# Increasing Renewable Energy Resources in the County of Marin

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Prepared for the County of Marin,
Community Development Agency

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## EXECUTIVE SUMMARY
## MARIN COUNTY RENEWABLE RESOURCE SUPPLY PLAN

Marin County has a long history of environmental leadership and responsibility. As the table below demonstrates, the County has opportunities to increase the amount of energy produced from renewable resources within the County, particularly solar, biomass, and wind in the short term, and ocean tides or currents in the longer term. The County also can significantly decrease the amount of energy consumed within the County through broader deployment of energy efficiency programs and education. Energy efficiency is the least expensive energy resource, and should be exploited to its maximum potential.

**Renewable Resource Potential in Marin County**

| Technology | Rated MW[1] | GWh/yr[2] | Million Therms/yr | Deployment Potential[3] |
|---|---|---|---|---|
| Solar | 220 | 316 | 6.7 | High |
| Small Wind | 11 | 20 | NA | Medium |
| Large Wind | 182 | 280 | NA | Low |
| Off-Shore Wind | 260 | 400 | NA | Low |
| Methane Capture (Landfill gas, dairies) | 6.5 | 49 | NA | High |
| Biomass (Waste to fuel) | 7 – 16 | 52 - 120 | NA | Medium |
| Ocean Power | 150 | 130 | NA | Low |
| **TOTAL** | **837 -846** | **1247 – 1315** | **6.7** | |
| **For reference, in 2005 Marin County used 1,421 GWh[4] and 81.7 million therms[5]** | | | | |

A short-term program (one to three years) the County could pursue to stimulate renewable resource deployment on private property would be to develop a power purchase agreement or a property tax assessment, through which the County would provide financing for

[1] Rated MW is the maximum amount of energy a generating unit can produce.
[2] One Gigawatt-hour ("GWh") is equivalent to one billion watts of electricity taken from or supplied to an electric circuit steadily for one hour. The average household in California uses between 400 and 800 kilowatt-hours ("kWh") per month, or between 4,800 and 9,600 kWh per year, according to the California Energy Commission.
[3] Deployment potential levels were determined based on the state of the technology and current policy, permitting, and cost constraints.
[4] California Energy Commission, "California Electricity Consumption by County in 2005."
[5] Data provided by PG&E.

individual property owners to undertake energy efficiency upgrades and install renewable technology.  Candidate technologies for this program would be rooftop solar photovoltaic, solar thermal water heating, and small-scale wind (projects that can be sited on one-quarter acre).

Over the medium-term (four to seven years), the County could facilitate development of larger scale solar and wind developments and biomass and biogas facilities.  Biogas can be deployed at landfills, water and wastewater treatment plants, dairies, and other food processing facilities.

Over the long-term, the County could encourage development of ocean power facilities off its western coast, or in the San Francisco Bay.  The City and County of San Francisco and Pacific Gas & Electric both are studying the viability of ocean power, and the County should continue to monitor and be involved in those tests.  The County also could over the longer term encourage development of off-shore wind farms.

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# I. Introduction

This report provides an overview of and recommendations on how the County of Marin ("County") can increase the amount of renewable energy generated within the County over short-, medium-, and long-term time horizons. The County has a long history of action to address environmental challenges, sustainable development, and economic growth, often developing policies in advance of state and national government.

### *A. Context for Marin's Renewable Energy Program*

Two interests have come together to spur development of this report. First, the County has become increasingly interested in local action to address climate change. Of particular interest to policy makers is reducing the amount of carbon-based energy consumed by Marin County residents, businesses, and municipalities. Second, the County is engaged in a study of community choice aggregation ("CCA"). As a community choice aggregator, the County would purchase and/or generate electricity on behalf of its constituents, as well as have access to funds for energy efficiency programs currently administered by Pacific Gas & Electric Company ("PG&E"). One option the County might pursue if it formed a CCA would be the development of renewable resource projects.

The County has adopted a Greenhouse Gas "GHG" Reduction Plan that outlines steps the County will take to reduce those GHG emissions.[6] The County also developed a report that identifies seven steps the County could pursue to eliminate emissions from fossil fuels by 2033.[7] Developing renewable resources within the County also increases Marin's energy security and control over price fluctuations, if the County has an ownership share and/or access to power generated from the facilities. Also, construction of electric generation facilities could provide

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[6] Marin County Community Development Agency, *Marin County Greenhouse Gas Reduction Plan,* October 2006.
[7] County of Marin Community Development Agency Sustainability Team, *Fossil Free by 2033,* October 2006.

local jobs and could benefit local businesses if materials needed for construction were purchased within the County.

