locations identified as having either high or low power potential should be conducted. Preliminary surveys revealed that several sites have been developed further upstream, making the resource unavailable.

5.6.8.2 Associate Potential Micro Hydro Sites with Adjoining Parcel Information

Potential micro hydro sites should be associated with parcel identification information. This information could be used to identify if potential resources exist on public lands or for future commercialization efforts.

5.6.8.3 Investigation of Additional Hydro Resource Areas

Additional resource potential may be developed by studying existing impoundments to see if un-utilized or under-utilized resource potential can be harnessed by adding hydropower facilities or by upgrading existing equipment.

5.6.9 References

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5.7 Ambient Energy: Geothermal Heating

5.7.1 Characterization of Ambient Geothermal Heating Resource

Natural heat from the earth, known as geothermal energy, has advantages in its dependability, high-energy efficiency and low environmental impacts. Geothermal resources come in all shapes, sizes, locations, and temperatures. However, temperature usually determines how it is used (refer to Figure 72). High-temperature geothermal resources have hot water above 302°F / 150°C and are an economic alternative for electric power generation. Low-to-moderate resource with water below 302°F are generally used directly for a variety of purposes including to grow flowers, raise fish, heat buildings, or dry vegetables. Lowest temperature geothermal resources are commonly harnessed by ground-source heat pumps. The shallow ground near the earth's surface maintains a relatively constant temperature of 50°- 60° F which can be used directly to provide heating and cooling in homes and other buildings. Of the two basic ways to capture geothermal energy – through power plants or through direct use – the later will be the focus of this study due to low temperature nature of the geothermal resources in SLO County.

5.7.1.1 Heating

Direct-use of geothermal energy refers to the immediate use of the geothermal heat resource rather than to its conversion to some other form such as electricity. Applications of direct-use geothermal resources include space and district heating, the heating of greenhouses, pools, and spas, and the support of aquaculture (farming of freshwater and saltwater organisms) and other industrial processes. Typically it is found that aquaculture, and spa and pool applications require the lowest temperature geothermal fluids (80°F / 27°C to 200°F / 93°C), space heating and greenhouse requirements are in the range of 105°F / 47°C to 200°F / 93°C, and industrial processes need the highest temperatures, over 200°F / 93°C (refer to CEC: Identifying New Opportunities).

5.7.1.2 Cooling

Another non-electrical, direct way to collect the Earth's ambient heat is through the use of geothermal heat pumps, which can provide significant cooling savings to buildings. Heat pumps use the constant temperature of the earth as the exchange medium to move heat from one place to another – that is why they are called "heat pumps." In the winter, they can move the heat from the earth into your house. In the summer, they pull the heat from your home and discharge it into the ground soil or into a nearby groundwater-source such as a pond or lake. More than 600,000 heat pumps, also commonly referred to as ground-source heat pumps (GSHPs), supply climate control in U.S. homes and other buildings, with new installations occurring at a rate of about 60,000 per year [Union of Concerned Scientists]. GSHPs are the largest user of direct-use geothermal energy in the U.S., yet they are largely still an underutilized technology in the United States. Geothermal space cooling will not be the focus of this section of the report. For more information about space cooling with geothermal resources please see the Ambient Energy: Ground-Sourced Cooling chapter of this report.

Figure 72: Geothermal Energy Uses

POTENTIAL USE	RESOURCE TEMPERATURE
Ground-source heat pumps	4ºC to 38ºC / 40ºF to 100ºF
Direct use	38ºC to 150ºC / 100ºF to 302ºF
Electricity generation	> 150ºC / 302ºF

Source: Geothermal Small Business Workbook

5.7.2 Technologies and Applications

Heating Direct-use systems with hot spring sources are typically composed of three components:

- A production facility—usually a well, to pump the hot water to the surface;
- A mechanical system— piping, heat exchanger, controls, to deliver the heat to the space or process;
- A disposal system—an injection well or storage pond, to receive the cooled geothermal fluid.

5.7.2.1 Aquaculture

Aquaculture is the production and sale of farm-raised aquatic plants and animals. Geothermal aquaculture uses naturally occurring warm water to accelerate the growth of fish, shellfish, reptiles, amphibians, and aquatic plants (e.g. algae). Low-cost, dependable geothermal fluids also allow production in the winter when it would otherwise not be possible. Aquaculture is a potential application for low-temperature geothermal resources.

Fish and other species can be raised in open-air earthen ponds or fiberglass tanks. In addition to the materials used, the cost of a geothermal aquaculture project depends on the size of the project, the species raised, and whether a well already exists. Well depths and drilling costs vary widely from $30-$200 per foot; most common drilling costs are $50-$100 per foot. Ninety percent of direct use wells are less than 1,800 feet deep (refer to Battocleti), and most large growers have two to three wells for their operations. Usually, geothermal heated water can be piped directly into the ponds, eliminating the need for heat exchange equipment. The maximum pond area that can be developed depends on the heat available from the resource. The fluid temperature also determines what species can be raised. Each species has an optimum temperature at which it grows best. Figure 73 shows the temperature requirements and growth periods for several aquaculture species.

Figure 73: Temperature Requirements and Growth Periods for Selected Aquaculture Species

Species	Tolerable Extremes (°F)	Optimum Growth (°F)	Growth Period to Market Size (Months)
Oysters	32-97 typ	76-78 typ	24
Lobsters	32-88	72-75	24
Penaeid Shrimp			
Kuruma	40-?	77-87	6-8 typ
Pink	52-104	75-85	6-8
Salmon (Pacific)	40-77	59	6-12
Freshwater Prawns	75-90	83-87	6-12
Catfish	35-95	82-87	6-24
Eels	32-97	73-86	12-24
Tilapia	47-106	72-86	12
Carp	40-100	68-90	—
Trout	32-89	63	6-8
Yellow Perch	32-86	72-82	10
Striped Bass	?-86	61-66	6-8

Source: Geothermal Small Business Workbook

5.7.2.2 Spas and Pools

The oldest recorded use of geothermal water was for bathing and health. One of the major attractions at a spa is that the water is naturally heated. The hot water from the earth containing certain minerals can give the spa a religious, aesthetic, or medical significance. Mineral and geothermal waters in the U.S. are developed in three major ways: hot springs resorts with hotel-services and accommodations, commercial plunges or pools and soaking tubs with camping facilities and food service, and undeveloped springs without any services (refer to CEC: Identifying New Opportunities). All of these applications rely on shallow wells, approximately 200 feet deep, with temperatures from 170°F / 77°C to 200°F / 93°C.

The typical temperature for a swimming pool is 81°F / 27°C. In a geothermal heated pool, the hot water is often cooled by mixing with cooler water, aeration, or in a holding pond. If the geothermal water is used directly in the pool, then a flow-through process is needed to replace the “used” water regularly. By allowing water to continuously flow, resorts and hot springs meet health department requirements without the use of chemical treatment. Yet, in many cases, geothermal fluids are used to heat water treated with chlorine in a closed loop. A heat exchanger transfers heat from geothermal fluids to the treated water. The water is then disposed of in drainage systems or using surface disposal without further treatment.

Solar energy or natural gas pool heaters are an alternative to geothermal heaters if the geothermal water does not flow directly into the pool. A solar heated pool is often less expensive in capital costs and operating costs than a geothermal system. However, a solar system cannot operate during all times of the day whereas a geothermal system is available on demand throughout the year. For this reason, the savings on fuel cost could offset the higher prices for the heat exchanger and piping needed for the geothermal system.

5.7.2.3 Space & District Heating

Space and district heating are technologically very different. Space heating systems use one well per structure. Geothermal District Heating (GDH) systems distribute hydrothermal water from one or more geothermal wells to several houses and buildings, or blocks of buildings. In both systems, the geothermal production well and distribution piping replace the fossil-fuel-burning heat source of the traditional heating system. Hot water, rather than steam, is the heat transfer medium.

Space heating of an individual building may be justified economically provided the heating load is large enough and there is a close geothermal resource. Typically, one production well supplies heated water, with temperatures of 160°F / 71°C to 180°F / 82°C being ideal, although systems with temperatures as low as 60°F / 15.5°C are being economically utilized. The hot water is piped to a heat exchanger or through a heat pump where the heat from the geothermal fluid is transferred to a space heating system. If the geothermal water is clean enough, it can flow through the space heating system without a heat exchanger, but there is concern with corrosion and degradation of system components. Hot geothermal fluids can also flow through a separate heat exchanger to heat domestic hot water. If chemistry is relatively benign, the cooled and clean geothermal fluids can be discharged into a drainage system, or evaporation pond.

Geothermal district heating systems provide hot water from a central location through a piping network to homes or buildings. The heat is used for space heating and cooling, domestic water heating, and industrial process heat. A geothermal well field is drilled to provide the primary source of hot water for the system. There are two types of geothermal district heating distribution methods: open and closed. The open distribution system pipes the geothermal fluid directly to the customer from the well, which is similar to the space heating system described earlier. Closed systems deliver the fluid to a central location where it goes through a heat exchanger that transfers its heat to another fluid. This heated system fluid is then delivered to each customer in a closed loop network. Disposal of the geothermal fluid may be a major issue for geothermal systems. They produce a large amount of groundwater, which must be disposed of either by surface disposal or injection. Surface disposal is considerably less expensive, but can have environmental problems, especially for larger systems.

The economics of converting to a GDH system vary depending on the size of the building to be connected, and the existing heating system. In large buildings, over 50,000 square feet, the economics of connecting to GDH system are often positive. Generally, small buildings under 10,000 square feet use heating systems that are not hot water based and must be retrofitted (refer to Battocletti). The Geothermal Small Business Workbook produced for the U.S. Department of Energy estimated that "an automotive repair shop with three unit heaters would have a retrofit cost of $12,600-$14,390 (and comparably) a small office with two roof top heat pumps would incur a retrofit cost of approximately $9,013.55." Small buildings should only connect to a GDH system if the system offers substantially lower heating costs because the building has high-energy use or the owner is currently using a high cost fuel.

5.7.2.4 Greenhouses

Greenhouse heating is a common use of geothermal resources. Although solar energy is a more widespread method of greenhouse heating, supplemental systems are necessary for year-round production. Greenhouses are an attractive application for geothermal resources because of the significant heating requirement and their ability to use low-temperature geothermal fluids. Greenhouse operators estimate that using geothermal resources instead of traditional energy sources saves about 80 percent of fuel costs—or 5 percent to 8 percent of total operating costs (refer to CEC: Identifying New opportunities).

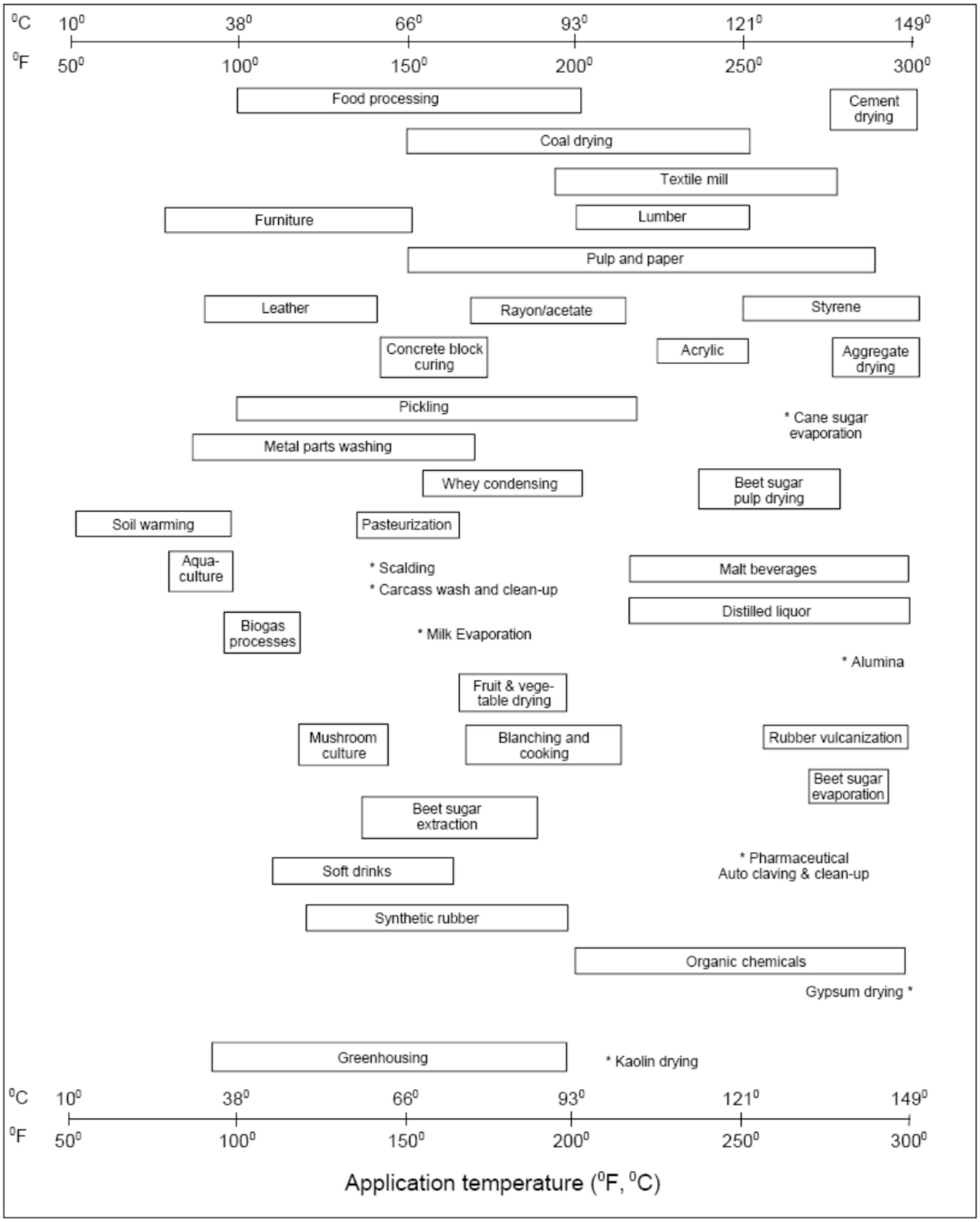
Geothermal greenhouses are similar to non-geothermal types except geothermal fluids are used to heat the air or water normally heated by fuels, electricity, or solar energy. A borehole is typically drilled to provide geothermal fluid in the 90°F / 32°C to 200°F 93°C temperature range. A heat exchanger is typically used to transfer the geothermal heat to a closed hot water system, which separates the geothermal fluid from the heating system to prevent corrosion and scaling in the heating system. Once this hot water is created, the system is similar to the central heating of a non-geothermal greenhouse. Small heating systems can have a standard forced air unit heater, which uses the geothermal water to heat and distribute hot air to the greenhouse. Large operations can use radiant heating and finned tube and fanned coil units to heat the air and soil in the greenhouse.

5.7.2.5 Agricultural Drying and Industrial Processes

Geothermal fluid can be used for a wide range of industrial and agricultural processes. Industrial applications include food dehydration, laundries, gold mining, and milk pasteurization. Dehydration of vegetables and fruits is the most common industrial use of geothermal energy.

Industrial applications make up the smallest portion of geothermal direct-use, with few in California. One explanation is that some industrial processes require steam at 250°F / 121°C or higher (refer to Figure 74: Temperature of Industrial Processes and Agriculture). Geothermal fluid temperatures above 250°F / 121°C are normally used for electric power generation. Another reason for limited application of geothermal direct-use technologies in industrial processes is that, in many industries, recovering waste heat from the process itself often satisfies lower-temperature process heat requirements. Despite these situations, opportunities in the industrial sector remain that are attractive for geothermal heating.

Figure 74: Temperature of Industrial Processes & Agriculture



Source: California Energy Commission

5.7.3 Local Resource Potential

In this section the potential for using geothermal energy as process heat and as a heating resource with ground source heat pumps. For resource potentials regarding ground source cooling and cooling please see the Ambient Energy: Ground-Sourced Cooling section of this study.

5.7.3.1 Process Heating

Figure 75: Geothermal Wells and Combined Technical Potential

Name of Well	MWh-th Potential	Type*	Lat.	Long.	Depth (Meters)	Temperature (Celsius)	Flow (Liters/ Min)	Total Dissolved Solids	Active Use?	Active Capacity	Active Energy
Paso Robles Artesian Sp.	6,108	SP	35.66	120.69		39	380		Yes	0.7	6,108
Paso Robles Mud Bath Sps.	6,446	SP	35.66	120.69		42	360	2300	Yes	0.74	6,446
Unnamed Spring	13,609	SP	35.65	120.69		42	760		No	0	-
Well 26S/13E-11L1 M	-	WW	35.68	120.54	630	31	N/A		No	0	-
Well 26S/12E-29C M	-	WW	35.64	120.7	185	32.7	N/A		No	0	-
Unnamed Well	-	WW	35.64	120.65			N/A		No	0	-
Santa Ysabel Springs	2,357	SP	35.58	120.66		33	190	900	No	0	-
Paso Robles City Baths	8,783	SW	35.63	120.69	122	38	568	1490	Yes	1	8,783
Calaqua No.1	-	X	35.58	120.55	316	47	N/A		No	0	-
Cameta Warm Spring	69	SP	35.4	120.25		23	11		No	0	-
Pecho Warm Springs	886	SP	35.27	120.86		35	65		No	0	-
Sycamore Hot Sps. Well	-	OIL	35.19	120.71	286	24	N/A		Yes	0	-
Avila Hot Springs Well	4,886	WW	35.18	120.7	609	55	189		Yes	0.56	4,886
Newsom Springs	812	SP	35.12	120.54		36	57		No	0	-
Total	43,000										

*Resource Types: Springs, SP; Well drilled to control spring flow, SW; Water Well, WW; Noncommercial low-temperature, NLT; Commercial low-temperature, CLT; Temperature gradient, TG; Injection Well, INJ; Petroleum well, OIL; Type not confirmed (most appear to be high-temperature exploration wells), X.

Source: California Energy Commission and SLO RESCO

5.7.4 Resource Types

Springs, SP; Well drilled to control spring flow, SW; Water Well, WW; Noncommercial low-temperature, NLT; Commercial low-temperature, CLT; Temperature gradient, TG; Injection Well, INJ; Petroleum well, OIL; Type not confirmed – most appear to be high-temperature exploration wells, X.

In San Luis Obispo County there are fourteen known geothermal wells with temperatures ranging from 73°F to 131°F (refer to CEC: Identifying New opportunities). These temperatures are relatively mild, but can still be harnessed for a number of purposes. As can be seen in Figure 5, most of these wells are located in the Paso Robles and Avila Beach areas where there are many active hot springs and bathhouses. Additionally in Paso Robles, geothermal power is used for aquaculture at the Paso Robles Fish Farm and the Franklin Lake Aquaculture Farm. According to CEC data and RESCO research San Luis Obispo County has an estimated 5 megawatts of thermal energy between its fourteen known wells with an estimated 60 percent of this thermal energy currently being used.

While the temperatures and flows of the wells throughout the County are not adequate for power generation or significant industrial use, geothermal energy has and will continue to play a role in San Luis Obispo's energy future.

5.7.4.1 Ground Source Heat Pumps

The Environmental Protection Agency (EPA) and the U.S. Department of Energy have both recognized geothermal ground-source technology as the most efficient and environmentally friendly home heating and cooling system available. According to studies by the Environmental

Protection Agency, significant energy savings can be achieved through the use of GSHPs in place of conventional air-conditioning systems and air-source heat pumps. Energy savings of 30 percent to 70 percent in the heating mode and 20 percent to 50 percent in the cooling mode can be obtained (refer to Space Conditioning: The Next Frontier).

Using these numbers, rough estimates for thermal heating energy savings in San Luis Obispo County can be quantified for the residential and commercial sectors. The data in from the 2010 California Residential Appliance Saturation Survey shows that space heating accounts for 37 percent of residential thermal energy load. Similarly, according to PG&Es Commercial Electric End Use study in space heating loads account for 44 percent of the thermal energy load. If 50 percent savings (average of 30 percent and 70 percent) can be realized through GSHPs for both sectors savings between 278,000-650,000 thermal megawatt-hours per year could be saved in SLO County.

More than 600,000 GSHPs supply climate control in U.S. homes and other buildings, with new installations occurring at a rate of about 60,000 per year (refer to Union of Concerned Scientists). It is unknown how many ground-source heat pumps are installed in SLO County. However, because of the climate and soil conditions San Luis Obispo residents can potentially save big on operating costs if they were to switch to GSHPs. Savings on heating and cooling are foreseeable especially in Climate Zone 4 which contains Paso Robles and Atascadero.

Climate influences the temperature of the ground and since a GSHP rejects and collects heat from the ground it makes sense that a region's climate can greatly influences a GSHP's efficiency. In climate zones with moderate soil temperatures, approximately 50-65°F, the soil can provide energy for heating in winter and a better sink for cooling in summer. Whereas a region with average soil temperatures of 70°F, would be efficient in heating for winter, but much less so for cooling in summer.

5.7.5 Maps and Charts

Figure 76: Known High-Temperature Geothermal Resource Areas

Source: California Energy Commission

Hot water or steam from below ground can be used to make electricity in a geothermal power plant. In California, there are 14 areas where we use geothermal energy to make electricity. The pink areas in Figure 76 show where there are known high-temperature geothermal areas. None are located in the San Luis Obispo area.

Figure 77: Geothermal Project Types by County

Source: California Department of Conservation / Division of Oil, Gas, and Geothermal Resources

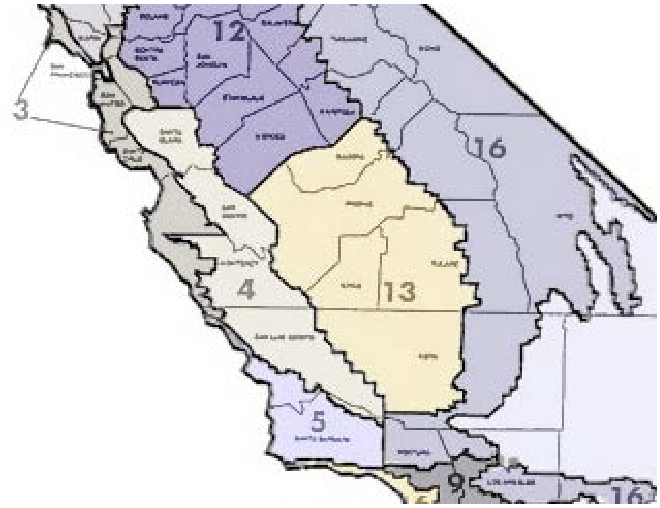
Figure 78: Map of Known Geothermal Wells in SLO County

ID	Name	Temperature (F)	Flow (GPM)
Well-1	Sycamore Hot Springs Well	75	N/A
Well-2	Pecho Warm Springs	95	17
Well-3	Cameta Warm Springs	73	3
Well-4	Calaqua No.1	117	N/A
Well-5	Paso Robles Mud Bath Springs	108	95
Well-6	Paso Robles Artesian Springs	102	100
Well-7	Paso Robles City Baths	100	150
Well-8	Santa Ysabel Springs	91	50
Well-9	Unnamed Well	N/A	N/A
Well-10	Well 26S/12E-29C M	100	N/A
Well-11	Well 26S/13E-11L1 M	88	N/A
Well-12	Unnamed Well	108	200
Well-13	Newsome Springs	97	15
Well-14	Avila Hot Springs Well	131	50

Source: CEC and SLO RESCO

The SLO RESCO team estimates that there are 5.02 MW of geothermal energy currently flowing from the 14 known wells throughout SLO County. This number is likely conservative, given that complete data is not available for all of the wells.

Figure 79: Snapshot of SLO County Climate Zones



Source: PG&E

5.7.5.1 California Climate Zone 3

The climate of Zone 3 varies greatly with elevation and the amount of coastal influence. Areas with more coastal influence experience moderate temperatures year round with precipitation in the winter and fog likely from June through mid-August. Inland from the beaches and sea cliffs, local geography may reduce the fog cover, lessen the winds, and boost summer heat. Winters are moderately cold with most of the annual rain falling between October and March. Winter sunshine nevertheless is plentiful. Summers are warm and dry, but the nights are cool. Rain is rare during the summer months. A need for heating is the dominant design concern, but the climate is mild enough that energy consumption is relatively low.

5.7.5.2 California Climate Zone 4

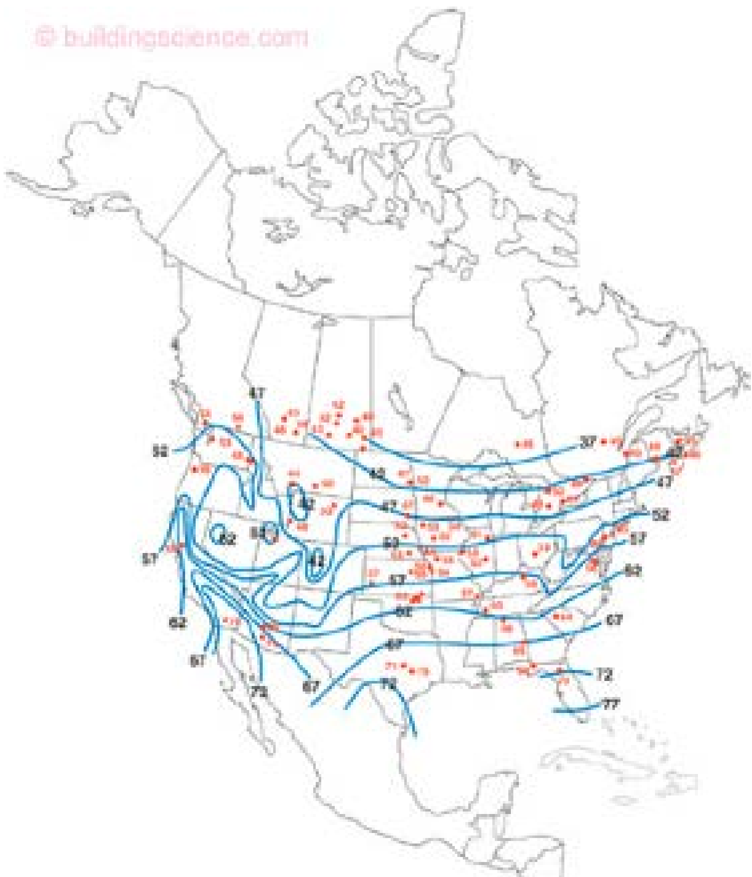
The Central Coastal Range is inland of the coast but has some ocean influence which keeps temperatures from hitting more extreme highs and lows. This zone covers many microclimates from northern to southern parts of the state. The reference city is in the Northern-most part of the zone. Seasons are sharply defined. Summers are hot and dry with a large daily temperature swing. Summers are hot enough that cooling is necessary. Winters are cool but not severe. Heating is necessary on many days in the winter. Days are typically clear with the coastal range blocking much of the fog and high winds.

5.7.5.3 California Climate Zone 5

Climate Zone 5 is situated along the coast where ocean temperatures are warmer due to the southern latitude. Summers are warm with afternoon winds blowing until sunset, which naturally cools the region. The air is usually moist. Fog and cloud cover commonly blocks the sun in the morning and evenings. Winters are cold but not severe enough to frost. The coolest parts of this region are the valley floors, canyons, and land troughs. The further inland the location, the fewer Heating Degree Days and more Cooling Degree Days can be expected.

Climate Zone 5 comes close to comfort standards, meaning little cooling is needed and heat is only necessary for part of the day, even in the winter. The mildness of the weather in Zone 5 is reflected in the fact that it is one of the lowest energy consuming climates.

Figure 80: National Average Soil Temperature Map



Source: Building Science Digest

5.7.6 Investigation and Methodology

5.7.6.1 Process Heat

To investigate geothermal resource potential in SLO County California Energy Commission data as well as consultant papers and scientific digests were used. With the known flow and temperature of the 14 known geothermal wells in SLO County the thermal energy resource was able to be calculated assuming 55 degree F ground water and a 95 percent capacity factor.

5.7.6.2 Ground Source Heat Pumps

While this section did not go into detail about ground source heat pumps, as they are more fully explained in the Ambient Energy: Ground-Sourced Cooling section, thermal energy potentials were calculated for heating with GSHPs. Using baseline heating consumption data, energy savings was calculated as a percentage reduction from the heat loads in both commercial and residential sectors.

5.7.6.3 Hot Rock Geothermal

This study did not investigate the potential for hot rock geothermal due to the fact that the technology is relatively immature, but because SLO County does have existing geothermal resources it may be worth investigating in the future.

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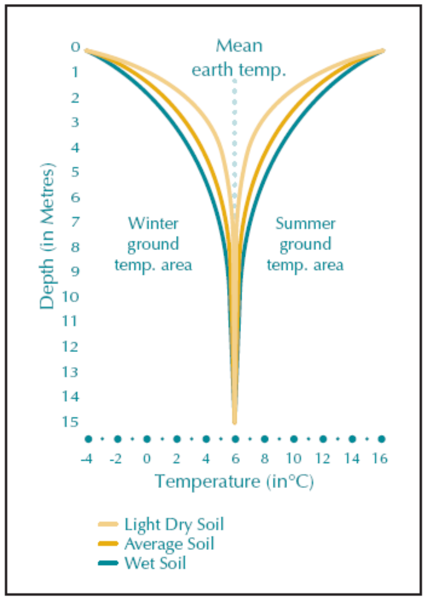
5.8 Ambient Energy: Ground-Sourced Cooling

5.8.1 Characterization of Ambient Ground-Sourced Cooling Resource

Ambient Cooling can be described as using the natural "cooling" resources in the natural environment to do work without energy conversion. While according to the 2nd Law of Thermodynamics nothing is actually ever "cold" or "cool", there is just a "lack of heat" there are significant resources which can be used to provide a cooling effect.

Figure 81: The Earth's Temperature by Depth



Source: RETScreen International

The 2nd Law of Thermodynamics essentially states that heat flows from hot to cold, not the other way around. For example, your air conditioner does not make your house cold, but rather removes the heat from it. And because heat is always moving from hot to cold, on warm days energy must be added to the system to constantly reject the heat. How much energy it takes to keep your house cold is dependent on number factors, but it's primarily the difference in temperature (Delta T) between inside and outside your house. The greater the Delta T, the greater the heat transfer rate. In this case the outside ambient air is what is called a "heat sink" or the place where the heat flows. Because more heat can be transferred if the difference in temperature is greater, less energy is required if there were to be a "cooler" heat sink.

One reliably cool heat sink which humans have been using for thousands of years is the earth's crust and large bodies of water. The Persians used cooled air for their shabestan, a common underground space with a qanat and a wind tower which created a space to keep cool in the summer months. While air temperature changes very rapidly due to its low thermal mass, just a few meters beneath the earth or water's surface there is a much cooler and more stable heat sink. Heat can be rejected here very easily here allowing for ambient cooling.

There are a number of factors such as depth, soil type, and moisture levels which contribute to the heat transfer rate, but when designed properly with the right technology such as ground source heat pumps, the earth beneath our buildings can be a very significant energy resource.

5.8.2 Local Resource Potential

The resource potential for ambient cooling potential is a function of the technology, the building, soil type, the demand and the climate. In SLO County, there are three different climate zones numbered 3, 4, and 5 (refer to Figure 86) and has an average soil temperature of 62 F (refer to Figure 85). Climate zone 3, which contains only a sliver of North County's coast

(San Simeon), is a cool climate in which heating is the dominant design concern. Zone 4 (Paso Robles and Atascadero) is inland of the coast but has some ocean influence which keeps temperatures from hitting more extreme highs and lows. Zone 4 summers are hot enough that cooling is necessary and winters are cool, but not severe. Zone 5 (San Luis Obispo and the 5 Cities) is situated along the southern coast where ocean temperatures are warmer due to the southern latitude. Zone 5 comes close to comfort standards, meaning little cooling is needed and heat is only necessary in the winter. The mildness of the weather in Zone 5 is reflected in the fact that it is one of the lowest energy consuming climates. According to Building Science Digest, GSHPs can be ideal heating and cooling solutions to SLO County, as it is a mixed climate region with nearly balanced annual heating and cooling loads and moderate soil temperatures.

The Environmental Protection Agency (EPA) and the U.S. Department of Energy have both recognized geothermal ground-source technology as the most efficient and environmentally friendly home heating and cooling system available. According to studies by the Environmental Protection Agency, significant energy savings can be achieved through the use of GSHPs in place of conventional air-conditioning systems and air-source heat pumps. Energy savings of 30 percent to 70 percent in the heating mode and 20 percent to 50 percent in the cooling mode can be obtained. (Refer to EPA/ Space Conditioning: The Next Frontier.)

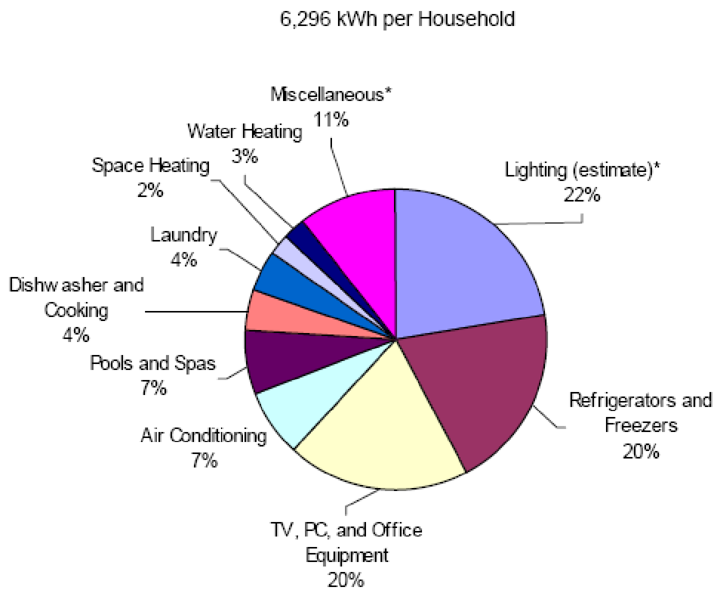
Using these numbers, rough estimates for energy savings in San Luis Obispo County can be quantified for the residential and commercial sectors. The data in Figure 82 from the 2010 California Residential Appliance Saturation Survey shows that air conditioning accounts for 7 percent of residential energy load. (Refer to KEMA.) Similarly, according to PG&Es Commercial Electric End Use study in Figure 3, cooling loads account for 12.4 percent of electric energy load. (Refer to Itron.) If 35 percent savings (average of 20 percent and 50 percent) can be realized through GSHPs for both sectors savings between 36,000 - 92,000 megawatt-hours per year could be saved in SLO County. Another significant attribute to GSHP for cooling is that they have the potential to reduce peak load as this is when air conditioning is primarily used. Combining both residential and commercial energy saving estimates, and assuming a 20 percent load factor, GSHPs could potentially reduce the peak load of SLO County by 21-51 megawatts.

More than 600,000 GSHPs supply climate control in U.S. homes and other buildings, with new installations occurring at a rate of about 60,000 per year. (Refer to Union of Concerned Scientists.) It is unknown how many ground-source heat pumps are installed in SLO County. However, because of the climate and soil conditions San Luis Obispo residents can potentially realize significant savings if they were to switch to GSHPs, especially in Climate Zone 4 (which contains Paso Robles and Atascadero).

Climate influences the temperature of the ground and since a GSHP rejects and collects heat from the ground it makes sense that a region’s climate can greatly influences a GSHP’s efficiency. In climate zones with moderate soil temperatures, approximately 50-65°F, the soil can provide energy for heating in winter and a better sink for cooling in summer. Whereas a region with average soil temperatures of 70°F, would be efficient in heating for winter, but much less so for cooling in summer. In Climate Zone 4 soil temperatures vary from approximately 50°F to 68°F depending on the depth (refer to Figure 84).

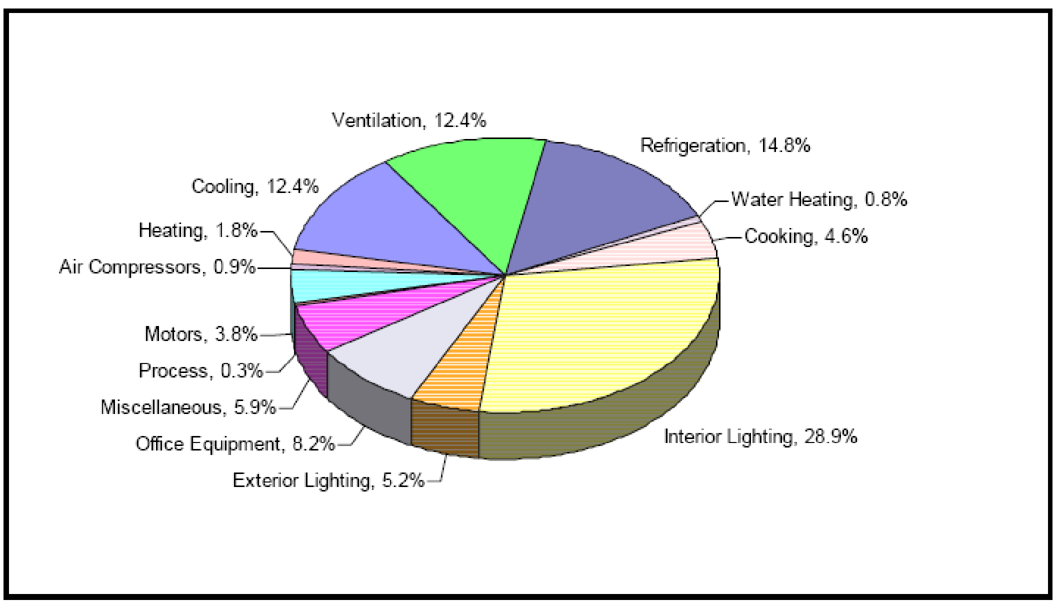
5.8.3 Maps and Charts

Figure 82: Residential Electricity End-Use Consumption in California



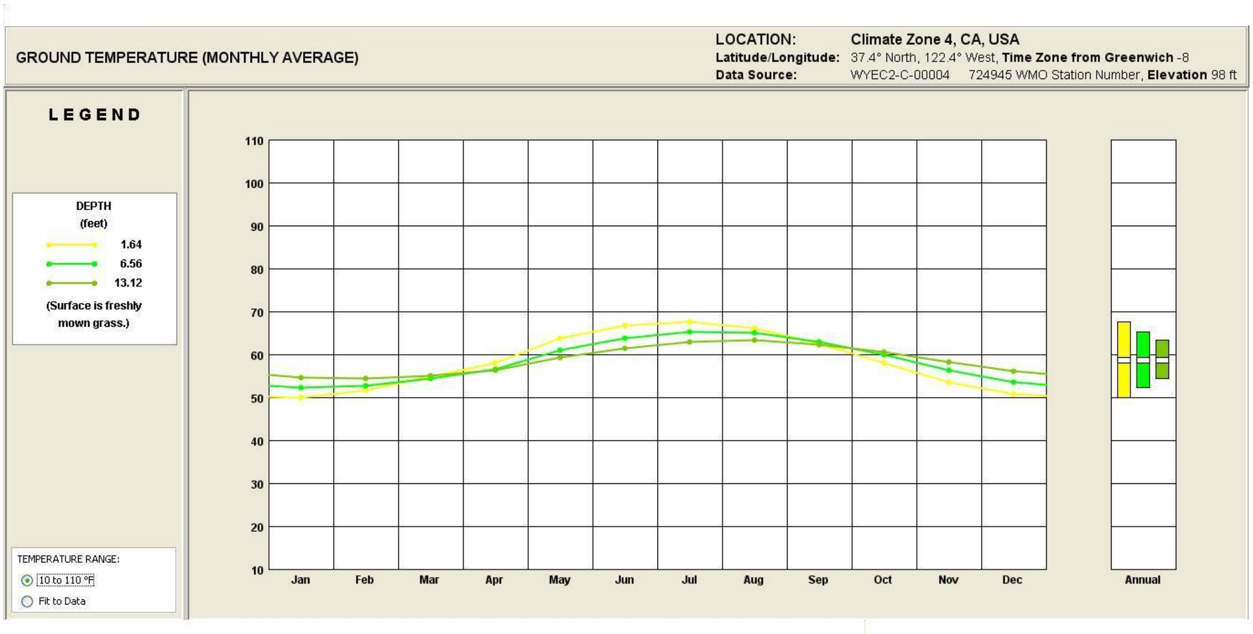
Source: 2010 California Residential Appliance Saturation Survey

Figure 83: PG&E Commercial Electric Usage by End Use



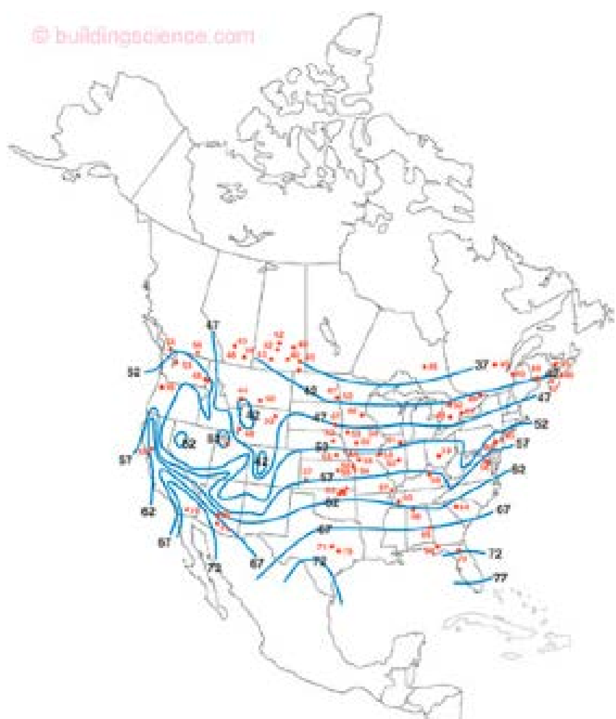
Source: California Commercial End-Use Survey in 2006

Figure 84: Ground Temperature at Difference Depths in Climate Zone 4



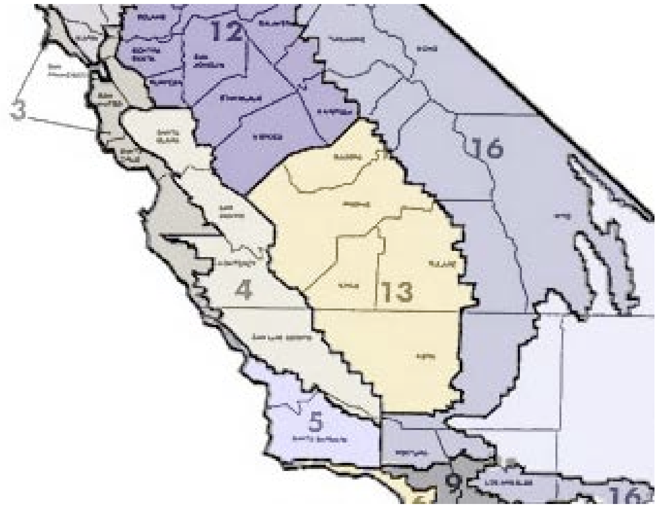
Source: Climate Consultant Version 5

Figure 85: Ambient Geothermal National Average Soil Temperature Map



Source: Building Science Digest

Figure 86: Snapshot of SLO County Climate Zones



Source: PG&E

5.8.3.1 California Climate Zone 3

The climate of Zone 3 varies greatly with elevation and the amount of coastal influence. Areas with more coastal influence experience moderate temperatures year round with precipitation in the winter and fog likely from June through mid-August. Inland from the beaches and sea cliffs, local geography may reduce the fog cover, lessen the winds, and boost summer heat. Winters are moderately cold with most of the annual rain falling between October and March. Winter sunshine nevertheless is plentiful. Summers are warm and dry, but the nights are cool. Rain is rare during the summer months. A need for heating is the dominant design concern, but the climate is mild enough that energy consumption is relatively low.

5.8.3.2 California Climate Zone 4

The Central Coastal Range is inland of the coast but has some ocean influence which keeps temperatures from hitting more extreme highs and lows. This zone covers many microclimates from northern to southern parts of the state. The reference city is in the Northern-most part of the zone. Seasons are sharply defined. Summers are hot and dry with a large daily temperature swing. Summers are hot enough that cooling is necessary. Winters are cool but not severe. Heating is necessary on many days in the winter. Days are typically clear with the coastal range blocking much of the fog and high winds.

5.8.3.3 California Climate Zone 5

Climate Zone 5 is situated along the coast where ocean temperatures are warmer due to the southern latitude. Summers are warm with afternoon winds blowing until sunset, which naturally cools the region. The air is usually moist. Fog and cloud cover commonly blocks the sun in the morning and evenings. Winters are cold but not severe enough to frost. The coolest parts of this region are the valley floors, canyons, and land troughs. The further inland the location, the fewer HDD and more CDD can be expected. Climate Zone 5 comes close to comfort standards, meaning little cooling is needed and heat is only necessary for part of the day, even in the winter. The mildness of the weather in Zone 5 is reflected in the fact that it is one of the lowest energy consuming climates.

5.8.4 Technologies And Applications: Ambient Cooling

There are a number of different technologies which harness ambient cooling. The most popular and growing technology is a Ground-Source Heat Pump (GSHP), also known as geothermal heat pumps, earth energy systems, or geo-exchange systems. A GSHP either collects heat from the ground and pumps it to a coil inside a building's ductwork to provide air heating, or collects heat from the same coil in the ductwork (thereby cooling the air) and rejects it to the ground. GSHP systems, like common heat pumps and air conditioners, make use of a refrigerant to help transfer (or pump) heat into and out of your home. The refrigerant helps the GSHP system take advantage of two primary principles of heat transfer:

1. Heat energy always flows from areas of higher temperature to areas of lower temperature;

2. The greater the difference in temperature between two adjacent areas, the higher the rate of heat transfer between them. Refrigerators, air conditioners, and heat pumps all operate by pumping refrigerant through a closed loop in a way that creates two distinct temperature zones–a cold zone and a hot zone.

There are four basic types of ground loop systems. Three of these—horizontal, vertical, and pond/lake—are closed-loop systems. The fourth type of system is the open-loop option. Which one of these is best depends on the climate, soil conditions, available land, and local installation costs at the site. All of these approaches can be used for residential and commercial building applications.

5.8.4.1 Horizontal Closed Loop

This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-inch wide trench. The "Slinky" method of looping pipe allows more pipe n a shorter trench, which cuts down on instillation costs and makes horizontal instillation possible in areas it would not be with conventional horizontal applications.

5.8.5 Vertical Closed Loop

Large commercial buildings and schools may use vertical systems because the land area required for horizontal loops is not available. Vertical loops are also used where the soil is too shallow for trenching, and they minimize the disturbance to landscaping. For a vertical system, holes approximately four inches in diameter are drilled about 20 feet apart and 100–400 feet deep. Into these holes go two pipes that are connected at the bottom with a U-bend to form a loop. The vertical loops are connected with horizontal pipe, placed in trenches, and connected to the heat pump in the building. Vertical loops are generally more expensive to install, but require less piping than horizontal loops because the Earth's temperature is more stable farther below the surface.

5.8.5.1 Pond/Lake Closed Loop

This type of loop design may be the most economical when a home is near a body of water such as a shallow pond or lake. Fluid circulates underwater through polyethylene piping in a closed system, just as it does through ground loops. The pipes may be coiled in a slinky shape to fit more of it into a given amount of space. Since it is a closed system, it results in no adverse impacts on the aquatic system.

5.8.5.2 Open Loop

This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the GSHP system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is practical only where there is an adequate supply of clean water, and all local codes and regulations regarding groundwater discharge are met.

5.8.5.3 Cost of Technology

As a rule of thumb, a GSHP system costs about $2,500 per ton of capacity. The typical sized home would use a three-ton unit costing roughly $7,500. That initial cost is nearly twice the price of a regular heat pump system (about $4,000), with air conditioning. It is necessary, however, to add the cost of drilling to this amount. The final cost will depend on whether the installation requires drilling vertically deep underground or if the loops are placed in a horizontally a shorter distance below ground. The cost of drilling can run from $10,000 to $30,000, or more depending on the terrain and other local factors. Yet, an efficient geothermal system can save enough on utility bills that the investment may be recouped in five to ten years.

Figure 87: Coefficients of Performances (COPs) of Various Heating Systems

Heating System	C.O.P.
Conventional Gas-Fired Forced-Air Furnace or Boiler	0.60 to 0.70
Conventional Gas-Fired Gravity-Air Furnace	0.57 to 0.67
Gas-Fired Forced-Air Furnace or Boiler with Typical Energy Conservation Devices, Intermittent Ignition Device, Automatic Vent Damper	0.65 to 0.75
Gas-Fired Forced-Air or Boiler with Sealed Combustion Chamber, Intermittent Ignition Device and Automatic Vent Damper	0.70 to 0.78
Gas-Fired Condensing Furnace or Boiler	0.80 to 0.90
Oil-Fired Furnace or Boiler	0.50 to 0.75
GeoSource Heat Pump Well Water System	3.5 to 4.4
GeoSource Heat Pump Earth Loop System	3.2 to 4.3

Source: Enocar Energy Systems

5.8.5.4 Selecting a GSHP System

The heating efficiency of ground-source and water-source heat pumps is indicated by their coefficient of performance (COP), which is the ratio of heat provided in BTU per BTU of energy input. Their cooling efficiency is indicated by the Energy Efficiency Ratio (EER), which is the ratio of the heat removed (in BTU per hour) to the electricity required (in watts) to run the unit. A geothermal heat pump with an ENERGY STAR label indicates an efficiency rating of at least 2.8 COP or 13 EER. Manufacturers of high-efficiency geothermal heat pumps voluntarily use the EPA ENERGY STAR label on qualifying equipment and related product literature.

5.8.6 Investigation Process and Methodology

The primary investigation methodology in developing ambient cooling resource potentials was to first make estimates of the cooling loads in SLO County. This was done using state wide data for the residential estimates and PG&E data for commercial cooling loads. At this point, a range of energy savings was applied as percentages provided by the EPA as to the savings potentials for ground source heat pumps.

To get a better estimate of the GSHP cooling potential for SLO County a better breakdown of the residential cooling loads would be very useful. This is primarily because there are two different climate zones with completely different cooling demands. Energy estimates for each climate zone for both residential and commercial sectors would lead to a much better energy savings estimates.

There are other technologies which can utilize ambient cooling resources such as air source heat pumps, roof evaporative cooling, and different ventilation strategies, but were not evaluated in this study.

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5.9 Ambient Energy: Solar Lighting

5.9.1 Characterization of Ambient Lighting Resource

Ambient lighting can be described as the light found naturally in nature which can be harnessed and used for human benefit. Most all ambient light comes directly from the sun, but technically includes light reflected back to earth from the moon and even light from the stars. On a clear day with the sun directly overhead, a bit less than half of the 1,000 watts per square meter which reaches the earth's surface is in the visible spectrum. The remaining energy is contained in the infrared and ultraviolet wavelengths. Harnessing this roughly 500 watts of visible light per square meter for use in the built environment is called "daylighting" or "day light harvesting."

In the past (and still in many parts of the world) ambient light was used as the primary lighting supply in the built environment as access to energy resources such as kerosene or electricity was limited or non-existent altogether. Hence, humans would generally wake up when the sun rose and go to sleep when the sun set to optimize the work day. With the widespread adoption of artificial indoor lighting, the need to wake and work with the cycle of the sun became less and less necessary. Work could be started earlier, stores and markets could be open later and thus energy demand grew. And while artificial light aided human progress in a number of ways, it marked society moving from a very efficient source of light to a very inefficient one.

To understand how much visible light energy comes from the sun compared to a standard incandescent light bulb the efficiencies of the entire energy conversion supply chain must be evaluated. Below in Figure 88, the power and conversion efficiencies of a nuclear power plant, a rooftop solar PV system, and daylighting are compared starting with 1,000 watts of raw energy potential prior to any conversion. It should be noted that this does not include the energy required for extraction of any raw resource (i.e. uranium). As can be seen, the overall efficiencies of nuclear and solar PV are 2.55 percent and 1.8 percent, respectively, which is a fraction of the 50 percent overall lighting efficiency daylighting. Incandescent

Figure 88: Energy Supply Chain Efficiency Comparison for Light

	Nuclear Power Plant	Rooftop Solar PV	Daylighting
Raw Resource Power (Watts)	1,000	1,000	1,000
Power Plant Conversion Efficiency	30%	19%	100%
Power Balance (Watts)	300	190	1,000
Transmission Efficiency	85%	95%	100%
Power Balance (Watts)	255	180.5	1,000
Incandescent Bulb Lighting Efficiency	10%	10%	N/A
Visible Light Conversion	N/A	N/A	50%
Final Lighting Power Balance (Watts)	25.5	18.05	500
Overall Lighting Efficiency	2.55%	1.81%	50%

Source: SLO RESCO

5.9.2 Local Resource Potential

San Luis Obispo County is located at 34.9° North Latitude, along a west ocean coast. This creates a mild Mediterranean microclimate providing the County with an average 315 days of full sunshine per year.

As defined by the California Energy Commission, SLO County has two primary climate zones—Zone 4 and Zone 5— which are used for energy planning and green building analysis. Climate Zone 4 covers a majority of the county, including Paso Robles and Atascadero, which are sunny inland climates, but have some ocean influence which keeps temperatures from hitting more extreme highs and lows. Climate Zone 5 includes the coastal cities of Morro Bay and Pismo Beach, and has warm summers with afternoon winds until sunset, which cools the region. The air is usually moist. Fog and cloud-cover commonly block the sun in the morning and evening.

In San Luis Obispo, during the longest day of the year (summer solstice) the day is over 14 hours long while during the shortest day of the year (winter solstice) the day is under 10 hours long. To conserve energy, the state of California participates in Daylight Saving Time which begins at 2 a.m. on the Second Sunday in March and lasts until 2 a.m. on the First Sunday of November. Daylight Savings Time was expanded by four weeks in 2007 through the Federal Energy Policy Act of 2005. (Refer to CEC/ Daylights Savings Time.)

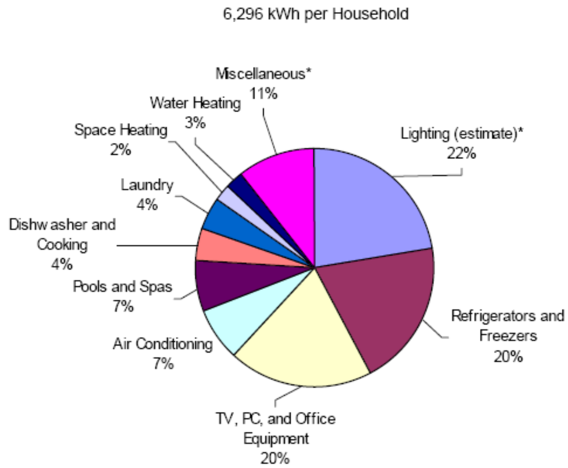
Many studies have been conducted to determine the energy savings from harnessing natural ambient lighting. One such study in 2003 by the New Buildings Institute titled "Advanced Lighting Guidelines – 2003 Edition, Final Report" found that dimming electric lights in day lit spaces could reduce annual lighting energy consumption in existing commercial buildings by 40-60 percent (refer to New Buildings Institute). Another white paper from Craig DiLouie of the Lighting Controls Association claims that harvesting daylight using continuous dimming equipment with photosensors can reduce electrical lighting usage between 30 percent-60 percent (refer to Craig DiLouie). A number of other studies show similar savings.

According to the California Energy Commission's Commercial End-Use Survey in 2006, interior lighting accounted for 28.9 percent of the overall usage for commercial buildings in California. (Refer to Itron.) Assuming an average of 45 percent energy savings, between an estimated 130,000 megawatt-hours of electricity could be conserved in interior commercial lighting in SLO County through effective daylighting technologies and strategies.

According to the 2010 California Residential Appliance Saturation Survey lighting accounted for 22 percent of the average California home's electrical consumption. (Refer to KEMA.) If the daylighting energy savings from the commercial sector (assuming 45 percent savings) were the same as the residential sector, roughly 80,000 megawatt-hours of energy could be saved. However there is reason to expect that savings from daylighting in the residential sector is significantly lower due to lower day time occupancy and a typically higher ratio of windows to square footage allowing for significant daylighting. For these reasons a modest 5 percent to 20 percent savings is estimated for daylighting in the residential sector. Assuming electric lighting savings of 12.5 percent (an average of 5 percent and 20 percent) in the residential sector and 45 percent (an average of 30 percent and 60 percent) in the commercial sector due to daylighting technologies and strategies roughly 153,000 megawatt-hours could be conserved in SLO County each year reducing up to 70 megawatts of peak load.

5.9.3 Maps and Charts

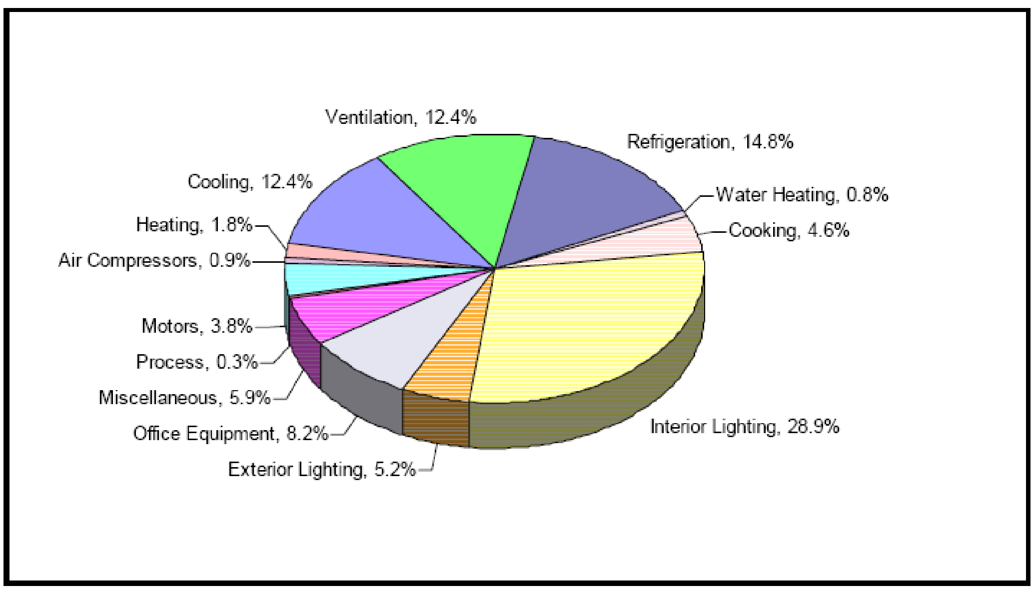
Figure 89: Residential Electricity End-Use Consumption in California



Source: 2010 California Residential Appliance Saturation Survey

As can be seen above in Figure 89, according the 2010 California Residential Appliance Saturation Survey lighting accounted for 22 percent of the electricity consumption for the average California home.

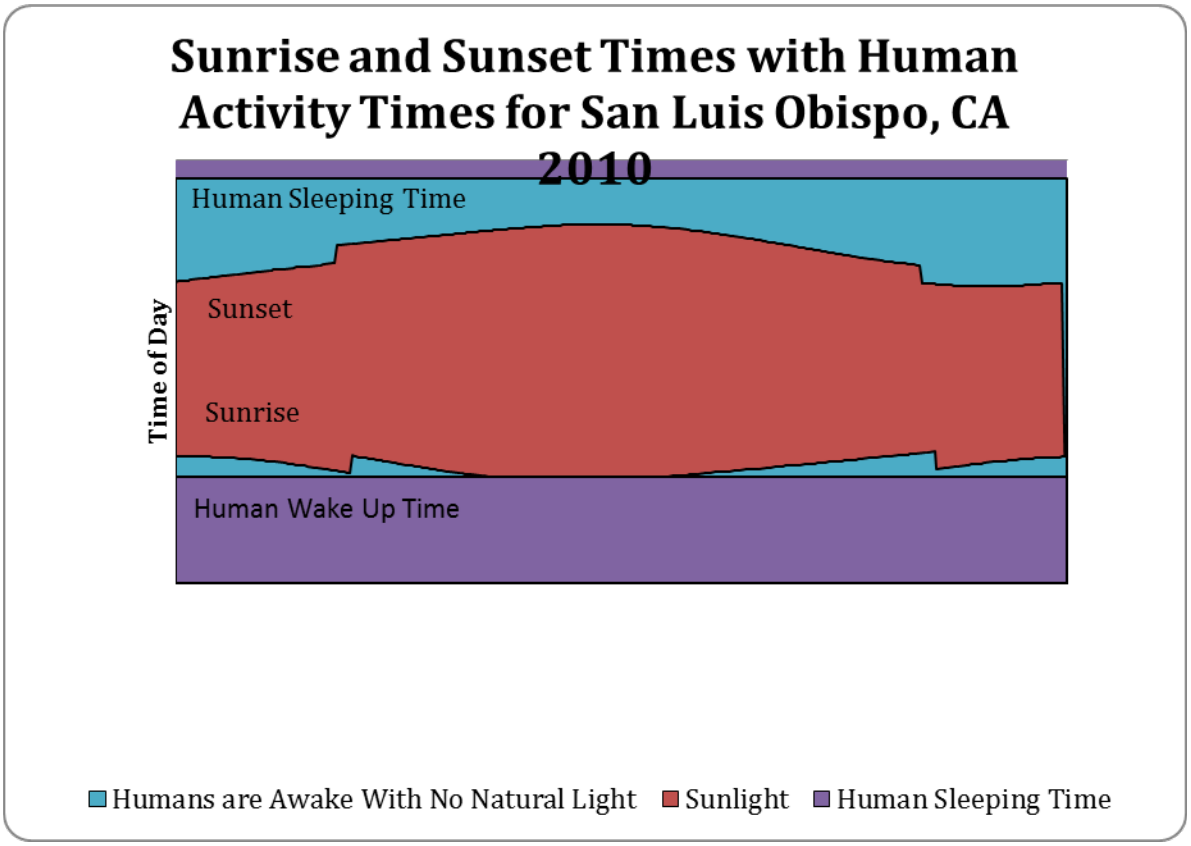
Figure 90: PG&E Commercial Electric Usage by End Use



Source: 2006 California Commercial End-Use Survey

As can be seen from the pie chart in Figure 90, in 2006 interior lighting on average accounted for 28.9 percent of electrical consumption in commercial buildings in California. This is more than three times the percentage of lighting consumption in residential units according to Figure 90. Additionally, it is interesting to note that interior lighting consumption is more than five times the amount of exterior lighting consumption in commercial buildings.

Figure 91: San Luis Obispo Sunrise, Sunset Graph



Source: U.S. Naval Observatory & SLO RESCO

Figure 91 shows sunrise and sunset times in San Luis Obispo County during the course of the year overlaid human awaking and sleeping times of 6am and 11pm. Daylights savings time can be observed from mid-march to mid-November as well. The blue color represents times in which people are awake and the sun has yet to rise, or has set before going to bed. The minimum amount of sunlight during December is 10 hours; the maximum in June is nearly 15 hours.

5.9.4 Technologies and Applications: Ambient Lighting

Ambient lighting technologies in the built environment can be divided into two main categories: daylighting collectors and controls.

5.9.4.1 Daylighting Collectors

5.9.5 Skylights

Skylights are horizontal windows or domes mounted on the roofs of buildings which allow for daylight to enter a space. Typically, skylights are made of a translucent acrylic which diffuses daylight and distributes it evenly in the space.

5.9.6 Light Tubes

Light tubes, also referred to as tubular daylighting devices, capture sunlight with a clear light collector on the roof and redirect the light through a highly reflective (sometimes non-linear) tube which then passes through a diffuser to allow light into a space. Light tubes are similar to a skylight, but have significant advantages. First, light tubes have a much smaller area on the roof therefore reducing the amount of heat gain. Additionally, because the tube itself does not have to be completely linear, light can essentially be directed anywhere in the building. Lastly, new technologies allow for interchangeable lenses to change the color and diffusion of the light at the fixture. Electric lighting can also be added inside of the light tube so it can serve as the only needed lighting fixture in a given area.

5.9.7 Hybrid Solar Lighting

Hybrid solar lighting brings daylight from a rooftop via a light collector into a building space using fiber optic technology. These light infused fiber optic cables can been routed throughout a building and coupled with existing dimmable lighting fixtures to save energy and provide natural daylighting in interior spaces.

5.9.8 Windows

Windows are the most common way to admit daylight into an interior environment. Windows admit direct sunlight and diffused daylight into a space, but the amount of light varies throughout the year. Different glazing applications and window designs can allow different amounts and light and heat into a space depending on the needs of the space.

5.9.9 Light Shelves

Light shelves are horizontal light reflecting overhangs placed on the outside of buildings (typically south facing) next to a window which allows daylight to penetrate deeper into a building. The top side of the light shelf has a high reflectance which reflects light to the ceiling which is then reflected and diffused to more parts of the space than would otherwise be lit from just a window. Additionally, light shelves help reduce solar heat gain in the summer, while still allowing light to penetrate deep into the building.

5.9.9.1 Controls: Photosensors With Daylight Harvesting

In order to maintain a minimum recommended light level in a space, daylight harvesting systems use a light level sensor called a photosensor to detect prevailing light, both natural and artificial. The signal from the photosensor will be interpreted by a control module which will then reduce/ increase the amount of light with an on/off, bi-level or dimmable switch. Dimmable switches have the greatest opportunity for energy savings and for occupant comfort.

5.9.10 Investigation Process and Methodology

The primary investigation methodology in developing ambient lighting resource potentials was to first make estimates of the lighting loads in SLO County. This was done using state wide data for the residential estimates and PG&E data for commercial cooling loads. At this point, a range of energy savings was applied as percentages determined by a variety of reports as to the savings potentials for daylighting.

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5.10 Ambient Heating: Solar Heating

5.10.1 Characterization of Ambient Solar Heating Resource

Ambient heating energy is the energy in one's immediate surroundings which can be used in its existing form to do work (heat) on a specific body such as a home. Ambient heating is not heating efficiency such as a more efficient furnace, nor is it a form of conservation such as lowering your thermostat. The goal of ambient heating is to transfer as much of the heat provided by the outside world into the built environment without energy conversion.

An example of ambient heating energy would be collecting solar radiation on a rooftop via solar hot water collectors to heat a swimming pool. The heat falling on the roof during the day is collected and transferred directly to the swimming pool water which is pumped through a solar hot water collector. Contrast this to a photovoltaic solar panel on a roof which converts sunlight into electricity which is then used to operate an electric pool heater.

This section will discuss the ambient heating resources in SLO County, and technologies and methods to harness ambient heat from the sun and make this heat usable in the built environment focusing on solar hot water and passive solar space heating. Another form of ambient heating, geothermal heating is discussed in the Ambient Geothermal section.

Below is a brief description of the quantification of solar energy. For more information on solar energy please see the Solar Energy section.

To quantify solar energy a few standard units are used. On a clear day with the sun directly overhead, about 1,000 Watts per square meter reaches the earth's surface. This amount of sunlight at 25 degrees Centigrade, as seen through 1.5 times the thickness of the atmosphere, is referred to as "Standard Test Conditions" or "One Sun" (refer to Brinkworth).

Kilowatts per square meter (kW/m^2) is a measurement of the amount of "power" per unit of area, either continuously or in a given instant. A given amount of power applied over time is often referred to as "energy", and is measured in kilowatt-hours (KWh). A kilowatt-hour is 1000 watts of power delivered for 1 hour, or any mathematical equivalent.

The amount of power delivered by the sun over time on a flat square meter surface is measured in kilowatt-hours per square meter (KWh/m^2); this can be over any named period of time—typically a day, a month or a year. Most of the regions of the earth inhabited by human beings receive an average of 3 to 7 kilowatt-hours of energy per square meter (KWh/m^2) in a day. This energy can be tapped to provide heat.

When discussing heating technologies and heat in general different units of measurement are often such as British Thermal Unit (BTU) and Therms. Both of these units are measurements of power over time and can be directly converted to kilowatt-hours. One BTU is approximately the amount of energy needed to heat one pound of water one degree Fahrenheit and is the equivalent of 0.0002929 kilowatt-hours. (Or 3,414 BTUs are equal to one Kilowatt-hour) One therm is equal to approximately 100,000 BTUs and is the unit of measurement commonly used by utility companies to bill for the amount of thermal energy consumed over a given time.

5.10.2 Local Resource Potential

5.10.2.1 Solar Hot Water

San Luis Obispo County is located at 34.9° North Latitude, along a west ocean coast. This creates a mild Mediterranean microclimate providing the County with an average 315 days of sunshine per year (refer to SLO County Figures and Facts).

As defined by the California Energy Commission, SLO County has two main climate zones—Zone 4 and Zone 5— which are used for energy planning and green building analysis. Climate Zone 4 covers a majority of the county, including Paso Robles and Atascadero, which are inland from the coast but have some ocean influence which keeps temperatures from hitting more extreme highs and lows. Climate Zone 5 includes the coastal cities of Morro Bay and Pismo Beach, and has warm summers with afternoon winds until sunset, which cools the region. The air is usually moist. Fog and cloud-cover commonly block the sun in the morning and evening.

The solar thermal energy potential in SLO County is very good compared to most of the U.S., as is documented in the section on solar electric power generation. The main difference between the resource potentials of solar hot water and solar photovoltaic is that the outside ambient temperature strongly affects how much useable hot water can be created, where this has much less effect on solar photovoltaics.

In 2005, the number of installed solar hot water systems around the world was over 46 million totaling roughly 88 GWth (Thermal Gigawatts are a way to measure power in the form of heat) with the United States having 1.6 GWth of solar hot water capacity installed, or 1.8 percent of global capacity (China currently holds 80 percent of the global installed capacity). (Refer to Environment California.)

A KEMA-Xenergy study found that commercial buildings in California could save 219 million therms of natural gas a year by installing solar hot water systems (refer to KEMA-Xenergy). According to Sempra Energy in 2008 San Luis Obispo County consumed roughly 37 million therms of natural gas.

Doing an analysis of the rooftop potential for SLO County it was determined that a majority of the water heating needs could be met with solar hot water. Using a variety of assumptions, including assuming that the solar hot water panels could capture 55 percent of the solar heat energy, it was determined that the residential and commercial rooftops could respectively generate 459,000 and 176,000 thermal MWh annually, or 27 percent of the county's thermal usage, as can be seen in the table below:

Table 18: Solar Thermal Resource Technical Potential

	MWh - thermal	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Solar Hot Water (Residential)	459,000	19.6%	120,258
Solar Hot Water (Commercial)	176,000	7.5%	46,112
Total	635,000	27.1%	166,370

Source: SLO RESCO

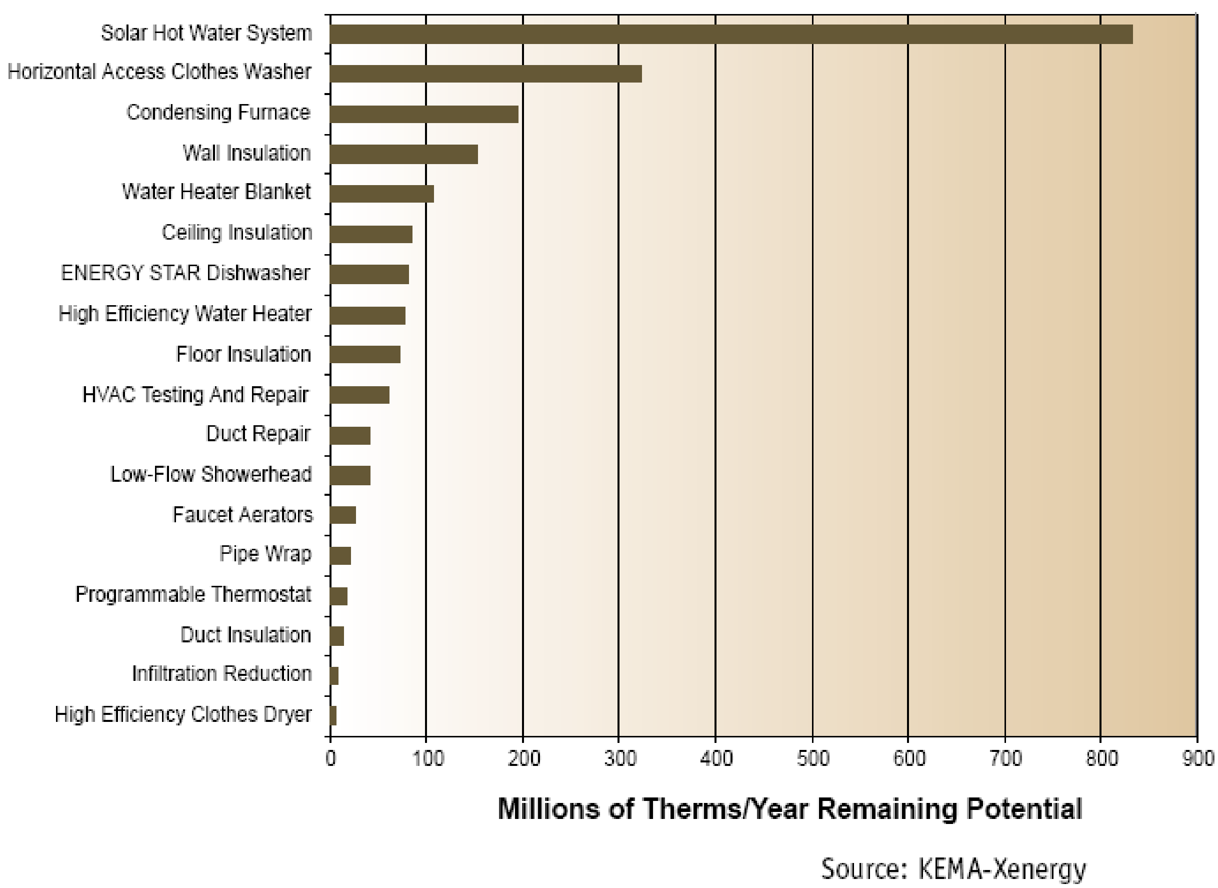
It should be noted that this estimate assumes that of the available solar accessible roof space only 25 percent of the area is used for solar hot water while 75 percent is reserved for solar photovoltaics. Were more roof space to be allocated to solar hot water the totals would be significantly higher.

5.10.2.2 Passive Solar Heating

According to the same CEC: California Energy Demand: 2000-2010 report 44 percent of all natural gas heating in California is used for space heating. If implementing passive solar technologies and techniques such as south facing windows with sunshades, trombe walls, or sunrooms on San Luis Obispo's existing residential building stock could reduce the residential space heating load by only 10 percent it would reduce the County's natural gas consumption by 4.4 percent.

5.10.3 Maps and Charts

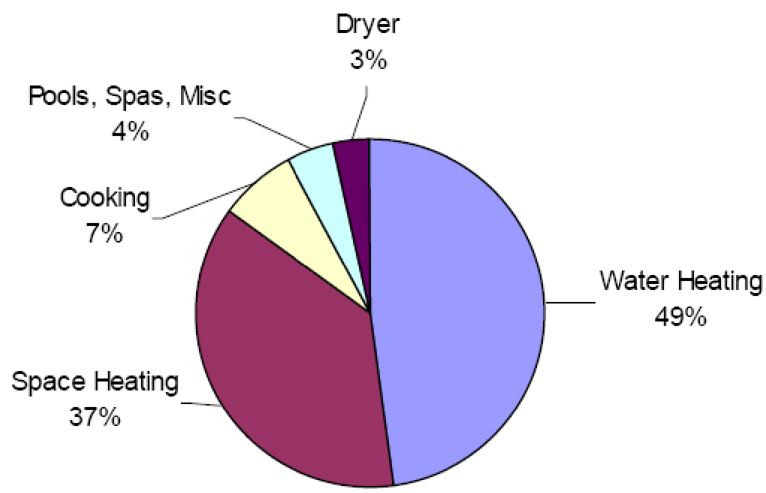
Figure 92: Remaining Potential Thermal Energy Savings in California in 2003



Source: KEMA-Xenergy

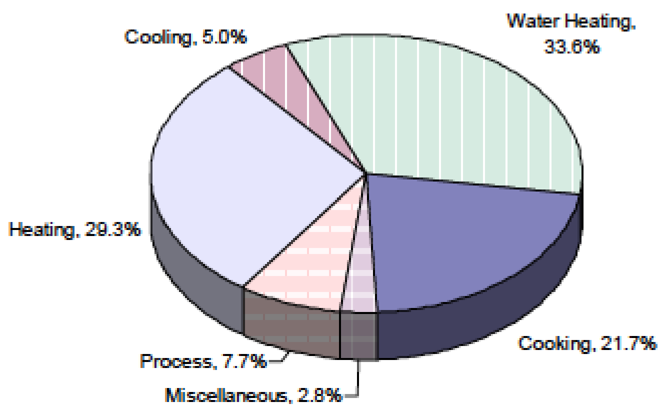
According to a 2003 study by KEMA-Xenergy, solar hot water systems hold the largest potential in California for reducing natural gas consumption in homes. Per Figure 93, solar hot water systems would save 831 million therms per year in California.

Figure 93: Percentage of Natural Gas Usage by End Use in California's Residential Sector (2009)



Source: 2010 California Residential Saturation Survey

Figure 94: Percentage of Natural Gas Usage by End Use in PG&E's Commercial Sector (2006)



Source: California Commercial End-Use Survey

Figure 95: Solar Hot Water Potential in San Luis Obispo County

Source: SLO RESCO

The SLO RESCO team found there to be very significant rooftop solar hot water potential throughout SLO County. Using the methodology of the Navigant Consulting report (explained further in the Investigation and Methodologies section in the Solar PV chapter) and a number of different assumptions, the SLO RESCO team found there to be 403 MW of rooftop solar hot water potential throughout SLO County.

5.10.4 Technologies and Applications: Heating

5.10.4.1 Solar Hot Water

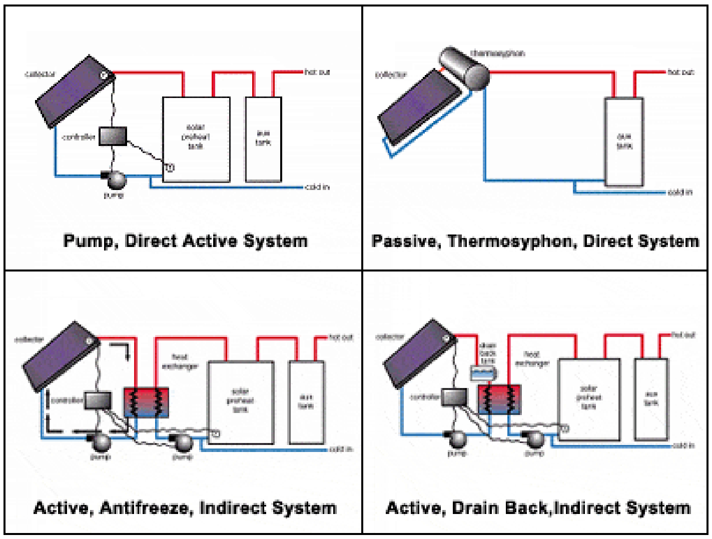
Solar hot water system technology has been used in California since the 1800s with boom in the 1970s where it then collapsed due to technological flaws, a withdrawal of government incentives and misinformation about the technology. Since then there have been many improvements in solar hot water technology bringing it mainstream in many developing countries such as China.

5.10.4.2 How does a solar hot water system work?

Solar hot water systems capture the sun's radiation to heat water for homes and businesses. In a basic system water is moved through a solar collector where it is heated then either used directly, stored, or moves to be heated further by a more conventional water heater. Many times solar hot water heaters are used to "pre-heat" the water, therefore reducing the amount of energy needed to create the desired temperature for a conventional water heater.

5.10.4.3 Components and Types of Systems

Figure 96: Different Types of Solar Hot Water Systems



Source: National Institute of Building Sciences

Every type of solar hot water system is typically comprised of four basic components: a solar collector to harness the sun's radiation, some type of thermal storage to hold the hot water, a controls system, and a conventional back-up heater when demand exceeds the solar collector's capacity or when there is limited radiation from the sun.

With these basic components, typically four types of solar hot water systems can be arranged which are shown in Figure 96. The main differentiation between the system type is whether it is an active/passive or direct/indirect system. An active system requires a pump to move water through the system where as a passive system relies on natural convection to move water through the system without a pump (e.g. a thermosyphon). In a direct system, the potable water is the heat transfer fluid whereas with an indirect system a heat transfer fluid (such as propylene glycol or antifreeze) is heated then transferred to potable water via a heat exchanger. Each of these systems has advantages and disadvantages and is largely dependent on the climate and application. For example, in colder climates where temperatures regularly drop below freezing, an indirect system is more appropriate to avoid pipe freezing.

5.10.4.4 Types of Collectors

There are four standard types of collectors currently used in industry for solar hot water generation as explained below.

Evacuated Tube Collectors contain parallel rows of transparent glass tubes reach tube contains a glass outer tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but prevents radiation heat loss. These efficient collectors are used for higher temperature systems can create hot water up to 350 degrees.

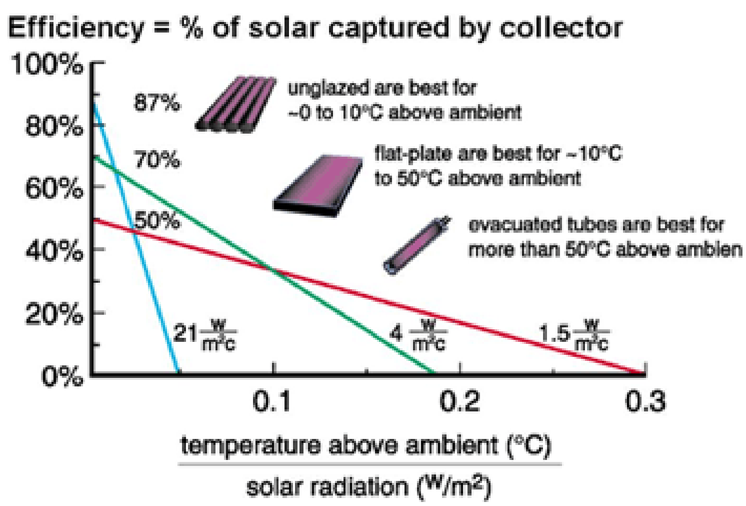
Unglazed Collectors are simply black tubes which water flows through and are commonly used for swimming pool heating as they typically cannot raise the temperature more than 20 degrees F over the ambient temperature.

Flat-plate glazed collectors are black water-filled boxes with a clear glass or plastic top facing the sun. The glazed finish on the glass or plastic is designed to let heat in, while minimizing how much heat escapes. This type of collector is the most popular in the U.S. for residential application and can heat water to 130 degrees F above ambient temperature.

Integral collector-storage system, also known as ICS or *batch* systems, house a storage tank for hot water inside a flat plate-like collector. They should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather.

5.10.4.5 Efficiency

Figure 97: Efficiency of Different Solar Hot Water Collectors



Source: National Institute of Building Sciences

Solar hot water collector efficiency is a function of the technology, the inlet water temperature, the ambient air temperature, and the intensity of solar radiation. In Figure 97, developed by the National Institute of Building Sciences, the three most common solar collector technologies are plotted as a straight line against the parameter (Tc-Ta)/I, where Tc is the collector inlet temperature (C), Ta is the ambient air temperature (C), and I is the intensity of the solar radiation (W/m²). Inexpensive, unglazed collectors are very efficient at low ambient temperatures, but efficiency drops off very quickly as temperature increases (refer to Whole Building Design Guide).

5.10.4.6 Passive Solar Heating

Passive solar heating technologies are a means of providing heating with sunlight without using active mechanical systems, such as a furnace. The technologies involved in a passive solar heating system in a residential or commercial application are fairly simple. There two elements which every passive solar heating system must have: a south facing exposure of transparent material (glass, plastic) to allow solar energy to enter; and a material to absorb and store the heat for later use. With these two basic elements there are a number of designs which arrange a variety of simple technologies to create effective passive solar heating systems.

Direct Heat Gain: the simplest solar passive heating design is the direct gain design where sunlight is admitted to a space (typically by a south facing window) and this solar radiation is then converted to thermal energy. The walls, floors and other objects with thermal mass intercept the solar radiation and store the thermal energy until the room temperature drops at night when it re-radiates this heat back into the space. The thermal mass in the space will continue to heat the room until the ambient temperature and thermal mass reach equilibrium. This design will reduce if not eliminate the amount of active mechanical heating needed at night when temperatures drop and can even keep a given space warm through many cloudy days.

5.10.4.7 Indirect Heat Gain

In indirect gain, a storage mass collects and stores heat directly from the sun and then transfers heat to the interior space. The key difference between direct and indirect heat gain is that the sun rays do not travel through the occupied space to reach the storage mass in an indirect system.

Water Wall: in a water wall the sun`s rays are intercepted by a south facing water storage mass (such as a tank in wall), then converted into heat and distributed by convection and/ or radiation to the living space.

Trombe Wall: a Trombe wall is masonry or concrete wall with a glass skin on the outside with a small air space of 4-8 inches is between the wall and the glazing. The sun's rays pass through the glass and are absorbed by the mass wall which radiates the heat into the space throughout the night. The glass and air barrier prevent heat from being lost to the outside environment.

Roof Ponds: a roof pond is essentially a water wall, but on the roof. Roof ponds are best suited for natural summer cooling in regions where large temperature swings exist.

5.10.4.8 Isolated Systems

Isolated systems are another common type of passive heating where the collection and storage of heat are independent of the building. (Isolated) A sunroom is the most common example of an isolated system which combines features of direct gain and indirect gain systems. Sunlight entering the sunroom is retained in the thermal mass and air of the room. The sunlight is transferred into the home through the shared mass wall of a house and the sunroom or by vents which allow warm air to enter the home.

5.10.4.9 Thermosyphon Systems

In a thermosyphon system heat flows when a cool fluid (air or liquid) naturally falls to the lowest point and once heated by the sun rises naturally into a storage mass for convective or radiant distribution to a living space. This causes somewhat cooled air or liquid to fall again, creating a continuous heating and circulation cycle. Thermosyphon systems are unique as they can be isolate or connected to the living space.

5.10.4.10 Passive Solar Retrofits

While passive solar systems are best integrated into initial home design, there are certain techniques which are more suitable for residential retrofits. According to www.naturalhandyman.com one of most common passive solar retrofits are increasing or adding windows to a south facing wall with sun shades or blinds which can allow more heat to enter the living space during the winter months. Another common retrofit is creating a trombe wall by adding glazing with a thermal air barrier to the outside of a south facing masonry or brick wall. Lastly, the addition of a sunroom onto a house is a way to create an isolated passive solar system.

5.10.5 Investigation Process and Methodology

The methodology to quantify the solar hot water potential was based on the 2007 Navigant Consulting rooftop PV potential study and modified to quantify solar hot water potentials. This methodology is explained in detail in the Solar Energy section.

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5.11 Regenerative Energy: Combined Heat and Power

5.11.1 CHP (Combined Heat and Power)

Combined Heat and Power (CHP) is an energy recycling technology that concurrently generates thermal energy and power (electricity and/or mechanical energy) in a single, integrated system. *Cogeneration* is a term that is often used interchangeably with CHP, but is defined more precisely as power generation and waste-heat recycling that "could be interconnected at distribution, sub-transmission, or transmission system voltages" (refer to CEC Staff Report). For the purposes of the SLO RESCO analysis, we are adopting the following distinction in the use of these two terms: CHP will refer to systems that are sized to produce power for on-site use only, while cogeneration will refer to systems that are sized for exporting power onto the grid. According to this definition, all existing SLO County installations are classified as CHP systems, while future installations may potentially expand into the cogeneration category.

5.11.2 Characterization of CHP Resource

Conventional power generators are inherently inefficient, converting only about a third of a fuel's potential energy into usable energy while the other two-thirds are lost as waste heat. As a result of this wasted heat, the average efficiency of power generated by US utilities has hovered around 35 percent over the past 50 years. CHP systems are identical to these modern power generators, with the exception that they collect the heat from the electrical generation process and use it to perform other onsite work, reaching efficiencies up to 80 percent. The excess heat can be used to heat air in an office building, provide hot water or steam, drive a dehumidifier, or even drive an absorption chiller to provide refrigeration and cooling. A facility producing electricity, heat and cold is sometimes referred to CCHP (Combined Cooling, Heat and Power – also referred to as 'tri-gen'). With this wide range of uses, a variety of buildings can benefit from the useful heat in a CHP system.

California ranks second in the nation, after Texas, for CHP deployment, with 1,200 sites totaling over 9,000 MW of installed capacity. This is primarily due to the state's large industrial and thermal energy demand, coupled with its high reliance on natural gas as a primary fuel for power generation. The industrial sector, comprising roughly 50 percent of state-wide CHP capacity, involves the manufacturing and processing of food, paper, wood, metals, and chemicals. Enhanced oil recovery operations account for ~30 percent of the installations, while the commercial and institutional sectors account for roughly 20 percent. A remaining small percentage (< 5 percent) of CHP is used in agricultural and mining applications (refer to CEC/IEPR 2009).