The County's actions are consistent with policy direction in California. Cities and counties have led the way by adopting various policies like those adopted in Marin, and also by joining campaigns like ICLEI – Local Governments for Sustainability, and/or the Mayors Climate Agreement. On the State level, in September 2006, California adopted Assembly Bill 32 ("AB 32"), the Global Warming Solutions Act of 2006. This landmark legislation makes California the first state in the nation to adopt the aggressive targets of reducing statewide greenhouse gas emissions to 1990 levels by the year 2020. The California Air Resources Board, working closely with nearly every department of state government, is developing rules and regulations to implement AB 32. These rules will affect every sector of the California economy, and likely will alter how businesses and individuals function. By identifying new ways to increase the amount of fossil-free energy used in Marin County, the County will provide its residents and businesses an advantage in complying with the AB 32 mandates.

Also worth noting as the County considers the mix of electricity generation resources consumed within its borders is the State of California's preferred order for adding new resources. California has determined that before it builds new fossil-fired power plants, or purchases electricity from fossil-fired power plants, it will first exploit all opportunities to reduce the amount of electricity consumed through installation of more efficient technology and hardware and conservation. California then will deploy renewable energy resources. Fossil resources are the last type of resource to be used. California's Energy Action Plan describes the policy as follows:

1. Energy efficiency and demand response (customers use less energy during periods of peak demand);
2. Renewable resources and distributed generation (generating electricity onsite);
3. Clean and efficient fossil-fired generation.[8]

On the national level, while there is not currently an equivalent to AB 32, Congress is actively working to develop a policy response to climate change. Other states and regions have adopted similar policies. For example, the Northeast states have established the Regional Greenhouse Gas Initiative, and states across the country are taking similar actions.[9]

**Figure 1. States with Greenhouse Gas Emissions Targets**

Source: Pew Center on Global Climate Change

Internationally, other countries are taking aggressive steps to reduce the rate of climate change. The Kyoto Protocol, adopted in 1997, is an international policy initiative to address climate change. Participating countries report to the United Nations on a regular basis their

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[8] California Public Utilities Commission, *California Energy Action Plan II*, August 25, 2005, p. 2.
[9] Pew Center on Climate Change, "What's Being Done … in the States," August 2007.

progress in meeting Kyoto Protocol commitments.[10] The European Union has adopted an emissions trading scheme that is the centerpiece of a large, coordinated effort in Europe to reduce emissions of greenhouse gases.[11] Individual countries also are taking action, as is seen from the table below.

**Table 1. International Emission Targets[12]**

| ***Entity*** | ***Target*** | ***Notes & Source*** |
|---|---|---|
| Australia | 8% above 1990 by 2008-2012 | Kyoto Target |
| Canada | 6% below 1990 by 2008-2012 | Kyoto Target |
| European Community | 8% below 1990 by 2008-2012 | Kyoto Target |
| Japan | 6% below 1990 by 2008-2012 | Kyoto Target |
| New Zealand | 1990 levels by 2008-2012 | Kyoto Target |
| United Kingdom | 20% below 1990 by 2020<br>60% below 1990 by 2050 | $CO_2$ target only.<br>Energy White Paper of 2003 |
| ***European Community Kyoto Bubble Targets[i]*** | ***Target for 2008-2012*** | *European Community Council Decision of April 2002* |
| Austria | 13% below 1990 | |
| Belgium | 7.5% below 1990 | |
| Denmark | 21% below 1990 | |
| Finland | 1990 levels | |
| France | 1990 levels | |
| Germany | 21% below 1990 | |
| Greece | 25% above 1990 | |
| Ireland | 13% above 1990 | |
| Italy | 6.5% below 1990 | |
| Luxembourg | 28% below 1990 | |
| Netherlands | 6% below 1990 | |
| Portugal | 27% above 1990 | |
| Spain | 15% above 1990 | |
| Sweden | 4% above 1990 | |
| United Kingdom | 12.5% below 1990 | |

[i] The EU-15 nations have joined a "bubble" which allows the joint fulfillment of emissions commitments and preserves the collective emissions reduction goal of 8% below 1990 levels by 2008/2012

10 United Nations Framework on Climate Change, "National Reports," August 2007.
11 Intergovernmental Panel on Climate Change, August 2007.
12 Pew Center on Global Climate Change.