Of existing CHP installations in California, approximately 40 percent are >100 MW, with systems of <5 MW representing ~5 percent. Therefore, the greatest market potential for new CHP capacity lies in smaller-scale installations. The CEC is recommending an additional installation of 6,500 MW of systems of <20 MW by 2020, in order to meet GHG reduction goals under AB 32. Additionally, the CEC is calling for a utilization of CHP to meet the goal of net zero energy for all commercial new construction by 2030 (refer to CEC/IEPR).

5.11.3 Potential Small-Scale CHP Markets

CHP technology exists in a wide variety of energy-intensive facility types and sizes nationwide including institutional, commercial, municipal and residential buildings. The following markets have already found success with CHP systems:

- Institutions: colleges and universities, hospitals, prisons, military bases;
- Commercial buildings: hotels and casinos, airports, high-tech campuses, large office buildings, data centers, nursing homes, health/fitness centers, postal services;
- Municipal: district energy systems, waste water treatment plants, K-12 schools;
- Residential: multi-family housing, planned communities, high-rise apartments.

Ideal candidates for CHP have a demand for both electricity and heat. A system is optimally designed when 100 percent of the heat is put to secondary use, and the system is able to run continuously throughout most of the year. However, a system can be very cost-effective running only during business hours, or as a demand-response solution generating power during peak-load hours, thus allowing businesses to avoid peak electrical rates. To assess a potential site for CHP installation, the site's electrical and thermal (natural gas) usage should be analyzed temporally. Based on electrical usage in MWh per month, the maximum system size can be approximated through Figure 98.

Figure 98: Total MWh Generated per Month* for Various Small-CHP System Sizes

System Size (MW)	Power Generated per month (MWh)*
.05	36
0.1	72
0.25	180

System Size (MW)	Power Generated per month (MWh)*
0.5	360
0.75	540
1.0	720

*Assuming 24 hour/day operation and a 30 day month

Source: Department of the Environment City and County of San Francisco

5.11.4 Local Resource Potential

There are many existing CHP installations operating in San Luis Obispo County. Together, these facilities generate a total of 3,265 kW (3.3 MW) of capacity (refer to Figure 101). The city of Paso Robles has plans to construct a new WWTP with state-of-the-art CHP features. In the institutional sector, California Polytechnic University (Cal Poly) has two student dormitory complexes currently serviced by CHP systems, one of which was installed in 1984, and the other recently commissioned in 2009.

Additional CHP installation in the county is promising. By taking a quick assessment of large commercial, institutional, and municipal facilities in the county it was estimated that an additional 21 MW could be produced with CHP, far larger than the current capacity. For a certain facility types, more accurate estimates were and can be found below in Figure 99, Figure 100, and Figure 101. These sites include speculative factors such as the status of emerging technologies, the strength of market demand, the cost-benefit analysis, and the ease of permitting regulations. Residential potential was not factored into the estimation as every residence in the county could conceivably install a small fuel cell or gas generator to assist in fulfilling their heating, cooling, and power needs. Furthermore, a more in depth look into commercial and municipal sites such as office buildings and large health centers could reveal several more candidates for CHP.

Figure 99: Combined Heat and Power (CHP) Technical Potential by Customer Segment

Segment	MW	MWh	MWh-Thermal	Count (est.)
Large Office > 30,000 sq. ft.	5	37,230	62,227	50
College/Universities	3	22,338	37,336	3
Small Lodging (<100 rooms)	2.5	18,615	31,114	50
Health	2.5	18,615	31,114	5
Vineyards	2	14,892	24,891	20
Military Bases	2	14,892	24,891	2
Lodging (>100 rooms)	1	7,446	12,445	10
Prison	1	7,446	12,445	1
Waste Water Treatment Plants	0.7	5,212	8,712	7
High Schools	0.6	4,468	7,467	6

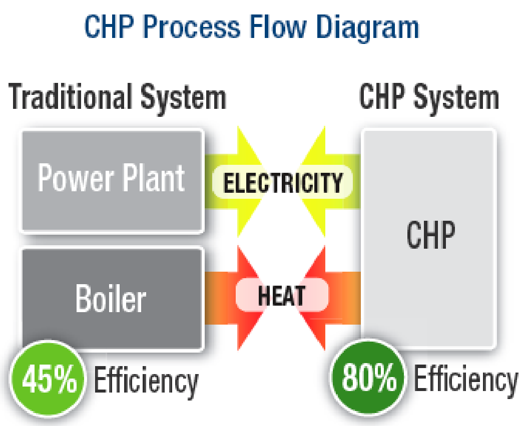
Segment	MW	MWh	MWh-Thermal	Count (est.)
Middle Schools	0.5	3,723	6,223	10
Airport	0.1	745	1,245	1
Total	20.9	155,000	260,000	165

Source: SLO RESCO

5.11.5 Maps and Charts

Figure 100 below shows how CHP technology can raise typical combined efficiency levels of 45 percent in traditional methods of separate production of heat and power, to as high as 80 percent in a system that produces combined heat and power.

Figure 100: CHP Process Flow Diagram



Source: Oakridge National Laboratory

There are eight CHP projects in SLO County, all of which have been installed during the last decade and with two exceptions – the SLO County office building in the City of San Luis Obispo and the City of San Luis Obispo's waste water treatment plant - they remain in operation.

Figure 101: Current CHP Facilities in San Luis Obispo County

Site	Location	Constructed	Generator(s)	Status
Embassy Suites Hotel	San Luis Obispo	2013	1 x 85kW	Online
Tesoro Gas Station & Carwash	Atascadero	2002	1 x 30kW	Online
SLO County Office Building	San Luis Obispo	2003	3 x 200kW	Off-line

Price Canyon Well Field	Arroyo Grande	2003	1 x 1400kW	Online
SLO City Municipal Pool	San Luis Obispo	2005	1 x 60kW	Online
SLO City Municipal Wastewater Treatment Plant	San Luis Obispo	2005	8 x 30kW	Off-line
Cal Poly San Luis Obispo Dorms	Cal Poly	1984	1 x 350kW	Online
Cal Poly San Luis Obispo Dorms	Cal Poly	2009	2 x 250kW	Online

Source: SLO RESCO

Combined the known installed (on and off-line) CHP capacity in SLO County is 3.26 MW of electrical capacity.

Figure 102: Candidate Hotel Sites for CHP Installation: End Uses, Description and Estimated System Size

Facility Name	System Size Estimate (kW)	Location	Phone	Facility Description	Thermal Demands
Avila Village Inn	30 (possibly too small)	6655 Bay Laurel Dr. Avila Beach, CA 93424	(805) 627-1810	30 Rooms	Cocktail Lounge, Fitness Room, Pool, Restaurant
Best Western Cavalier Oceanfront Resort	50	9415 Hearst Drive San Simeon, CA 93452	(805) 927-4688	90 Guest Rooms, 2 Floors, 110 Person Conference Facility	Pool, Day Spa, Restaurant, Guest Laundry, Fitness Center
Best Western Shore Cliff Lodge	50	2555 Price Street Pismo Beach, CA 93449	(805) 773-4671	100 Rooms	Heated Pool, Jacuzzi, Fitness Center

Facility Name	System Size Estimate (kW)	Location	Phone	Facility Description	Thermal Demands
The Cliffs Resort	100	2757 Shell Beach Road Pismo Beach, CA 93449	(805) 773-5000	160 Guest Rooms & Suites, 10,000 Sq. Ft. Banquet Space	Spa, Restaurant, Pool, Jacuzzi, Sauna, Fitness Center
Dolphin Bay Resort & Spa	100	2727 Shell Beach Rd. Pismo Beach, CA 93449	(805) 556-3887	200+ Rooms	Day Spa, Restaurant, Pool, Fitness Center
Holiday Inn Express - SLO	50	1800 Monterey Street San Luis Obispo, CA 93401	(805) 544-8600	100 Rooms	Fitness Center, Laundry Services
La BellaSera Hotel & Suites	50	206 Alexa Court Paso Robles, CA 93446	(805) 238-2834	Spacious 59 Suites & 1 Penthouses, 150 Person Conference Facility	Personal Whirlpools, Personal Kitchenettes, On-Site Restaurant And Lounge
Kon Tiki Inn	50	1621 Price St. Pismo Beach, CA 93449	(805) 773-4833	86 Rooms, Conference Facility	Pool, Fitness Room, Guest Laundry
Madonna Inn	50	100 Madonna Road San Luis Obispo, CA 93405	(805) 543-3000	110 Rooms, Banquet Space, Conference Facility	Bakery, Lounge, Day Spa, Pool, Fitness Center, Restaurant, Café
Mission Inn of Pismo Beach	50	601 James Way Pismo Beach, CA 93449	(805) 773-6020	120 Rooms, 1660 Sq. Ft Banquet & Conference Facility	Laundry Services, Fitness Center, Lounge, Pool
Oxford Suites	50	651 Five Cities Dr. Pismo Beach, CA 93449	(805) 773-3773	132 Rooms, 536 Sq. Ft Meeting Room, 252 Sq. Ft Boardroom	Heated Pool, Fitness Center, Laundry Services

Facility Name	System Size Estimate (kW)	Location	Phone	Facility Description	Thermal Demands
Paso Robles Inn	50	1103 Spring Street Paso Robles, CA 93446	(805) 238-2660	98 Rooms, Executive Board Room,	Pool, Spa
SeaVenture Resort	30 (possibly too small)	100 Ocean View Avenue Pismo Beach, CA 93449	(805) 773-4994	50 Rooms, Banquet Room	Restaurant, Private Jacuzzis
TOTAL:	710				

Source: SLO RESCO

Hotels with greater than 100 rooms generally have the electrical and thermal loads necessary to benefit greatly from a cogeneration system. If they have additional thermal loads through on-site pool heating, laundry facilities, or restaurants, as the above hotels contain, they can be very well suited. Larger hotels in the several hundred room category are excellent cogeneration candidates.

Figure 103: Potential Institutional Sites for CHP Installation

Facility Name	System Size Estimate (KW)	Location	Facilities Description	Thermal Demands	Size (sq. ft.)
Robert E. Kennedy Library, Cal Poly	250	1 Grand Ave San Luis Obispo, CA 93407	2,576,300 items	Air-Conditioning, Computers	208,433
Performing Arts Center, Cal Poly	100	1 Grand Ave San Luis Obispo, CA 93407	Roadhouse, seats 1,298		101,030
Recreation Center, Cal Poly	100	1 Grand Ave San Luis Obispo, CA 93407	Gym seats 4,000	Heated Pool, Air-Conditioning	90,337
Cuesta College	50		11,315 total enrollment (2008)	Heated Pool	
Men's Colony State Prison Hospital	100		6,512 occupancy, 350 acres	Hospital, Dining Room, Classrooms	5,162

Facility Name	System Size Estimate (KW)	Location	Facilities Description	Thermal Demands	Size (sq. ft.)
French Hospital Medical Center	250	1911 Johnson Avenue San Luis Obispo, CA 93401	Hospital complex (500 Employees, Operates 24-7)	Various	25,000
TOTAL:	850				

Source: SLO RESCO

A potential institutional site in SLO County is the California Men's Colony, which has a large space-heating and water-heating load, as well as substantial electrical usage. Hospitals, food processing plants, and schools are other likely candidates for CHP installation.

Figure 104: Potential Wastewater Treatment Sites for CHP Installation

Facility Name	System Size Estimate (kW)	Location	Million Gallons per Day (MGD)
Cambria Community Services District	25 (possibly too small)	Health Lane Cambria, 93428	0.5
Pismo Beach WWTP	55	550 Frady Lane Pismo Beach, 93449	1.1
San Luis Obispo WTP	240	25 Prado Rd. San Luis Obispo, 93401	4.5
Morro Bay/Cayucos WTP	85	160 Atascadero Rd. Morro Bay, 93442	1.7
South San Luis County SD	135	1600 Aloha Place Oceano, 93445	2.7
Paso Robles WTP	145	3400 Sulfer Springs Rd. Paso Robles, 93446	2.9
Total	660		

Source: SLO RESCO

On the municipal scale, wastewater treatment plants with anaerobic digesters are ideal sites for CHP applications (refer to CEC/IEPR Workshop).

5.11.6 Technologies and Applications

The deployment of CHP/Cogeneration can be accomplished by a variety of designs that optimize the cost-effectiveness, performance capabilities, and efficiency of traditional technologies for heating, cooling, and power generation. There are generally four major components to a CHP system: a heat engine (i.e. prime mover), a generator, a heat recovery mechanism, and an electrical interconnection. Typically, systems are identified by their prime movers. In California, the most common prime movers are gas turbines. Combined cycle turbines are used in the largest-scale installations, while simple cycle turbines are used in medium-scale systems. Smaller-scale systems –comprising the greatest number of CHP sites (62 percent)-- are driven by natural gas-fired reciprocating engines (refer to CEC/IEPR).

5.11.6.1 Reciprocating internal combustions engines

These are generally reliable, relatively easy to maintain, and readily available in a range of sizes capable of powering generators up to several MW. They can be easily modified to run on biogas, natural gas, or propane, and are well-suited for applications that require low pressure steam or hot water.

5.11.6.2 Simple cycle combustion turbines

These are employed where the load is 40 MW or less. They have dual-fuel capacity, and can choose from natural gas, petroleum, landfill gas, or biogas. They have exhaust gases of 700-800 degrees F, which make them appropriate for high temperature heat recovery. In a once-through process, the turbine runs with efficiencies of only 35-38 percent.

5.11.6.3 Combined cycle gas turbines

These combine a heat recovery process with a steam generating process, optimized for additional heat or power generation. The first turbine is run by gas, with a second run by steam. Throughout the process, there are waste heat opportunities that can be captured. CCTs can be deployed in systems of over 100 MW and can reach efficiencies of 45-55 percent.

Commercial, industrial or institutional operations that employ boilers in constrained locations where factors prevent the use of a heat engine may be prime candidates for CHP installations using fuel cells. Fuel cells employ an electrochemical process to convert hydrogen into water and electricity. The hydrogen can be readily obtained on-site from the existing natural gas infrastructure. They are highly reliable, and their electrical output is suitable for sensitive electronic equipment. They are also quieter, cleaner, and can deliver much higher efficiencies than heat engines in CHP applications.

Over the past decade, new industrial ecology scenarios and zero waste solutions have been applied to CHP/Cogeneration models. While natural gas is still the preferred fuel for over 80 percent of CHP generation in California, advanced systems incorporating renewable, sustainable, and environmentally friendly fuels are growing. On-site and near-site renewable fuels are being used in 4.5 percent of CHP systems (most commonly for steam boilers) in California. They include: anaerobic digester gas, biomass gas, crop residues, food-processing residues, landfill gas, municipal solid waste, and wood waste (refer to CEC/IEPR).

5.11.7 Investigation Process and Methodologies

In interviews with SLO County and municipal officials, the SLO RESCO team has been informed that the potential benefits of CHP/Cogeneration are recognized and desired. A small number of CHP systems are currently in use within the commercial, institutional, and government sectors; a larger number of installations would exist if they were more affordable. As reported in interviews, one possible reason for the familiarity with CHP technologies in SLO County is the role that Southern California Gas/Sempra Utilities has played in familiarizing its larger-scale consumers with the efficiencies that can be reached through CHP installations.

A July 2009 draft staff report for the CEC (refer to References) discusses the significant untapped potential for CHP systems to be installed at wastewater treatment plants throughout the state.

5.11.7.1 Assumptions

Estimates of SLO County hotel and wastewater treatment plant potentials for CHP power are based on case studies documenting current CHP systems. Principle data was received from the San Francisco Department of the Environment assessment of CHP for the city of San Francisco. The same conservative calculations that San Francisco used to estimate office buildings were used to estimate the average system of potential SLO County Institutional buildings (refer to Figure 105).

Figure 105: Energy Estimate of CHP Installations in Office Buildings

Building Size (Square Feet)	Average System Size (MW)
> 800,000	1.5
450,000 – 800,000	1.0
250,000 – 450,000	0.5
200,000 – 250,000	0.25

Source: Department of the Environment City and County of San Francisco

5.11.8 References

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5.12 Regenerative Energy: In-Conduit Hydropower

5.12.1 Characterization of In-Conduit (Pipeline) Hydro Resource

Studies have shown that the movement of water throughout the state of California accounts for upwards of 8 percent of total electricity use (refer to LBNL). Since a majority of that energy is used for pumping water up hill, there is potential to recover some of that energy at certain points where water is flowing downhill.

Pipeline water is also part of the water cycle. A large number of man-made reservoirs throughout California collect water from their surrounding watershed from rainfall and snowmelt. The water is contained in the reservoir basin usually behind a dam. Once the flow of water is controlled behind the dam, it can be directed into a pipeline and transported to where it is needed. Water throughout California, especially in San Luis Obispo County is transported through a complex system of canals and pipelines assisted by large pumps and support facilities. These conveyance systems are often built through very rough terrain where these large pumps are necessary for lifting the water up hill. Once the water is lifted over a ridge, gravity carries it back down to a lower elevation. This downward flowing water has energy that can be recovered in a similar way to a conventional hydropower system found at a dam or on a river.

The amount of energy that can be obtained from a potential pipeline site is similar to a conventional hydro power resource such as an impoundment or run-of-the-stream system in that it is dependent on the distance the water falls and the volume of water available to do work. These factors are called head and flow respectively.

5.12.1.1 Head

The head is defined as the vertical distance that the water falls. This distance can be measured in feet or units of pressure (usually psi). For any type of hydropower system the gross head and net head have to be considered. The gross head is the change in vertical height between the intake pipe of the system and the water turbine. The net head takes into account losses of energy due to friction. In general, the higher the head, the more potential power the site will have and more economical the hydropower will be to develop.

5.12.1.2 Flow

The flow is the volume of water over time moving through a pipeline. It is often measured in either cubic feet per second (cfs) or gallons per minute (gpm). There are several factors influencing the flow within a pipeline. Capacity of the reservoir that feeds the pipeline is a critical because it can change based off of changing conditions in the watershed around the reservoir. The capacity or volume of a reservoir is measured in acre-feet per year or AFY.

5.12.2 Local Resource Potential

San Luis Obispo County has a unique potential for pipeline power recovery because of its extensive existing water conveyance system. There are six pipelines within the County, described in Figure 106, supplying water to many communities and institutions. Many of the pipelines have hydropower potential, but only a few of those opportunities have been developed.

Figure 106: San Luis Obispo County Water Conveyance Pipelines

Name	Source	Supply (AFY)	Owner	Potential	Developed
State Water Pipeline	State Water	4,830	CA Dept. Water Resources	Yes	No

Name	Source	Supply (AFY)	Owner	Potential	Developed
Nacimiento Water Pipeline	Nacimiento Reservoir	9,655	SLO County Flood Control & Water Conservation District	Yes	No
Santa Margarita Pipeline	Santa Margarita Reservoir	6,950	U.S. Army Corp of Engineers	Yes	Yes**
Chorro Valley Pipeline	Chorro Valley Reservoir	140	U.S. Army Corp of Engineers	Unknown	No
Lopez Pipeline	Lopez Reservoir	4,530	SLO County Flood Control & Water Conservation District	Yes*	Yes
Whale Rock Pipeline	Whale Rock Reservoir	40,660	City of San Luis Obispo, Cal Poly, California Men's Colony	Yes	Yes
* No pipeline resource; conventional hydro power facility below the Lopez Reservoir dam. **Resource was developed, but now decommissioned due to flow issues with WWTP.					

Source: SLO RESCO

5.12.2.1 Existing Pipeline Hydro Resources

Out of the six operational hydropower pipelines in San Luis Obispo County, two have been developed for hydropower recovery. Both generating facilities, described in Figure 107, are located near the northern border of San Luis Obispo City. One facility, connected to the Whale Rock pipeline, is apparently in operation, although this information has not been officially verified. This facility has a rated power of 700kW.

Figure 107: San Luis Obispo County Existing Pipeline Hydro Generators

Name	kW	Count	Location	Status
Santa Margarita Pipeline	800	1	Stenner Canyon	Decommissioned
Whale Rock Pipeline	700	1	TBD	Operational/ Unverified
Total	1,500	2		

Source: SLO RESCO

The generator on the Santa Margarita (Salinas Reservoir) pipeline is confirmed to have been operational, but is now fully decommissioned. When in operation, it had a rated power of 800kW. Interviews with several County and City staff concluded that the facility was decommissioned due to difficulty managing required flow rates between the hydropower facility located in Stenner Canyon and the nearby San Luis Obispo City water treatment plant. Another local topic expert observed that flow issues could be resolved through better utilization of the existing automation system at the water treatment plant. During staff interviews, it was also verified that the pipeline is physically disconnected from the generation station and would require excavation and construction to re-commission the facility. The current condition and potential for reuse of the original facilities and equipment needs further investigation.

5.12.2.2 New Pipeline Hydro Potential

Several existing pipelines have potential to either generate new hydropower or to be re-commissioned to once again utilize the energy resource.

A study on small hydro, ocean wave, and pipeline hydro potential in California conducted by the California Energy Commission concluded that within the Coastal Branch of the California Aqueduct, a hydropower potential exists for an up to 3.8MW facility.

The Nacimiento Water Pipeline was recently completed in late 2010. It is a 50 mile pipeline from the northern border of San Luis Obispo County all the way to the City of San Luis Obispo. Study of the hydraulic profile and estimated water delivery schedule for the pipeline shows that there may be up to four different sites along the pipeline that have the potential for hydropower resource development. These sites occur only at turnouts where water leaves towards a participating community. Only the water allocated for a specific project partner travels through a given turnout. This means that power potential is based off of the allocated flow and not the total pipeline flow.

Figure 108: San Luis Obispo County Potential Pipeline Hydro Generators

Pipeline	# of Sites	kW	Location	Status
State Water Pipeline	1	3,800	TBD	Studied
Nacimiento Water Pipeline	4	330	TBD	TBD
Santa Margarita Pipeline	1	800	Stenner Canyon	Decommissioned
Total	6	4,930		

Source: SLO RESCO

Although it is currently decommissioned, the Santa Margarita Pipeline still has a resource potential to generate up to 800kW of power. Further investigation needs to be conducted into the causes and possible solutions of the operational issues between the Santa Margarita Pipeline hydropower facility and the San Luis Obispo water treatment plant.

5.12.3 Maps and Charts

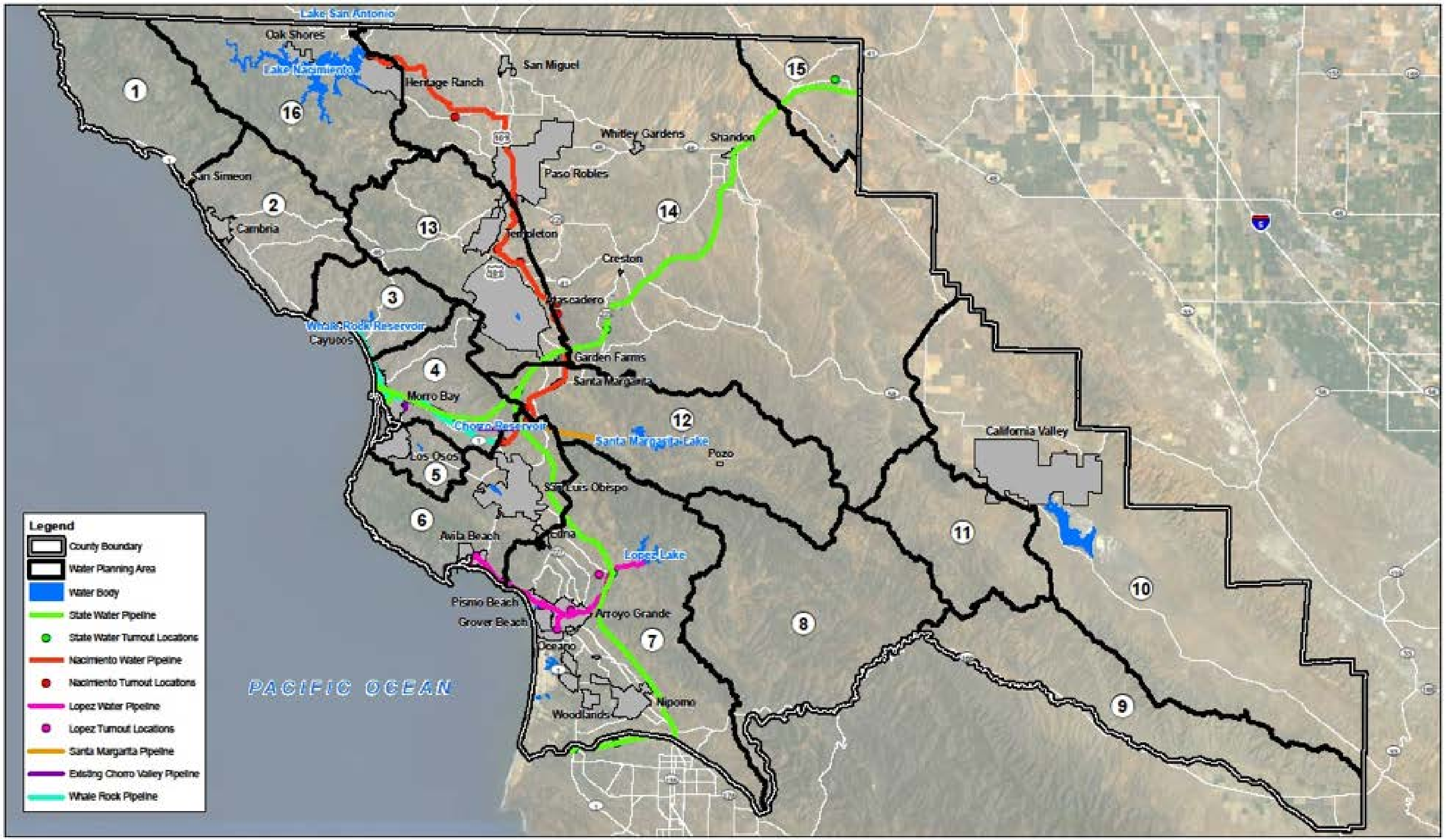
Figure 109: SLO RESCO Pipeline Hydro Power

Source: SLO RESCO

The SLO RESCO Pipeline Hydro Power map, Figure 109, describes the general locations of existing water conveyance pipelines in SLO County along with existing and potential pipeline hydro sites.

The water conveyance map, Figure 110, excerpted from the Master Water Plan describes the water conveyance system for San Luis Obispo County. It provides valuable information about water sources, pipeline turnout locations, and general paths taken by the pipelines.

Figure 110: San Luis Obispo County Water Conveyance Map



Source: San Luis Obispo County Flood Control and Water Conservation District, Master Water Plan

5.12.4 Technologies and Applications

Pipeline hydro systems operate in nearly the same way as conventional impoundment type hydropower systems. In these systems, the pipeline is equivalent to the penstock. As water flows downhill through the pipeline it will, ideally with the greatest head possible, pass through a turbine or certain type of two way pump converting the kinetic energy of the falling water into mechanical energy within the turbine. The spinning turbine shaft is connected to an electric generator which also turns. This results in the production of energy. This energy can then be transported through power lines and be either connected to the electric grid or power an off-grid load.

In San Luis Obispo County, the areas where there is greatest potential for energy recovery is at places in the pipeline called turnouts. At these turnouts a smaller volume of water is redirected towards a participating community. Water travels quickly through the pipeline and must be slowed down at these turnouts prior to entering the local water treatment plant and municipal piping system. Mechanical valves and other pressure reducing equipment are used to slow the water down to the appropriate flow and pressure by "breaking" the head. When this occurs, the energy that could have otherwise been recovered through other means is lost. When economical, it is best to install a turbine or other energy recovery equipment to help meet the need to reduce the water's speed and pressure before entering the community water system while generating clean renewable electricity at the same time.

Besides being clean and renewable, pipeline hydropower has additional value because the flow of water through the pipeline often has the capability of being controlled. This means that by controlling the flow of water, the generation of electricity can also be controlled. This capability is especially valuable in a local energy system because electricity can be generated as needed and can be used to follow the community's changing energy demand throughout the day.

5.12.5 Investigation Process and Methodology

The INL Hydropower prospector was used to identify existing infrastructure and generation sites (refer to Virtual). This initiated further research into additional pipelines in the County and their resource potential.

Interviews with County public works staff and other local topic experts, some of whom requested to remain anonymous, provided historical context, access to data and reports, and technical assistance (refer to Public Works). Analysis of the hydraulic profile and estimated water delivery schedule for the Nacimiento Water Project was conducted to acquire head and flow data for four turnout sites along the pipeline. Calculations of power and energy were made using the data to determine hydropower potential.

Internet research provided access to reports and other documents containing information about San Luis Obispo's water pipelines, reservoirs, and usage.

5.12.6 Next Steps

5.12.6.1 Verify Existing Generator Status

Information is missing regarding the history and current status of the existing pipeline hydro systems. This information will be valuable for understanding the existing systems and the potential for future resource development.

5.12.6.2 Verify new generation potential with San Luis Obispo County public works staff

County partners in the public works department have special knowledge that will be valuable to validate the estimated potential for new pipeline hydro generators.

5.12.6.3 Site prioritization, location and characterization

Once new generation potential has been validated, resource sites will be prioritized and more information on location and resource character will be acquired.

5.12.6.4 Site Visits

Visit sites of potential new pipeline hydropower to document and further characterize resource potential.

5.12.7 References

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5.13 Regenerative Energy: Energy Storage

5.13.1 Characterization of Energy Storage Resource

Energy storage has a few potential major uses in the electric power system— meeting peak energy demand, balancing and firming intermittent renewables, and even supplying stable 24/7 power. These represent stages of evolution of storage technologies.

5.13.1.1 Meeting Peak Load

Energy storage for conventional power systems are currently used for meeting peak electric power demand, usually during the daytime.

For conventional power systems, the lowest level of daily demand is met by running 24/7 base load plants at stable output, which maximized their efficiency. Peak energy is frequently met by generators that only operate a part of the day, and their varying level of power generation greatly reduces their efficiency. Thus, meeting peak demand consumes a considerable amount of extra fuel, at higher cost and with greater pollution. A peak load can add 50 percent or more to the minimum daily demand load.

An important alternative for meeting peak demand is drawing from low cost, night-time baseload power and using energy storage technologies to transfer that energy to the time when it is most needed. This can reduce air pollution at peak hours, and it allows the base load plants to maintain efficient operation, while reducing the need for inefficient and polluting peaking generators.

5.13.1.2 Balancing Renewable Energy

An electrical system based on renewable energy (RE) resources and distributed generation (DG) can greatly benefit from increased reliability with appropriate storage components. Wind power tends to blow most in the evening and the middle of the night when demand is low; while the sun can generate power during the day, but cannot by itself supply power into the evening when residential customers arrive home and turn on electrical appliances. Energy storage can make the use of high levels of renewable energy far more feasible, and it certainly increases the range of energy services that renewable technologies can provide.

At a staff workshop on energy storage held at the California Energy Commission in April 2009, there was general agreement among representatives from private and public electric utilities and service providers, grid operators, and government regulatory agencies that 4-5 GW of storage (for load-shifting, load-shaping, and grid support) is going to be needed to meet California's 2020 RPS goal of 33 percent. Participants expressed concerns regarding the readiness of various storage technologies, how energy storage options would be chosen, and which rules and regulations would be applied during the process of increasing renewable energy resource volume by 12-14 percent over the next 10 years (refer to Staff Workshop).

5.13.2 Technologies and Applications

Spurred on by the urgent need for reliable methods of integrating renewable energy resources and distributed generation into the power grid, energy storage technologies are rapidly developing. In recognition of this need, the US DOE ARPA-E agency recently funded eight new projects for energy storage development. The technologies are: a new class of metal-air batteries using ionic compounds; a planar liquid sodium beta battery; a high energy density lithium-ion battery; a nanotube enhanced ultracapacitor; a silicon-coated carbon nanofiber paper for the anode of next generation lithium-ion batteries; an all liquid metal grid-scale battery; and a novel catalyst to enhance the efficiency of splitting water into hydrogen and oxygen (refer to Transformational).

While the development of new battery technologies will likely play a definitive role in constructing a sustainable system for meeting California's peak energy and grid reliability needs, there are already commercially available options that can be implemented immediately – chief among them are pumped storage and compressed-air technologies.

5.13.2.1 Pumped Water Storage

Pumped water storage is the most widespread large scale energy storage system in use on power networks. The US has about 20,000 megawatts of pumped storage; and California has just over 4000 megawatts. Its main applications are for time-shifting baseload power to times of peak demand, voltage and frequency control, and reserve power. It can be critical infrastructure not only for large remote renewables and utility-scale thermal power plants, but also for local energy systems in communities with suitable locations for such facilities. "Suitable" would generally mean an existing lake, river, or reservoir that provides the main water source with steep grade nearby connecting to a site where a secondary storage impoundment either already exists, or that can be placed with manageable intrusion.

Local renewable systems will need multi-hour deep cycle storage as much as large central renewable systems; large central systems will also need storage to provide for short periods with rapid changes in power demand. Pumped storage can provide both. It can also balance wind power by absorbing excess generation with the pumps and delivering power to the grid when the wind is low. Thus, pumped storage is worth much more than its power generation capacity. There is currently over 4100 megawatts of pumped storage in California, and this should be able to balance significantly more megawatts of wind and other renewables, if it were dedicated to this purpose.

It is very important to distinguish between the environmental impact of pumped storage and other types of projects with which it is often confused. Most pumped storage facilities in the state, including the Helms site, were originally built either as water storage or conventional hydroelectric facilities and are sized and designed for this original purpose. Water storage, like conventional hydroelectricity, is vastly more land-intensive than pumped storage. In fact, the Helms pumped storage has almost no incremental land impact, since all generation facilities are underground, and it was a decades-later add-on to a conventional hydroelectric dam and reservoir.

To illustrate this vividly: for conventional hydroelectric power one can consider as a baseline Folsom Dam, which generates nearly 200 megawatts of power from a 11,450 acre impoundment of Folsom Lake—a large lake that was artificially created by the dam. By comparison, SMUD is planning a 400 megawatt pumped storage unit (referred to as Iowa Hill) that uses a small existing lower reservoir that is part of its conventional hydroelectric system, and will build a new reservoir 1000 feet higher for energy storage. The upper reservoir only occupies 100 acres. In other words, 100 times less land is required to generate twice as much power capacity as Folsom Dam & powerhouse.

Then one can also compare the infrastructure. Folsom dam includes a 340 feet high concrete segment with two earthen dams structures on either side, with the powerhouse embedded into the concrete dam structure. By contrast, the SMUD pumped storage conduits and powerhouse unit is entirely underground and requires only a slight elevation around the 100 acre upper reservoir to retain the water.

There is no current system of storage that can compare to pumped water storage either in capacity, cost, performance, durability, or environmental impact. Certainly, sodium-sulfur batteries are an important advancement, but all batteries suffer when cycled excessively or under varying load conditions. Pumped storage does not. Batteries can cause some problems for the grid that may need further mitigation. Pumped storage can help solve nearly all the problems of a renewable system (refer to Freehling; Electricity Storage Association).

5.13.2.2 Compressed-air energy storage (CAES)

Compressed-air energy storage conventionally uses air compressors to force large amounts of air into above-ground storage tanks or underground caverns (aquifers, abandoned mines, depleted oil or gas fields, or salt domes). When demands for electrical power rise during the day, the compressed air can be used to spin turbines, turning the energy back into electricity. This provides a reliable, cost-effective method of addressing intermediate and peaking power generation needs. CAES improves the efficiency of natural gas-fired turbines, while meeting the more rigorous regulatory standards being applied to GHG emissions (refer to Shepard & van der Linden).

CAES is a viable option within the electric power industry because it is a proven technology that has been successfully used in a 290 MW German plant since the 1970s and a 110 MW Alabama plant since the 1990s. A second US plant is planned in Ohio, which will be the world's largest, at 2700 MW. The compressed air will be stored in an existing limestone mine 2200 feet underground (refer to Koerth-Baker).

Compressed-air systems have some drawbacks; for example, they require a constant-volume or constant-pressure airtight underground space, limiting the locations where they can be installed. The current designs also rely on combustion of natural gas in conventional gas generator. However, they also have a number of clear advantages. They have high overall efficiency (up to 70 percent). They are particularly well-suited for increasing the level of wind power penetration into existing grids, and for increasing the cost-effectiveness of wind power (refer to Patel). They also greatly reduce the amount of natural gas required to run a gas turbine.

5.13.2.3 Electrochemical Secondary Batteries

Electrochemical secondary batteries convert energy in a reversible reaction, and are recharged by connecting them to a direct current from an independent source. Their round-trip conversion efficiency is 65-80 percent (refer to Patel). Until recently, lithium-ion and lithium-polymer have been the state-of-the art in storage batteries. Their major drawbacks are heavy weight, high cost, inability to hold a charge over long periods, slow recharging characteristics, and negative environmental life-cycle impacts.

5.13.2.4 Sodium-Sulfur Batteries

Sodium-sulfur batteries are advancement technology commercially developed in Japan over the past two decades that are touted as a "new generation" of battery storage design. They are the first battery systems to be manufactured with megawatts of storage. General Electric recently announced that it will build a $100 million plant in New York, set to begin operation in two years, to manufacture sodium batteries for its future hybrid locomotives (refer to Dwinnell).

One US company has developed a prototype for a much smaller scale sodium battery that is projected to deliver 5 KW of electricity continuously over four hours, with the ability to deep-cycle daily over a period of 10 years. The company hopes to build a refrigerator-sized battery with a targeted retail price of $2,000. The cost of electrical output over the battery's life would be ~3 cents/kWh (refer to Wright).

Sodium-sulfur batteries have the highest energy density and energy performance of all storage batteries, which translates into smaller size, lower cost per kilowatt-hour, and larger amp-hour capacity. The chief components are plentiful, readily available, and relatively low in life-cycle environmental impact.

5.13.2.5 Electrochemical Capacitors

Electrochemical capacitors store electrical energy in the electric double layer (EDL) of two series capacitors, which is formed between each of the electrodes and the electrolyte ions of the capacitor module. They are chiefly used in hybrid and plug-in electric vehicles to provide instantaneous bursts of power for quick accelerations above the capacity of the main battery. They can also be applied to smooth out grid fluctuations in electric power delivery. EC capacitors can be charged and discharged up to 100,000 times and are much more powerful than EC batteries. Additionally, they have high energy density, high cycling efficiency, high reliability, fast recharge time, and excellent cold temperature performance.

While the small electrochemical capacitors are well developed, the larger units with energy densities over 20 kWh/m3 are still under development. Excessive cost is currently the major barrier to using larger capacity systems for bulk storage of energy (refer to Electricity Storage Association; Ionic Power).

5.13.2.6 Flywheels

Flywheels store kinetic energy in rotating wheels or cylinders connected to a motor/generator. Small-scale and medium-scale flywheels are an older technology that are currently being developed due to advances in the strength and weight of fiber composite rotors and magnetic bearings, which eliminate wear on the bearings and increase system life. Current research is directed toward developing high-speed flywheels for large-scale storage. The technology is designed to increase energy efficiency and smooth power to the grid, without using fossil fuels or producing polluting emissions. The round-trip conversion efficiency of a large-scale flywheel is very high, and can approach 90 percent (refer to Electricity Storage Association; Patel).

Advantageous features of flywheels include low maintenance, environmentally inert materials, and long life. They can last twenty years, tens of thousands of deep cycles, or longer. In November 2009, Beacon Power Corp announced that it will begin construction of the first full-scale (20MW) flywheel frequency regulation plant in the US. The plant is designed to support the integration of intermittent renewable energy resources, such as wind and solar (refer to Silverstein).

5.13.2.7 Thermal Energy Storage (TES)

Thermal energy storage can be used as an energy efficiency or demand shifting measure attached to an electric cooling system, either to lower the temperature of the water component or to turn it into ice. Using TES can reduce the overall size and cost of air conditioning installation—distribution temperatures are lower and pipe sizes can be smaller, with lower cost of operating and maintaining the system—compressors and pumps are smaller and peak demand costs are lower. This normally translates into lower utility bills for the consumer. Smaller TES systems are designed to augment mechanical cooling in order to assist at peak demand. Larger systems can entirely eliminate the need for compressor use when demand is high (refer to WSU, "Thermal").

Water storage systems are currently being used in large cooling applications by regional energy districts, often in conjunction with cogeneration. The cost-performance ratio is most advantageous in office, retail, or medical building complexes with high cooling needs (refer to WSU, "Thermal").

5.13.3 Local Resource Potential

5.13.3.1 Compressed Energy Storage

Energy storage resource potential in SLO County is largely anecdotal and virtually uncharted. Studies at the national and state levels appear to discount the county's geological capacity for Compressed Air Energy Storage (CAES). There may be suitable sites for CAES where enhanced gas and oil recovery is taking place now, or has in the past.

5.13.3.2 Pumped Water Storage

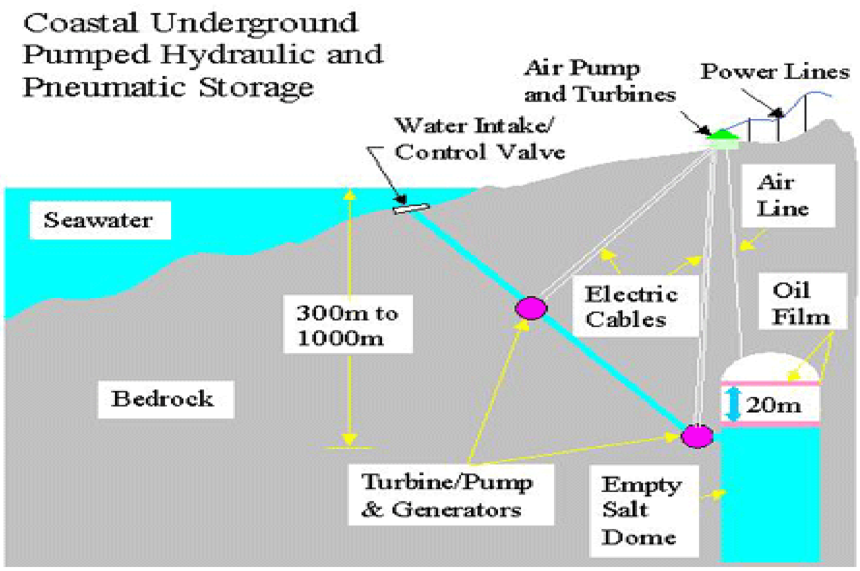
There may be a candidate site for pumped water storage at Lopez Lake and an adjacent smaller reservoir, in close proximity to the city of Arroyo Grande. Initial estimates suggest that there may be a potential in range of megawatts to tens of megawatts, but further investigation is needed.

5.13.3.3 Battery Storage

Battery storage options present the greatest potential for installation in SLO County. They are versatile, self-contained, and require minimal site preparation. New battery technologies are being rapidly developed, with decreases in cost and increases in efficiencies. Batteries are especially well suited to store solar energy, but can also be used on-site at a range of RE installations. The primary technical limiting factors are manufacturing and availability of large amounts of battery storage, as well as cost. Aside from these factors, there is no practical limit to battery storage, other than demand for it.

5.13.4 Maps and Charts

Figure 111: Coastal Underground Pumped Hydraulic and Pneumatic Storage



Source: Valentine, Energy Pulse.

Figure 111 envisions a new variation on pumped storage that may be applicable to the California Central Coast, including SLO County, if suitable geological formations can be found.

The Riverbank Power Company of Toronto, Canada is pioneering a technique of excavating cavities into the bedrock next to large rivers at depths of 2,000-feet or 600-metres below river surface level. Their technology could also be adapted to excavating such cavities into the interior of coastal mountains at elevations of 2,000-feet above sea level. Such excavation is unlikely to attract opposition from environmentalists if there is no seepage of ocean water into the surrounding water that may be at a great distance from the excavation site. The excavated cavity is an option where no suitable remnants of salt domes may exist either within a coastal mountain or below the coastline in the general vicinity of where remnants of salt domes exist. There are plans to introduce excavated subterranean cavities in the state of Maine to convert wind energy and ocean energy to stored pumped hydraulic energy (refer to Valentine).

Figure 112: Energy Storage Technologies

Storage Technologies	Main Advantages (relative)	Disadvantages (Relative)	Power Application	Energy Application
Pumped Storage	High Capacity, Low Cost	Special Site Requirement		●
CAES	High Capacity, Low Cost	Special Site Requirement, Need Gas Fuel		●
Flow Batteries: PSB VRB ZnBr	High Capacity, Independent Power and Energy Ratings	Low Energy Density	◐	●
Metal-Air	Very High Energy Density	Electric Charging is Difficult		●
NaS	High Power & Energy Densities, High Efficiency	Production Cost, Safety Concerns (addressed in design)	●	●
Li-ion	High Power & Energy Densities, High Efficiency	High Production Cost, Requires Special Charging Circuit	●	○
Ni-Cd	High Power & Energy Densities, Efficiency		●	◐
Other Advanced Batteries	High Power & Energy Densities, High Efficiency	High Production Cost	●	○
Lead-Acid	Low Capital Cost	Limited Cycle Life when Deeply Discharged	●	○
Flywheels	High Power	Low Energy density	●	○
SMES, DSMES	High Power	Low Energy Density, High Production Cost	●	
E.C. Capacitors	Long Cycle Life, High Efficiency	Low Energy Density	●	◐

Source: Electricity Storage Association

Figure 112 compares energy storage technologies. Dark Circles show best potential and white circles the least. “Energy” applications means that the storage can supply large amounts of power over an extended period of time, while “Power” applications provide can quick power but may or may not supply long-term energy supply. Sodium-Sulfur batteries are the only option rated high in both power and energy density, and they have no special site requirements.