## *B. Overview of Report and Findings*

This report examines various financial models the County could use to encourage greater investment in renewable energy resources. It also provides an overview of the various renewable energy technologies, including the amount that could be generated within the County, as well as energy efficiency and conservation. When looking at renewable resources, some resources are commercially available now, particularly both rooftop and large solar, wind, biomass, geothermal, and hydroelectric (the latter two are not necessarily available within Marin County borders and therefore are not discussed in this report). Other resources are still in the development stage, but could well become viable in the medium and longer term, particularly ocean technology.

Some technologies are more appropriate for widespread deployment in the short-term, particularly rooftop solar. Other technologies are operated in a central station mode, so the most likely way to develop those would be some form of investment in a particular facility. Still other technologies are still being developed. To the extent there is potential to develop them within the County, the County should pursue those opportunities as part of its long-term economic development and legislative agendas.

**Table 2. Renewable Resource Potential in Marin County**

| Technology | Rated MW[13] | GWh/yr[14] | Million Therms/yr | Deployment Potential[15] |
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| Solar | 220 | 316 | 6.7 | High |
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Something the County will need to address as it develops any renewable resource program is whether there will be a price differential between renewable energy generated and purchased under a County program and rates that a customer would otherwise pay PG&E if the customer did not participate in the County program. It is not clear that power generated under a County program would be more expensive than the utility's standard tariff electricity rate. If there is a differential, the County will need to determine whether it would be temporary (for a few years), or ongoing.

Past experience has shown that customers are willing to pay a premium for "green" energy. When California's retail energy markets were open to competition in the late 1990s, one of the most active markets was the residential market for renewable energy. More recently, PG&E in early 2007 received regulatory approval for a "Climate Smart" program that is

13 Rated MW is the maximum amount of energy a generating unit can produce.
14 One Gigawatt-hour (GWh) is equivalent to one billion watts of electricity taken from or supplied to an electric circuit steadily for one hour. The average household in California uses between 400 and 800 kilowatt-hours ("kWh") per month, or between 4,800 and 9,600 kWh per year, according to the California Energy Commission.
15 Deployment potential levels were determined based on the state of the technology and current policy, permitting and cost constraints.
16 California Energy Commission, "California Electricity Consumption by County in 2005."
17 Data provided by PG&E.

promoted as helping customers be "climate neutral" by investing in projects that reduce greenhouse gas emissions (but are not necessarily renewable energy projects) based on the electricity they use, for an average monthly residential fee of $5.[18]

A County program that actually displaces emissions of fossil-fuel energy by deploying renewable resources could very well be of interest to Marin residents, who have a long history of supporting environmental initiatives.

## II. Financing Renewable Energy and Energy Efficiency

In order to increase alternative energy generation, Marin County must devise new and creative financing methods to encourage interest in adopting clean power in both the public and private sectors, including residential and commercial. This section looks at financial models and methods for raising funds.

A key objective for Marin County is to reduce upfront cost and complexity and eliminate risk that residents or businesses may perceive from investments in renewable energy technology and energy efficiency. In some instances, residents or businesses may perceive renewable technology as unproven or unreliable. Some may be deterred by the initial capital cost for installing renewable energy technology or energy efficient equipment. In the case of energy efficient equipment, these investments usually pay for themselves over one to four years, depending on the technology. Creating packages of energy efficient equipment in one investment can help amortize the payback cycle. In the case of renewable technology, the County can help lessen the initial upfront cost through a variety of programs, described below.

[18] Pacific Gas & Electric Company, "Climate Smart: How it Works," August 2007. "PG&E will calculate the amount needed to make the greenhouse gas emissions associated with your personal or business energy use "neutral" and will add this amount to your monthly energy bill. The typical PG&E residential customer will pay less than $5 per month for ClimateSmart."