5.13.5 Investigation Process and Methodologies

For this portion of the SLO RESCO project, storage technologies and applications have been researched by reviewing technical texts, commercial web sites, and trade association web sites, and through interviewing individuals and companies that invent, manufacture, evaluate, and install various storage options.

5.13.6 Next Steps

Potential sites for battery installations in SLO County should be further investigated, and the Lopez Lake and Lake Nacimiento sites should be investigated for potential use as a pumped water storage facility.

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5.14 Negawatts - Energy Efficiency

5.14.1 Characterization of Energy Efficiency Resource

Energy efficiency standards and technologies in California and around the world have been influenced by technological research at the Center for Building Science, Lawrence Berkeley National Laboratory (LBNL) from 1975-1994. During those decades, the Center developed low-emissivity windows and the DOE-2 computer program for the energy analysis and design of buildings. The Center also invented electronic ballasts for fluorescent lamps, which later evolved into compact fluorescents.

California’s energy efficiency programs are built on Appliance Standards, Building Standards, and Utility Programs (refer to Figure 116). In 2010, the state saved about 60,000 gigawatt-hours (million kilowatt-hours) of electricity from its three-pronged efficiency programs. Assuming an average utility rate of 12.5 cents per kilowatt-hour, the 2010 electricity savings would be valued at $7.5 billion.

The Center for Energy, Resources, and Economic Sustainability (CERES) at the University of California Berkeley has modeled how Californians spent the money they have saved through efficiency programs between 1972 and 2006, during which time the state’s households saved $56 billion on their electric bills. The report indicates that this has led to the creation of 1.5 million full-time equivalent jobs, and employee compensation of $45 billion. Not only have efficiency programs stimulated net job creation, they have had a compounding effect over time as efficiency savings continue to improve. The analysis links sustainable energy practices to a sustainable economy—an aspect that is becoming a well-recognized component of our state's vision for a clean energy future (refer to Roland-Hoist).

The characterization of an efficiency resource in any region consists of measuring the effects of behaviors and the results of market transformation and program design in the past, as well as predicting these effects for the future. Measurements are established against a baseline-year, with annual savings generally increasing in response to technology improvements and the combined impact of improved building codes and appliance standards, as well as increased funding for utility efficiency programs (refer to Figure 115 and Figure 116). Had energy consumption continued to increase from the 1975 baseline without the benefit of these efficiency improvements, the state would have been using 20,000 gigawatt-hours more electricity by 1990. By 2020 this annual savings is projected to increase to 80,000 gigawatt-hours—about 20 percent reduction from what demand would have reached without the efficiency savings. (Refer to CEC, "California Energy Demand".) Annual state-wide utility bill reductions from efficiency will be close to $16 billion per year.

As California's efficiency programs have matured and evaluation has evolved, the newest forecasting of energy use reductions has included a fourth component – "Naturally Occurring Savings" (refer to Figure 117). This category helps quantify the changes in energy use– such as technology improvements and transformation of markets— that are not directly caused by the continued operation of efficiency programs (refer to CEC, "California Energy Demand"). However, customers who, for instance, were introduced to efficient lighting by utility programs, might continue to purchase the more efficient lighting even without the assistance of a rebate or product distribution program. This would be considered "market transformation", and its effects would persist into future years. As the graph in Figure 3 shows, the forecasting utility program efficiency savings peaks in 2010 and then decreases to 2020. That is because the funding cycle for current programs goes to 2012, after which time there is no commitment or program funds, program design, or program savings targets. After 2012, there would be a natural decay of energy savings from measures that had been put in place prior to that time. As efficiency codes and standards become more embedded within the legal framework of governments and in the social choices of individuals, an increasing share of savings may result from "naturally occurring efficiency savings"– non-funded consequences of personal choices, technology development, and former public programs.

5.14.2 Local Resource Potential

According to EPRI, the definition of "potential" efficiency can include economic, technical, and achievable energy savings, while "Energy Efficiency Drivers" can include Codes and Standards, Market-Driven Efficiencies, and Implicit Programs.

The characterization of an efficiency resource in SLO County consists of measuring the results of actions in the past, as well as predicting effects and results for the future. Past measurements will apply to a baseline-year through the present, while future predictions will apply to the present year through a chosen end-year. Predictions of future results of efficiency measures would be based on current usages. To give a general idea of where such baselines would fall, some gross figures for energy use are:

There are approximately 117,000 residences in SLO County, with electricity use of about 670 gigawatt-hours for 2006 and 2007 (refer to CEC, "ECDMS: Electricity Consumption"). Natural gas use was about 40 million Therms in those years (refer to CEC, "ECDMS: Gas Consumption").

Non-residential electricity use in 2006 was about 900 gigawatt-hours, rising to about 1000 gigawatt-hours in 2007 (refer to CEC, "ECDMS: Electricity Consumption"). Natural gas usage in the non-residential sectors remained fairly constant at 40 million Therms during both years. While natural gas use has been evenly divided between the residential and non-residential sectors, electricity use has been approximately 30 percent greater in the non-residential sectors, as compared to residential.

Estimates of potential reduction in total energy use through efficiency measures vary widely, and estimates range from 20 to 36 percent (refer to CPUC; EPRI). However, forecasting potential reductions in energy use from efficiency measures for SLO County is complicated by a number of factors. For example, there may be as many as 40,000 residences in the county that use propane instead of natural gas for heating and cooking needs. Since propane is an unregulated fuel, it is more difficult to quantify usage.

According to the US Census Bureau, only 61 percent of the county's housing stock is owner-occupied. As has been widely recognized, there is often a lack of incentive for landlords to upgrade rental homes with efficiency retrofits, especially if the landlord does not pay the utility bill. Also, home energy use can be dependent upon the age of the home– newer houses can use half as much energy as older houses. Thus, the relative ages of the SLO County housing stock must be taken into account to approximate efficiency savings potential.

Due to the work of CAP-SLO, a percentage of low-income housing units have already been retrofitted; some businesses have taken advantage of efficiency upgrades offered under the state Utilities Program; while some municipalities have participated in state-sponsored incentive programs for retrofits. An exhaustive inventory of county-wide efficiency accomplishments, their quantitative results, and the potential for replication is beyond the scope of this RESCO study.

5.14.2.1 Flagging Utility Programs

According to third-party evaluation, measurement and verification studies, the programs run by the IOUs in California have increasingly under-performed over the past decade. The table below depicts the IOU-reported versus evaluated savings from the past three program cycles, benchmarked relative to program goals:

Figure 113: Reported and Evaluated Net Savings as a Percentage of Savings Goals since 2002

	kWh		kW		Therms	
Program Cycle	Reported	Evaluated	Reported	Evaluated	Reported	Evaluated
2002-2003	118%	104%	104%	86%	98%	81%
2004-2005	127%	79%	133%	75%	182%	55%
2006-2008	151%	62%	122%	55%	117%	50%

*In this table the 2002-2003 and the 2004-2005 accomplishments are compared to IOU program specific goals; and in 2006-2008 the CPUC adopted goal is the point of comparison.

Source: California Public Utilities Commission, 2006-2008 Energy Efficiency Evaluation Report July 2010

Both energy and capacity savings have been revealed to be significantly less than those reported by the utilities. This is particularly worrisome as it is peak demand which necessitates expensive grid upgrades and the construction of new power plants.

5.14.2.2 Adequate DSM Potential

The underperformance of IOU programs cannot be explained by a lack of cost-effective efficiency potential. As background, the characterization of an efficiency resource in any region consists of measuring the effects of behaviors and the results of market transformation and program design in the past, as well as predicting these effects for the future. Measurements are established against a baseline-year, with annual savings taking into account the combined impact of improved building codes and appliance standards, as well as increased funding for utility efficiency programs. Technology improvements are generally not forecasted, and hence the studies are seen as conservative and inaccurate beyond a five planning horizon. Below is a table comparing PG&E's most recent evaluated program cycle against the most recent DSM potential study for the utility:

Figure 114: PG&E Efficiency Savings versus Potential

	MWh	MW
Evaluated (06-08)	589	107
Potential - mid	616	203
Potential - high	993	348

Source: CPUC 06-08 Evaluation Report; ITRON-KEMA California EE Potential Study, 2008 (scenarios: mid-restrict and high-restrict, net savings, 2007-2009 average)

In other words, PG&E achieved only 59 percent of the energy savings and 31 percent of the demand savings that it could have.

5.14.2.3 Advanced Public Policy Goals

The CPUC has adopted savings targets for PG&E in line with the potential savings detailed above. For the 2010-2012 program cycle, PG&E's targets are 3,100 GWh of energy and 703 MW of capacity, with a budget of $1.34 billion.

Beyond this program cycle, the CPUC and CEC have established ambitious DSM targets in California's Long-Term Energy Efficiency Strategic Plan, which were adopted in D.08-09-040.

These include Zero Net Energy (ZNE) new construction goals for residential by 2020 and commercial by 2030, 20 percent savings by 2020 and 40 percent by 2030 for the residential and governmental sectors, and ambitious savings in the existing commercial, multifamily, and agricultural sectors totaling up to 50 percent ZNE by 2030.

The estimated investment required to achieve these policy goals is approximately $4.8 billion a year, or twice the current DSM expenditure of the state. (Refer to Harcourt Brown & Carey, Inc.)

5.14.2.4 Potential for Savings

The California Energy Efficiency Potential Study, (Itron and KEMA, 2008) has delineated numerous energy efficiency measures that can be implemented in the three investor-owned utilities' service territory in the baseline period between 2007 and 2016. For PG&E the technical resource potential was estimated at 20,418 gigawatt-hours in 2016, "approximately 21 percent of the CEC forecast of PG&E energy consumption in 2016." (Itron and KEMA, p. B-1) The study gives different technical resource potentials for the industrial, commercial and residential sector. The allocations of consumption between these sectors in SLO County is somewhat different than for PG&E as a whole, in that there is relatively little local industrial demand and much more residential and commercial electricity market share than PG&E as a whole. Adjusting for these factors, approximately 19 percent of forecast local electricity demand could be saved through efficiency measures by 2016 at an estimated weighted average cost of approximately 5 cents per kilowatt-hour. It is likely that a portion this potential will be captured by existing programs, but more could be achieved in that timeframe if additional local programs are implemented. Furthermore, the technical resource potential for savings increases as the timeframe extends further into the future.

5.14.2.5 Energy Programs

Recognizing the need for new funding streams for private and public efficiency improvements, SLO County has been evaluating its participation in financing opportunities such as those enabled under AB 811, which allows local governments to attach a tax assessment on a property with the voluntary consent of the property owner, for energy efficiency improvements. AB 811 programs have received federal funding from the EECBG (Energy Efficiency and Conservation Block Grant) programs; however, challenges to the AB 811 tax assessment by the federal housing loan agencies have effectively blocked implementation of this program for residential properties. Thus the potential still remains to tap this resource by other means.

In October 2009, the SLO County Board of Supervisors approved a resolution to participate in the CaliforniaFIRST AB811 financing program offered by the California Statewide Communities Development Authority (CSCDA). The program offers a "one-stop-shop" for California local governments to participate in the AB 811 structure (legally designating a contractual assessment area and corresponding loan pool) without having to assume the responsibilities of designing, establishing, and funding the program. The CSCDA fulfills all program administrator functions, enabling local businesses to borrow money from the loan pool to install EE/RE improvements, including rooftop solar panels, and to repay the loans through contractual assessments on their secured property tax bills. The improvements are "owned" by the business, and the loan repayment schedule transfers to the purchaser upon sale of the upgraded property. Also refer to 'On Bill Repayment for Power Meters' on page 54, and the section "California Energy Efficiency Finance Initiative' contained therein for information on a potential broader funding mechanism being initiated at the California Public Utilities Commission.

San Luis Obispo County receives funding from the CPUC, collected from ratepayers through a non-bypassable surcharge, to run an Energy Watch Partnership program in conjunction with PG&E, SCE, the cities within the county, and the Economic Vitality Corporation, as well as a Small and Medium Business Energy Efficiency Pilot Program. The latter program offers information on broader rebate programs and preliminary energy analyses to medical, hospitality, and office businesses, and will perform detailed analyses on a total of 21 businesses. The Energy Watch Partnership program helps to tailor program design and outreach at a local level to increase participation in broader statewide and regional programs.

SLO City and County have been working collaboratively and individually laying the foundation for community involvement in conservation and efficiency programs, most notably since the passage in 2006 of AB32, California's climate protection law. The city and county have adopted and implemented conservation and efficiency goals into their General Plans, with attention being given most recently to adoption of the County's COSE and EnergyWise Action Plan, relevant excerpts of which may be found in the appendix.

Energy efficiency upgrades to older construction is in its incipient stages in SLO County, with the vast majority of improvements being instituted by private homeowners and small businesses with access to utility rebates and their own sources of financing. There are more than 70,000 homes throughout the county— out of approximately 117,000 total— that were built prior to 1978 when Title 24 building codes were first enacted. Depending upon the extent of the renovations and the applicability of municipal code requirements, homeowners may choose to, or may be required to, comply with Title 24 standards when they upgrade their building envelopes or their systems for heating cooling and ventilation.

The Community Action Partnership of San Luis Obispo County (CAP-SLO) is conducting the a large local program for energy efficiency. Incorporated in 1965 as the Economic Opportunity Commission, the organization changed its name in 2009. CAP-SLO offers a range of social services to low-income residents, including health care, emergency care, adult day care, homelessness support, headstart schooling, and youth and family counseling. Based in SLO County, the agency serves eight other counties, has a yearly budget of over $60 million, and employs 850 people. Its Energy Services Program is funded by nine different contracts with federal, state, county, and municipal agencies; in 2010 the Energy Services funding will be over $3 million. Since 1980, it has contracted with PG&E and Southern California Gas to provide home and appliance retrofits for low-income households at no cost to the residents. CAP-SLO employees are trained to be "energy specialists" by the utilities, and enabled to determine which efficiency upgrades are needed. CAP-SLO employs 27 installers and technicians to do weatherization installations and home repairs in the county.

Residential efficiency programs and green building practices are being promoted by a local non-profit organization, SLO Green Build. Working with city, county, and state agencies to enact building codes that adhere to efficiency certification standards in new construction, SLO Green Build has also been actively seeking funding for efficiency retrofits of older buildings and homes. It has an aggressive plan of retrofitting 85,000 homes in SLO County and is building the capacity and network of trained contractors and energy professionals locally to do this work through the Green Building Alliance. Among its activities are: providing citizens with green building resources; conducting workshops for professionals in building, architecture, and design; engaging in extensive local work force training and development (refer to SLO Green Build).

Since legal requirements for efficiency certification standards in new construction are still being developed in SLO County, efficiency specifications in new buildings have largely been dependent upon individual owner commitment. A non-governmental standard developed by the US Green Building Council, called Leadership in Energy and Environmental Design (LEED), offers certification of buildings and has been widely recognized and adopted throughout the world. There are currently sixteen LEED-certified projects in the county (refer to Figure 118). Six are commercially-owned buildings, three are owned by religious institutions, two are academic complexes, two are office complexes, one is a state government-owned building, one is a private residence, and one is a non-profit housing development. The majority of the projects are located in the City of SLO, with one in Paso Robles (North County); and one in Grover Beach (South County). Clearly, the inventory shows that there is significant potential in SLO County for new construction fulfilling LEED requirements, or even higher green energy building standards such as Architecture 2030 guidelines, that exceed current energy codes. Both the city and county of San Luis Obispo are planning to adopt green building ordinances in the year 2010.

Energy Watch is a relatively recent set of utility-administered efficiency programs funded by a state surcharge on utility bills. The electric and gas service providers have recently begun these programs in SLO County by focusing on commercial, industrial, institutional, and governmental applications. Their stated goal is to reduce overall demand for energy consumption, and they are assuming that regional energy consumption can be ameliorated more quickly by first addressing the largest end-users. In October 2009, Pismo Beach became the first SLO County municipality to pass a resolution supporting the SLO Energy Watch Program, and has agreed to allow PG&E to conduct an energy audit of all city facilities to determine what improvements may be installed to improve energy efficiency (refer to Pismo).

5.14.2.6 Energy Policies

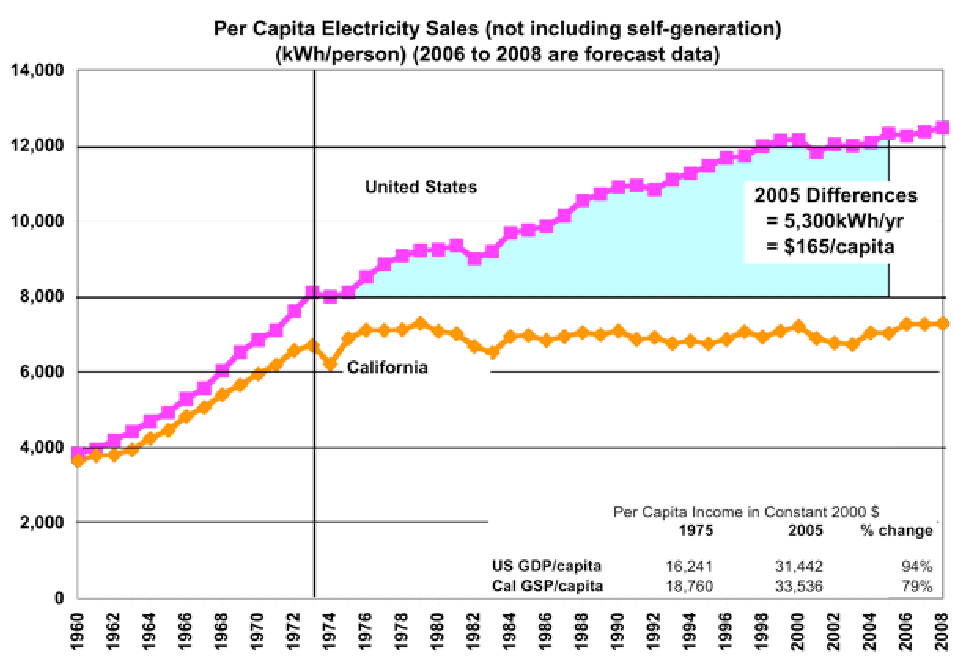
Following Santa Barbara County's lead with its recently adopted goal of 30 percent reduction in energy use as a core strategy of its 2007 Blueprint, "A New Energy Direction" (refer to Community Environmental Council), the SLO County General Plan COSE (Conservation and Open Space Element) sets a 20 percent energy use reduction target by 2020. All seven of the COSE Energy goals are closely aligned with the RESCO vision for both Renewable Energy and Energy Efficiency implementation:

1. The County will have an environmentally sustainable, local supply of energy for all county residents.
2. Energy consumption at County facilities shall be reduced by 20 percent from 2006 levels by 2020.
3. Energy efficiency and conservation will be promoted in all new and existing development.
4. Green building practices will be integrated into all development.
5. Recycling, waste diversion, and reuse programs will achieve as close to zero waste as possible.
6. The use of renewable energy resources will be increased.
7. Design, siting, and operation of non-renewable energy facilities will be environmentally appropriate.

SLO County's planning goals are divided evenly between efficiency and renewable energy objectives, with a strong commitment to becoming a renewable energy secure community that values and employs local sustainable resources. Regional initiatives for the development of local sources of renewable energy, conservation and energy efficiency programs, green jobs training, and green building ordinances are well-aligned for a successful implementation of the RESCO vision. Relevant excerpts from the COSE may be found in the appendix.

5.14.3 Graphs and Charts

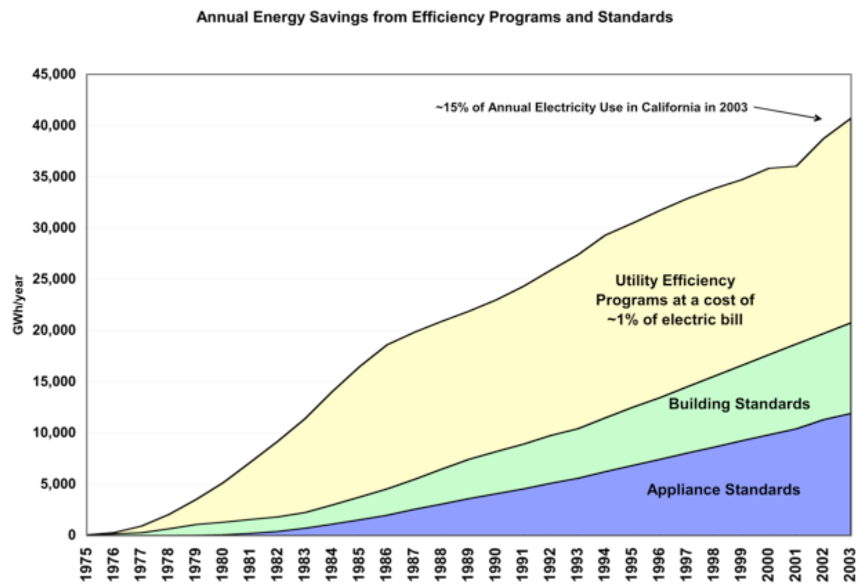
Figure 115: Per Capita Electricity Sales in California 1960-2008



Source: CEC, "2007 Integrated Energy Policy Report"

Figure 115 compares California's electricity use per capita with the country as a whole. From 1973-2006, the state's per capita electricity use has been almost flat, whereas in the average person in the US uses 50 percent more than they did in 1973.

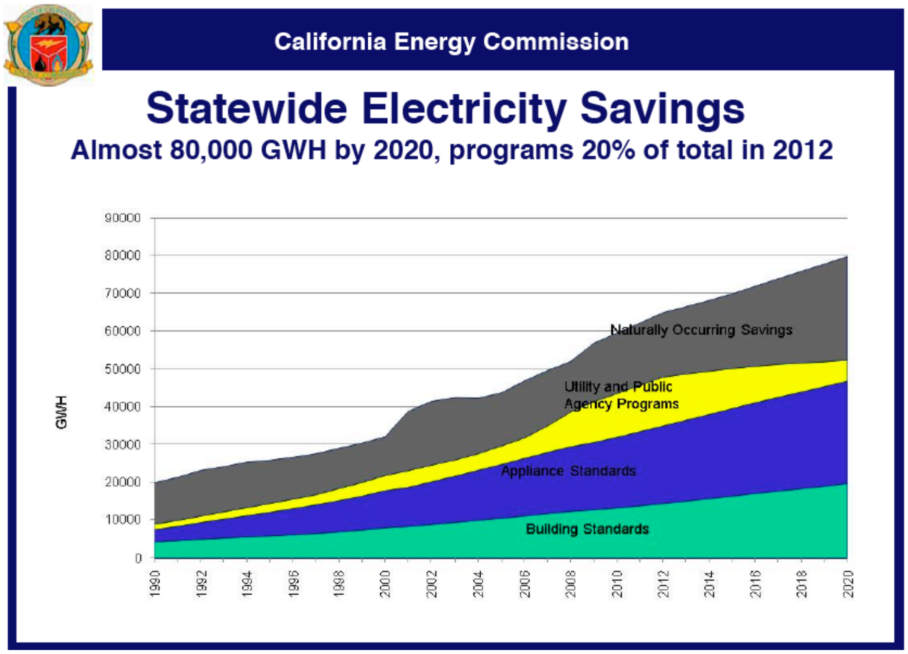
Figure 116: Annual Savings from California Efficiency Measures



Source: CEC, "2007 Integrated Energy Policy Report"

Figure 116 illustrates the estimated energy savings—measured in "gigawatt hours per year" — that have been derived from California's efficiency standards and programs during the years 1975-2003. The year 1975 is used as a baseline for measurement of savings.

Figure 117: Statewide Electricity Savings



Source: CEC, "California Energy Demand"

Figure 117 shows a further evolution of calculating energy use reduction from efficiency programs and standards, with the inclusion of a fourth component: "Naturally Occurring Savings".

Figure 118: LEED-Certified New Construction Projects in SLO County (2009)

Project	Location
Airport Hotel (SLO)	San Luis Obispo
Unitarian Universalist Fellowship	San Luis Obispo
RRM Corporate Headquarters	San Luis Obispo
Poly Canyon Village Housing	San Luis Obispo
Jamba Juice, Poly Canyon Village	San Luis Obispo
Faulty Offices East	San Luis Obispo
Beth David Synagogue	San Luis Obispo
San Luis Obispo Jet Center	San Luis Obispo

Project	Location
MindBody Online Tenant Improvement	San Luis Obispo
Mountainbrook Church Campus	San Luis Obispo
DIR California State Office Building	San Luis Obispo
1317A Palm Street	San Luis Obispo
Cannon Southwood Office	San Luis Obispo
California Men's Colony (50 Bed Facility)	San Luis Obispo
River Oaks Center	Paso Robles
Long Branch Avenue Affordable Housing	Grover Beach

Source: SLO RESCO

5.14.4 Technologies and Applications

5.14.4.1 Efficiency

Efficiency is the energy output of a system or device divided by its energy input, usually measured as a percentage. Physical laws and mechanical design limit efficiency to less, often much less, than 100 percent. Some technologies, such as electric motors, can be very efficient—an efficient electric motor can convert up to 90 percent of electric power input to mechanical power. Electric generation is typically much less efficient, with coal and nuclear plants often converting not much more than 30 percent of the heat energy from uranium fission or coal combustion into electrical power. The remaining 70 percent gets lost as heat that escapes into the atmosphere.

Electric lighting is even worse. A typical incandescent light heats up a tungsten filament to such a high temperature that it glows a brilliant white. This white hot filament turns about 95 percent of the electric power input into heat, and only about 5 percent into light. Switching from an incandescent to a compact fluorescent (CFL) bulb will improve efficiency four-fold—to about 22 percent. This simple measure will reduce electricity consumption for lighting by 75 percent, and even with this amount of savings there is clearly much room for further technological improvement.

Using efficiency as an energy resource means obtaining the same amount of service while consuming less energy. In practical terms, if Heating, Ventilation and Air Conditioning (HVAC) duct work is poorly installed or maintained, much of the energy input can be lost to constriction in the ducts or through leaks to the outside of the building. 100 Therms of natural gas fed to the furnace may only produce 30 Therms of heat inside the building. Repairing the duct work can inexpensively but dramatically increase the efficiency of the system. Thus, improving insulation and sealing air leaks are staples of residential and non-residential efficiency retrofits of building envelopes.

5.14.4.2 *Building and Appliance Standards*

In California, the newest policy concept in Building Standards is the "Zero Net Energy" goal for all new residential construction by 2020 and all new commercial construction by 2030. The roads to accomplishing these goals are being defined, and will include consideration of available renewable energy technologies, land use policies, distributed generation, and community-wide integration (refer to CEC, 2009 IEPR). Efficiency retrofits to residential building envelopes have traditionally included: sealing air leaks, weatherization, high-performance windows, insulation, and light-colored roofing. Efficiency retrofits to residential systems for heating, cooling, and ventilation includes programmable thermostats, LED or compact fluorescent lighting, passively-heated swimming pools, fireplace inserts, and zone-controlled ventilation and furnaces. At this time, the CEC is recommending that efficiency retrofits on residences be mandated at times of resale, remodel, or refinancing. Additionally, the California Energy Commission (CEC) is calling for residential building standards to be applied to industrial and commercial structures.

California's Appliance Standards apply to 21 product categories, including a dozen that are not regulated under federal law. Regulated appliances include: air conditioners, heat pumps, dehumidifiers, ceiling fans, space heaters, furnaces, water heaters, lamps, dishwashers, clothes washers, clothes dryers, refrigerators, ovens, microwaves, and electronics. As with the expansion of building standards, the CEC is recommending the extension of residential appliance standards to the commercial and institutional sectors.

5.14.4.3 *Utility Efficiency Programs*

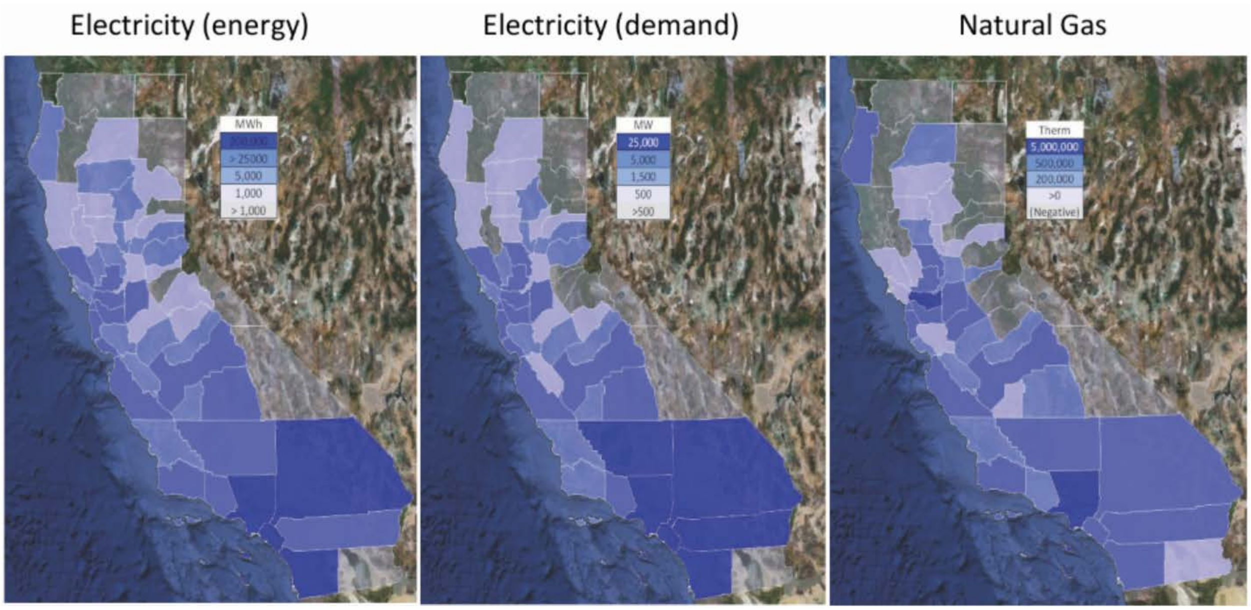
Utility Efficiency Programs have been officially funded in California since 1996 through AB 1890, establishing a Public Goods Charge, and AB 995, extending the programs through 2012. The public goods charge— also called a public benefits charge– is a small added amount that consumers pay on their electric bills, which is set aside by the state for energy efficiency rebates and services, the purchase and/or installation of renewable technologies, and conducting public interest research. Under California Public Utility Code Sections 384, appropriations from the fund have an encumbrance period of no longer than two years, and a liquidation period of no longer than four years.

Energy Watch is the most recently inaugurated public goods charge-funded utility efficiency program. In addition to public workshops, seminars, and demonstrations, the Energy Watch programs primarily consist of utility representatives conducting energy audits of customers' buildings and/or equipment, and then providing recommendations for prioritizing the retrofitting of equipment and infrastructure, according to a comparative analysis involving a cost-performance ratio. The utilities also participate in Codes and Standards Enhancement (CASE) studies, conducting research on new technologies for conservation and efficiency implementations. Energy Watch has been deployed over the past four or five years, most notably for the East Bay Area Governments, Monterey County, and Kern County.

5.14.5 Investigation Process and Methodologies

Efficiency savings figures could not be obtained in time for inclusion in this study, though the CPUC is in possession of this data, and it is available upon request. Below are maps depicting efficiency savings for electricity energy and capacity as well as natural gas savings by county in California resulting from the 2006-2008 program cycle (but excluding upstream lighting savings):

Figure 119: California's 2006-2008 Evaluated Energy Efficiency Savings by County



Source: California Public Utilities Commission

5.14.6 Next Steps

Acquire San Luis Obispo County efficiency data from the CPUC.

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5.15 Negawatts - Conservation

5.15.1 Characterization of Conservation Resource

Conservation measures are “first responder” strategies for reducing energy consumption in the residential, commercial/industrial, and government sectors because they generally result in monetary savings with minimal economic investment, and they can offer the quickest results of any policy tool. However, since the US energy crisis of the 1970s which culminated in President Carter’s “Cardigan Sweater Speech” in 1979, energy conservation has been dismissed as both a politically disastrous platform in the public arena and a course of conduct in the private sphere that is difficult to affect using policy or planning tools.

Decades later, Vice President Dick Cheney was in part responding to the Carter legacy in declaring: "Conservation may be a sign of personal virtue, but it is not a sufficient basis for a sound, comprehensive energy policy." (Benedetto, USA Today) By this time, language use in energy policy had come to divide the old concept of conservation into two parts: improving the performance of machinery on the one hand, and on the other hand the personal behavior of voluntarily doing with less. Getting more energy out of machines (more miles per gallon of gasoline, or more light for a kilowatt-hour of electricity) is now formally referred to as “efficiency”, while voluntarily turning down the thermostat, or turning off the light switch, retains the name “conservation”.

In energy policy, conservation has been conceived as in the post-Carter world as something that belongs in the realm of personal choice, and thus not something that can be easily regulated or controlled. On the other hand, California has led the US in the adoption of state and local programs promoting efficiency, with the assumption that it is easier to enact legislation than it is to effect behavioral changes.

Developing a new perspective and characterization of conservation is a key to opening this resource. It is possible to design conservation as a feature of the social, technological and economic environment in such a way that it creates options for behavior rather than commanding or requiring them. Examples include automating appliances and end-uses with enabling technologies (for example, a business could install motion sensors set to turn off lighting circuits instead of relying on employees to do), providing information, offering incentives, and giving people increased ability to make low energy consumption decisions.

Some of these principles were applied in the “Flex Your Power” campaign during the California energy crisis. Consumers were informed through the media during summer peak energy events when there was risk of power outages. Many people, aware of the crisis, reduced consumption to levels that were not previously thought possible from voluntary programs. According to the California ISO (CAISO), California’s independent grid operator:

> In 2001, Californians worked together and flexed their power to reduce peak demand by an historic 14 percent. More recently, conservation played a critical role in 2006 by helping the state weather a historic heat wave and record demand.

The grid operator went on to add that during the 2006 heat storm conservation "helped keep the lights on and wholesale prices low", and reduced peak demand by "at least 1,500 megawatts" (CAISO, August 2006). These reductions came from several different program designs. Businesses were cited as saving 55 megawatts by purely voluntary efforts without any compensation, while another program that offered payments to businesses resulted in 855 megawatts in demand reduction (CAISO, August 2006).

California has implemented a variety of demand reduction programs beyond Flex Your Power. Utilities are required to obtain 5 percent of their peak load needs through Demand Response, which pays large industrial and commercial customers to reduce their load during grid emergencies. Reduction of demand can also occur through automated controls that customers voluntarily allow to be placed on residential air conditioners or large factories. Referred to as "Interruptible Load", the grid operators can cycle through these resources by turning off each one for up to a pre-agreed period of time.

In addition to reducing peak demand, "conservation by design" may also be effective at saving energy over time. For example, in California residential rates are designed in "tiers" that increase the customer's rates dramatically as their level of energy usage increases. In fact, the California Public Utilities Commission is engaged in a multi-year strategy to transition to 'peak time' and 'real time' pricing, under which electricity costs more closely reflect the wholesale cost of purchasing energy at any given moment in time (electricity costs generally cost more at peak usage times – generally, hot summer afternoons when the air conditioning is turned up, and cold winter evenings when heating is switched on); this transition is expected to save customers money, as enabling technologies (such as appliances that can modulate usage in response to price signals) become more widespread and the average cost of electricity declines as usage patterns change. Another technique is harnessing social momentum -- by using social marketing to establish a community culture of conservation and/or by fashioning effective packages to elicit the desired behaviors.

Conservation can be steadily advanced through a combination of analytics, technology, policy, programs, system design, and market forces. Behavioral modifications can occur rapidly and result in statistically significant reductions in energy usage when the situation requires it – such as during the California energy crisis and 2006 heat wave.

5.15.2 Technologies and Applications

5.15.2.1 Enabling Technologies

There are various technologies (appliances, sensors, controls and software) that enable conservation and that are becoming increasingly widespread, such as:

Lighting Sensors

Motion sensors that turn off lighting after preset periods of inactivity, and ambient lighting sensors can adjust lighting levels in response to surrounding conditions, for example by dimming office lighting near windows during a clear day. The City of San Jose even has a pilot program to dim street lighting if there is sufficient ambient light (i.e. moonlight on a clear night) to do so while still maintaining safe levels of illumination on the street below.

Smart Thermostats

'Smart Thermostats' controlled by software to trim back on over-heating or over-cooling (taking into account customer preferences, building and HVAC system characteristics, and outdoor air temperatures, etc.), saving customers money while maintaining comfort levels. The thermostats can also communicate with local energy service providers or utilities to enable demand response for short periods of time (the practice of 'cycling' large numbers of distributed appliances to mimic, in aggregate, the behavior of a fossil-fueled single-cycle combustion turbine power plant that would otherwise be used to balance the electrical grid in times of peak usage or high renewable ramping events – i.e. when the wind stops blowing – saving money on wholesale power costs and/or stabilizing the grid). In fact, the California Energy Commission proposed a requirement for Smart Thermostats in California's Title 24 building code back in 2008 that would have ensured the ubiquity (over time) of Smart Thermostats throughout the state. However, a clause specifying that customers would not be allowed to override their thermostat settings during an emergency electrical grid event (presumably, when the utilities would be automatically lowering thermostat setpoints by a few degrees at tens or hundreds of thousands of homes around the state to avoid brownouts and/or rolling blackouts implemented by the California Independent System Operator to avoid the specter of grid destabilization and collapse), proved to be the initiative's undoing. The conservative radio personality Rush Limbaugh was highly and publicly critical of the proposal; the Commission was unprepared for the backlash engendered by the negative publicity and the requirement was rescinded.

Smart Buildings

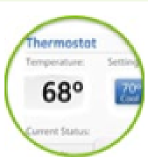
Many medium and large commercial buildings are equipped with Building Automation Systems (BAS), which monitor, record, and control end-use appliances and circuits; these systems are increasingly communicating with remote, cloud-based software platforms that analyze the data from these buildings to pinpoint sources of inefficient or wasteful uses of electricity. For example, fault-detection pattern recognition algorithms can detect when individual dampers need to be reset in commercial HVAC systems, or when a refrigeration unit at a grocery store requires a refrigerant recharge – and this can be communicated directly to the facility manager via text message or email.

Home Appliance Automation

Individual appliances that can communicate with and/or be controlled remotely by energy service providers, utilities, grid operators, and their owners (in a manner similar to Smart Buildings and Smart Thermostats), and automatically shift energy usage patterns in response to price and grid stability signals are available today and will become increasingly widespread in the near-term. Most manufacturers have been held back from re-tooling their production lines to make these ‘smart-grid enabled’ appliances for the simple reason that there is no widespread agreement amongst utilities, grid operators, and energy service firms around the country (much less around the world) as to what type of radio the appliances should use to communicate with them. Luckily, in March of 2013, the Electric Power Research Institute (EPRI), U-SNAP Alliance, and CEA implemented a testing and certification program for the ANSI/CEA-2045 Modular Communication Interface (MCI) Standard from the Consumer Electronics Association. This technical standard fills the gap, by instructing manufacturers how to produce appliances with a communication interface into which a range of different communication radios may be inserted at a later date (depending on which utility territory the appliance ends up being installed). General Electric offers line of smart-grid enabled appliances (depicted in the figure below), though customers must be in a utility territory that has deployed smart meters with Zigbee radios (a leading type of smart meter radio, and is used by smart meters in PG&E’s territory):

Figure 120: Smart Grid Enabled Appliances Offered by General Electric

Appliances with Brillion Technology can help you make smarter decisions, so you are better able to...

		... save money	...save energy	...control your energy use
Dishwasher		Run the dishwasher during low-cost hours with Delay Start Cycle.	Avoid the energy-zapping dry cycles. This dishwasher automatically sets to Air-Dry during high-cost hours.	Need to wash that load of dishes before your guests arrive? Simply override the Delay settings and select your preferred cycle.
Double-Oven Range		Self-clean feature is temporarily disabled during high-cost times.	Cooktop surface automatically reduces power use by 20% during high-cost hours. This double-oven range automatically defaults to the smaller, less energy-consuming upper oven during peak use times.	If you're on the hook for cookies and a casserole for the school fundraiser, just bypass the power-saver settings to use both ovens.
Front-Load Washer & Dryer		Both the washer and dryer automatically delay start until energy rates go down, so you can set them to run during low-cost hours.	**Clothes washer** During high-cost periods, the washer automatically defaults to the Low Energy wash cycle. **Clothes dryer** Select Low Energy setting during peak use hours.	You can always override the automatic settings. Need your favorite jeans in time for a night out? No worries.
Refrigerator		Defrosting cycles are automatically delayed until low-cost times of day.	Quick Chill and Quick Defrost features are disabled during high-cost hours, but only until the peak-use period is over.	These power-saving settings happen automatically, with no inconvenience or risk to your food storage. But if you need that wine chilled or steak defrosted in a snap, you can easily enable the features with the press of a button.
GeoSpring™ hybrid water heater		Automatically sets to use the lowest amount of energy during high-cost hours.	Conserve energy using eHeat™ mode, when the Geospring water heater operates using just 550 watts (vs. 4500 watts in standard electric mode).	These power-saving settings happen automatically, with no disruption to your hot water needs. But if family visits for the weekend and extra hot water is needed for morning showers, simply set the water heater to standard electric mode.
Programmable Thermostat		Set different temperature levels for different times of the day and week. Programming your thermostat is one of the easiest and most effective ways to reduce your energy bill.	Programmed thermostats can automatically raise or lower home temperatures at night while you sleep, or when you leave the house.	Program your thermostat from your computer using Nucleus software. You can customize the thermostat to fit your lifestyle, whether it be a normal week or an extended absence such as a vacation.

Source: General Electric

Not each smart grid enabled appliance communicates directly to an entity outside the home; rather, all appliances in a home relay data to and from a 'gateway' device, which in turn relays data to and from the grid operator, energy service provider, utility, and customer. This system is typically referred to as a Home Area Network (HAN) or less commonly as a Personal Area Network. The point at which the remote signals are translated into appliance-specific actions may be hosted remotely (i.e. on a cloud server), locally (in the gateway device), at the appliance itself, or across all three locations. HAN are still under development, with several promising test pilots and nationwide action across all parts of the value chain to deliver these products, standards, and services in the medium-term. It should be noted that Smart Thermostats that act as gateways for the HAN are commercially available.

5.15.2.2 Feedback Systems

A 2009 pilot study involving Sacramento electricity consumers indicates that Californians can respond rapidly to minor stimuli encouraging energy conservation in their homes. SMUD hired Summit Blue Consulting to conduct the study, which involved monitoring the energy usage of 85,000 single-family residential customers for a one year period. 35,000 homes received monthly reports normatively comparing their household energy use to their neighbors' use, along with suggestions for actions they could adopt to reduce their electric bills. 50,000 homes received their monthly bills without the reports and suggestions. Billing data for all households were also compared to a one year period prior to the study (refer to Summit Blue).

The findings demonstrate a robust result of 2 percent average annual savings from the 35,000 households in the treatment group (refer to Figure 122 and Figure 121). The savings varied from 2.6 percent during the summer months (when the control group's energy consumption increased the greatest amount, while the treatment group's use was more restrained), to 2.2 percent during the winter months, and 1.7 percent during the most temperate months. The statistics for average annual savings remained constant when the consultants applied three different quantitative methodologies: 1) a difference-in difference statistical analysis, 2) linear regression modeling, and 3) a differenced linear fixed effects model (refer to Summit Blue).

5.15.2.3 Social Drivers

Summit Blue concludes that there is a "social driver" underlying the documented behavioral changes in Sacramento household energy use: "If households learn they use more energy than their neighbors, it is assumed they will be motivated to reduce energy use and possibly do more than their neighbors [to conserve]" (Summit Blue). This type of social driver has previously been labeled by psychologists as "peer pressure" among teens and as "keeping up with the Joneses" among suburbanites.