## A. *Potential Program Structures*

The following is an overview of several program structures that are likely to increase the total clean power production in the County, and reduce energy demand. The analysis focuses on solar energy, but each structure could easily be adapted to integrate other types of generation, such as wind, waste-to-energy, or biomass, as well as energy efficient equipment, which is a demand-side tool. Each model will require an in-depth financial analysis to ensure viability. Models examined in the course of this study include: bulk purchases and/or pre-designed packages; power purchase agreements; loans; demonstration projects; community power trust; performance contracting; and public/private partnerships. The models described below could be pursued in combination or separately.

### 1. Bulk purchases and/or pre-designed packages

There are several ways to use bulk purchases and/or pre-designed packages. One option would be for Marin County (or a partner organization) to procure large quantities of a technology, for example, a shipping container of photovoltaic ("PV") components such as panels, inverters, and mounting racks. The County and/or its partner would then sell pre-designed systems that reduce installed cost. This would result in fewer design issues, pre-arranged paper work, and simplicity of decision-making. The County could choose not to impose pre-designed packages but simply offer products at a discount to qualified applicants or installers (say 10% below actual cost). The price difference could be passed along to customers or used to enable the program to pay for itself.

Alternatively, the program could be supported through nominal fees for program participants or with seed money. Applying the County's purchasing power by obtaining renewable energy equipment in large quantities should ensure substantial discounts. Because a primary barrier to implementing renewable energy can be cost, bulk purchasing presents a good opportunity to encourage customer interest by reducing retail price. Marin could use a revolving fund to bulk purchase solar, wind, or other promising technologies and sell the equipment to customers in discrete packages. Additionally, customers would be able to take advantage of federal and state subsidies and production credits to further reduce the cost of the package.

A second option would be to couple a revolving loan program with bulk purchasing. By buying in bulk, the County could offer discrete technology packages to customers as well as provide the loans necessary for implementation. By offering a low interest loan with less expensive equipment, Marin County would be providing a very unique service to residential and commercial customers in order to meet alternative energy generation goals.

A third option would be to establish an energy assessment district, an option approved in November 2007 by the City of Berkeley, California.[19] The energy assessment district would be citywide, and is modeled after existing underground utility districts. Under the program Berkeley is considering, participating property owners would be able to install solar systems and make energy efficiency improvements, and then pay for the cost as a 20-year assessment on their property tax bills. No property owner would pay an assessment unless they had work done on their property as part of the program. Participants would pay only for the cost of their project and the fees to administer the program. The City would finance the program through a bond. The tax assessment would transfer between owners at the time of sale, and the City would require multiple projects to be aggregated as a way to reduce construction costs.[20]

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[19] Berkeley staff will study the concept and report back on how to implement it in 2008. The City is negotiating with the U.S. Environmental Protection Agency for a grant that would cover program development costs. (Memo to Berkeley City Council from Mayor Tom Bates, November 6, 2007.

[20] Telephone and electronic mail exchange with Cisco DeVries, Chief of Staff to Berkeley Mayor Tom Bates, August 2007.

## 2. Power Purchase Agreements

The County would lease or rent renewable energy packages to residential or commercial customers. Upfront costs would come from the County working with a partnering financial firm. The costs would then be paid off by the customer as a monthly payment equal to the customers' original monthly energy cost through a 10-20 year contract. Operating this type of program in concert with bulk purchases would help lower overall program costs.

A key element of a power purchase agreement would be an energy efficiency audit of the building on which the equipment is to be placed. The building owner would only be able to access the power purchase agreement if s/he first upgrades the building to maximize its use of energy. This helps ensure that the renewable energy system is sized to meet the energy demand of the building, and that the building is not using any more electricity than necessary. The City of Santa Monica operates its Solar Santa Monica program in this way. The statewide California Solar Initiative operated through the investor-owned utilities and the California Center for Sustainable Energy (in San Diego) has similar requirements.

The next step in the program would be an assessment of which renewable technology is most appropriate for the property. (In most situations over the next several years, it will likely be some form of rooftop solar electric or hot water, but it could also be small wind.) The County would hire an installer to mount the hardware and maintain the system. The customer would lease or rent the package from the County in lieu of paying the energy-related portion of their bill until the lease or rent expires. At this point, the customer would be provided the option to purchase the equipment already installed at a discount. Using this model, a building owner would sign a contract allowing an installation on their property and paying the County the equivalent of their energy cost monthly until the system has been paid back.

The Power Purchase Agreement model would require some start-up funding from the County. Once operational, fees should pay for administrative costs.

**Example: City of Santa Clara Solar Hot Water Program**

The City of Santa Clara, through its municipal utility, offers solar equipment for heating swimming pools, process water, and domestic hot water. The pieces of hardware (solar collectors, controls and storage tanks) are owned and maintained by the city and are offered to customers under a rental agreement. The renter pays an initial installation fee and a monthly utility fee. These amounts vary according to the size of the installation. Current installations include 350 Solar pool heating systems and 500 residential solar hot water systems. Installation cost for a solar pool heating system is $625 plus $40 per panel.

- Solar Domestic Hot Water System (Single Family) -- approximate installation cost is $540
- Monthly Charges- For all above installations there is a monthly service charge based on the number of panels. Pool systems are billed a monthly service charge for six billing cycles per year (generally from April to September), although the system is available for use all year.

## 3. Loans

Another way to finance renewable energy projects would be for the County to loan money to residents or business owners. A key goal of a County-sponsored program would be to mitigate the cost associated with currently available on-site renewable energy. Loans can be low- or no-interest, and can be funded in different ways, including a revolving fund or pre-approved financing.

Any loan program would need an initial pool of money. Funding constraints may limit the size of the initial program. Options for generating an initial fund are described in the next section, "Raising Capital." Below is a general overview of each potential model of providing loans.

### a) County-sponsored low interest loans

In this scenario, the County would establish a "seed fund" that would allow for a simplified, dedicated funding source. Companies or individuals would be able to borrow money for approved technologies. The revolving fund could initially be funded through bonds, fees, or grants, and its purpose would be an energy loan program specifically for alternative energy production projects. The program would likely need a set of guidelines for payback times, energy generation requirements, fees, and the approval process. Once approved, the money would be released to initiate the project. Money would be returned to the revolving fund through payments that could include interest.

Other municipal entities have established revolving funds for energy projects, including Phoenix, Arizona; Portland, Oregon; Duluth, Minnesota (in association with the local utility); and Ann Arbor, Michigan.[21] The State of California uses a revolving fund in its low-interest loan program for local governments and public agencies, administered by the California Energy Commission. The states of Texas and Missouri also have revolving loan programs.[22]

Benefits of the County providing low interest loans include environmental benefits from alternative energy, interest from loans, and the ability of the County to set the interest rate. Potential risks include foreclosure risk and administration fees.

**Example: Sacramento Municipal Utility District (SMUD) Solar Domestic Hot Water Program**

SMUD has successfully installed 3,000 solar hot water systems. Program features include:

- A 10-year low interest loan covering all of the costs associated with a new system.
- A $1500 rebate per system
- Homeowner can earn federal tax credits of 30% of the system cost per year up to $2000 for solar hot water systems
- Homeowner contracts for installation and funds the system through SMUD's solar hot water program.
- Program currently not viable for customers who heat water with gas. (SMUD customers purchase gas from PG&E.) Customers that use electricity to heat water can save up to 60% in electricity rates.

[21] Jody London Consulting for the Southern California Edison – Southern California Gas - County of Los Angeles Energy Efficiency Partnership, *Public Agency Participation in Energy Efficiency Programs: Technology Transfer Feasibility Study,*" December 2, 2005, pp. 16-19.
[22] Jody London Consulting, *Public Agency Participation in Energy Efficiency Programs.*

### b) County-provided low interest loans through partnership with an FDIC insured financial institution

In this scenario, the County would work with a partner, perhaps a local FDIC-insured bank, to establish pre-approved financing or low-interest loans for residents and businesses. Benefits could be very similar to a revolving fund, with less risk to County. By working with local lenders, the County would not only use its bargaining power to negotiate favorable rates, but would also actively promote local businesses. The City of Santa Monica has recently introduced a program like this on a demonstration basis. (See Solar Santa Monica inset below and Appendix A.)

The purpose of this type of partnership would be to reduce administrative costs associated with loans, while providing an insured loan to customers. Benefits of providing loans in partnership with a financial institution include reduced foreclosure risk, the environmental benefits of alternative energy, working with an FDIC insured institution, and reduced administrative fees. Issues to consider in this scenario include additional fees associated with financial institution involvement, guidelines for loans being set by the bank and not Marin County, and interest rates that may be subject to market rate.