Agreeing with Summit Blue's analysis, Columbia University's Center for Research on Environmental Decisions approaches energy conservation as a set of behaviors which can be encouraged by a group identity "to create a sense of affiliation and increase cooperation" (CRED 36). Among many examples cited in "The Psychology of Climate Change Communication", CRED reports that a Massachusetts reality television series, "The Energy Smackdown," sponsored a competition among household teams from three different communities to see which town could make the biggest energy reduction in twelve months. The winners reduced their household energy consumption by 73 percent (CRED 32). The report emphasizes the importance of developing community-based conservation efforts, where the group's social norms activate both a pressure to conform and a desire to share in the rewards.

5.15.2.4 Other Tools

A 2009 article in the journal for the National Academy of Sciences asserts that a package of synergistic interventions oriented towards behavioral change can provide short-term options with "substantial potential" for effecting rapid reductions in US carbon emissions. The authors advocate for "altering the adoption and use of technologies in US homes and non-business travel by means of behaviorally oriented policies and interventions" (Dietz 18452). They itemize seventeen types of household actions that have the potential to reduce national energy consumption by up to 20 percent within the next ten years. The actions are sub-categorized as weatherization, equipment maintenance, equipment adjustments, equipment replacement, and conservation behaviors. Once adopted nation-wide, the actions will provide a "behavioral wedge" for rapidly reducing US carbon emissions. In order to spur rapid adoption, the authors recommend a package of interventions that combine multiple policy tools -- education, information, economic incentives, persuasive appeals, participatory activities, multi-level targeting, social marketing, and political networking.

A report from the Center for Research on Environmental Decisions at Columbia University (CRED—see References) offers several suggestions for making behavioral changes easier.

1. Provide near-term economic and/or social incentives.

Although not mentioned in the SMUD study, perhaps an additional reason for the average annual 2 percent reduction in energy usage was the recurring immediacy of the reward—the household monthly reports could demonstrate cost savings every thirty days due to conservation behaviors that had been adopted during the past few weeks.

2. Take advantage of default effects: "the human tendency to stick with the option that is selected automatically instead of choosing an alternate option" (CRED 37)

By making double-sided printing the default option on its school printers, Rutgers University saved 14,000,000 sheets of paper a year.

Organizers of the 2009 Behavior, Energy and Climate Change Conference in Washington, DC made a vegetarian lunch the default option, and gave meat eaters the choice of opting out. Only 20 percent of the 700 attendees opted out, meaning that 80 percent ate vegetarian. Strikingly, at the 2008 BECC Conference in Sacramento when meat was the default option, 17 percent opted out for the vegetarian alternative. If the proportion of vegetarian attendees remains fairly constant from year to year, this would suggest that 60 percent of the meat eaters accepted a vegetarian meal in 2009, rather than take the time and trouble to opt out (refer to Gunther).

3. Expedite the adoption of new technologies.

The US DOE is spearheading a national campaign to install 18,000,000 smart meters in homes and businesses that will have the capacity to convey two-way information between the utilities and their customers. Smart meters have been used mainly to report back usage for monthly billing, but are being adapted to incorporate efficiency capabilities. Additionally, the DOE is funding 1,000,000 in-home displays for real-time energy usage and for the digital programming of large appliances. Real-time feedback is designed to help consumers conserve energy usage and to shift demand to off-peak hours when cheaper rates are in effect.

PG&E began installing Smart Meters in its territory in 2006, and has the goal of reaching all electricity and natural gas customers by mid-2013. PG&E will be installing Smart Meters in SLO County from March 2011-March 2012. Consumers are promised secure online access for tracking their real-time energy usage, along with offers of new pricing plans for incentivizing off-peak energy use (refer to PG&E).

Taken as a whole, these strategies and findings suggest that a combination of new technologies, social networking, participatory activities, and economic incentives can support a robust reduction of energy usage through conservation behaviors while furthering RESCO goals in SLO County.

5.15.3 Local Resource Potential

Conservation has been historically validated in San Luis Obispo County as an important component of land stewardship and water/wastewater management. Cautionary principles against overuse of natural resources have been incorporated into guidelines and local regulations governing human activities that may impact the ocean and its inhabitants, the coastline, parks and wilderness areas, lakes and streams, and groundwater wells and aquifers. Due to an arid climate, SLO County is especially vulnerable to overuse of its water resources, and use restrictions are imposed by municipalities and community service districts during times of drought. For these reasons, we are assuming that SLO County residents will identify fairly easily with a community culture characterized by behaviors that conserve energy.

5.15.3.1 Examples of Energy Conservation Options for SLO County

Encourage the adoption of Smart Thermostats and other enabling technologies and practices.

The utility or community choice aggregation (CCA) program sends monthly reports to customers detailing their energy usage in comparison with their neighbors.

5.15.4 Maps and Charts

Figure 121 below shows a robust result of ~2 percent average annual savings from household conservation behaviors elicited by comparative neighborhood Home Energy Reports, using three different statistical methods of analysis.

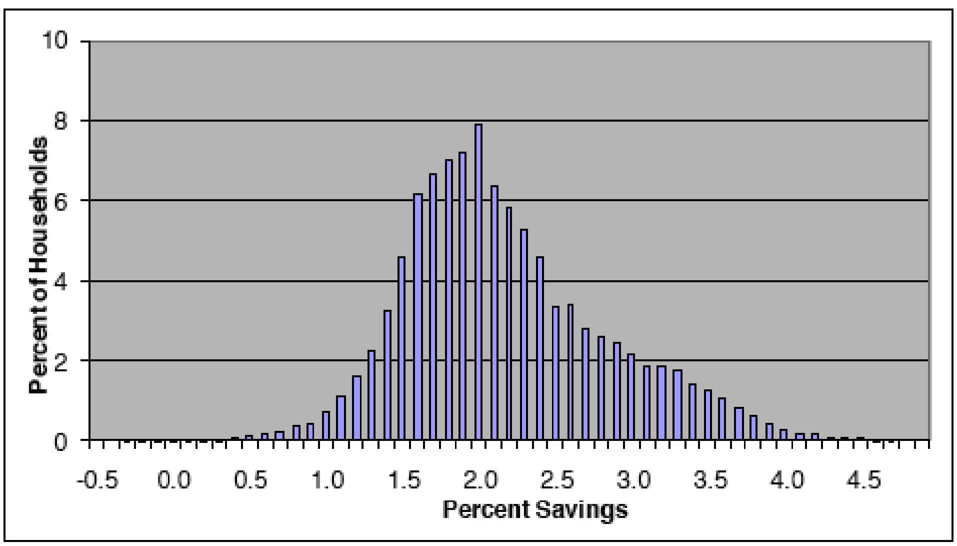
Figure 121: SMUD Pilot Program Statistical Analysis of Savings

Method	*Average annual kWh savings*	*95% Confidence interval on avg. annual savings*	*Average annual percent savings*	*95% Confidence interval on avg. percent savings*
Method 1: Difference-in-Difference Statistic	257	-	2.20%	-
Method 2: Baseline OLS Linear Model	253.75	{216.81, 290.69)	2.24%	{1.91%, 2.56%}
Method 3: Baseline Differenced Linear Fixed Effects Model	240.88	{222.81, 258.95)	2.13%	{1.97%, 2.28%}

Source: Summit Blue

Figure 122 illustrates the frequency distribution of household savings within the SMUD study group during 2008, using 2007 as a baseline. A linear regression model was used to predict that savings would occur for nearly all customers, rather than just being possible for a small subset

Figure 122: SMUD Pilot Program Distribution of Energy Savings



Source: Summit Blue

5.15.5 Investigation Process and Methodologies

At this point, no documentation of energy conservation activities and potential in SLO County has been found.

5.15.6 Next Steps

- Extrapolate quantitative results from other locations, and hypothesize how those results might apply to SLO County.

- Perform direct investigation of stakeholders and members of the community into options and potential for conservation measures, programs, systems, and policies.

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CHAPTER 6: Site Specific Resources: Biomass Potential

6.1 Summary

This analysis provides a detailed inventory and assessment of end uses and site-specific applications for biomass resources in San Luis Obispo County. Resources are divided into five categories:

1. Agriculture;
2. Forestry;
3. Municipal Waste;
4. Dedicated Biocrops;
5. Ocean Biomass.

The most compelling findings of this analysis, in terms of potential for site-specific and end-use energy utilization, include:

1. The abundance of winery grape pomace and broccoli crop residues as possible biodigester feedstock;
2. The potential for utilizing wastewater treatment plant biodigesters to process those feedstocks in addition to their own biosolids;
3. The potential for harvesting forestry biomass during fuel reduction projects.

Overall, this analysis creates a more detailed inventory as well as a clearer understanding of commercialization barriers and opportunities than has been provided in previous reports, such as the 2007 CEC/CBC Biomass Inventory. Further work is needed, regarding the technical potential of ocean biomass, the economic and technical potential of biomass resources, and strategies to harvest, deliver, and process biomass. Estimates of biomass potential in San Luis Obispo are given in the tables below. Biomass within the county has the technical potential to provide 14 percent of electrical energy demand and meet 18 percent of thermal energy demand (2020 consumption levels:

Table 19: San Luis Obispo Biomass Technical Potential (Electric)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Biomass (Ag Residuals)	10	-	-	72,000	3.8%	18,864
Biomass (Forestry Residuals)	16		-	118,000	6.3%	30,916

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
		-				
Biomass (Municipal Waste)	11	-	-	79,000	4.2%	20,698
Total	37	-	-	269,000	14.3%	70,478

Source: SLO RESCO

Table 20: San Luis Obispo Biomass Technical Potential (Thermal)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Agricultural Residuals	15	-	-	111,000	4.7%	29,082
Forestry Residuals	24	-	-	181,000	7.7%	47,422
Municipal Waste	17	3	22,338	123,000	5.3%	32,226
Total	56	3	22,338	415,000	17.7%	108,730

Source: SLO RESCO

In addition, a quantification of the energy potential that would result from dedicating 5 percent of agricultural land to dedicated biocrops is shown below:

Table 21: San Luis Obispo Dedicated Crop Biomass Representative Potential (Electric)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Biomass (Dedicated Crop)	49	-	-	364,000	19.4%	95,368

Source: SLO RESCO

Table 22: San Luis Obispo Dedicated Crop Biomass Representative Potential (Thermal)

	Potential Capacity (MW)	Current Installed Capacity (MW)	Current Generation (MWh)	Potential Generation (MWh)	Share of County Usage (2020)	Avoided GHG Emissions (Tons)
Dedicated Crops	75	-	-	558,000	23.9%	146,196

Source: SLO RESCO

Dedicated biocrops are relatively undeveloped in the county and research is needed to identify appropriate crops, establish processing and distribution infrastructure, and initiate pilot commercializations.

The methodologies underpinning this analysis were developed after a thorough review of the 2007 CEC/CBC Biomass Inventory (Williams). The attempts to refine the figures provided within CEC/CBC by utilizing locally collected data and accounting for local practices and resources. Specifically, it is informed by nearly 20 interviews with farmers, food processors, wastewater treatment managers, foresters, and other professionals experienced with practices related to biomass in their respective disciplines. Local data sources outside of interviews included local crop reports, reports from wastewater treatment plants and landfills, strategic plans, and CalFire GIS datasets.

Quantitative data from local sources was not available for most potential feedstocks; studies supplying the calculation and per-acre resource yield data are drawn from statewide, national, or international sources. Data provided in expert interviews was used to inform the when judged consistent and rational. Specific quantities and factors related to calculating the inventory as well as factors used to calculate the energy potential of the biomass are contained in the Resource Identification Tool and Biomass Dataset.

CEC/CBC inventory values are presented and compared with this inventory in each section below. Gaps in data are also discussed within each section. Current practices for select resources are discussed in-depth based on interviews for each resource. Finally, barriers and opportunities to utilizing select resources are noted, based on related interviews and studies.

Overall, while less intermittent than other alternative energy sources such as wind and solar, biomass does have intermittency issues that warrant summarizing. For example, many crops produce a surfeit of a particular resource at seasonal intervals. These influxes, depending on whether they are moist grape pomace or dry vineyard trimmings, need to be either processed immediately or stored in a manner that minimizes breakdown of energy potential. The various influxes of sources is fairly predictable, though, and energy generation facilities could be constructed with the intent of rotating feedstocks, based on availability, using more dependable baseline sources such as greenwaste, foodwaste, ocean kelp, or dedicated biocrops as buffers. It may be advantageous to chart the seasonality of resources to assess the design, capacity and location necessary for a facility to best utilize available disparate biomass feedstocks cost-effectively. Alternately, some resources could be used on-site as their availability may coincide with peak on-site loads—e.g. wineries where pomace is produced during the height of activity and energy use.

General barriers to utilization exist for all resources, including seasonality of resources, inability to cost-effectively harvest and/or a lack of proven harvesting equipment (e.g. for open-range cattle manure), and lack of infrastructure and bioenergy production facilities (e.g. for municipal greenwaste). Competing uses make some biomass resources unavailable (e.g. alfalfa is sold at a premium for animal feed). However, many opportunities exist in capturing and utilizing biomass, and several are being actively pursued by entities within the county. Several facilities are being upgraded with this intention:

- Paso Robles Wastewater Treatment Plant is upgrading its biodigesters and intends to supplement the plant's biosolids with grape pomace.
- San Luis Obispo Water Reclamation Facility may take a similar approach, adding fats, oils and greases currently shipped out of county to these resources.
- Cold Canyon landfill has long-term ambitions of capturing foodwaste for processing in a biodigester.

Significant potential likely exists in utilizing existing equipment to process new feedstocks. In biodigestion many factors influence energy generation potential. First, maintaining the ideal ratio of carbon, nitrogen and phosphorous (C:N:P) is vital for biogas production processes. A 100:5:1 ration is recommended for some processes. Biogas production varies according to feedstock retention time, volatile solid dilution, particle size, C:N ratios, availability of other nutrients and other factors (Steffen, 15). A more thorough characterization of the nutrient content of biomass resources is needed in order to better understand local biogas potential.

For combustion of woody biomass, wastewater sludge, and municipal solid waste, local air restrictions increase the required pollution controls and costs. Notably, some biomass is shipped out of county for energy production by combustion.

6.2 Methodologies

6.2.1 Overview

In contrast to the CEC/CBC report, this analysis does not escalate estimates over time, looking into the future, but only offers a current snapshot of the timeframe surrounding the data (generally 2008 - 2011). This approach is taken due to the more limited scope of the SLO RESCO project, the difficulty in making such projections without considerable error, though is expected that resources will fluctuate over time due to population increases, changes in policy, or shifts in agriculture and weather.

Data used in the analysis were taken from the most recently available sources. For agricultural residues, they are taken from the county's 2010 Crop Report. For wastewater treatment plants, data is as recent as 2011. Landfill data is taken from 2009 reports published online. Data sources are cited within each section below as well as associated with each figure within the Biomass Dataset.

Biomass resource streams were categorized based on the CBC/CEC methodology into three categories: agriculture, forestry, and municipal waste. In addition, categories for dedicated biomass crops and ocean biomass were added. Agriculture and municipal waste possess subcategories based on the CBC/CEC inventory.

Energy production processes were assigned to resources based on the CBC/CEC methodology, which uses an heuristic based on the inherent moisture and nutrient content of a resource. The method by which each resource was converted into energy varied for the gross resource and technical potential estimates, according to the table below.

Figure 123: Conversion Classifications for Gross and Technical Potential by Resource Category

Resource Category	Gross Potential	Technical Potential
Biosolids: landfilled	Included in MSW Other Landfilled	Included in MSW Other Landfilled
Biosolids: diverted	Thermochemical	Thermochemical
MSW: Waste in-place (2003)	Landfill gas	Landfill gas
MSW: paper/cardboard landfilled	Thermochemical	Landfill gas
MSW: lumber landfilled	Thermochemical	Landfill gas
MSW: leaves, grass, trimmings, prunings, stumps landfilled (green waste)	Biochemical	Landfill gas
MSW: other landfilled	Thermochemical	Landfill gas
MSW: food waste landfilled	Biochemical	Landfill gas
MSW: diverted	Thermochemical	Thermochemical
Animal manure	Biochemical	Biochemical
Orchard and Vineyard	Thermochemical	Thermochemical
Field and Seed	Thermochemical	Thermochemical
Vegetable	Biochemical	Biochemical
Food Processing-meat	Biochemical	Biochemical
Food Processing-others	Thermochemical	Thermochemical
Forest	Thermochemical	Thermochemical
Dedicated Crop	Thermochemical	Thermochemical

Source: California Energy Commission

Refer to the resource specific subsections below for assumptions regarding how potential physical harvest yields were derived. Resources yields were estimated in Bone Dry Tons per year (BDT/year) units for calculation purposes only, though it may be desirable to dry thermally-processed resources prior to utilization. The quantity of biomass available for the gross resource potential was calculated as:

BDT/yr., gross quantity = (acres/yr.) (BDT/acre, dry basis)

The technical resource potential availability was determined from the gross resource potential quantity by modifying the above equation with a technical availability factor:

BDT/yr., technical quantity = (acres/yr.) (BDT/acre, dry basis) (technical availability factor)

The energy yield was then calculated based on the resource-specific energy content in British Thermal Units per pound (BTU/lb.) from the California Energy Commission Biomass Report. Drier, carbon-rich resources such as orchard and vineyard trimmings, municipal solid waste, and forestry residues are treated thermally (combusted). Moist, nitrogen rich resources, such as vegetable crop residues, manure, and WWTP biosolids are treated biologically in an anaerobic digester. Moist resources are converted (for the purpose of calculation only) to BDT/year yields and then converted to pounds per year (lb./year). The energy yield of BTUs per year for the resources is calculated as:

BTU/yr. = (lb./year) (Volatile Solids %) (Biodegradability %) (Biogas Production Factor, ft^3 biogas/lb. of Volatile Solids destroyed) (Biogas Specific Heat, BTU/ft^3 biogas)

The above factors were averages of several resources in the overall estimate. More resource-specific calculations could be pursued for a particular resource to refine future analyses. Water needs of biodigestion are not considered, though water may need to be added or removed to process a particular crop, which is an important consideration in the local climate. Alternatively, wet resources could be mixed with dry resources to yield desirable moisture content.

Both thermal and electrical energy generation potential were evaluated for each resource based on a combined heat and power (CHP) system utilizing single cycle combustion with integrated heat recovery. The electrical generation efficiency of the plant was assumed to be 30 percent, the thermal recovery factor was set at 46 percent, and the power plant capacity factor, which defines the fraction of rated power capacity for a system achieved over the year, was set at 85 percent. The thermal and electrical generation potential was calculated by the following equation:

MWh/yr. = [(8,760 hrs./yr.) (plant capacity factor) (electrical generation efficiency or thermal recovery factor)] / (3,412,000 BTU per MWh)

The capacity impact was assumed to be:

MW = (MWh/yr.) / [(8760 hrs./yr.) (plant capacity factor)]

Energy potentials are considered separately for each of the five resource categories, with specific tools and methods for agricultural, forestry, municipal waste, and dedicated biocrops found in the Resource Identification Tool.

6.2.1.1 Agricultural Residues

Agricultural residues were processed either thermally or biologically to estimate their energy and power potential, as described in the introduction.

Farm Residues

Agricultural biomass sources are inventoried using methods from the CEC/CBC inventory. For crop residues, a residue yield/acre/year is found based on studies and/or interviews and factored with moisture content to produce a per acre per year yield in dry tons. Significantly, residues for broccoli and cauliflower were substantially larger sources of biomass than listed in the CEC/CBC report. The figures were adjusted upwards after interviewing a broccoli farmer. Snap peas are moved from the Crop Report's Vegetable category and placed with Field and Seed crops in keeping with the CEC/CBC report's organization. The 2010 Crop Report lists the 'Vineyards and Orchards' category as 'Fruit and Nut' category and is congruous with the Williams report except for strawberries. Strawberries are not included as they apparently yield insubstantial residues. Grain stubble was listed in the Crop Report but is not included in the resource estimate, and has little practical availability.

Animal Manure

For animal manures, range cattle are the only source considered. Their annual production is calculated based on lbs. of waste/animal/day and number of animals and converted to Bone Dry Tons/year.

Food Processing

Wine grapes were included as a source of biomass in the form of pomace. Residue yields and moisture content were corroborated by two interviews and one study and estimated by applying the fresh grape to pomace conversion rate (% wet tons) to total grape harvest in the county. Grape pomace was not considered in the CEC/CBC inventory.

6.2.1.2 Forestry

The forestry inventory was prepared using GIS software. Original data is sourced from the SLO County Vegetation layer. Relevant individual vegetation types were categorized into aggregate types: forest, woodland, chaparral, using a method that sorted and categorized based on individual vegetation type labels.

To calculate gross acreages within each type vegetation type, the following areas were removed from consideration: Los Padres National Forest Wilderness and roadless areas, areas with a slope greater than 30 percent, and areas falling within the coastal zone. The acreages of remaining lands in each aggregate type were used as an input to calculate gross acreage. Urban forestry was not considered and requires further investigation.

To calculate technically available acreages within each vegetation type, county-wide roads were intersected with each filtered aggregate type. A buffer on either side of the road was chosen as a baseline access depth based on the assumption that biomass would be need to be harvested, processed, and transported by road. Roads within each aggregate resource area received a 100 yard buffer. The acreage within the road buffer was calculated for each aggregate type and used as an input to calculate technical acreage for each type.

Total biomass load and associated recovery rate were estimated using the CalFire / FRAP: Surface Fuels dataset for San Luis Obispo County to identify the occurrence of different fuel model values within each aggregate type. These values were used in connection with the CalFire and Riggan reports to generate a rough estimate of total biomass load and sustainable recovery rate of biomass from each aggregate type measured in BDT/acre/year. The recovery values (BDT/acre) multiplied by the acreage of the respective vegetation type provided the final gross and technical resource potential for forestry resources measured in BDT/yr.

Energy potential was estimated assuming combustion of the resource.

6.2.1.3 Municipal Waste

Municipal waste is divided into two categories for the analysis: solid waste and wastewater. Solid waste was inventoried by interviewing three local landfill operators and accessing annual reports. Landfills represent two sources of potential biofuels; incoming waste that can be processed for bioenergy, and landfill gas emitted by existing, landfilled waste. Waste was characterized based on a statewide study. Energy and power potential for annual landfill tonnages were estimated based on thermal conversion (incineration) of construction, plastics, paper, cardboard and demolition waste and trimmings, and biological conversion (anaerobic digestion) of foodwaste and greenwaste, using the average energy content of the waste. Landfills in San Luis Obispo County are listed in the table below:

Table 23: Landfills in San Luis Obispo County

Landfill Site	Daily Permitted Capacity (Tons)	Landfill Gas Control & LFGTE Systems
Cold Canyon	1200	Active / LFGTE
Chicago Grade (with Nipomo Transfer Station)	700	Flaring / None
Paso Robles	500	Flaring / None

Source: California Energy Commission

Wastewater treatment plants (WWTP) presented a slightly more complicated resource to estimate. Methane is generated in biodigesters at many of them, so volumes were obtained in many instances. For WWTPs with unknown processes or biogas production, biogas production was estimated based on flow rates of influent waste and a conversion factor that links influent volume with biogas production. Where no actual biogas production values are provided, a Biogas Production Ratio (BPR) is used to approximate the value. The BPR is the ratio of biogas production to influent water (in Million Gallons per Day, or MGD) for all known plants in SLO County. For plants with unknown biogas production, the average ratio is multiplied by the daily influent to approximate biogas production. Particularly, values for WWTPs in Pismo and

Cayucos were not obtained directly, but estimated by this method. WWTP in San Luis Obispo County are listed in the table below:

Table 24: Wastewater Treatment Plants (WWTP) in San Luis Obispo County

Facility Name	Facility Owner	Location & Contact	Members
Cambria Community Services District	Cambria CSD	Health Lane Cambria, 93428 Sean Grauel: 805-927-6250	Cambria
Pismo Beach WWTP	City of Pismo Beach	550 Frady Lane Pismo Beach, 93449 Stuart Stewart: 805-773-7075	Pismo Beach
San Luis Obispo WWTP	City of SLO	25 Prado Rd. San Luis Obispo, 93401 David Hix: 805-781-7039	San Luis Obispo
Morro Bay/Cayucos WTP	City of Morro Bay	160 Atascadero Rd. Morro Bay, 93442 Bruce Keogh: 805-772-6272	Morro Bay
South San Luis County SD	South SLO CSD	1600 Aloha Place Oceano, 93445 Chuck Ellison: 805-489-6666	Oceano, Arroyo Grande, Grover Beach
Paso Robles WTP	City of Paso Robles	3400 Sulfer Springs Rd. Paso Robles, 93446 Edwin Moldrem: 805-238-0845	Paso Robles, Templeton, CYA

Source: California Energy Commission

Notably, the incoming biochemical oxygen demand over 5 days, (BOD5) of these plants was similar to the plants with known data points. BOD of WWTP influent can be used to estimate biogas production, as it was in the CEC/CBC report, because it correlates with nutrient content. However, different WWTP are more or less efficient at lowering BOD in initial processing. This can lower the quantity of nitrogen reaching the digestion chambers, due to dentrificiation taking place in the secondary treatment process. This could be one explanation for the variance in BPR across different plants.

Wastewater sludge is not considered for incineration, though it is included in the CEC/CBC calculations.

6.3.1.4 Dedicated Biocrops

No dedicated biocrops exist in the county. Dedicated biocrops were not extensively addressed in the CEC/CBC report as none existed in the state at the time of its creation. Growing dedicated biomass crops for energy has yet to emerge as an agricultural enterprise of any scale in California. However, an anticipated shift to biomass production led the CEC to predict 5 million tons per year of energy crops to be present in the state by 2020. Despite the arid climate and the challenge of water shortages, San Luis Obispo County has the potential to grow biofuel crops, especially offshore in the form of marine algae, though this poses challenges not addressed in this analysis. For the purposes of estimating their potential, an arbitrary 5 percent of the county agriculture lands were designated for hypothetical planting of biomass crops using a 5 BDT/acre/year annual biomass yield rate suggested in the CEC/CBC report. The crops were processed thermally, although an alternative use is for these feedstocks to be utilized as transportation fuels after being processed for oils or alcohols.

6.2.1.5 Ocean Biomass

For this inventory, a kelp harvesting operation was investigated as a case study. Kelp harvesting was not considered in the CEC/CBC report. Additional steps need to be taken to assess the full range of possibilities for the harvesting of kelp. The case study and recommendations are discussed in the Ocean Biomass section below.

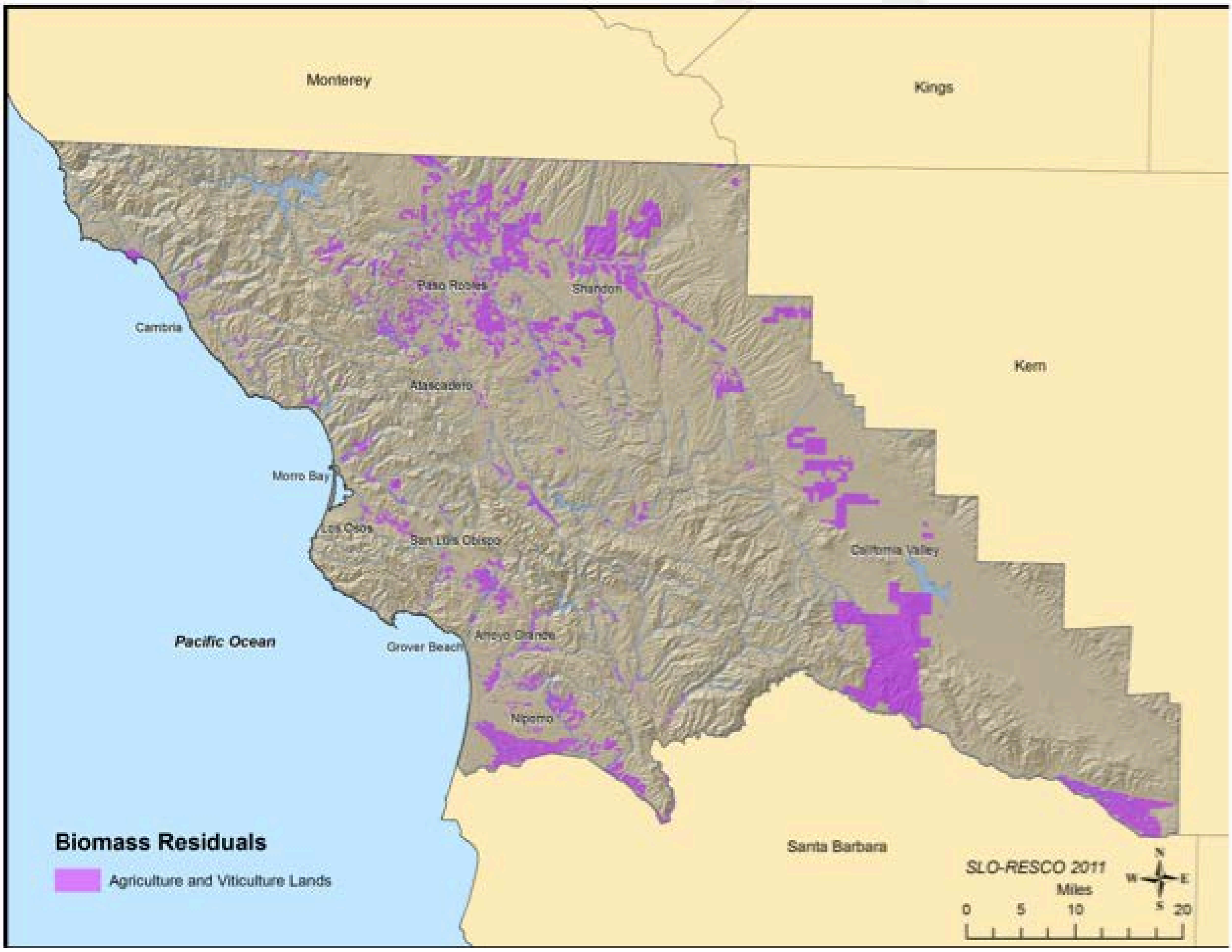
6.3 Resources

6.3.1 Agriculture

6.3.1.1 Introduction

San Luis Obispo County has over 100,000 acres of agricultural land (Figure 124). The county possesses characteristics of a Mediterranean climate--moderate temperatures, dry summers with rainfall occurring exclusively in the winter months. Temperatures vary from seasonal lows of 10 degrees Fahrenheit in the eastern reaches of the county to 35 degrees in the coastal regions (between USDA Hardiness Zone 8a and 10a, respectively). The county receives on average 12 - 13 inches per year of rainfall in the north portion of the county, and twice that or more in the more coastal south regions of the county. Temperature and precipitation varies greatly moving from dryer, more extreme conditions to the east to moderate, wetter conditions west of the coastal mountains. Heavy fogs provide substantial moisture through condensation in parts of the county. These conditions dictate crop patterns throughout the county.

Figure 124: San Luis Obispo County Agricultural Lands



Source: SLO RESCO

Agricultural biomass resources are divided into five categories, in accordance with the Williams assessment: field and seed, orchard and vineyard, vegetable, animal, and food processing residues. Local data provided by the San Luis Obispo County Agriculture Commission (Ag. Com.) 2010 Crop Report provided acreages by crop and number of animals in the county. The Crop Report is mandated by Section 2279 of the California Food and Agricultural Code and represents an annual compilation of county agricultural data. Further information on current treatment of residues was gathered through interviews with vineyard and winery managers, vegetable processing center managers, farmers, Ag Com. crop inspectors, University of California Cooperative Extension advisors, and the Paso Robles Wine Country Alliance.

The 2010 Crop Report listed separate figures for *acreage harvested* and *acreage planted*—*acreage harvested* was used for resource estimates. Usually the difference between these acreages was less than 10 percent, with *acreage harvested* being the lesser value due to economic and weather influences. For crops with small total acreage or where fewer than three farmers cultivate a given crop (to maintain confidentiality), acreages are lumped under the 'Miscellaneous' category. According to the Ag Com., a "Freedom of Information Act request" could be filed (for a nominal fee) to retrieve contact information for all farmers, and they could be contacted individually, but the Ag. Com. was unable to provide further breakdowns for this category. An average of the different crop's residue yields was used for estimates in the 'Miscellaneous' category.

The inventory of agricultural biomass in the county closely mirrored the CEC/CBC inventory. However, significant revisions were made in the area of vegetable crops by identifying the potential of broccoli and cauliflower for harvesting, as well as for food processing, as grape pomace was added to the inventory. Also, animal manures were identified as largely impractical to harvest, as they are attributed to free ranging cattle (Figure 125).

Figure 125: Agricultural Biomass - CEC/CBC Estimates Compared with SLO RESCO Estimates

	CBC 2010 Gross	CBC 2010 Technical	CBC 2020 Gross	CBC 2020 Technical	SLORESCO 2012 Gross	SLORESCO 2012 Technical
	bone dry tons per year (BDT/y)					
Orchard and Vineyard Crops	56,800	39,800	68,400	47,900	57,632	40,343
Seed and Field Crops	13,900	7,000	9,000	3,000	32,766	3,167
Vegetable Crops	35,400	1,800	38,300	1,900	44,198	21,507
Food Processing	900	800	1,000	800	27,629	13,531
Animal Manures	96,700	23,400	103,800	26,030	95,640	-
Total	**203,000**	**73,000**	**220,500**	**79,630**	**257,865**	**78,548**

Source: SLO RESCO

Agricultural biomass has significant energy potential, as it occurs in semi-industrial settings: Some residues may occur and be utilized during peak agricultural energy demand. More research needs to be done to more clearly link these resources with the on-farm demand.

From interviews, it is apparent that much of the biomass residues from crops are desirable as soil amendments and so are often chipped, composted, or tilled into the soil to retain biomass nutrient content and build soil organic matter. Therefore, if biomass is removed from the fields, it would be agronomically preferred for biomass energy residues such as biogas sludge or ash to be reapplied to fields. The precise amount of residue required to maintain soil health varies by crop and soil type, and was not determined in this research, but overall, the preference is to retain residues.

Moisture content and wet and dry biomass yield per acre conversion factors are taken from Williams, and originally from Knutson and Miller.

Pressure on local aquifers from over-pumping attenuates water availability; some uncertainty exists in the future of agriculture in the county, and should be a factor in considering the long-term stability of the agricultural biomass sources.

Significant variations from the CEC/CBC inventory exist. Broccoli's and cauliflower's potentials were dramatically underestimated previously, and were revised upward here. Manure was viewed as more available than it actually is in the CEC/CBC report since most of the cattle in

SLO County are free ranging and not held in enclosures; manure on the range is not cost-effective to collect. Finally, winery wastes were not considered for SLO County in the CEC/CBC report at all, and are one of the most substantial resources.

6.3.1.2 Field and Seed Crops

Data Sources

Field and seed crop data was collected from the 2010 Crop Report. In addition, Ag Com. inspectors specializing in field and seed crops and a former barley farmer and working rancher were interviewed. Data for energy estimate calculations were taken from the following sources: (2010 Annual Report, 10); (Williams, 18-19; 94); (Steffen, 17); (Zhang, 15-16).

Gaps in Data

- No studies were found to estimate biomass residue yields specifically in San Luis Obispo County. All figures are taken from statewide, national, or international data.
- There is a need to better understand technical and financial feasibility of harvesting residues. The rationale for the assignment of each technical availability factor is discussed for each crop in the Biomass Dataset.

Current Practices

- Generally, harvesting crop residues is not currently practiced. Significant acreages exist for: barley, alfalfa hay, grain hay, and miscellaneous field and seed crops.
- Barley is an annual crop that grows marginally in dry-land areas such as SLO County. Typically it is grown on a plot of land every other year, leaving the field fallow in the interim. Barley Straw is not bailed, except for a small specialty market as animal bedding, so may be available for collection. Harvester can be set to chop and spread barley straw or gather it in windrows—but is usually cut and spread to speed decomposition.
- Alfalfa and grain hay are currently marketed as animal feed. In the last number of years significant alfalfa cropland has been converted to grapes. Alfalfa and grain hay requires irrigation.
- Within the 'Other' category, bean and pea residues are sometimes harvested and bailed for animal feed due to high protein content. For peas, after harvest stakes are pulled and runners lain to dry on the ground. Most peas are grown in Los Osos Valley, but some on the north side of the Morros along Hwy 1.

Barriers and Opportunities

- Annual field and seed crops such as barley and grain hay grow marginally in the low-rainfall areas of SLO County. Technical barriers for collection of biomass arise as barley may be grown on rocky soil, so harvesters often cut barley to high stubble to avoid damage to harvester. Also, these crops have shallow root systems and risk eroding soils during tillage. No-till practices for annual crops and the cultivation of deep-rooted perennial crops could be pursued. A more ecological method, 'no-till' practices plant directly into untilled fields. Besides conserving energy, this method may reduce the impacts of removing above-surface biomass by maximizing retention of below surface biomass. Without no-till practices, farm equipment passes over ground 4 - 5 times per crop. In no-till farming, specialized equipment plants into solid seed beds. Cattle are often fed in the field on stubble after grain is harvested. In one interview, an example was given where no-till methods lowered soil erosion from 50 tons to 5 tons per year. A diversity of crops was also viewed favorably from an ecological standpoint. Removal of biomass from annual crops was viewed unfavorably by one farmer, due to limited organic matter in dry-lands. It is difficult to build organic matter in an intensive farming system.

- Irrigated crops, such as alfalfa and irrigated pasture, would not be cost-effective, due to the costs of irrigation (unless the crops were sold at premium prices, primarily as livestock feed).
- Perennial crops, such as grains, are currently being developed and could potentially be harvested without degrading soil, since perennial root structures are more extensive and build soil carbon.

6.3.1.3 Vineyard and Orchard Crops

Data Sources

Vineyard and Orchard Crop acreages were gathered from the 2010 crop report. Ag Commission inspectors Tamara Kleemann, University of California Cooperative Extension staff Mark Battany and Mary Bianchi, Lisa Bodrogi from Paso Robles Wine Country Alliance, and Ian Herdman from Tolosa Vineyards were interviewed to gain insight into current practices. Data for estimate calculations taken from the following sources: (Battany Interview); (2010 Annual Report, 11); (Williams, 7-8; 94); (Steffen, 17); (Zhang, 11; 15-16).

Gaps in Data

- No local studies have been conducted to assess biomass availability or yield. All data is taken from statewide, national, and international sources.
- More information is needed regarding practices surrounding vineyard trimmings and the implications of removing them for energy generation.

Current Practices

- Generally, all nuts are sent for processing in the Central Valley or sold to an in-shell market. Many orchards shred trimmings on site as mulch. Orchard crops are limited to less than 10,000 acres in the county.
- Citrus, avocado, and lemon comprise the majority of orchard crops in the county, and typically are not heavily pruned, or are pruned on a yearly basis. Evergreens such as

avocados and citrus are currently minimally pruned unless they are regrafted to a new variety (in which case nearly the entire tree is coppiced).

- Almonds are fading from local importance, and virtually none were harvested in 2010.
- The majority of the walnuts are dry-farmed, and so do not produce a great deal of new growth each year. Pruning is not performed on a regular basis. Most of the walnuts are sold to an in-shell market.
- Pistachio orchards are reported to be expanding in the county.
- For grapes, there is potential to harvest the trimmings. The grape industry generally embraces efforts to improve the sustainability of agricultural practices. How the vines are trimmed, trained, and irrigated would also play a significant role in the amount of excess vines that need trimming. Trimmings are currently chopped and tilled into the soil.

Barriers and Opportunities

- Orchard crops face the challenges of high energy costs for harvesting (since many are on hilly terrain), small acreages that may not produce quantities of trimmings to make harvesting/transportation cost-effective, and varieties of trees that do not receive regular pruning. These sources may at least serve as complimentary or supplemental feedstocks for grape trimmings, greenwaste or forestry residuals. Occasionally an orchard is coppiced—a practice where the entire tree is cut back—so that new varieties can be grafted in its place to the existing rootstock. This practice results in periodic influxes of biomass resource.
- Grapes, due to their extensive acreages and regular pruning present the most feasible orchard and vineyard biomass crop. However, harvesting on hilly terrain may not be cost-effective. Some varieties of grapes may not be trimmed as often. Furthermore, dry-farmed grapes typically do not produce as much growth and trimmings, and dry-farming or reduced watering may become more common as a response to limited water resources. Trimmings may have some value as mulch in the soil, but many vineyards depend primarily on fertilization, compost application, and cover-cropping, so tilling grape vines into the soil may not be necessary as an amendment. Removing trimmings may in fact be desirable to limit the spread of pathogens

6.3.1.4 Vegetable Crops

Data Sources

- Acreages were taken from the 2010 Crop Report. Current practices were assessed in interviews with Lynda Auchinachie, Kate O'Reilly and James Moore. Data for estimate calculations taken from the following sources: (2010 Annual Report, 12); (Giljum, 40); (USDA-NRCS, 30); (Zhang, 15-16); (Steffen, 17); (Williams, 29; 95).

Gaps in Data

- No local studies of biomass availability or yield have been conducted. All estimates rely on statewide, national, and international sources.

Current Practices

- Vegetable crops are usually tilled under, not grazed. Few farmers are using no-till methods that would reduce the impacts of biomass removal on soil health. Methods of applying nutrients to soil vary widely. Some farmers conduct soil sampling, others may apply fertilizer prior to every crop, or may do annual applications; some don't apply nutrients at all and depend on cover crops, and some base amendment application rates based on the rate of observed crop growth.

Barriers and Opportunities

- In general, residues help improve soil nutrients, increase beneficial bacterium, soil stability, lower pollutants, and improve structure—which saves money that would otherwise be spent on soil amendments.
- Lettuces, cabbage, carrots, and most other crops do not have significant resides, and what little residues exist may be low to the ground and difficult to harvest.
- Broccoli and cauliflower yield the most residues after harvest. The plant remains upright after harvest, enabling machine harvesting methods. The breakdown of broccoli in the soil forms natural fumigants that help control pathogens. To limit the impact of biomass removal on soil health, no-till farming is a viable option for broccoli. High diesel prices may outweigh the need to work the residue into the soil extensively. Even assuming no-till practices, the soil still receives the fumigant benefit of the broccoli decomposition from decaying root matter. Based on an interview, only 20 percent of the entire broccoli and cauliflower plant is harvested as a vegetable product; the rest may be available for biomass. Removing the plant would deplete soil nutrients including: calcium, potassium, phosphorus, and nitrogen. Cover cropping, compost, and/or fertilizer application would be necessary to replace these nutrients. Machinery may exist that could be adapted to harvesting broccoli residues--especially corn harvesters for silage or grain harvester.
- Bell peppers and tomatoes may have some biomass potential as significant biomass remains after the crop is harvested.
- Artichokes may also be a potential feedstock; it is a perennial crop (so biomass may not be critical to maintaining soil health), and many farmers cut them back to the ground after harvesting to stimulate new growth. However, there are not significant acreages of artichokes in San Luis Obispo County.

6.3.1.5 Animal Manures

Data Sources

- The number of animals was taken from 2010 Crop Report, with current practices informed by interviews with Agriculture Commission Inspectors Lynda Auchinachie. Data for estimates taken from the following sources: (2010 Crop Report, 10); (Steffen, 17); (Williams, 49; 97 – 99); (USDA-NRCS, 15).

Gaps in Data

- Cattle reported in the 2010 Crop Report are not divided into age classes. Manure production estimates are based on adult beef cattle. Estimates may be able to be derived by interviewing local ranchers.
- There is uncertainty whether or not the 2010 Crop Report data includes the cows, swine and chicken at Cal Poly.
- Horse manure may exist on a large scale, but is distributed across private stables throughout the county.

Current Practices

- Free range cattle comprise the bulk of agricultural animals in SLO County. Manure collection as such would not be cost-effective.
- The Templeton Auction Facility confines animals in close quarters, in small numbers for short periods of time, but that the facility may be shut down soon due to residential development pressure. Cal Poly also has chicken, swine and dairy units.

Barriers and Opportunities

- Free range cattle manure not be able to be harvested cost-effectively. In addition, it serves as a valuable ecological nutrient and sustains rangelands.

6.3.1.6 Food Processing

Data Sources

- University of California Cooperative Extension staff Mark Battany was interviewed and provided estimates for the approximate ratio of pomace to harvested ton of grapes. Data for estimate calculations was taken from the following sources: (Ingels); (Steffen, 17); (2010 Annual Report, 11); (Williams, 39; 95); (Zhang, 15-16); (AgrEnergy).

Gaps in Data

- Actual amount of wine processed in the county due to an unknown quantity of grapes shipping into and out of the county. No record of grape imports/exports is kept.
- Ratio of pomace produced to grapes processed is unknown for particular varieties of grapes.
- Some produce may be shipped out of county to other packaging/processing plants such as Opio, Babe Farms, and Bonita Packing.

Current Practices

- Grape pomace has several possible end uses. Some wineries pay cattle ranchers to haul it away for use as feed as it possesses substantial nutrients. Other wineries compost and return pomace to vineyards to increase soil nutrients and structure. Wineries that process a mix of grapes from multiple vineyards may prefer to send pomace away for feed or rigorous composting to destroy any residual pathogens. The harvest of grapes begins in September or October and seldom lasts beyond November. Grapes are processed immediately after harvest. Today, more than half of grapes leave the county for processing. This is due to the fact that large producers from Sonoma, Monterey, and San Bernadino counties came to SLO County after establishing their own processing facilities elsewhere. With current transportation costs being relatively low, they continue to ship the grapes rather than building local processing facilities.
- Vegetable processing culls and trimmings from may be sold to cattle ranchers.

Barriers and Opportunities

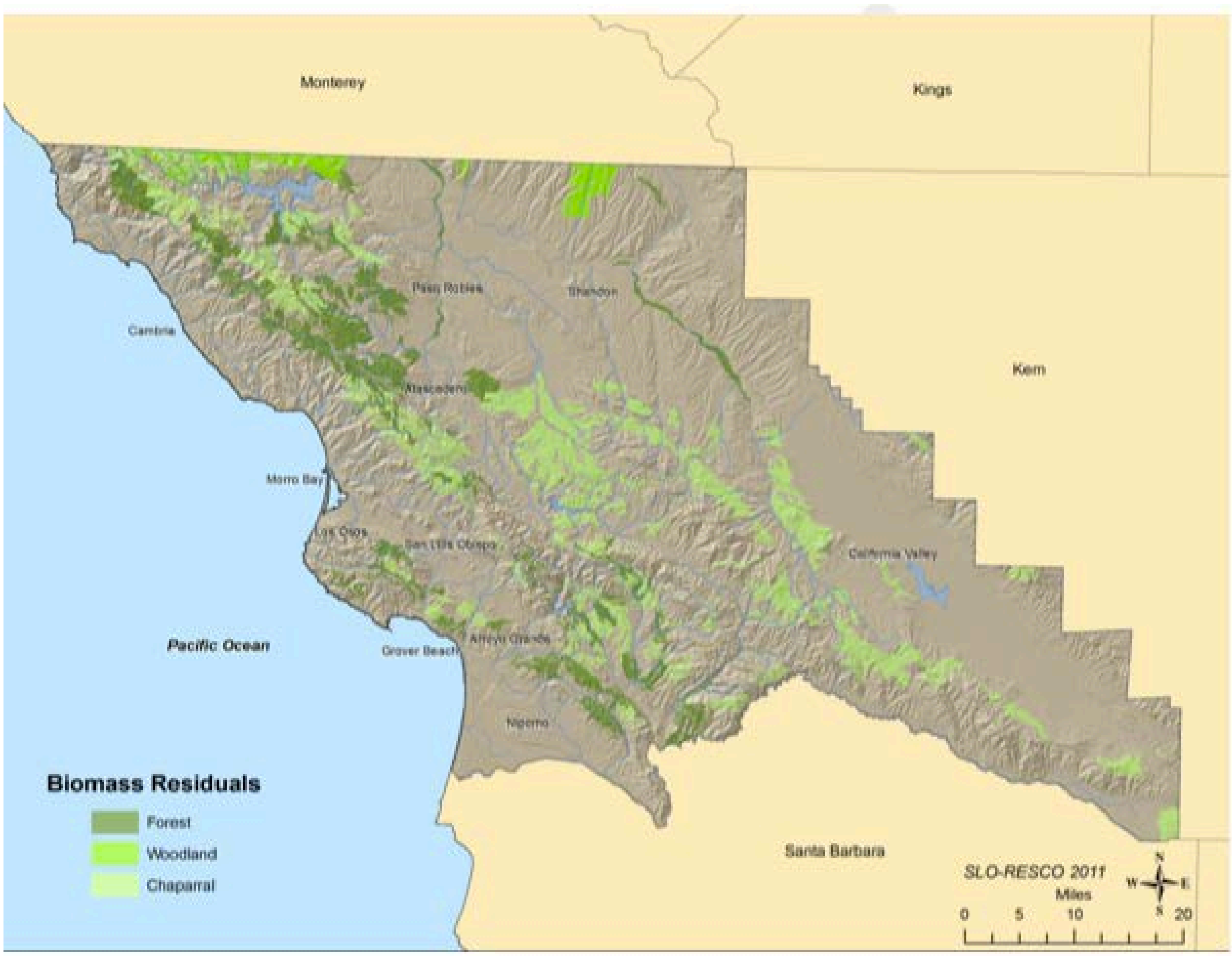
- Grape pomace has a high potential for energy generation due to large amount of local production and processing. There is strong industry desire to scale up local processing in order to increase the economic value of grapes locally. The pomace is relatively acidic and may contain alcohol (especially for red grapes, as the pomace is fermented in the tank at first as opposed to with white grapes, where the grapes are crushed and the pomace removed comparatively quickly, such that little to no alcohol is retained in the pomace). Pomace availability is highly seasonal, coinciding with the three months of the fall harvest. Sustainable winery certifications such as the Central Coast Vineyard Team's SIP program may eventually give credit towards certification for energy production from pomace.
- Vegetable processing tends to have few by-products. Most farmers harvest the plants in such a way as to leave the parts of plant that you would trim in processing in the field, to avoid transportation and disposal costs.
- Processed bell peppers and tomatoes yield culls (e.g. vegetables and fruits of sizes and shapes that the processor cannot use and must discard).
- Grape seeds present the potential for oil extraction.

6.3.2 Forestry

6.3.2.1 Introduction

Forestry resources in the county are comprised of Chaparral, Woodland and Forest (Figure 126). Forestry inventories for SLO County in the CEC/CBC report dramatically overestimated forestry resources. This is because no active timber operations that exist in the county; there are no thinnings, no mill residues, and no slash. Active forestry-related biomass projects in the county consist of fuel reduction by US Forest Service and Cal Fire operations. Additionally, forestry residuals from urban forestry and tree trimming operations require further investigation. See Methodologies above for a discussion of how this inventory was conducted.

Figure 126: Forestry Resources in San Luis Obispo County



Source: SLO RESCO

Forestry resource estimates were revised downward from the CEC/CBC report, mainly due to differing methodologies in accounting (Figure 127). Technical availability of forestry biomass is much less in this analysis, due to the inaccurate assumption that timber harvesting operations exist in the county, resulting in thinnings, slash, and mill residues. Also differing from the CEC/CBC report, this analysis does not consider fuel break clearing around most municipalities, since they tend gradually give way to rural/residential areas, rather than bordering directly on wild lands. Cambria is one location currently taking action to create a fire-buffer around the city by removing vegetation. The action is highly controversial for ecological reasons, and dependent on grant funding. Cambria may be one of the few municipalities where the surroundings lend themselves to the creation of a buffer.

Figure 127: Comparison of CEC/CBC and SLO RESCO Inventories of Forestry Residues

	CBC 2010 Gross	CBC 2010 Technical	CBC 2020 Gross	CBC 2020 Technical	SLORESCO 2012 Gross	SLORESCO 2012 Technical
	bone dry tons per year (BDT/y)					
Forest	135,000	79,000	135,000	79,000	59,548	19,282
Woodland	n/a	n/a	n/a	n/a	108,080	3,806
Chaparral	77,100	39,600	77,100	39,600	154,379	41,975
Total	**219,400**	**122,400**	**219,000**	**122,400**	**322,007**	**65,063**

Source: SLO RESCO, CBC

If used in tandem with municipal greenwaste, urban tree trimmings, and vineyard trimmings, forestry products may be a backbone feedstock for a large central facility. More research needs to be completed to investigate the life-cycle energy use of these projects, especially transportation. However, if the biomass harvesting were stacked on existing energy use through fuel harvesting, the energy lifecycle may be more attractive. Biomass harvesting could ostensibly subsidize these projects, and grants may be available through Cal Fire and the US Forest Service to initiate them.

Data Sources

- County Ag Commission inspector Tamara Kleemann was interviewed as well as Meladie Fountain, Resource Officer for Santa Lucia District of the US National Forest and Andy Hubbs, Forester 1 for CalFire to obtain information on current practices. Figures for calculations of estimates are taken from: (Riggan, 149); (Sethi, 16).

Gaps in Data

- No data was gathered regarding urban forestry operations, but these and similar entities could be approached to develop estimates: Pacific Coast Lumber, local tree trimming companies, and PG&E power-line clearing with Davies Tree Company. Some of this waste flow is assumed to be handled through the municipal waste's greenwaste category, but many tree trimming companies have private storage yards and sell or dump wood chips as mulch outside of the municipal waste stream.

- CalFire offers periodic home chipping for private homeowners to avoid brush burning. Quantities of biomass involved are unknown.

- Quantities of trimmings and thinnings by Cal Fire are known, but the US Forest Service run similar projects generating an unknown quantity of biomass.

- Fire and Resource Assessment Program (FRAP) provided GIS data for vegetation types as well as biomass in BDT/acre by vegetation type; however, no data was available for regeneration rates, so approximations were used.

Current Practices

- Forestry operations are limited to fire management carried out in the county. There are no commercial logging operations in San Luis Obispo County forests. Fire management practices are limited to burning some forest, woodland, and chaparral in controlled burns, and brush trimmings along roads by hand crews and mechanical masticators (tractors with shredding attachments). CalFire employs hand crews on roadsides, emergency egresses and ridgelines for fuel reduction. Biomass is typically chipped on-site, or piled and burned. If the site is close to a road, biomass is chipped; otherwise it is generally piled and burned. Only a few hand crews currently are likely to be able to cost-effectively collect this biomass. Trimming is also conducted by US Forest Service hand crews.
- Chaparral is sometimes removed with masticators, generally on strategic ridgelines where fires must be stopped. Some species of chaparral grow back if cut, while others depend on fire for regeneration. Most of the chaparral species are 'sprouters', and whether burned or cut, sprout back. A 5 to 10 years regeneration rate is generally estimated. Some farmers reportedly perform controlled burns of chaparral, sometimes three times in same spot because of the rate of regrowth.

Barriers and Opportunities

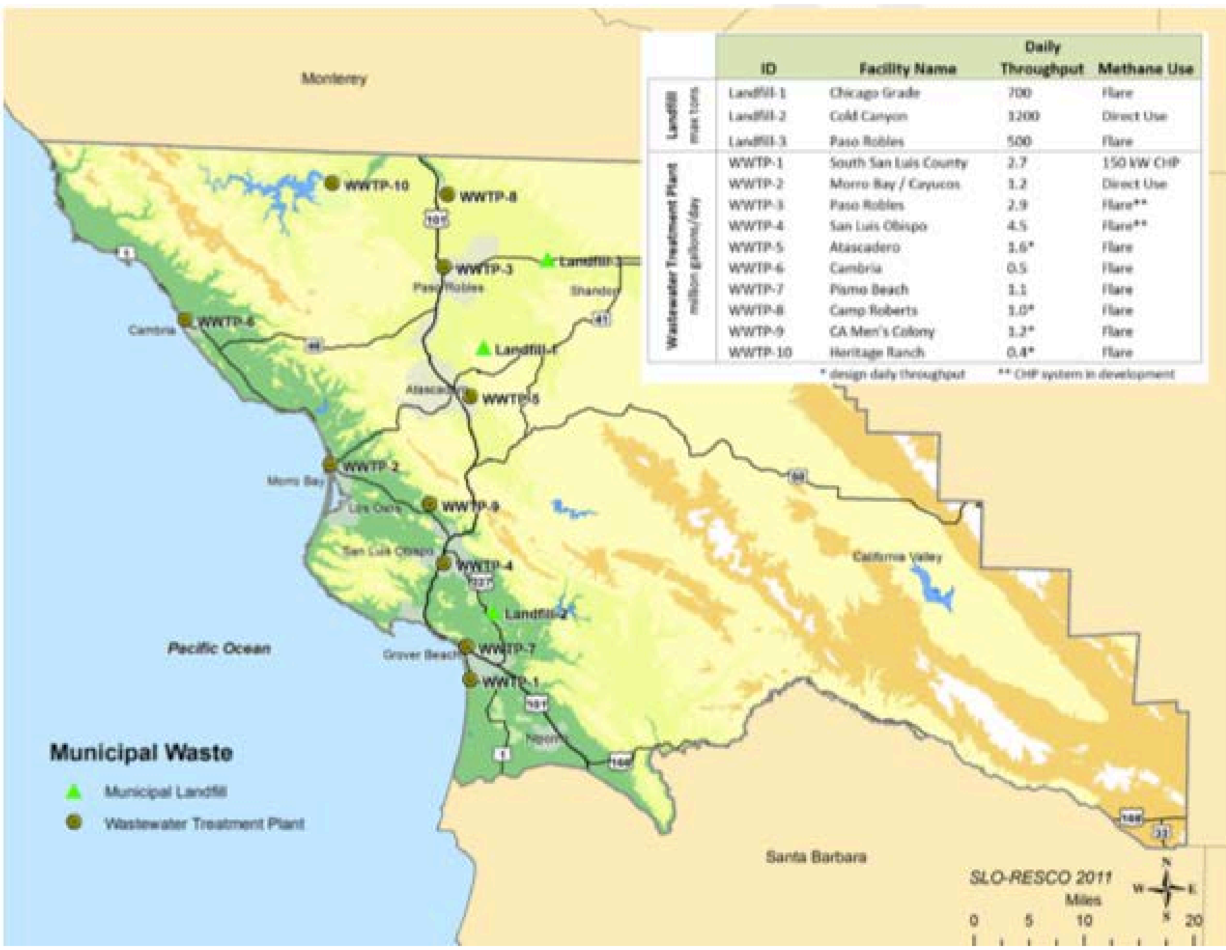
- Forestry may include Monterey pines and oaks which may experience large pathogen outbreaks here, as they have in other parts of the state. Large pathogen outbreaks would make oaks, Monterey pines, and other susceptible trees feasible for biomass harvesting. Permitting is required to remove biomass from National Forests on a case-by-case basis, and proponents may have to pay fees to do so. However, it seems to be an acceptable practice: Objective ME 2 of the Los Padres National Forest management plan is to seek opportunities to offer biomass for utilization. Normally, there is insufficient rainfall to provide growth rates reasonable for high rates of harvest. Wild fires and prescribed burns regulate forest health. Forests are adapted to burning; other fuel reduction measures such as thinning and mastication do not necessarily simulate burning, and may have long-term ecological effects. Prescribed burns mimic natural processes. Some of the forest is proposed for wilderness area, which would preclude biomass harvesting.
- Chaparral may be harvested mechanically. Mechanical harvesting may be cost-prohibitive, or may help offset costs of mastication. Removal of mulch after mastication has uncertain implications for regeneration, as the mulch holds moisture and nutrients in the soil but may also stifle seed growth (possibly both for native and invasive species). Masticators currently used do not have equipment to harvest biomass, but may be modified to do so.

6.3.3 Municipal Waste Streams

6.3.3.1 Introduction

The municipal waste stream represents the only category where biomass is currently utilized as an energy resource in San Luis Obispo County. Cold Canyon landfill currently captures and resells landfill methane gas, while other landfills and wastewater treatment plants generate but flare the gas (Figure 128). Barriers for utilization may be lowest at such facilities with existing sources of biogas. In addition, most wastewater treatment plants of size in the county have existing biodigesters that generate biogas, though the equipment may not necessarily be used. These facilities may have the capacity to take feedstocks, such as fats, oils, greases, pomace, greenwaste, and foodwaste for processing. Being dispersed fairly regularly throughout the county, and being nearby municipal centers of energy demand, these processing facilities may play a role in the future utilization of biomass.

Figure 128: Wastewater Treatment Plants and Landfills in San Luis Obispo County



Source: SLO RESCO

As can be seen from the table below, the CEC/CBC inventory of municipal solid waste closely reflected the SLO RESCO inventory, due to similar methodologies:

Figure 129: Comparison of CEC/CBC and SLO RESCO Estimates of Municipal Waste Biomass Resources

	CBC 2010 Gross	CBC 2010 Technical	CBC 2020 Gross	CBC 2020 Technical	SLORESCO 2012 Gross	SLORESCO 2012 Technical	Units
Municipal Solid Waste	111,100	55,525	119,200	241,800	125,049	51,024	Annual Volume (BDT/y)
Wastewater Gas	-	-	-	-	311,668	204,500	Daily Biogas Production (ft^3/day)
Landfill Gas	-	-	-	-	1,850,000	1,850,000	Daily Biogas Production (ft^3/day)

Source: SLO RESCO, CEC, CBC

Solid waste flows have declined recently due to economic conditions and a slowing in construction and demolition projects that contribute heavily to landfill waste. A number of large wastewater plants contribute to the bulk of potential, but many smaller on-site waste treatment plants exist around the county. Smaller wastewater treatment plants and septic systems are not considered in this inventory. Inflowing waste water is correlated with biogas production; about 23,000 cubic feet of biogas are produced for every 1 million gallons of wastewater that flows through a plant. Landfill gas is collected after a landfill has been capped, and represents a significant source of local potential.

6.3.3.2 Solid Waste

Data Sources

- A statewide characterization study from 2008 was used to estimate landfill waste composition. Landfill tonnages were taken from 2009 quarterly reports. There was a dramatic (in instances, nearly 25 percent) decrease in tonnages landfilled from 2007 to 2009, possibly due to a decrease in construction and demolition waste during the economic recession. However, no adjustments were made to the 2008 characterization study in this report. Data for estimate calculations taken from the following sources: (Williams, 65-66); (Cascadia, 6); (Zhang, 15-16); (Steffen, 17).

Gaps in Data

- The Integrated Waste Management Authority calculates diversion rates by estimating per-capita waste production. Per-capita production is calculated by dividing total waste production for a region by the population. These figures are compared over time to a baseline to determine the relative diversion rate. Actual tonnages of locally-diverted waste, such as recyclables, are not publicly-available. Reportedly, diversion rates are at 70 percent as compared to a 1990 baseline. It is challenging to calculate the mass of diverted waste available for energy production based on the mass of landfilled waste and the diversion rate, since some of the 'diversion rate' may actually be due to waste avoidance. Furthermore, some diverted waste is used as alternative daily cover (ADC) at landfills, a sanitary barrier of construction waste, greenwaste, or other debris placed on the landfill daily. ADC is counted as diverted waste, and represents the only category of diverted waste that is tracked. Therefore, this analysis examined only landfilled waste and ADC as potential biomass sources.

- No local waste characterization studies exist. Statewide averages were used.

- An undetermined fraction of waste goes out of county to a Santa Maria facility. Some greenwaste sent there is used as ADC because it is more cost-effective for collection trucks to drive to Santa Maria facility than to haul waste back to Cold Canyon.

Current Practices

- For landfill waste, Cold Canyon currently harvests landfill gas and sends methane to oil fields across the street for use heating water as part of the extraction process. Chicago Grade currently flares its gas, and so does Paso Robles.

- The county handles approximately 20,000 tons/year of diverted waste. Covanta, a power plant in the Central Valley takes 200 – 300 tons of wood chips per month from Cold Canyon Landfill. The plant processes 800 tons/day of ADC, which is currently counted as 'diverted' waste towards the state's waste diversion goals. Interviewees believed that it is likely the state will change this classification, since this 'diverted' waste in fact goes into the landfill, though it serves a function there. Recyclables are processed at local facilities, baled by type and sold for manufacturing material feedstock.

Barriers and Opportunities

- For recyclables, it may be possible to purchase paper/cardboard for incineration. However, an IWMA commissioned lifecycle assessment asserts that the energy saved by recycling (due to avoided energy expenditure in raw material extraction and refining) is greater than energy gained by incinerating recyclables.

- Greenwaste is available on a large scale, for incineration or biodigestion. Local air regulations may require prohibitively expensive pollution controls. Since Cold Canyon's greenwaste processing permit has been revoked due to complaints of "pine scents" by neighbors from ground greenwaste, they are looking for alternative methods of handling it, including anaerobic digestion. Preliminary tests have shown that there is little methane potential due to the high carbon content of the feedstock (more nitrogen and other nutrients are required for methanogenic bacteria growth). Food compost, grape pomace, and fats, oils and greases, and municipal waste water sludge may be available to supplement greenwaste in anaerobic digestion.

- Compostable foodwaste is not currently separated, but has been used elsewhere in anaerobic digesters. A south county composting company, Engel and Grey has been collecting food waste in the county for several years, including from Cal Poly San Luis Obispo Campus Dining pre-consumer kitchen waste, and may have experience and insight in the practical, regulatory and other aspects of collecting foodwaste.

- Fats, oils and greases are currently handled outside the county, or at a local rendering plant, but could be used for energy generation. It has a very high energy content and is a desirable feedstock to increase biodigester efficiency.

6.3.3.3 Wastewater

Data Sources

- Interviews were conducted with: Matt Thompson, Wastewater Resources Manager for Paso Robles Wastewater Treatment Plant; Bruce Koegh, Wastewater Division Manager for Morro Bay Wastewater Treatment Plant; Mathew Keeling, Water Board Engineer for Regional Water Quality Board; Bob Barlogio, Superintendent of South San Luis Obispo County Sanitation District. Data for calculations was taken from the following sources: (Sound, 7); (Zhang, 15-16); (Williams, 64-65); (CalRecycle); (Cascadia, 6); (Steffen, 17).

Gaps in Data

- See points on estimating biogas production based on MGD influent rates and BOD above in Methodology section.
- For wastewater, only the largest treatment plants are considered as sources, though there are a number of smaller (influent flow rate < 0.5 MGD) onsite treatment plants as well as home septic systems that may be a source of biodigester feedstock. Also, wastewater biosolids are not considered for incineration as they are in the CEC/CBC report.
- More information needs to be collected on Atascadero's WWTP.

Current Practices

- Generally, local wastewater treatment plants (WWTPs) capture biomass in the form of greases, oils, fats, feces, food scraps, and household residues that travel through municipal sewage systems to the plants. The plants separate biosolids from water during the treatment process in three steps. First, preliminary treatment removes the largest debris (rags, sand, gravel, and other items). In the primary treatment, suspended biosolids are skimmed off the top or settle to the bottom of a tank, depending on their density. In secondary treatment, water is treated biologically by microorganisms that remove nutrients and organic matter from the water; excess microorganism growth is removed and added to biosolid sludge. Biosolid sludge is treated by anaerobic digestion to decrease volume and reduce odors, and the resulting methane gas is burned to heat the digestion process and/or generate electricity, or flared. Finally, sludge is dried and shipped out for application to agricultural fields outside of SLO County.
- Morro Bay/Cayucos WWTP currently digests sludge but flares methane. A boiler is reported to be heated by flared methane, and is probably connected to the digester. Sludge is composted on site. The facility is currently trucking 192.2 wet tons per year (@ 80 percent solids, equivalent to 153.76 dry tons) of digested biosolids away for agricultural application.
- South San Luis Obispo County Sanitation District (serving Arroyo Grande, Oceano, and Grover Beach), reported that their sludge is either air dried in sludge beds with an under

drain leading back to the front of the plant, or centrifuged. The district pays the lowest bidder to haul away the dried cake. The current service provider is McCarthy Farms / Liberty Composting, which uses the cake as fertilizer. The methane gas is utilized by the cogeneration system to produce electricity, and the waste heat is used to heat the anaerobic digester. The cogeneration system has a capacity of 150 KW. The amount of sludge hauled off-site for composting was 196.1 dry metric tons in 2011. Typically, the plant generates around 68,000 cubic feet of methane per day.

- San Luis Obispo Water Reclamation Facility processed biosolids with a post-digestion, wet weight of 2,767 tons in 2011. A belt filter press takes out more water after digestion, raising the solids content to 15 percent. All biosolids go to Engel and Grey Composting. Biosolids from pre-treatment are landfilled. The system operates with digesters in series and offers a higher than average 40 day retention time, which increases breakdown of volatile solids. Biosolids are 67 percent volatile solids.
- Paso Robles Wastewater Treatment Plant is currently undergoing a multi-million dollar upgrade to enhance and replace outdated equipment, some of which was damaged in a recent earthquake. The city adopted new sewer rates and facilities charges to pay for the upgrade, and met little organized protest by rate-payers. The plant currently has functional digesters, but no filtration system or generator to utilize the gas.

Barriers and Opportunities

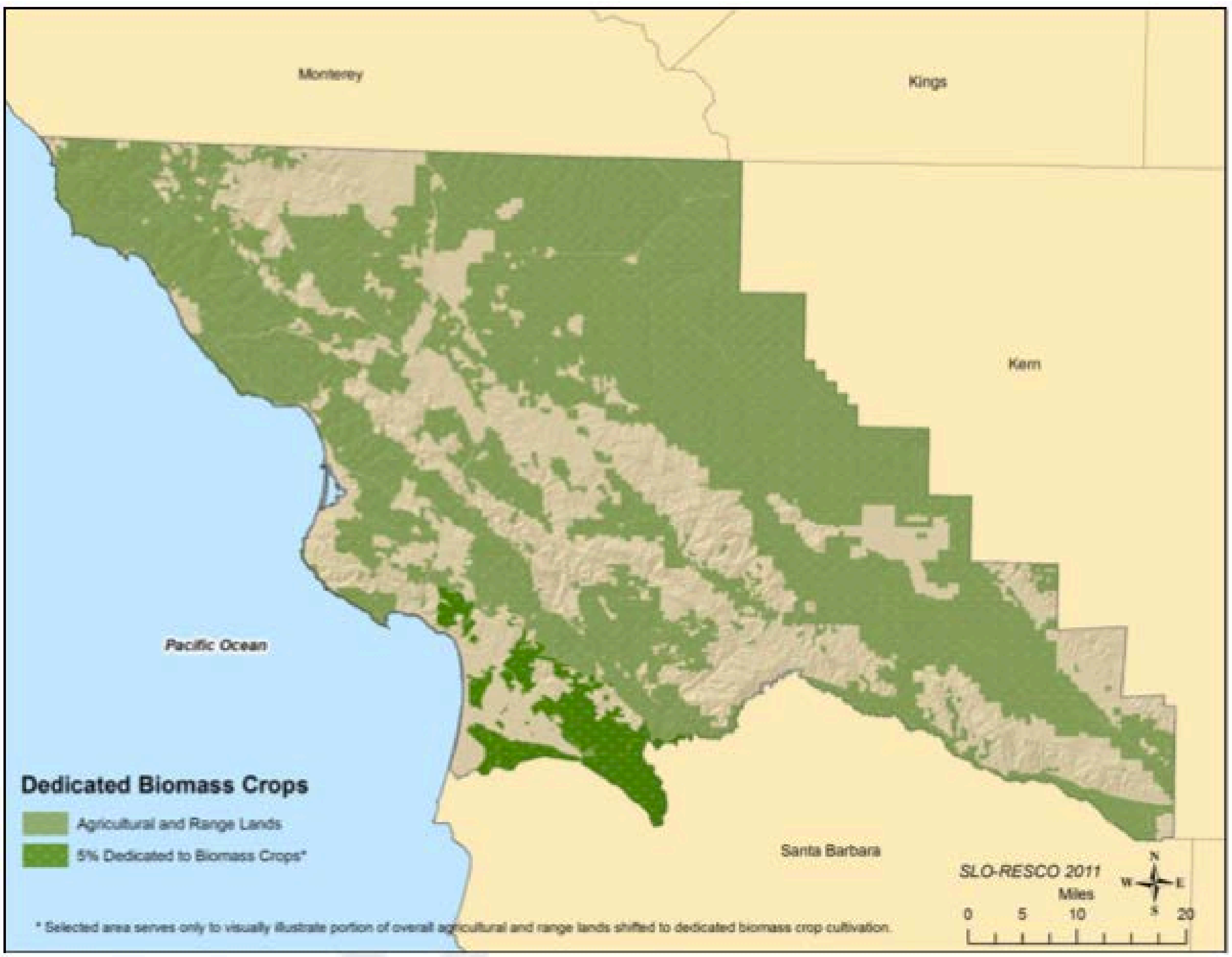
- The Paso Robles Wastewater Treatment Plant provided plans for the 2012 – 2013 plant upgrades, which will include a methane biodigesters and a cogeneration system.
- Morro Bay/Cayucos WWTP stated that upgrades are planned but would not include methane digestion due to cost considerations of connecting upgraded treatment processes to old digesters, which would cost approximately $7 million. Waste will be shipped to Kern County for agricultural application due to the costs of composting on site. If digesters were used, stable dry sludge could be composted. The new plant will not have digesters, but will have aerated sludge, which would cause fly and odor issues, and so the sludge needs to be sent elsewhere for composting. The new plant will dispose of 25 percent of its solids by trucking 615.04 wet tons per year to Kern County.
- San Luis Obispo Water Reclamation Facility is planning upgrades to its plant. A screw press should improve solids content of sludge to 20 - 23 percent. Incineration has been considered, but air emissions make purification necessary, increasing the cost of generation. It was suggested that San Luis Obispo County should look at the regional plants where all the sludge comes from. The plant is undergoing an efficiency retrofit and a cogeneration system is being installed. The facility also received a $2 million grant to put in fats, oils, and grease (FOG) receiving station, and handle 12 percent solids content in their digesters. FOGs are currently sent to Fresno and Santa Maria for energy production; with a high BTU value, FOGs are a highly desirable feedstock for digesters. However, there is not a significant amount in the county; the facility has engaged waste

haulers in the area to see whether they will increase shipments to the facility. They are very interested in vineyard pomace and will also approach vineyards; however, pomace supplies fluctuate seasonally. Greenwaste is not ideal in for the mixer and digester. Foodwaste is preferable, and there is a possibility of partnering with IWMA/Cold Canyon for food digestion. Dedicated Biocrops

6.3.4 Dedicated Biocrops

No dedicated biocrops are currently cultivated in the county. To gain a basic understanding of the potential of biocrops in the county, the analysis set aside 5 percent of agricultural land in the county and estimated the yield of an average biocrop at 5 BDT/year/acre (based on the CEC/CBC methodology) (Figure 130).

Figure 130: Hypothetical Planting of Dedicated Biocrops on 5% of Agricultural Lands



Source: SLO RESCO

Barriers and Opportunities

- Biocrops would likely go towards biodiesel or other fuel, rather than thermal or electrical generation. Steps could be taken towards developing local biocrops by running test plots that vary species planted in various locations around the county. Recommendations for crops include: low water usage (because of the limited availability from natural rainfall and pressure on aquifers) and cost of inputs, such as fertilizer and fuel. Perennial crops may be preferred for their deep root structure which conserves soils, sequesters carbon dioxide, and reduces water requirements. Other considerations include the trend that higher quality soil and water suitable for dedicated biocrops are under pressure from higher value crops such as strawberries. There is also uncertainty around agricultural land protection because of the uncertain future of Williamson Act funding. A lifecycle assessment is needed to gain a better understanding of the energy costs and benefits of biocrops in SLO County.
- Native tree crops, particularly *Quercus agrifolia* (Coast Live Oak) may hold some potential as a perennial biomass crop suitable for periodic harvesting. West of Paso Robles, early pictures of the country have dense forests of coastal live oak. The trees resprout vigorously when cut, but may grow somewhat slowly. They are well adapted to local climate conditions and fulfill a keystone role, ecologically. Other species of potential include grey pine (*Pinus sabiniana*), and poplar (*Populus spp.*), which is more suited to moist environments. These species, as well as Monterey cypress and eucalyptus are already used to some extent as windbreaks along fields of produce throughout the county, and especially in windy coastal areas.
- Besides being a potential source of biofuels, these dedicated crops could generate revenues to support their planting through markets for carbon sequestration, and the production of biochar (essentially pyrolized organic matter, a potent soil amendment that increases moisture and nutrient contents while remaining carbon neutral). Used in conjunction with biocrops, biochar could further reduce watering needs and improve crop yields.
- Dedicated biocrops could possibly be grown on marginal lands, or as with windbreaks, integrated with agricultural croplands without displacing them. Crops that mature and could be harvested and stores could be utilized during gaps in the supply of other biomass resources.

6.3.5 Ocean Biomass

As a case study on how to harvest ocean biomass, interviews were conducted with a local Abalone Farm that harvests kelp as a food supply for its abalone cultures.

Current Practices

- Giant kelp grows out a maximum of 1 mile from shore and to a water depth down to 70 feet, while bull kelp grows much closer to shore. Only giant kelp may be harvested, and not bull kelp. Kelp follows long-term growth cycles and is affected by weather and storms. Strong winter storms can dislodge kelp beds, and deposit substantial kelp mass onto the shore. Weather and storms add additional uncertainty to harvest production volumes from kelp.
- Harvesting requires piloting the boat at very slow speed through the kelp bed with a rake that cuts to a depth of three feet. Harvesting is allowable up to a depth of 5 feet. Kelp grows seasonally: on the central coast, kelp is abundant in the spring and fall. Kelp at the abalone farm is harvested at a rate of approximately 20 tons per trip. The rate of harvesting may be generalized as: 2 hours @ 10 tons/hr. + 2 hour travel. The estimated additional costs and labor include: 20 man hours @ $25/hour; fuel for two John Deere 6 cylinder marine engines or equivalent; unloading, usually done be a truck with a crane mounted on it sitting on the dock when the boat comes in; transportation and delivery by truck from the pick-up dock to the Abalone farm; and lastly onsite transportation by a tractor-trailer. In processing, kelp is fed directly into abalone tanks or is kept in salt water storage tanks until needed. Average harvests may be estimated by assuming: 20 tons per trip x 4 trips/week x 52 weeks = 4,160 tons per year. Historic annual yields from those interviewed range from 3,000 to 5,000 tons per year.
- No ocean biomass is currently harvested for energy in San Luis Obispo.

Barriers and Opportunities

- Learning to pilot the vessels required to harvest kelp, especially in shallow waters, may pose barriers to market entry for inexperienced pilots.
- The boats need to have a commercial harbor where kelp can be offloaded to be delivered to the processing plant. Possible existing harbors to serve SLO County include Ventura, Santa Cruz, Morro Bay, Avila - Cal Poly/Unocol, and Diablo Canyon.
- Transportation, labor, and traffic are all issues that need to be addressed for commercial energy production. To deliver kelp to the abalone farm, for example, a tractor trailer that can carry 20 tons is required.
- No processing infrastructure currently exists for using ocean biomass for energy in San Luis Obispo.
- In Marine Protected Areas (MPAs), harvesting kelp is not permissible. San Luis Obispo County does not have any MPA areas. In a Marine Sanctuary, harvesting is permissible but activities within the sanctuary are subject to various other regulations. The Monterey coast line is protected as a marine sanctuary. Danger to fish larvae is a common concern. The Nature Conservancy, led by Dr. Mike Beck, is conducting monitoring of kelp beds

to determine the importance of the kelp forest canopy for nursery habitats and marine biodiversity. One interviewee stated that the Nature Conservancy found that the harvesting boats move at slow enough speed to provide time for larvae to seek safety.

- A life cycle assessment is necessary to determine if there is any net energy benefit in harvesting and processing kelp for energy or liquid fuel.
- Kelp harvesting may need much larger economies of scale to overcome energy and financial thresholds.

6.4 Interview Sources

These contacts were interviewed during the development of this analysis, and their input is cited within the section where it is used.

6.4.1 San Luis Obispo County Agriculture Commission

- Lynda Auchinachie, Environmental Resource Specialist at Ag. Com., Project or Organizer for 2010 Ag. Com. Crop Report (805) 781-5914
- Kate O'Reilly, Ag. Inspector at Ag. Com., Field and Seed Crops (805) 781-5917
- Mary Bianchi, Horticultural Advisor at Ag. Com. (805) 781-5949 mlbianchi@ucdavis.edu
- Tamara Kleeman, Ag Inspector/Biologist at Ag. Com., Orchard Crops (805) 781-4696
- James Moore, Weights and Measures Tech. at Ag. Com., Vegetable Crops (805) 473-7096

6.4.1.1 Agriculture

- Ian Herdman, Production Manager at Tolosa Vineyards
- Tom Ikeda, Farmer/Operator of Pismo Oceano Vegetable Exchange
- George Work, Farmer/Owner Work Family Guest Ranch
- Mark Battany, Grape Agriculturalist at UCCE, (805) 781-5948, cell: (805) 305-7502
- Lisa Bodrogi, Government Affairs Coordinator, Paso Robles Wine Country Association (805) 260-2461

6.4.1.2 CalFire

- Andy Hubbs andy.hubbs@fire.ca.gov office: (805) 543-4244 ext. 2126, cell: (805) 903-3408

6.4.1.3 Air Pollution Control District

- Karen Brooks, Compliance and Monitoring Manager (805) 781-5912

6.4.1.4 United States Forest Service

- Meladie Fountain, Resource Officer for Santa Lucia District (805) 925-9538 Ext. 214

6.4.1.5 Solid Waste

- Mary Whittlesey, Solid Waste Coordinator for SLOCo., 805-781-5252, voice mail 5259

- Robert Barlogio, Superintendent South San Luis Obispo County Sanitation District 805/489-6666
- Bruce Keogh, Wastewater Division Manager at the Morro Bay - Cayucos WWTP
- Lacy Ballard, Cold Canyon Landfill
- Howard Brewen, Treatment Plant Manager San Luis Obispo Water Reclamation Facility
- Randy Friedlander, Integrated Waste Management Specialist. (916) 341-6718

6.4.1.6 Subject Matter Expert

- Steve Ela, local subject matter expert

6.4.1.7 Ocean Biomass

- Ray Fields, abalone farmer **rcfields@fix.net** 805.995.2495

6.4.2 Suggested Contacts

These contacts and entities were not reached prior to this analysis, but are suggested as sources for further information.

- Dale Glantz , Calco - 619.818.2261 (foremost kelp expert in CA)
- Dr. Mike Beck, Nature Conservancy – mbeck@tnc.org
- Rebecca Flores-Miller, Dept. Fish & Game – office: 831.649.2835, rfloresmiller@dfg.ca.gov
- Pacific Coast Lumber Mill
- Jackie Crabb, Farm Bureau (805) 543-3654
- SLOCo Environmental Health and Safety (805)781-5544
- Cal Poly Crop Science Dept.
- Alan Peters, Forester - Cal Fire **alan.peters@fire.ca.gov**
- Los Padres Forest Watch (805) 617-4610
- Don Bedford, GIS Specialist - US Forest Service (805) 961-5721
- Regional Water Quality Board - detailed records available for retrieval at offices
- SLO Agriculture Commission - detailed records available for retrieval at offices
- Greg Thompson, Forester - US Forest Service (661) 245-3731 Ext. 236

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Zhang, R.; El-Mashad, H.; Hartman, K.; Wang, F.; Rapport, J.; Choate, C. and Gamble, P. (July 2005): Anaerobic Phased Solid Digester Pilot Demonstration Project – Characterization of Food and Green Wastes as Feedstock for Anaerobic Digesters. California Energy Commission.

CHAPTER 7: Site Specific Resources: Parking Lot Solar Photovoltaic Potential

7.1 Introduction

With an average of 315 days per year of sunshine, San Luis Obispo County has extensive solar energy resources. The SLO RESCO analysis characterized five different types of solar photovoltaic energy end-uses: central station, substation, commercial, residential and parking lot applications. This section details the site specific methodology, assumptions, resource potentials and future uses for San Luis Obispo County's parking lot solar resource.

7.2 Methodology

To quantify the solar parking lot resource potential, the total parking lot area of the county first had to be approximated. Using Google Earth, a standard grid was created for the entire county. Next, each grid square was systematically searched and every parking lot identified was manually traced using the Google Earth polygon tool. With each grid square evaluated and all of the polygons drawn, the information was imported into a GIS mapping tool and a layer was created. GIS tools were then used to calculate the area of each parking lot and the total parking lot area throughout the county. Additionally, other relevant statistics such as average area and standard deviation of the mean parking lot area were quantified.

Subsequently, a PV access factor, a module efficiency, a de-rate factor, a packing factor and a capacity factor were applied to determine the technical potential in megawatts and megawatt-hours. This methodology was modified from the Navigant Consulting California Rooftop PV Resource Assessment. (Refer to Navigant.) Refer to Figure 135 for the disposition of the parking lot solar resource quantification.

The parking lot solar PV resource tool was used in this study to estimate parking lot resource potential. It is designed to allow for the simple adjustment of underlying assumptions in the resource calculation in order to conduct sensitivity analysis or to improve resource potential estimates as improved information becomes available.

7.3 Assumptions

Below is a list of assumptions used in calculating the parking lot solar potential in SLO County.

- A 50 percent access factor was based on a number of conversations with different solar developers in SLO County. The value of this factor means that roughly 50 percent of a given parking lot could be covered with PV parking lot arrays.
- Module efficiency was conservatively estimated to be 15 percent.

- A packing factor of 1.25 was used to account for spacing for wiring and other hardware (refer to Navigant). This means that for every 1 square foot of available array space, only 80 percent would be filled with PV material.
- An overall de-rate factor of 79 percent was determined using a number of de-rate factors from the NREL PV Watts calculator. The 79 percent valued is the product of the following: Panel mismatch/98 percent * Wiring/98 percent * Inverter/95 percent * Orientation/95 percent * Temperature/96 percent * Degrade/95 percent (refer to PV Watts).
- A capacity factor of 20 percent was assumed for all parking lot solar systems.

7.4 Resource Potential

Using the methodology and assumptions summarized above, it was determined that there are an estimated 1,200 acres (52,272,000 square feet) of parking lot space in SLO County among 1,659 parking lots. The average size parking lot in SLO County was measured to be roughly .75 acres with a standard deviation of 1.37 acres. If all 1,200 acres were to be developed using the assumptions above, the technical resource potential is 230MW (AC) and 403,000 MWh/year. While it is unrealistic for all of this resource to be developed, even if only 10 percent of this resource (23MW) could be developed it would roughly match the estimated 20.7 MW of distributed solar currently installed in SLO County (as of March 2013). (Refer to California Solar Initiative.)

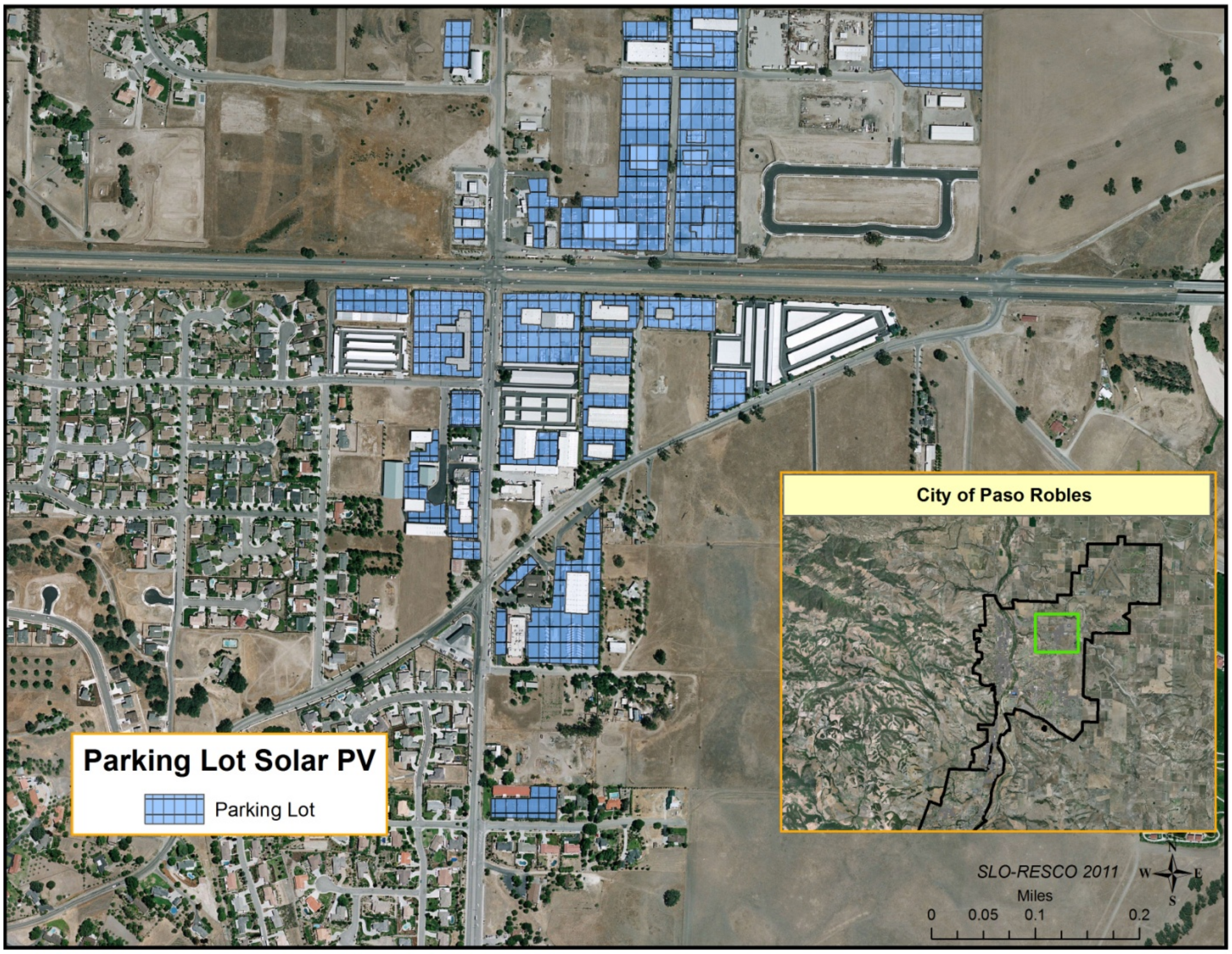
As of early 2012, the first parking lot solar project in SLO County was being installed between four campuses of the San Luis Coastal Unified School District for a total of 1.6MW.