**Example: Solar Santa Monica**

The City of Santa Monica in early 2007 launched a two-year demonstration pilot program to both increase renewable production in the City and take advantage of all available energy efficiency opportunities in buildings before solar technology is installed. Santa Monica has a stated goal of becoming "energy self-sustaining" by 2020. The Solar Santa Monica program is at first geared towards 50 residential and business "demonstration sites." It is estimated that the typical residential application will be approximately 2 kW and cost about $15,000 to install. Most commercial applications would be much larger and have a fixed price of $6.86 per watt of delivered electricity. The program in its initial two-year demonstration phase is funded by the City.[23] The City has retained four outside entities to finance the program on a longer-term basis.

[23] Interview with Susan Munves, Energy and Green Building Program Administrator, City of Santa Monica, June 6, 2007.

These entities will provide loans directly to interested residents and businesses; the City is not directly involved in the financing agreements.[24]

Santa Monica offers four pre-designed packages. Two of these packages are focused mainly on energy efficiency. These packages are designed for apartments/condos, or for those who are not ready to make a large financial investment (packages are expected to cost around $1,000 or $2,000 respectively). The other two pre-designed packages are much more expensive (approximately $15,000 or $22,000 respectively). In addition to energy efficiency improvements, the more costly packages result in installation of a solar PV or solar thermal system.

Solar Santa Monica's two-year demonstration phase is being funded by $1 million collected in utility franchise taxes during the 2000-2001 energy crisis and put into a reserve account at that time. The start-up funding is being used to pay for City staff time and consultants who are helping develop and launch the program.

### c) Zero Interest Loans

Zero interest loans for alternative energy projects are another way to finance projects. A zero interest loan program works by using a revolving fund to provide zero interest loans for approved alternative energy generation projects. Payback times are figured into the loan after an energy generation potential assessment is complete to ensure projected energy production. As payments are received, they are returned to the revolving fund for re-distribution.

Harvard University is using this model to increase energy efficiency and renewable onsite generation on its campus. Departments submit projects to the Green Campus Loan Fund. The loan is repaid by savings that the projects achieve in lower utility costs, waste removal costs, or operating costs. The Loan Fund was established in January 2002, and as of March 2007, projects were projected to save Harvard $3,912,099 per year, with an average project return on investment of 35%.[25] The projects have produced environmental benefits as well: greenhouse gases have been reduced by 27,414 metric tons of eCO2, the university has saved 15,269,877 gallons of water, and it has reduced waste by 200,000 pounds.

[24] Presentation by Susan Munves, City of Santa Monica, to Local Government Commission quarterly meeting, August 17, 2007.
[25] Harvard University, "Green Campus Loan Fund," August 2007.

The community around Aspen, Colorado has established a non-profit organization sponsored by municipalities and utility companies, the Community Office for Energy Resources ("CORE"). One of the programs CORE offers is a loan program for customers to install solar hot water or photovoltaic equipment. The customer enters into a loan agreement with the local bank, and CORE pays the interest.[26]

Benefits of a zero interest loan program include increased customer interest in alternative energy generation, and the environmental benefits of green power production. Issues to consider include foreclosure risk, administrative fees, and depreciation of payments.

### 4. Demonstration Projects

The County could undertake demonstration projects of different technologies. Demonstration projects would provide the County with better information about how various technologies function and the contribution each can make to the County's greenhouse gas reduction goals. Demonstration projects also would provide venues where residents and businesses could learn more about each technology. While solar technology is more common and demonstrations may not be needed for it, the County could install wind turbines on its property, or biomass and biogas projects at landfills, water and wastewater treatment facilities,[27,28] as well as food waste and food processing facilities.

The County also could investigate demonstration projects focused on building technologies. Possible candidate technologies are Building Integrated photovoltaic, net-zero energy homes, or model homes. Funding could be augmented through partnerships with the

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[26] Interview with Gary Goodson, CORE staff, September 27, 2007.

[27] Assembly Bill 1969 (2006) requires California's investor-owned utilities to enroll up to 250 MW of biomass and biogas energy from water and wastewater treatment facilities. Each facility must be sized under 1.5 MW to qualify under this particular program, which was adopted by the California Public Utilities Commission in Decision 07-07-027 (July 26, 2007). PG&E has been directed to extend its program to other similarly situated facilities. Larger facilities have other options for selling power to PG&E.