7.5 Future Uses

Conversations with members of the SLO RESCO Professional Advisory Committee who work in different planning organizations throughout the county informed the SLO RESCO team that no such GIS layer of parking lots currently existed for SLO County and that it would be useful in their organizations. Additionally, at the 3rd SLO RESCO PAC meeting there were conversations of how to make use of this data through city and/or county-wide ordinances to promote the development of SLO County's parking lot solar resource.

7.6 Maps and Charts

Figure 131: Screenshot of Parking Lot Solar Photovoltaic Map



Source: SLO RESCO

Figure 132: Screenshot of Parking Lot Solar Photovoltaic Tab in the Resource Identification Tool Spreadsheet

START	Description	Values	Units
Resource	*Total Parking Lot Space*	*52,272,000*	Square Feet
Technology	*Solar Module Efficiency*	*15.0%*	
	Derate Factor (Inverter Efficiency, Temperature, Wire Loss)	*79%*	
Spacing and Access	PV Access Factor	50%	
	Packing Factor	*1.25*	
	PV System Power Density	11.15	Watts/ Square Foot
Technical Resource Potential	Gross Technical Potential	291	Megawatts Peak (MW-DC)
	Net Technical Potential	**230**	Megawatts Effective (MW-AC)
	Capacity Factor	*20.0%*	
	Annual Generation	**403,000**	Megawatt-hours

Solar PV Derate Factors	
Panel Mismatch	*98.0%*
Wiring	*98.0%*
Inverter	*95.0%*
Orientation	*95.0%*
Temperature	*96.0%*
Degrade	*95.0%*
Subtotal	79.0%

Toggle Cell	
Total Megawatts	
Total Megawatt-hours	

Source: SLO RESCO

7.6.1 References

- **SLO County Facts and Figures**
  http://www.sanluisobispocounty.com/media/facts-figures/
- **California Rooftop PV Resource Assessment and Growth Potential by County: CEC-500-2007-048**
  Navigant Consulting, September, 2007
  http://www.energy.ca.gov/2007publications/CEC-500-2007-048/CEC-500-2007-048.PDF
- **Google Earth**
  www.earth.google.com
- **PV Watts**
  http://www.nrel.gov/rredc/pvwatts/grid.html
- **California Solar Initiative**
  www.gosolarcalifornia.org

CHAPTER 8:
Site Specific Resources: Large-Scale Photovoltaic Potential

8.1 Introduction

The purpose of this ground mounted solar suitability study is to develop and apply a method to identify site specific resource potential for ground mounted solar photovoltaic at several scales. This analysis builds off of the methodology described in APPENDIX A:
SLO RESCO Field Solar Siting Methodology.

Site-specific solar resources are diverse and challenging to evaluate in ways that provide useful quantitative potentials or actionable information. The SLO RESCO team quantified residential and commercial rooftop potential based off of further analysis of available state-wide studies. An analysis of site specific resource potential was also conducted for solar development on parking lots county-wide. Other methods were considered for better quantifying urban solar resource potential including a method utilizing LIDAR technology and graphical information systems (GIS). This method identifies a building's rooftop from high resolution LIDAR data which can discern discrete elevation changes and then uses GIS tools to access surface area, orientation, and solar access. Unfortunately, insufficient data was available to pursue this method.

It was determined that ground mounted systems at several scales offer a significant solar resource that should also be accessed. Since there are potentially many factors influencing the suitability of ground mounted solar, it is difficult to apply basic assumptions to access resource potential. Identification of a method for site specific analysis was required. The renewable energy transmission initiative (RETI) worked to identify sites for large central station, 150 MW, and substation scale, 20 MW, ground mounted solar photovoltaic system. From the methodology description in the RETI phase 1B resource report, the substation scale projects were determined by applying a guideline whereby every substation in the state is assumed to have excess capacity to accommodate a 20MW solar project. The larger substations above 100 kV are assumed to be able to accept 40MW of solar. Project sites were located adjacent to substations, but from the methodology description, it is uncertain whether site specific criteria were applied to optimally site the solar projects. Since the RETI study provides only limited visibility of ground mounted solar resource potential for San Luis Obispo County, a more flexible and transferable methodology is necessary.

8.2 Methodology

After review of literature for site-specific resource identification methodologies, it was determined that the analytic hierarchy process (AHP) type of multi-criteria decision making (MCDM) offered a useful method for evaluating either the suitability or constraint of areas with potential for solar or other renewable energy resource development. The method provides for the integration of both analytical datasets such as insolation and orography with qualitative criteria such as visual impact. This integrated approach allows for valuation of a diverse set of criteria including environmental considerations, safety, land use, and others. Additionally, the method can function well within a public dialogue and decision framework to identify community specific issues. Appropriate subject matter experts then work to value individual considerations and negotiate values of considerations in relation to the others. A mathematical method is then used to analyze the consistency of the valuation process. This is important to evaluate objectively the success of the valuation process by the subject matter experts. Once the suitability criteria and weighted values have been established, relevant GIS datasets are organized and prepared. The weighted overlay tool is used to implement the suitability model and generate the suitability map. This map is useful to understand the suitability of specific sites. The resolution of the map, in this case, was chosen to be 50 foot by 50 foot. The quality of the GIS datasets impacts the useful resolution of the map. Additionally, a statistical process known as hot-spot analysis can be performed to identify general areas that have higher incidence of suitable sites.

8.3 Results

This model in particular provided greater insight into possible sites for substation and large central station solar development. It was decided the initial implementation of the model would identify sites most suitable for interconnection to substations. Analysis of the resulting map shows that the suitability hot-spot areas are highly incident with the RETI data. In addition, the suitability analysis also identifies areas of potential suitability not contained in the RETI data.

8.4 Conclusions

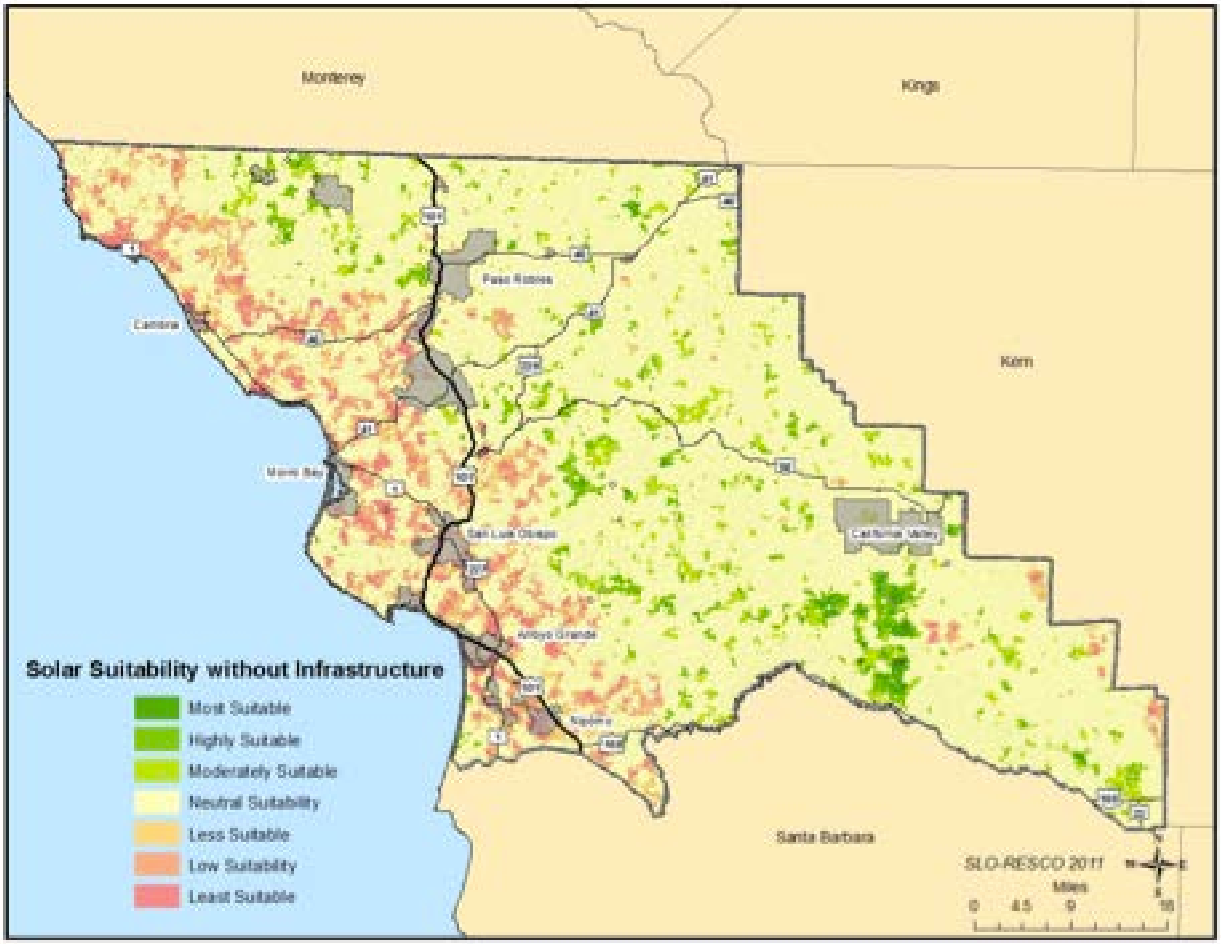
Development of this solar suitability model is useful in addition to and independent of the substation data contained in the RETI report due to the uncertainty in RETI’s site evaluation methodology and the potential to apply this model at other scales. Having the RETI substation site data to help validate the effectiveness of the model is another important consideration.

8.5 Flexibility of The Model

The multi-criteria decision making methodology is dynamic and supports identification, measurement of suitability and quantification of solar resource sites at a variety of scales.

Preliminary study of smaller scale ground mounted solar was conducted. However, limited time prevented further refinement of that model. Since the analysis was based off of the original substation model with only the infrastructure criteria removed and the weighting evenly distributed the result over valued solar insolation. This can be seen in Figure 133 by the distinct line between changes in solar insolation in the coastal zones of the county and the inland zones. It can also be seen by the occurrence of hot spots in those distinct regions.

Figure 133: Solar Suitability without Infrastructure



Source: SLO RESCO

Further development of this model would include use of more detailed distribution infrastructure locational data and capacity information. It could also be enhanced by application of certain types of land-use designations. Obtaining additional datasets related to energy use by parcel would allow for integration of considerations such as a parcel size to building square footage ratio and even parcel energy density to parcel size ratio. Lastly, the integrity of the criteria weighting process would be further enhanced by revisiting the criteria selection and valuation process using a larger cross section of subject matter experts, especially related to specific environmental criteria and project development.

CHAPTER 9:
SLO RESCO Outreach and Education Activities

9.1 Summary

Significant local outreach was undertaken to form an advisory committee (composed of local elected officials, activists, educators and business owners), to educate the general public, and to inform the county's EnergyWise Action Plan. An 'Energy Atlas' was created to summarize the findings of the resource inventory of San Luis Obispo County, among other outreach tools for the general public.

9.2 Professional Advisory Committee and Project Partners

The San Luis Obispo Air Pollution Control District, County of San Luis Obispo and the San Luis Obispo County of Governments contributed staff time to the research and meetings of the SLO RESCO project. In addition, a Professional Advisory Committee (PAC) was assembled from key local stakeholders. This group met to advise the project four times:

- PAC I - January 28, 2010
- Meetings with individual PAC member - Spring 2010
- PAC II - July 15, 2010
- PAC III - April 21, 2011
- PAC IV - Oct 6, 2011

The table below lists the title, organization, relevance and role in the project of each PAC member and project partner:

Table 25: SLO RESCO Key Stakeholders

Organization	Title	Relevance	Role in SLO RESCO
California Energy Commission	Project Manager	Grantor Project oversight	CEC Project Manager
SLO County	District 5 Supervisor	Political Champion	Project Partner / PAC Member
SLO County	District 5 Legislative Asst.	Assistant to political champion of SLO RESCO project	Project Partner
SLO County - Long Range Planning	Energy Coordinator	Staff champion of SLO RESCO project	Project Partner
SLO County - Long Range Planning	Division Manager	Staff responsible for Long Range Planning priorities	Project Partner
SLO County - Long Range Planning	Senior Planner	Staff responsible for Climate Action Plan	Project Partner
SLO County Facilities	Facilities Manager	Staff responsible for all utilities, projects, and County facilities	Project Partner
SLO County	Supervising Mapping Specialist	Staff support for mapping data and GIS resources	Project Partner

Organization	Title	Relevance	Role in SLO RESCO
SLO County Air Pollution Control District (APCD)	Planning & Outreach Manager	Protecting air quality and climate for region	Project Partner
SLO County Council of Governments	Planning Director	Regional transportation and land use planning organization	Project Partner
CA Institute for Energy and the Environment, UC	Retired Director	SLO RESCO Senior Advisor	PAC Member / PAC Chair
Cal Poly State University San Luis Obispo	Co-Director Renewable Energy Institute	Cal Poly Academic Representative / Energy Research	PAC Member
Land Conservancy	Board Member	Technical and Environmental Representative	PAC Member
SLO County Farm Bureau	Executive Director	Agricultural Representative	PAC Member
Rabobank Grover Beach	Asst. Vice President / Branch Manager	Financial Representative	PAC Member
SLO County Office of Education	Superintendent of Schools	Educational Representative	PAC Member

Source: SLO RESCO

9.3 Further Targeted Outreach

The local SLO RESCO team conducted a vigorous outreach campaign, giving presentations and project updates or soliciting necessary support at a variety of key events and targeted meetings. These are summarized in the in the table below:

Table 26: SLO RESCO Core Outreach Activities

Event	Format	Date	Audience	Outcome
SLO County Supervisor's RESCO Grant Support Meeting	Meeting	Jan 2009	Met with County Supervisor from each of 5 districts	Introduced RESCO grant opportunity and sought County leadership support
SLO County Staff RESCO Grant Support Meeting	Meeting	Jan 2009	Met with County Planning and Facilities staff	Introduced RESCO grant opportunity and sought County staff support
Arroyo Grande City SLO RESCO Introduction Meeting	Meeting	Nov 2009	Met with the Arroyo Grande Facilities Manager	Explained RESCO concept, learned about AG's efforts regarding energy efficiency and renewables. Learned about their proposed Green Business District and why it failed.
Paso Robles City SLO RESCO Introduction Meeting	Meeting	Oct 2009	Met with Paso Robles's Asst. City Manager	Explained RESCO concept, learned about the city's ongoing efforts with attempting to utilize a local geothermal resource
SLO City SLO RESCO Introduction Meeting	Meeting	Nov 2009	Met with City Utility Manager	Explained RESCO concept, learned about the city's efforts around energy efficiency and their recently commissioned geothermal project

Event	Format	Date	Audience	Outcome
Grover Beach SLO RESCO Introduction Meeting	Meeting	Nov 2009	Met with City Planners	Explained RESCO concept, learned about the city's efforts around climate action planning
Morro Bay City SLO RESCO Introduction Meeting	Meeting	Nov 2009	Met with City Planners	Explained RESCO concept, learned about the city's efforts around climate action planning
Pismo Beach City SLO RESCO Introduction Meeting	Meeting	Nov 2009	Met with Facilities Manager	Explained RESCO concept, learned about the city's efforts around energy
SLO-APCD/ SLO RESCO Introduction Meeting	Meeting	Oct 2009	Met with Technical Staff	Explained RESCO concept, learned about the APCD's efforts around climate action planning and greenhouse gas regulation
SLO Green Build/ SLO RESCO Introduction Meeting	Meeting	Nov 2009	Met with President & former President	Explained RESCO concept, learned about the non-profits' efforts around community education and green building
SLO Greenhouse Gas Committee	Presentation	July 2010	Local government representatives, APCD representatives	Explained RESCO concept and delivered project updates
SLO Green Build Learn-Build-Save Event: Zero Net Energy Buildings	Public Presentation	May 2011	Local contractors and building professionals	Explained RESCO concept and delivered project updates. Explained the role Zero Net Energy Buildings play in a RESCO.
Association of Energy Engineers: California's Energy Future Under Governor Brown	Presentation	April 2010	Local energy professionals	Explained RESCO concept and delivered project updates and spoke about California's energy future under Governor Brown
USGBC- SLO RESCO Intro/ Update	Presentation	Feb 2011	Architects and building professionals	Explained RESCO concept and delivered project updates
Cal Poly Experimental Architecture Class (3)	Presentation/ Mentoring	Spring 2011	Architecture and Engineering students	Explained RESCO concept, helped students brainstorm creative ways to display local renewable energy resources through art displays.
Cal Poly City and Regional Planning Classes (3)	Presentation	Dec 2010, March 2011, March, 2012	City and Regional Planning Students	Explained RESCO concept and discussed centralized vs. decentralized energy systems
SLO Bioneers Conference- Renewable Energy in Abundance	Presentation	Oct, 2010	Conference attendees	Explained RESCO concept and discussed centralized vs. decentralized energy systems

Event	Format	Date	Audience	Outcome
Central Coast Clergy and Laity for Justice- Renewable Energy in Abundance presentation	Presentation and discussion	Sept 2011	Local religious leaders	Explained RESCO concept and discussed centralized vs. decentralized energy systems

Source: SLO RESCO

9.4 SLO RESCO Input on The County's EnergyWise Action Plan (Climate Action Plan)

The Air Pollution Control District requested support from the SLO RESCO local team to review energy measures in the draft SLO County EnergyWise Action Plan (formerly the Climate Action Plan). Input from the SLO RESCO analysis was included in their written comments to County Staff. Additionally, county planning staff reviewed the analysis. As a result, additional measures were added to the final CAP including the regional energy authority concept, community choice aggregation, and other measures.

9.5 SLO RESCO Outreach Tools

9.5.1 Website

At the beginning of the project the RESCO team developed a website www.sloresco.net to communicate the goals of the project, who was working on the project and to serve as a location to post updates and relevant information. As the project evolved, project newsletters were posted for download.

9.5.2 Newsletters and Project Updates

The SLO RESCO team periodically updated a wide range of local officials, stakeholders, interested community members and the Professional Advisory Committee on the status of the project. The three updates are described below:

9.5.2.1 SLO RESCO Newsletter-Summer 2010

Nine months after the project commenced in October of 2009, the SLO RESCO team created a newsletter to communicate the status and findings of the project to date. In this newsletter there were four main articles: an introduction of SLO RESCO project to the community, a description of "the lens through which we are looking" at renewable energy in the SLO RESCO project, an explanation of the Resource Identification Tool and a profile of the project's research director. The newsletter was circulated through email, posted www.sloresco.net, and printed for key stakeholders.

9.5.2.2 SLO RESCO Newsletter-Winter 2010/2011

In the Winter of 2010/2011 the SLO RESCO team created another newsletter to update its project stakeholders and the community on the status of the RESCO project. In this newsletter there were four main articles: an introduction to the SLO RESCO project, a description of the parking lot solar photovoltaic resource study, a write-up discussing the benefits of distributed energy generation and a profile of the project's local team lead. The six page newsletter was circulated through email, posted www.sloresco.net, and printed for key stakeholders.

9.5.2.3 Spring 2011 Project Update and RESCO Symposium Summary

In the spring of 2011 the SLO RESCO team created a three page project update and a RESCO symposium summary to share with key project stakeholders and the Professional Advisory Committee. The project updates included updates on the solar suitability study, the resource tool, the energy history document, case studies and more. The updated also shared an overview and highlights from the 2nd Annual 2011 RESCO symposium. Three communities and their initiatives were highlighted that the SLO RESCO team felt were relevant to San Luis Obispo County: the Redwood Coast Energy Authority in Humboldt County, the Sonoma County pilot-level RESCO project, and Marin County's implementation of Community Choice Aggregation. The three page update was shared via email to key stakeholders and the Professional Advisory Committee.

9.5.3 Case Studies and Lessons Learned

The SLO RESCO team investigated six local energy projects that either worked or failed and determined what lessons could be learned from each. The six case studies focused on financial, workforce, technical, environmental and regulatory issues. In each of the six investigations important relationships were made with education officials, facilities managers, businesses and planners. Each interview was an opportunity to share about the RESCO project and to share ideas with the respective stakeholder. For example, in one case study focusing on the Atascadero Unified School District's solar efforts, it was clear that they were unaware of the San Luis Coastal Unified School District's solar efforts. San Luis Coastal had already encountered many of the challenges Atascadero was now facing and subsequently, the RESCO team shared the case study and connected the two facility managers with hopes of talking best practice. The case studies are intended to be posted on www.sloresco.net and shared widely.

9.5.4 Geographic Information System (GIS) Shapefiles

The GIS files prepared for the SLO RESCO resource inventory and end-use analysis will be shared with the San Luis Obispo County Planning Department, as they have indicated that they would be immediately useful for current projects.

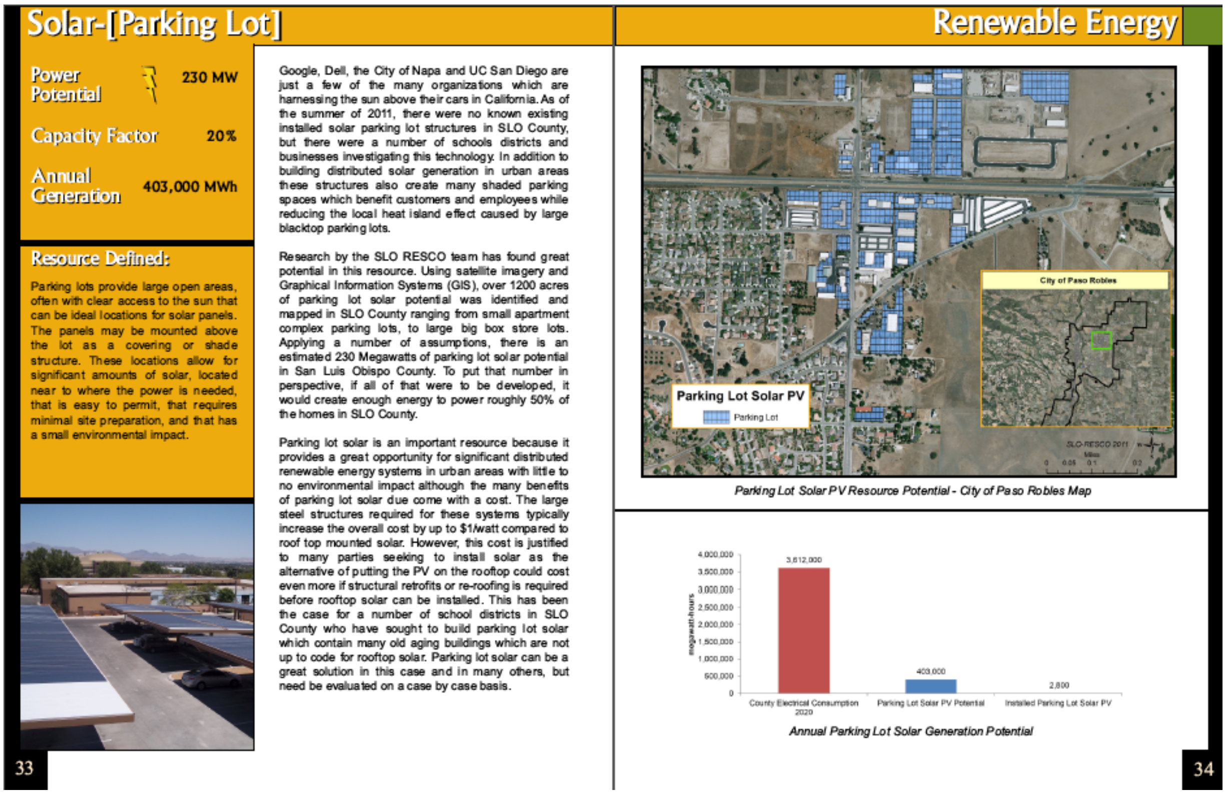
9.5.5 Resource Identification Tool

The Resource Identification Tool spreadsheet was designed to allow interested individuals in the San Luis Obispo community and other communities to understand their community's local renewable energy resource potential. The spreadsheet tool is fully adjustable and relatively straight-forward, allowing users to input a number of variables on all of the resources. For each resource in the Resource Identification Tool, the methodology, assumptions and references are stated in a transparent manner. This tool was designed as a generic model that could be useful to communities across California.

9.5.6 Energy Atlas

The Energy Atlas is a publication over ninety pages in length that details the renewable and distributed energy resource potential of San Luis Obispo County. Despite its length, it is written in an accessible and engaging manner. While a limited number of copies will be printed to deliver to key elected officials and stakeholders, primary circulation of the Energy Atlas will be digitally. A PDF will be available for download on www.sloresco.net and it will be published in an embedded viewer-friendly application on the website using the free program Issuu. The screenshot below shows the Energy Atlas entry describing the solar parking lot photovoltaic potential estimated using GIS analytics by the SLO RESCO project team.

Figure 134: Screenshot of the SLO RESCO Energy Atlas Publication



Solar-[Parking Lot]

Power Potential 230 MW

Capacity Factor 20%

Annual Generation 403,000 MWh

Resource Defined:

Parking lots provide large open areas, often with clear access to the sun that can be ideal locations for solar panels. The panels may be mounted above the lot as a covering or shade structure. These locations allow for significant amounts of solar, located near to where the power is needed, that is easy to permit, that requires minimal site preparation, and that has a small environmental impact.

Google, Dell, the City of Napa and UC San Diego are just a few of the many organizations which are harnessing the sun above their cars in California. As of the summer of 2011, there were no known existing installed solar parking lot structures in SLO County, but there were a number of schools districts and businesses investigating this technology. In addition to building distributed solar generation in urban areas these structures also create many shaded parking spaces which benefit customers and employees while reducing the local heat island effect caused by large blacktop parking lots.

Research by the SLO RESCO team has found great potential in this resource. Using satellite imagery and Graphical Information Systems (GIS), over 1200 acres of parking lot solar potential was identified and mapped in SLO County ranging from small apartment complex parking lots, to large big box store lots. Applying a number of assumptions, there is an estimated 230 Megawatts of parking lot solar potential in San Luis Obispo County. To put that number in perspective, if all of that were to be developed, it would create enough energy to power roughly 50% of the homes in SLO County.

Parking lot solar is an important resource because it provides a great opportunity for significant distributed renewable energy systems in urban areas with little to no environmental impact although the many benefits of parking lot solar due come with a cost. The large steel structures required for these systems typically increase the overall cost by up to $1/watt compared to roof top mounted solar. However, this cost is justified to many parties seeking to install solar as the alternative of putting the PV on the rooftop could cost even more if structural retrofits or re-roofing is required before rooftop solar can be installed. This has been the case for a number of school districts in SLO County who have sought to build parking lot solar which contain many old aging buildings which are not up to code for rooftop solar. Parking lot solar can be a great solution in this case and in many others, but need be evaluated on a case by case basis.

33

Renewable Energy

Parking Lot Solar PV Resource Potential - City of Paso Robles Map

Annual Parking Lot Solar Generation Potential

34

Source: SLO RESCO

GLOSSARY

AB	Assembly Bill
AC	Alternating Current
AES	Advanced Energy Storage
ALJ	Administrative Law Judge
AQMD	Air Quality Management District
BAAQMD	Bay Area Air Quality Management District
BAS	Building Automation System
BMS	Building Management System
BOS	Board of Supervisors
BPA	Bonneville Power Administration
BTU	British Thermal Unit
CAISO	California Independent System Operator
CalEPA	California Environmental Protection Agency
CAP	Climate Action Plan
CARB	California Air Resources Board
CCA	Community Choice Aggregation
CCT	Combined-Cycle Turbine
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CHP	Combined Heat and Power
CMUA	California Municipal Utilities Commission
CPUC	California Public Utilities Commission
CSI	California Solar Initiative
CT	Combustion Turbine
CT	Current Transformer
CTC	Competition Transition Charge
DA	Direct Access
DBOM	Design, Build, Operate & Maintain
DC	Direct Current
DER	Distributed Energy Resources
DG	Distributed Generation
DOE	U.S Department of Energy
DR	Demand Response
DRA	The Division of Ratepayer Advocates
DSCR	Debt Service Coverage Ratio
DSM	Demand Side Management
DU	Distribution Utility
DWRBC	Department of Water Resources Bond Charge
ECRA	Energy Cost Recovery Amount

EE	Energy Efficiency
EIA	Energy Information Agency
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESA	Energy Savings Agreement
ESCO	Energy Service Company
ESP	Energy Service Provider
EV	Electric Vehicle
EV2B	Electric Vehicle to Building
FERC	Federal Energy Regulatory Commission
FIT	Feed-In Tariff
FMV	Fair Market Value
GHG	Greenhouse Gas Emissions
GIS	Geographic Information System
GSHP	Ground Source Heat Pump
HAN	Home Area Network
HLW	High Level Radioactive Waste
ID	Irrigation District
IOU	Investor Owned Utility
JACE	Java Application Control
JPA	Joint Powers Authority/Agency/Agreement
KW	Kilowatt
kWh	Kilowatt-Hour
LADWP	Los Angeles Department of Water and Power
LAFCO	Local Agency Formation Commission
LBNL	Lawrence Berkeley National Laboratory
LCOE	Levelized Cost of Energy
LLW	Low Level Radioactive Waste
LPI	Local Power Inc.
LPS	Localization Portfolio Standard
MAIFI	Momentary Average Interruption Frequency Index
MCE	Marin Clean Energy
MEA	Marin Energy Authority
MU	Municipal Utility
MUD	Municipal Utility District
MW	Megawatt
MWh	Megawatt-Hour
NCPA	Northern California Power Agency
NDC	Nuclear Decommissioning Charge
NEM	Net Energy Metering
NMDL	New Municipal Departing Load

NOx	Nitrogen Oxides
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory (DOE)
OASIS	Open Access Same-Time Information System
OBF	On-Bill Financing
OBR	On-Bill Repayment
OCLD	Original Cost Less Depreciation
OpenADR	Open Automated Demand Response
OTF	Over the Fence transaction
PCIA	Power Charge Indifference Adjustment
PG&E	Pacific Gas and Electric
PIER	California Energy Commission Public Interest Research Program
PM	Particulate Matter
POU	Publicly Owned Utility
PPA	Power Purchase Agreement
PPM	Parts per Million
PPPC	Public Purpose Programs Charge
PUC	Public Utilities Code/Commission
PURPA	Federal Public Utilities Regulatory Policy Act of 1978
PV	Photovoltaic
RAM	Renewable Auction Mechanism
RCNLD	Replacement Cost New Less Depreciation
RESCO	Renewable Energy Secure Community
RFI	Request for Information
RFO	Request for Offer
RFP	Request for Proposals
RFQ	Request for Qualifications
RPS	Renewable Portfolio Standard
RTP	Real-Time Pricing
SAIDI	System Average Interruption Duration Index
SAIFI	System Interruption Frequency Index
SB	Senate Bill
SC	Scheduling Coordinator
SCAQMD	South Coast Air Quality Management District
SCCPA	Southern California Public Power Authority
SCE	Southern California Edison
SCE	Sonoma Clean Power
SCWA	Sonoma County Water Agency
SDG&E	San Diego Gas and Electric
SLO	San Luis Obispo
SMUD	Sacramento Municipal Utility District
SOC	Self-Optimizing Customer

SOx	Sulfer Oxides
T20	California Title 20 Appliance Code
T24	California Title 24 Building Code
TMDL	Transferred Municipal Departing Load
TURN	The Utilities Reform Network
VPP	Virtual Power Plant
WAPA	Western Interconnection Coordination Forum
WCI	Western Climate Initiative
WECC	Western Electricity Coordinating Council
WSPP	Western Systems Power Pool

APPENDIX A:
Field Solar Photovoltaic Siting Methodology

Summary

This report section describes the creation of a siting methodology for medium scale photovoltaic power generators at greenfield sites in San Luis Obispo County, California, in order to provide general guidelines to other communities seeking to determine appropriate areas for these types of facilities. As the SLO RESCO team's potential survey identified substantial physical potential for solar photovoltaic generation at greenfield sites, the methodology presented in this report attempts to address issues related to greenfield site evaluation through an open decision and dialogue process followed by an analytical and visualization process which is structured to help decision makers, the public, and experts clearly describe the value system they wish to use in the siting process.

As used in this analysis, a medium scale photovoltaic power generator is a facility that provides up to 20 megawatts of power, as opposed to small scale behind the meter rooftop installations. These are not the large-scale facilities, such as the Carrizo Plains solar power project, but are large enough to contribute to an area's energy portfolio. The goal of this type of development is to provide a distributed power generation system that allows individual communities to have a range of secure and local sources of power.

This summary provides general information on the two main processes detailed in the body of the paper, describes the results of the analysis for San Luis Obispo County, and gives an outline for the remaining portions of the report. The primary goal is to provide an understanding of why this methodology may be of use for communities seeking to develop photovoltaic energy production on a small scale in their area.

Decision and Dialogue Process

This decision and dialogue process is modeled after an accepted research methodology termed a *multi-criteria decision making process* (MCDM), with the specific type used in this report being termed an *analytic hierarchy process* (AHP). The process involves considering and comparing different values and requirements for medium-scale photovoltaic systems in order to create a hierarchy among these site factors. The benefit of this process for communities is that it can be done as part of a public process where both stakeholders and experts can help determine the appropriate hierarchy of values for the community. It also allows the public to quantify qualitative values such as good views or neighborhood character in comparison to more analytical requirements such as parcel size or slope orientation.

While this section only examines the more analytical requirements, the process described can be used for qualitative factors as well. The lack of qualitative values here is due to the fact that this analysis was done primarily to determine areas of positive physical characteristics for medium-scale solar photovoltaic technology and not as part of a public forum. The requirements used in this section are listed and described in detail, to provide a baseline of knowledge on the needs of the technology.

Analytical and Visualization Process:

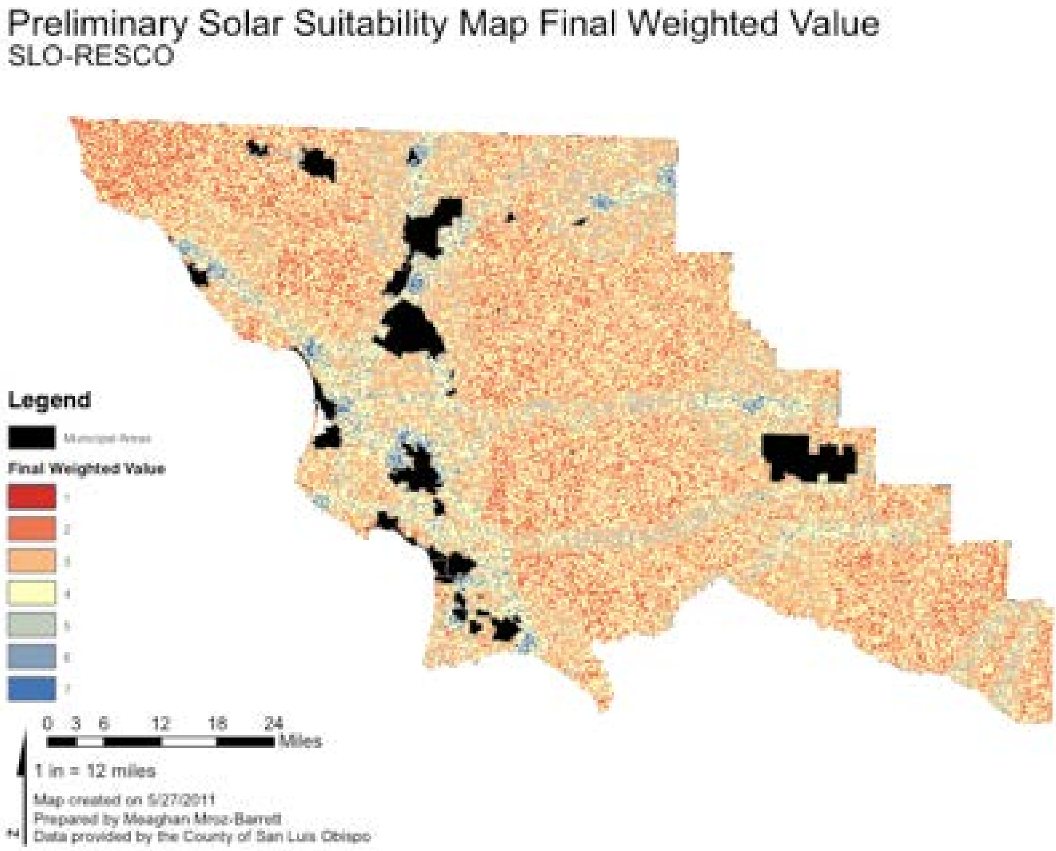
The analytical and visualization portion of the process can be accomplished through the use of any number of geographic information systems (GIS) programs that are designed to both analyze and visualize geographic information. The program used in this report is ArcGIS from ESRI, which is a common and recognized program for geographic analysis and visualization. The purpose of this step is to use the values developed in the decision and dialogue process to create useable maps that illustrate the hierarchical suitability for solar photovoltaic development in a defined area such as a county. Depending on the program and desires of the community, the information can be interpreted and illustrated in multiple ways. In this report, the final maps describe photovoltaic suitability overall for the county of San Luis Obispo, as well as by parcel.

Solar Suitability Findings for San Luis Obispo County

This report finds that there is variable solar suitability in San Luis Obispo County as illustrated by Figure 135, which is shows the findings of the process not constrained to individual parcels. In Figure 135, areas of higher suitability are shown in blue, while less suitable areas are in reds and oranges. An important fact to remember when viewing this map is that it does not show areas that are *unsuitable* for photovoltaic development, only describes the range of suitability based on the physical characteristics of the land. In order to determine parcels or areas that are unsuitable for development, a constraints model is required. A constraint model can be built using the same process by substituting factors that make an area unable to be developed (either physically or politically) such as the presence of endangered wildlife or proximity to conflicting land uses.

One of the clear results of the weighting process was that areas near substations and transmission lines tended to be viewed as more suitable regardless of other factors. This represents the fact that (1) solar potential in San Luis Obispo County far exceeds domestic demand, and (2) the team's belief that projects of this size would not have the funds to build significant infrastructure to connect to the existing grid, and therefore would likely need to be located near existing lines and stations. Other factors used in the process ended up not having as strong of an effect on suitability as the location of these features, as illustrated by the more generalized suitability in areas not in proximity to existing energy infrastructure.

Figure 135: Preliminary Solar Suitability Map



Source: SLO RESCO

Report Structure

The report follows the following structure:

Summary

Photovoltaic siting requirements

Problems facing photovoltaic siting

Explanation of the decision and dialogue process

Description of San Luis Obispo County

Description of the specific process used in San Luis Obispo County by SLO RESCO

Process description

Criteria and factor descriptions

Description of the analytical and visualization process

Final results for San Luis Obispo County

Introduction

Multi-Criteria Decision Making Process

The multi-criteria decision making process (MCDM) is a type of decision support system (DSS) with the objective "to discover what would happen if a series of decisions are taken" (Carrion, J.A. et al. 2008 p.2360). While some systems are problem-specific, MCDM can be altered to fit a wide range of complex issues where multiple factors can influence outcome. MCDM is often used in the geographic information system (GIS) environment, which is "an integrated collection of computer software used to analyze, create, store, edit, transform, view, and distribute geographic data" (Carrion, J.A. et al. 2008 p.2361). Carrion notes that GIS is "increasingly popular as a tool for…the selection of optimal sites for different types of activities and installations" (Carrion, J.A. et al. 2008 p.2361). The programming environment of GIS programs, particularly ArcGIS, lends itself directly to the implementation of MCDM.

While there are different forms of MCDM, one of the most commonly used is the analytic hierarchy process (AHP) first described by Thomas L. Saaty in 1980. Saaty developed this methodology as a way of incorporating the necessary characteristics of a decision making approach with the variety of data required to make an informed choice. Saaty describes the vital characteristics of a decision making approach as:

Be simple in construct,

Be adaptable to both groups and individuals,

Be natural to our intuition and general thinking,

Encourage compromise and consensus building, and

Not require inordinate specialization to master and communicate (Saaty, T. 1980 p.76)

This process has been described in use for land use suitability mapping by multiple authors (Carrion, et al. 2008, and Banai-Kashani, 1998). According to Carrion, this process has the advantages of:

It allows qualitative evaluations

Elements are assigned weights, which are used as decision-making criteria

A sensitivity analysis of the results can be carried out

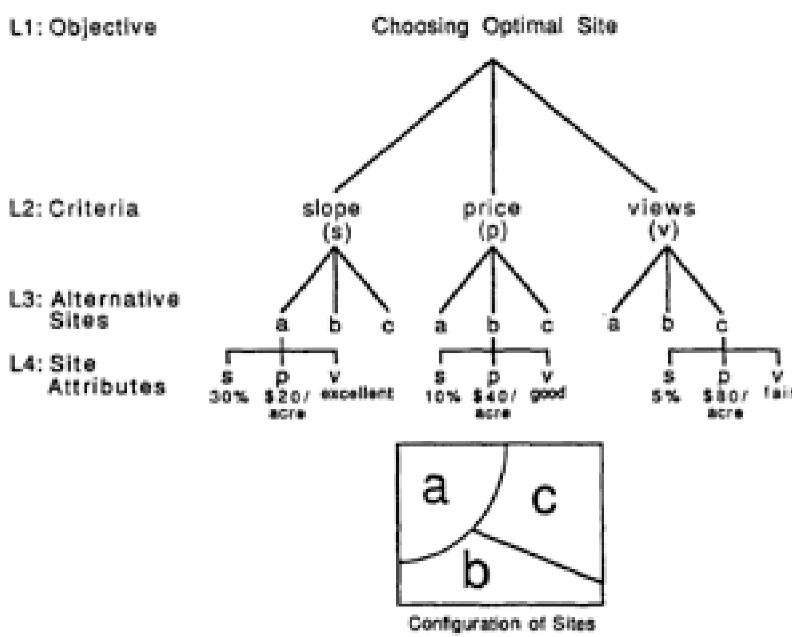
A consensus can be obtained among decision makers and stakeholders, since this technique facilitates communication between different groups of people

It identifies and accounts for inconsistencies of decision-makers since their judgments are rarely totally in consonance with qualitative factors

It can deal with complex real-world problems whose boundaries are not clearly defined (Carrion, 2008, p. 2362)

Banai-Kashani describes the AHP as used in a site selection process as a four-step methodology: The problem is defined, criteria are defined, locations are determined, and analysis is conducted (Banai-Kashani, 1989). The problem definition in the case of site selection is described as "choosing an optimal or most suitable site, subject to a set of criteria" (Banai-Kashani, 1989, p. 686). In the second step, criteria are determined based on the requirements of the desired land use, which is followed by "determining a measure of the relative importance, or priority, of the criterion factors" (Banai-Kashani, 1989, p. 686). In the third step, the area being analyzed is defined and delineated. The final step uses data on the defined area and the defined criteria, in order to determine suitability of the area for the desired land use. Figure 136 shows the process in a flow chart format, as described by Banai-Kashani.

Figure 136: Analytic Hierarchy Process (AHP) Flowchart



Source: Banai-Kashani

The benefit of the AHP process for site selection is that allows for the use of both quantitative and qualitative criteria. In the example in Figure 136, the criterions of slope and price are quantitative, while the views criterion is qualitative. Banai-Kashani notes that "the AHP offers an advantage of a ratio scale, which can be effectively applied to the measurement of both qualitative and quantitative factors in site suitability evaluation" (Banai-Kashani, 1989, p. 687).

AHP specifically weights different criteria based on pair-wise comparisons of factors, followed by a normalization procedure, and a consistency check (Saaty, 1980, p. 77). This process is done through the creation of a reciprocal matrix where all criteria are listed in both horizontal and vertical axes and the cells show relative weights. The main diagonal of cells is valued at 1, which indicates equal value, since it shows each criterion compared to itself. According to Banai-Kashani, the matrix can be solved to “determine the priority of factors, which is expressed in relative (or percentile) weights” (Banai-Kashani, 1989, p. 687). When comparing elements, the AHP scale of relative importance is used, as shown in Figure 137. It is important to remember that this process is predicated on the idea that each criterion should have a different relative weight, and not assume that the weights are all equal (Anderson, 1987).

Figure 137: AHP Weighting Scale

Table 1. The AHP scale for paired comparisons.[a]

Intensity of importance	Definition and explanation
1[b]	Equal importance—two activities contribute equally to the objective.
3	Moderate importance—experience and judgment slightly favor one activity over another.
5	Essential or strong importance—experience and judgment strongly favor one activity over another.
7	Demonstrated importance—an activity is strongly favored and its dominance is demonstrated in practice.
9	Extreme importance—the evidence favoring one activity over another is of the highest possible order of affirmation.
2, 4, 6, 8	Intermediate values between the two adjacent judgements—when compromise is needed.
Reciprocal of above numbers	If an activity has one of the above numbers assigned to it when compared with a second activity, then the second activity has the reciprocal value when compared to the first.

[a]Adapted from Saaty (1987).

[b]The scale 1.1, 1.2, . . . , 1.9, or even a finer one, can be used to compare elements that are close together, or are near equal in importance.

Source: Banai-Kashani, 1989, p. 688

Figure 138 and Figure 139 provide an example of a reciprocal matrix and its solution to determine the relative weights of the criteria from Banai-Kashani’s example from Figure 136. The figure shows the criteria being evaluated in the left column, with the comparison criteria listed across the top row. Therefore, when trying to determine the importance of slope, slope is located in the left hand column, and the values across that row show the weight of slope compared to each criteria in the top column. A higher number indicates a higher level of importance, with fractions indicating that the comparison criterion holds a higher weight.

Figure 138: Example of Reciprocal Table

Table 2. Pairwise comparisons of the criteria.

Criterion	S	P	V
Slope (S)	1	3	6
Price (P)	1/3	1	2
Views (V)	1/6	1/2	1

Source: Banai-Kashani, 1989, p. 688

Figure 139: Example of Matrix for Determining Relative Weights of Criteria

Table 3. Determining the relative weight of criteria.

	Step I			Step II			Step III		
Criterion	S	P	V	S	P	V	Row average	%	Geometric mean
Slope (S)	1	3	6	6/9	6/9	6/9	6/9	67	.67
Price (P)	1/3	1	2	2/9	2/9	2/9	2/9	23	.23
Views (V)	1/6	1/2	1	1/9	1/9	1/9	1/9	10	.10
Totals	3/2	9/2	9	1	1	1	1	100%	100%

Source: Banai-Kashani, 1989, p. 688

In the example described by Banai-Kashani, slope was given a moderate importance over price and a strong importance over views. The relationship between price and views was then determined based on the previously determined relationships. In more complex situations with additional criteria, this process would require further analysis between each criterion in order make sure the values were consistent across the table.

To solve the reciprocal table, each column's value is divided by the total sum of that column. In the example show in Figure 139, the values in column S are divided by the value 9/5, while the values in column V are divided by 9. This provides a set of normalized values for each criterion. These values are then averaged for each criterion (across the row as opposed to columns), with the average representing the criterion's relative weight (refer to Figure 139).

An added feature of the AHP process is that it "provides a procedure for checking the consistency of expert judgment in the process of pair wise comparison of factors" (Banai-Kashani, 1989, p. 688). This process helps make sure that all the assigned values align with all other values. In the case described by Banai-Kashani for example, the value of price compared to views was determined based on the comparison to the other determined values. If it were independently chosen to be another number, this would make the matrix inconsistent. In such a simple example as this one, it is simple to find inconsistencies, but in matrices that are, more complex a simple visual check is impossible. The AHP provides a mathematical method for determining is the values are consistent. Figure 140 shows an example of an inconsistent table for the Banai-Kashani problem.

Figure 140: Inconsistent Matrix

Table 4. Inconsistent matrix.

Criterion	S	P	V	Row avg
Slope (S)	1	3	6	0.63
Price (P)	⅓	1	[4]	0.27
Views (V)	⅙	[¼]	1	0.10

Source: Banai-Kashani, 1989, p. 689

The AHP provides a procedure to determine the amount of inconsistency with Figure 141 showing the calculations based on the Banai-Kashani example. To mathematically determine the amount of inconsistency in a matrix, the columns are multiplied by the row average in decimal format. Therefore, in the example table shown in Figure 138, column S would be multiplied by 0.63, column p by 0.27, and column v by 0.10. The columns s, p, and v in Figure 139 show the values generated by this operation. Following this, the rows are then totaled, and then multiplied by the original row average (also known as the criterion weight). These new values are averaged, with this number being known as λmax.

Figure 141: Inconsistency Calculation for Figure 139

Table 5. Determining a measure of inconsistency in judgment with λ_{max}.

	S	P	V	(4) Row total	(5) Criterion weight	(6) (4):(5)	(7) λ_{max}
Slope (S)	0.63	0.81	0.60	2.04	0.63	3.23	3.02
Price (P)	0.20	0.27	0.40	0.87	0.27	3.22	
Views (V)	0.10	0.06	0.10	0.26	0.10	2.60	

Source: Banai-Kashani, 1989, p. 690

The consistency calculation uses λmax to create a consistency index (CI) which "provides a measure of departure from consistency" (Banai-Kashani, 1989, p. 689). This is calculated with the equation:

Figure 142: Calculation of Consistency Index (CI)

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Source: Banai-Kashani, 1989, p. 689

where n is the number of columns. A matrix is more consistent the closer λmax is to n. This CI value is compared to a consistency index value for a randomly created table (RI) which were "derived from a sample size of 500 of a randomly generated reciprocal matrix using the scale 1/9, 1/8, …, 1,…, 8, 9 given by the size of the matrix (or the number of factors, n, in the comparison matrix) (Saaty, 1987, p. 171)" (Banai-Kashani, 1989, p. 689). Figure 143 shows these RI values.

Figure 143: Random Consistency Index (RI) Values

	Size of matrix (*n*)				
	1	2	3	4	5
Random consistency index (*RI*)	0	0	0.58	0.90	1.12
	Size of matrix (*n*)				
	6	7	8	9	10
Random consistency index (*RI*)	1.24	1.32	1.41	1.45	1.49

Source: Banai-Kashani, 1989, p. 689

To determine the ratio of inconsistency, RI to find the consistency ratio (CR), which can be expressed as either a decimal or a percentage divides CI. According to Saaty, an acceptable amount of inconsistency is any CR less than 10 percent, or 0.10 (Saaty, 1982). If the CR is greater than this, the criteria values need to be re-examined to bring this value down. Saaty (1987, p. 172) explains:

The reason is that inconsistency itself is important, for without it new knowledge, which changes preference order, cannot be admitted. Assuming all knowledge consistent contradicts experience, which requires continued adjustment in understanding. Thus, the objective of developing a wide-ranging consistent framework depends on admitting some inconsistency.

For the example, inconsistent matrix (Figure 140) provided by Banai-Kashani, the CR value falls within the acceptable range of variance. Figure 144 shows the calculation of CR for this table.

Figure 144: Consistency Ratio Calculation for Inconsistent Table (Shown in Figure 138)

$$\begin{aligned} CR &= CI/RI \\ &= 0.005/0.58 \\ &= 0.008\text{, or } 0.8\% \end{aligned}$$

Source: Banai-Kashani, 1989, p. 689

It is important to note that each criterion has sub-values that describe different levels of that particular factor, which have also been determined using the pair wise comparison process.

Relative weights for the factor slope are described based on observed slope values and the impact these values have on the desired land use. These values are then weighted in the overall analysis based on the weight of the criteria itself.

The process of applying the criteria to the analysis area requires using GIS, particularly when analyzing a large area such as San Luis Obispo County. Through GIS, data can be compiled on all the criteria for the desired land use. These data layers are then used in a "Weighted Overlay" using the values determined in the pair wise comparison procedure. According to Legato and Trapp (2010, p. 10)

Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis. It is akin to a standard overlay analysis where multiple layers are placed upon one another in an overlapping-layering effect. Where the various layers overlap, the weights become more pronounced. The Weighted Overlay analysis allows values to be assigned to not only individual layers but also different data within the layer itself.

This process dovetails nicely with the AHP process, with the sub-criteria values being assigned to the data within the layer, and the criteria weights being given to the data layer itself. The overall GIS process is described by Legato and Trap (2010, p. 10) as:

A numeric evaluation scale is chosen. We chose 1 to 10 however it may be 1 to 5, 1 to 9, or any other scale. Values at one end of the scale represent one extreme of suitability (or other criterion); values at the other end represent the other extreme.

The cell values for each input raster in the analysis are assigned values from the evaluation scale and reclassified to these values. This makes it possible to perform arithmetic operations on the rasters that originally held dissimilar types of values.

Each input raster is weighted, or assigned a percent influence, based on its importance to the model. The total influence for all rasters equals 100 percent.

The cell values of each input raster are multiplied by the raster's weights.

The resulting cell values are added together to produce the output raster.

An important part of this process in GIS is the conversion of all layer files into raster layers, which are composed of individual pixels as compared to vector files, which are more schematic. This can be accomplished using a conversion tool often found in the GIS program. Values for each pixel are then assigned based on the sub-factor weights from the original data.

When run through the weighted overlay process, the outcome is a raster layer where the pixel values represent the sum of all the criteria that affect that pixel in the original data files. In the case of the AHP model, a higher value on a suitability criteria process indicates that the pixel has a higher level of suitability for the desired land use. On a constraints map, a higher value indicates that the pixel has a high level of constraint for the desired land use. A suitability map and constraints map can be complied together to determine the best sites based on positive and negative factors through the weighted overlay process using the two layer files.

San Luis Obispo Analysis

Constraints Analysis

The constraints analysis portion was not done by the SLO RESCO team, but was adopted from the San Luis Obispo County Geographic Information Systems Subdivision Potential, Constraints, and Suitability Models Methodology. The rational for this decision was the fact that the local stakeholders in the development process have vetted this model, and is already in use by the county planning department. While the model was developed with residential subdivision development in mind, the constraints are similar enough to those for photovoltaic plant development that the SLO RESCO team decided to adopt the county model. For an in-depth description of the process involved with the creation of this model, see Legato and Trapp, 2010.

Suitability Analysis Process

For the suitability analysis, a literature review was conducted to determine what criteria factors are considered necessary for solar power facilities. The criteria described in Carrion, et al. were used as the basis for the criteria in this model based on their breadth of coverage. The criteria were adjusted for the analysis of San Luis Obispo County based on the local contextual issues such as fault line and landslide potential, as well as the current existing data for the county.

Using these criteria, factors were determined, and indicator values for those factors described and weighted using the AHP process based knowledge from the Carrion, et al. model or an understanding of the suitability of local conditions. The factors were then weighted using the AHP criteria, followed by the criteria. The SLO RESCO team completed all of the AHP.

These weights were then applied to raster layer files within ArcGIS for use in the Weighted Overlay process.

Description of Criteria

Criteria: Site Factors

The criteria of site factors indicates the suitability of the land based on issues relating to both natural hazards, agricultural potential, and current agricultural use. Much of the land in San Luis Obispo County is at risk of one or more natural hazards including landslides and earthquakes. Development in the county must be sensitive to areas of higher risk, not only for worker safety, but also the economic viability of the site in the face of possible dangers. Land was deemed more suitable for solar development in the absence, or lowered risk to natural hazards.

The agriculture portion of these criteria examines factors that describe the suitability for solar facilities based on any agricultural potential the site might have in terms of soil and active agricultural uses. Less agricultural potential is considered more suitable for solar use based on the value of agriculture to the county's economy and values. San Luis Obispo County is a prime rural agricultural area with high value crops and ranch land, as well as vineyards and wine production. Any development in the county must consider these factors before making a proposed land use change.

Factor: Flood

Land located outside of 100-year flood plains, and those not located in dam inundation areas.

Factor: Liquefaction

Land that has a low potential for liquefaction in earthquakes and rainfall.

Factor: Landslide

Land that has a low potential for landslides in rainfall and saturation conditions

Factor: Fire

Land that has a moderate level of danger of wildfire. The moderate level was chosen for this factor due to the fact that it is the lowest level of risk in this category present in the county.

Factor: Percentage of prime/state/other soil

Land that has a low amount of prime agricultural soil

Factor: Acreage of grazing

Land that has a low amount of prime pastureland

Factor: Active crops

Land that currently is not categorized as having a prime economic active crop

Criteria: Orography

Orography is the criterion that describes the land's potential for solar power based on the slope and orientation of the land itself. Solar power production is dependent on solar radiation hitting the photovoltaic cells attached to the installed panels. While these panels can be adjusted to maximize exposure, certain slope orientations, such as to the south, are more suitable for power production. Steepness of slope can also reduce the suitability of a site for power due to construction difficulties. Since San Luis Obispo County is an area of high topographic change, containing two high ridgelines, it is important to consider these factors in the suitability analysis.

Factor: Orientation

Describes the orientation of a portion of sloped land using ordinal directions.

Factor: Slope

Describes the slope of the land in percentage.

Criteria: Location

The Location criterion describes the suitability of land based on distance to certain desirable features for construction and power production. Since San Luis Obispo County is a rural county with disperse infrastructure, it is more economical to build closer to existing infrastructure rather than pay for longer infrastructure extensions to a new development site. This is particularly true for small scale photovoltaic development where economics do not support construction of extensive power lines or other facilities.

Factor: Road Access

Describes the distance to current state, county, and city roads

Factor: Distance to Substations

Describes the distance to existing electrical substations

Factor: Distance to Transmission Lines

Describes the distance to existing transmission lines

Criteria: Climate

The Climate criterion describes the suitability of the land based on its potential for solar power based on insolation, which measures the amount of solar radiation in an area, and climate zone. While the insolation values do not differ greatly over the county of San Luis Obispo, it is an important factor in solar power suitability.

Factor: Insolation

Describes the solar radiation of the land in pvWh.

ArcGIS Model Development

The base data for this model was provided by the County of San Luis Obispo and the National Renewable Energy Laboratory as GIS shape files in varying formats (point, line, polygon, raster). The initial files were used to create layers that reflected the site criteria, factors, and indicators used in the AHP process through functions available in the Spatial Analyst, 3D Analyst, Analysis, and Conversion extensions of ArcGIS. Below is the description of the individual processes applied to each layer.

Criteria: Site Factors

Factor: Flood

The initial data was provided in a polygon shapefile. A new attribute was applied to the file, which valued all land located outside of the designated flood zones with a value of 5. The flood prone areas received a value of 1.

Factor: Liquefaction

The initial data was provided in a polygon shapefile. A new attribute was applied to the file, which valued all land with a low potential for liquefaction in earthquakes and rainfall as 3 and remaining land as 1.

Factor: Landslide

The initial data was provided in a polygon shapefile. A new attribute was applied to the file, which valued all land with a low potential for landslides in rainfall and saturation conditions as 3. All other areas received a value of 1.

Factor: Fire

The initial data was provided in a polygon shapefile. A new attribute was applied to the file, which valued all land has a moderate level of danger of wildfire as 2, with the rest valued at 1.

Factor: Prime/state/other soil

The initial data files were provided in a polygon shapefile. The polygon shapefile was converted to a raster file using the prime/other classifications, and reclassified to represent the value of the varying levels of prime categorization.

Factor: Acreage of grazing

The initial data files were provided in a polygon shapefile. A new shapefile was created using the Spatial Analyst tool "zonal statistics", where each parcel polygon was analyzed for the number of acres of prime grazing soil using the County parcel file and the soil class layer developed by the National Resource Conservation Service. An additional attribute was added to the new polygon shapefile was which applied the AHP determined values to parcels based on the calculated number of prime grazing acres soil in each parcel.

Factor: Active crops

The initial data was provided in a polygon shapefile. A new attribute was applied to the file, which valued all land not categorized as having active crop production as 7 and no production as 1.

Criteria: Orography

Factor: Orientation

The initial data was provided in a digital elevation model file. Using the 3D Spatial Analyst tool "aspect", which is another term for orientation, a new raster file was created that described the orientation of the slopes in the county as a numerical value. Using the Spatial Analyst tool "reclass," the orientation numerical values were translated into the values determined for each slope orientation in the AHP process.

Factor: Slope

The initial data was provided in a digital elevation model file. Using the 3D Spatial Analyst tool "slope", a new raster file was created that described the topography of the county in terms of numerical values for slope. Using the Spatial Analyst tool "reclass," the slope values were translated into the values determined for different ranges of slope in the AHP process.

Criteria: Location

Factor: Road Access

The initial file was provided in a line shapefile. The goal was to use the Analysis tool "multiple ring buffer" to create a polygon shapefile reflecting the AHP determined desired distances from existing roadways. However, none of the computers available at the time were able to run the analysis, and this criteria factor was dropped from the final analysis.

Factor: Distance to Substations

The initial file was provided in a point shapefile. Using the Analysis tool "multiple ring buffer," a polygon shapefile was created reflecting the AHP determined desired distances from existing substations. An additional attribute was added to this file which valued each buffer with the AHP determined value.

Factor: Distance to Transmission Lines

The initial file was provided in a line shapefile. Using the Analysis tool "multiple ring buffer," a polygon shapefile was created reflecting the AHP determined desired distances from existing transmission lines. An additional attribute was added to this file which valued each buffer with the AHP determined value.

Criteria: Climate

Factor: Insolation

This file was provided as a polygon shapefile. An additional attribute was added to value the insolation ranges at the AHP determined values.

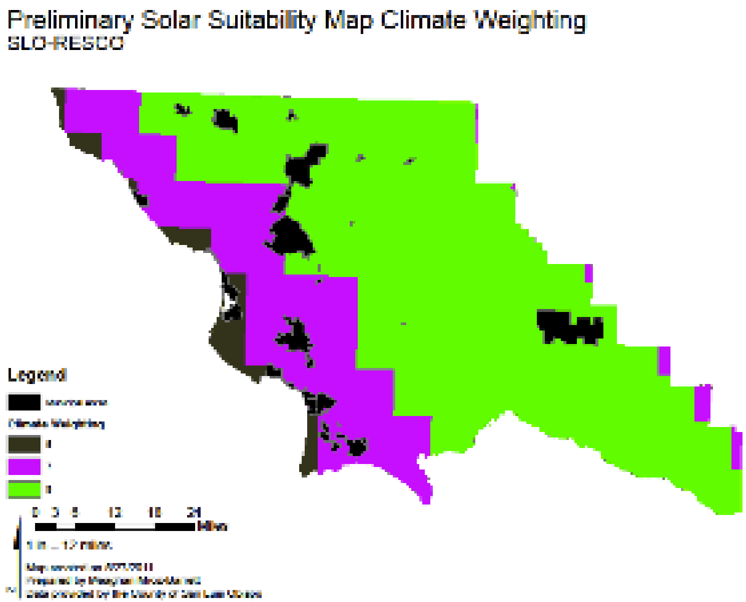
Final File Preparation

Due to the fact that ArcGIS's Spatial Analyst "weighted overlay" tool only accepts raster files as input, the non-raster shapefiles created for each factor were converted to raster files using the Converions "to raster" tool in ArcGIS with 50 foot by 50 foot cells. Existing raster files remained unchanged during this step.

Weighted Overlay

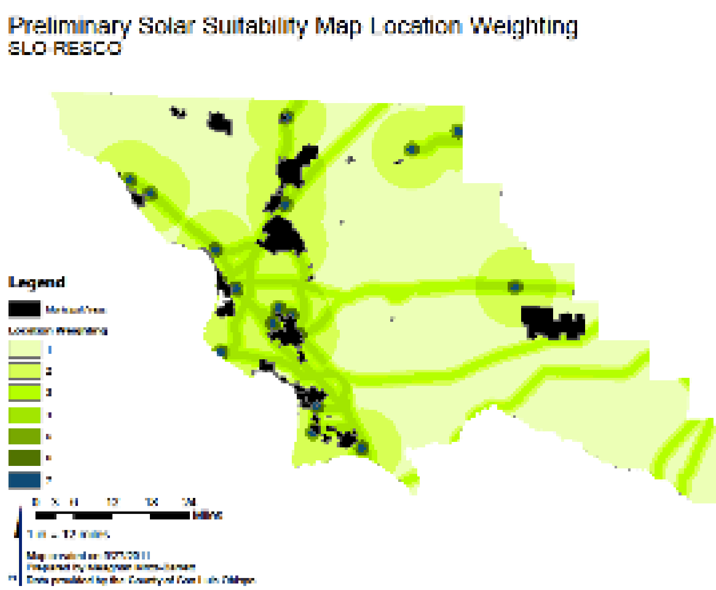
Using the weights developed during the AHP process, the Spatial Analyst "weighted overlay" tool created a new shapefile for each criteria (site criteria, location, climate, and orography) using the prepared files. Figure 145, Figure 146, and Figure 148 show these results. These new files were used in a second weighted overlay using the same tool, to determine the final solar suitability based on the comparative weights of each criteria as found during the decision making process. Figure 149 shows the final raster image created in this process.

Figure 145: Climate Weighting Raster Shapefile



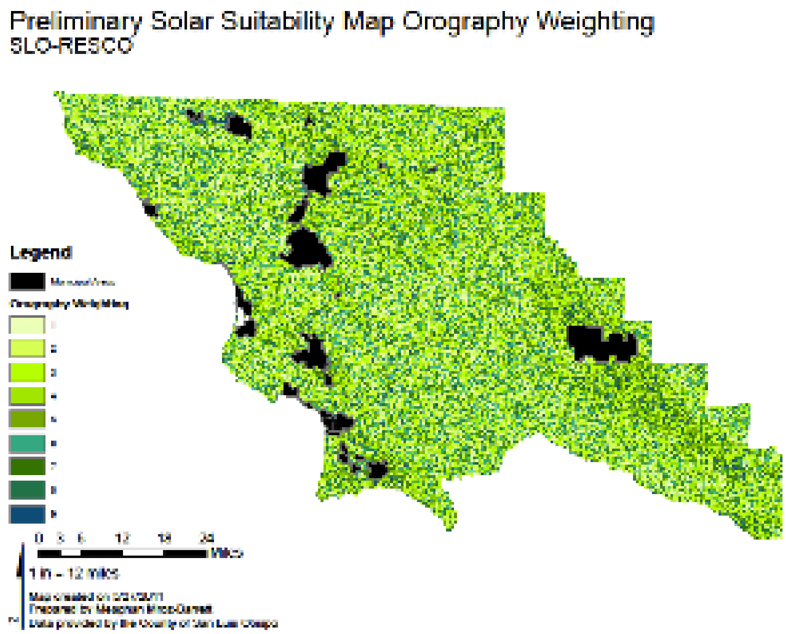
Source: SLO RESCO

Figure 146: Location Weighting Raster Shapefile



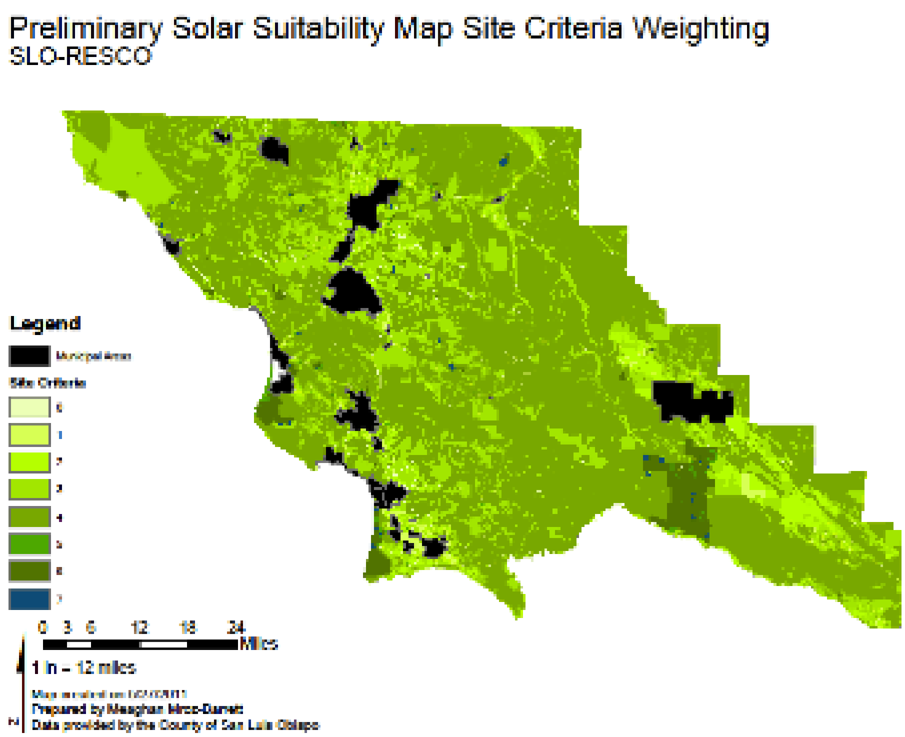
Source: SLO RESCO

Figure 147: Orography Weighting Raster Shapefile



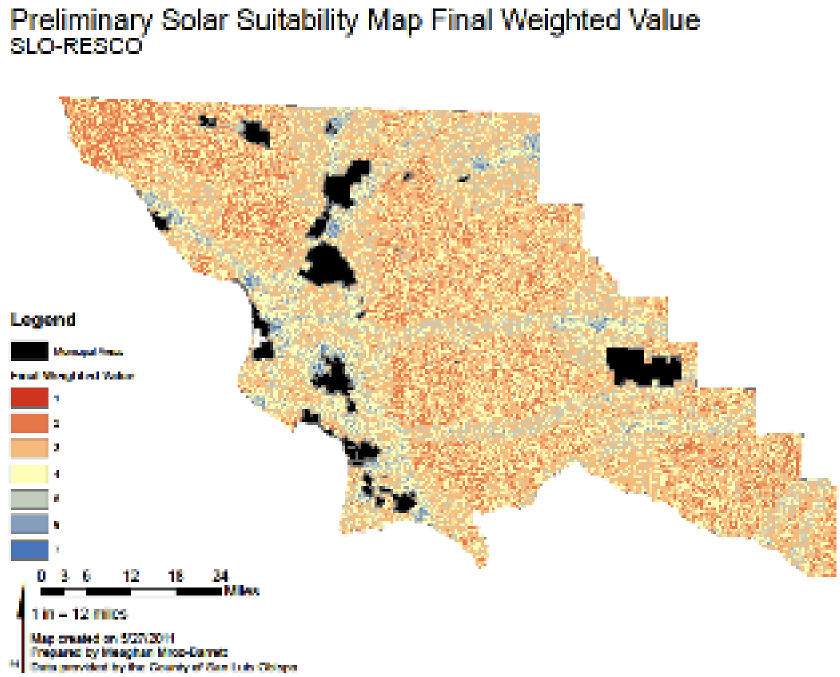
Source: SLO RESCO

Figure 148: Site Criteria Weighting Raster Shapefile



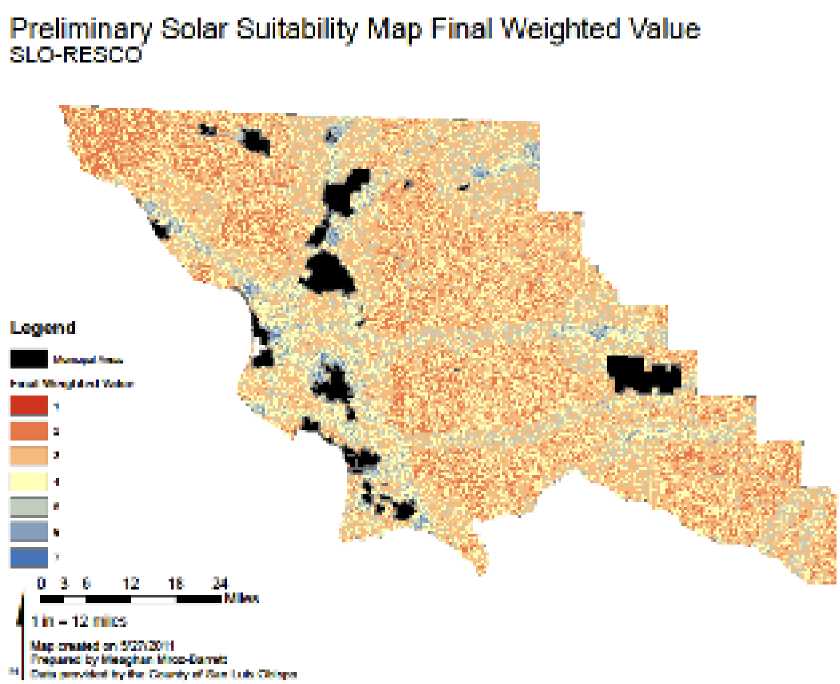
Source: SLO RESCO

Figure 149: Final Weighting Raster Shapefile Including the Location Criterion



Source: SLO RESCO

Figure 150: Final Weighting Raster Shapefile without the Location Criterion

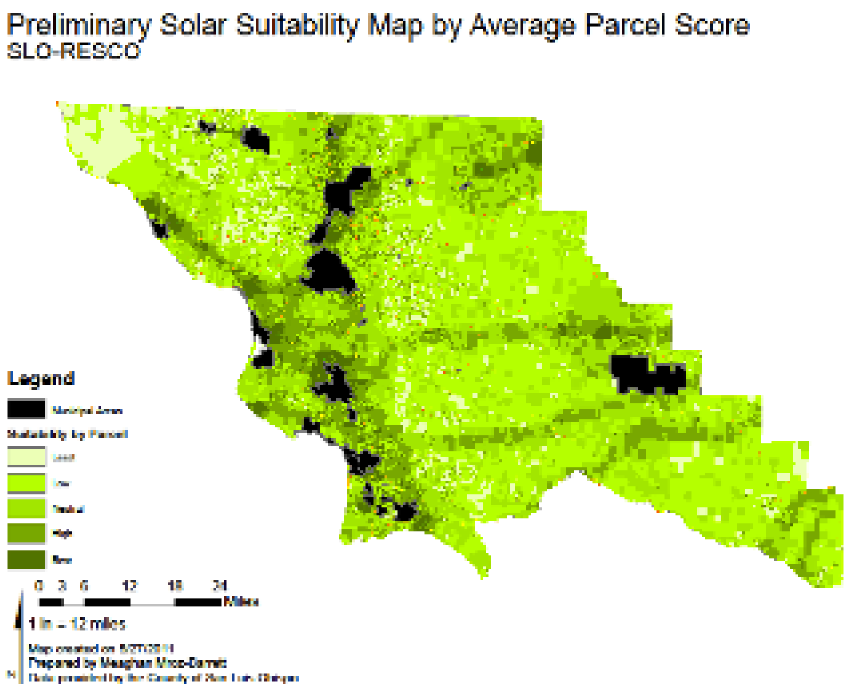


Source: SLO RESCO

Further Analysis

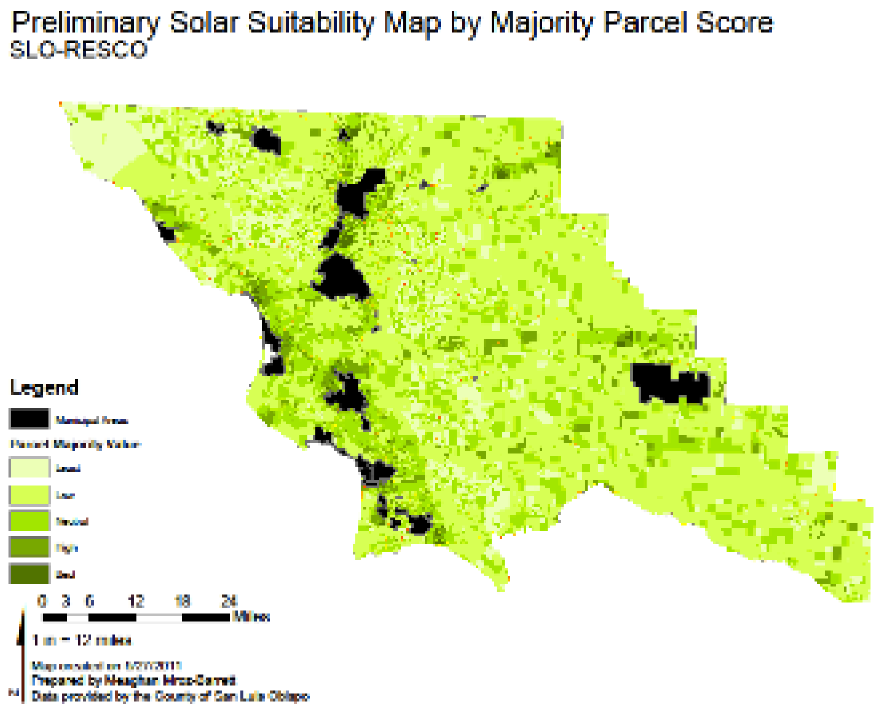
The final suitability raster provided by the weighted overlay function in ArcGIS is non-parcel specific. Using the Spatial Analyst "zonal statistics" tool, included can be combined with the original parcel file to create a new file, which represents suitability by parcel. Possible ways to calculate the parcel value are the maximum or minimum value present, the average score, or the most represented score. Figure 151 shows suitability based on the average parcel score while Figure 152 illustrates suitability based on the most represented score by parcel from the solar suitability analysis including the location criterion.

Figure 151: Suitability by Average Parcel Score



Source: SLO RESCO

Figure 152: Suitability by Majority Parcel Score



Source: SLO RESCO

Results

As illustrated in Figure 149, Figure 150, and Figure 151, San Luis Obispo County has a range of suitable areas for medium-scale photovoltaic development. One of the most influential factors in the weighting process, as seen in Figure 149, was the location criterion containing the factors of substation and transmission line locations that are critical to greenfield solar photovoltaic facilities development. As noted in the description of the location criterion earlier in the report, the SLO RESCO team determined that infrastructure cost would likely be a limiting factor in the development of this scale of greenfield photovoltaic facility. As such, greenfield locations near existing lines and stations are clearly more suitable than those in more rural locations in the county. It is important to remember that the factors in the location criterion lose importance as the scale of the facility increases, since larger facilities would be more able to pay for expensive line extensions as well as possibly installing new substations.

Other factors ended up having less effect on suitability, despite their perceived importance in the weighting process such as those listed under the site criteria criterion. This is most likely representative of the fact that the majority of the county has average suitability due to a high amount of agricultural lands, and small proportion of land with low risk factors. The lack of dissimilarity also may play a role in the low of influence of other criteria on the final weighting map.

One area that may have had a larger role in suitability was the orography criterion. This is likely a result of the layer preparation process, which left the slope and orientation shape-files with a very fine level of detail which most likely was overwhelmed by the more generalized criteria later in the process. In future analysis, these factors could be generalized to larger cells or even averaged over parcels. This could prove useful if a community is particularly interested in what parcels show the highest suitability as opposed to simply showing land suitability with no regards to ownership boundaries.

Conclusions

The methodology described in this report allowed the creation of a medium-scale greenfield photovoltaic suitability map for the county of San Luis Obispo County based on the technical requirements of this type of facility. Future work will involve the inclusion of qualitative factors such as view sheds and area acceptance into the analysis to provide a clear vision of where these projects should be pursued. Further refinement of this model is also possible, particularly in the areas of the site criteria and orography, as well as examining the usefulness of pursuing a generalized suitability map as compared to a parcel based examination.

The model should also be updated as photovoltaic technology improves and changes to accurately reflect any modification in the hierarchy of requirements. This may include a lessening of the importance of orography and climate criteria as the photovoltaic cells become more efficient in energy conversion. Separate site evaluation criteria should be developed for non-greenfield, behind-the-meter, rooftop commercial, and parking lot sites for photovoltaic facility development.

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APPENDIX B:
Relevant Excerpts from The Conservation and Open Space Element of The General Plan and EnergyWise Action Plan of San Luis Obispo County

Below are relevant excerpts (emphasis added) of the San Luis Obispo County Conservation and Open Space Element & EnergyWise Action Plan.

Conservation and Open Space Element

Relevant Permitting, Zoning and Siting References

Policy E 1.4 Methane: Increase the use of methane as an energy source from wastewater treatment plants and active and inactive, closed landfills.

Implementation Strategy E 1.4.1 Capture methane from landfills and wastewater treatment facilities: Encourage landfill and wastewater treatment operators to capture and use methane for energy production where feasible. Land use permit applications for landfill expansions, new wastewater treatment facilities, and amendments to previous permits shall propose the capture and use of methane for energy production where feasible.

Policy E 3.1 Use of renewable energy: Ensure that new and existing development incorporates renewable energy sources such as solar, passive building, wind, and thermal energy. Reduce reliance on non-sustainable energy sources to the extent possible using available technology and sustainable design techniques, materials, and resources.

Implementation Strategy E 3.1.1 Incorporate renewable energy systems in new and existing development: Where feasible, incorporate on-site renewable energy systems (i.e., solar or wind powered) in new and existing development. Collaborate with stakeholder groups, including business and property owners, wineries, and other agricultural operations to increase awareness of renewable systems, to streamline the permitting process, and to identify incentives.

Policy E 4.1 Integrate green building practices: Integrate green building practices into the design, construction, management, renovation, operations, and demolition of buildings, including publicly funded affordable housing projects, through the development review and building permitting process.

Implementation Strategy E 4.1.2 Develop Green Building Program: Develop a mandatory Green Building Program in collaboration with stakeholders that includes performance standards, guidelines, review criteria, incentives, and implementation schedules based on building type, size, and location. Amend existing ordinances as necessary to implement the Green Building Program using the California Green Building Code as a minimum standard. Perform an annual review of the Green Building Program for consistency with state requirements and amend as necessary.

Implementation Strategy E 4.1.4 Collaborate to develop uniform Green Building Codes: Work with local governments, nonprofit organizations, special districts, and other public organizations to develop uniform green building policies and programs.

Policy E 4.2 Green building incentives: Offer incentives to encourage green building practices in all development projects, including retrofits of existing buildings.

Implementation Strategy E 4.2.2 Provide expedited permitting for green building projects: Implement an expedited or "fast track" permitting process for green projects in all County departments that review development applications.

Policy E 6.1 Sustainable energy sources: Promote the development of sustainable energy sources and renewable energy projects through streamlined planning and development rules, codes, processing, and other incentives.

Implementation Strategy E 6.1.1 Eliminate obstacles to renewable energy use in the County Revise County policies and regulations as needed by the end of 2010 to eliminate barriers to or unreasonable restrictions on the use of renewable energy.

Policy E 6.7 Cogeneration facilities: Encourage cogeneration facilities as a method of reducing overall energy use.

Implementation Strategy E 6.7.1 Cogeneration facility guidelines: In cases where a cogeneration facility does not meet the criteria for an exemption from an environmental determination review the project both for environmental and fiscal impacts of development consistent with the following guidelines:

a. Cogeneration facilities should be built and operated in conjunction with existing facilities whenever possible.

b. The risk of public exposure to hazardous materials should be minimized by using the least hazardous materials feasible, engineering safety systems, and state-of-the-art safety management practices.

c. The cogeneration project will not change performance standards regarding air pollution, noise, traffic, or other possible nuisances to nearby property owners.

d. The proposed facility shall comply with emission standards for harmful air pollutants, as determined by the San Luis Obispo Air Pollution Control District and the California Energy Commission, when appropriate.

e. The applicant shall demonstrate that sufficient buffers exist to protect the housing units on adjacent properties from all hazards.

Policy E 6.2 Commercial solar and wind power and other renewable energy systems Encourage and support the development of solar and wind power and other renewable energy systems as commercial energy enterprises.

Implementation Strategy E 6.2.1 Review of large solar projects Evaluate large-scale commercial solar projects (i.e. over 10 MW) to favor technologies that maximize the facility's power production and minimize the physical effects of the project. Physical effects include, but are not limited to, noise, area of land disturbance and water use.

Implementation Strategy E 6.2.2 Encourage development of wind power facilities Encourage the development of wind power in areas where wind speeds make commercial wind power feasible. Focus should be placed on locations near existing power facilities and existing transmission lines.

Implementation Strategy E 6.2.3 Use of disturbed sites Examine the potential for use of previously disturbed sites such as former mine sites, or disturbed urban areas such as parking lots.

Implementation Strategy E 6.2.4 Use of existing energy generating sites Collaborate with local and State agencies and energy facility operators to develop renewable energy resources at existing energy generating sites.

Policy E 6.8 Renewable Energy Resources: Designate and protect areas that contain renewable energy resources such as wind, solar, geothermal, and small hydroelectric.

Implementation Strategy E 6.8.1 Mapping of resources: Use state, federal, or other available data to map areas that contain renewable energy resources.

Implementation Strategy E 6.8.2 Renewable energy combining designation Amend the Framework for Planning, the Area Plans, and the Land Use Ordinance (LUO) by establishing and applying a Renewable Energy (RE) combining designation based on the mapping in Energy Implementation Strategy 6.8.1. The RE designation and implementing LUO standards are to:

a. Encourage the development of renewable energy while maintaining a high level of environmental quality;

b. Avoid areas that are not appropriate for renewable energy due to existing incompatible uses; and

c. Protect areas of renewable energy resources, as well as existing and expanding renewable energy projects, from encroachment by incompatible land use categories and development.

Policy E 6.9 Commercial Renewable Energy Facility Siting

Renewable energy is developed most effectively where sufficient renewable energy resources exist (e.g., solar energy requires a certain amount of sunlight to be efficient and wind energy requires a certain amount of wind.) In areas where renewable energy resources have been identified and mapped pursuant to Policy E 6.8, renewable energy development is dependent on the mapped resource and shall be given high priority while balancing the protection of other environmental resources.

Relevant Permitting, Zoning and Siting References

7. Energy-Efficient New Development *Require new development projects to comply with the County's Green Building Ordinance.*

Supporting Actions:

Require the use of energy-efficient equipment in all new development, including but not limited to Energy Star appliances, high-energy efficiency equipment, heat recovery equipment, and building energy management systems.

Amend community design plans, guidelines, and other documents to promote the following design techniques to maximize solar resources:

Passive solar design, thermal mass, and insulation to reduce space heating and cooling needs;

Shading on east, west, and south windows with overhangs, awnings, or deciduous trees; and

Sustainable site design and landscaping to create comfortable microclimates.

Require new projects to provide ample daylight within the structure through the use of lighting shelves, exterior fins, skylights, atriums, courtyards, or other features to enhance natural light penetration.

Minimize the use of dark materials on roofs by requiring roofs to achieve a minimum solar reflectivity index (SRI) of 10 for high-slope roofs and 64 for low-slope roofs (CALGreen 5.1 Planning and Design).

Minimize heat gain from surface parking lots by utilizing the following strategies for a minimum of 50 percent of the site's hardscape:

Provide shade from the existing tree canopy or within five years of landscape installation;

Provide shade from structures covered by solar panels;

Provide shade structures or hardscape materials with a minimum SRI of 29;

Use an open-grid pavement system (at least 50 percent pervious).

Use light-colored aggregate in new road construction and repaving projects adjacent to existing cities and in some of the communities north of the Cuesta Grade.

Renewable Energy Goal: INCREASE THE PRODUCTION OF RENEWABLE ENERGY FROM SMALL-SCALE AND COMMERCIALSCALE RENEWABLE ENERGY INSTALLATIONS TO ACCOUNT FOR 10 percent OF TOTAL LOCAL ENERGY USE BY 2020.

10. Commercial-Scale Renewable Energy: Develop a comprehensive renewable energy strategy to encourage the commercial-scale installation of renewable energy projects within the county.

Supporting Actions:

Complete the Renewable Energy Secure Community (RESCO) contract project by 2012.

Use state, federal, or other available data to map areas that contain renewable energy resources by 2015.

Designate and protect areas that contain renewable energy resources such as wind, solar, geothermal, and small hydroelectric.

Continue participation in the Energy Watch Partnership.

Amend the Land Use Ordinance to apply renewable energy overlay designations to areas identified in COSE Implementation Strategy E 6.8.1.

11. Small-Scale Renewable Energy

Implement a financing program to provide property owners with low interest loans for the installation of renewable energy resources.

Supporting Actions:

Revise County policies and regulations as needed to eliminate barriers to or unreasonable restrictions on the use of renewable energy.

Designate and protect areas that contain potential small scale renewable energy resources such as wind, solar, geothermal, and small hydroelectric.

Amend the Land Use Ordinance to apply small-scale renewable energy overlay designations to areas identified in the RESCO study. Also see COSE Implementation Strategy E 6.8.1 for commercial scale.

Promote the development of sustainable energy sources and renewable energy projects through streamlined planning and development rules, codes, processing, and other incentives.

Collaborate with stakeholder groups, including business and property owners, wineries, and other agricultural operations, to increase awareness of renewable energy systems, to streamline the permitting process, and to identify incentives.

Assign a single point of contact within the County Planning and Building Department for energy efficiency and renewable energy project questions.