[28] Many of the County's waste water treatment facilities have some biogas generation capacity currently, with the potential to install more with proper incentives and opportunity to sell excess energy.

California Energy Commission, solar businesses, or builders. While demonstration projects may provide useful models, implementing them will be subject to available capital. (See section below on raising capital.)

### 5. Community Power Trust

A community power trust is a relatively new form of generating funds for alternative energy. In fact, few examples exist for this method of generating resources. The community land trust model provides the basis for which a community power trust could operate. A community land trust purchases properties and sells only the buildings to typically low income families. The trust then leases the land in 100 year leases. By removing the land expense from the price of the house, the trust can provide housing that is affordable.

A community power trust could work in a similar fashion. Marin County could create a community power trust and use funds to purchase alternative energy equipment. The trust could then use the funds to further "buy down" the high costs of energy equipment. Another option would be to purchase equipment and lease to residential or commercial customers at rates comparable to their energy bill. By providing buy-down funds and leasing options, the community power trust could ensure that more affordable alternative energy generation could be implemented in Marin County.[29] Community wind projects that use this model have been developed in other states and on tribal lands, including Illinois, Minnesota, Iowa, and the Northwest states.[30]

A community power trust would allow the County to purchase and install alternative energy equipment and sell the electricity. Funds generated could be used to purchase large solar arrays or other renewable generation facilities that could be installed in Marin County. The

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[29] The Marin Community Foundation recently has commissioned a study of community solar in West Marin.
[30] Windustry, "Community Wind," July 2007.

electricity would be sold to customers at competitive rates. In addition, the County could sell the renewable energy credits from its power generating facilities on an open exchange for additional revenue, assuming it does not require the credits for other greenhouse gas mitigation purposes.

One model of a community power trust recently announced in California is the SolarShares Program. The Sacramento Municipal Utility District announced in September 2007, a program that allows customers to purchase blocks of power from several 1 MW solar installations the utility is installing in its service territory. Customers can pay between $5 and $30 per month, which provides them with between 10% and 50% of their electricity.[31]

The funds for a community power trust could be raised in various ways. One option would be for the trust to accept donations from individuals or businesses. A second option would be for County residents to participate by having their energy bills rounded up to the nearest dollar. The rounded portion would go towards the community trust fund for alternative energy project buy-downs (see example below).[32] Benefits of a community power trust include being able to provide cost-effective equipment to customers, and the option of leasing, as opposed to purchasing, equipment. One issues to consider is the level of responsibility as an owner to maintain the leased systems. Also, unless the County becomes a community choice aggregator, it may have difficulty implementing a program that is funded through a surcharge on utility bills.

**Central Indiana Power Trust Inc. (CIPT)**

The Central Indian Power Trust accumulates and distributes funds for charitable purposes to individuals, families, groups, and organizations located within the utility's service area. Funds for the program are generated by customers of the utility, which is a cooperative, voluntarily opting to round up their utility bills to the nearest dollar. The rounded portion of the bill constitutes the Trust's funds. The funds are collected and distributed by the utility and are then transferred to the CIPT. The Trust has a 13 member Board that determines the allocation of

[31] "Sacramento Municipal Utility District Launches SolarShares Program," September 27, 2007, press release.
[32] Central Indiana Power Community Trust, Inc. "Guidelines for Applicants."

funds, which are allocated to members whose project/mission benefits a significant portion of the co-op members. Only projects that have significant community support are considered. One request per year and a maximum of $2,500 per request is allowed.

Were such a model to be adopted in Marin, the charitable purpose for the Trust could be to fund alternative energy projects. Marin also would have to work with PG&E to develop a mechanism for collecting funds on participating residents' bills. This would be the case whether or not the County becomes a community choice aggregator, because the local utility still provides metering, billing, transmission, and distribution service under a Community Choice Aggregation model.

### 6. Performance Contractor

Another method for deploying renewable energy technology in Marin County is for the County to facilitate opportunities for customers to work directly with performance contractors. In this scenario, the County merely connects contractors and property owners, while in the power purchase agreement model described above, the County has a role in program design and vendor selection. Performance contractors purchase, install, and maintain equipment, and guarantee energy rates to customers. Below is an overview of the performance contracting process:

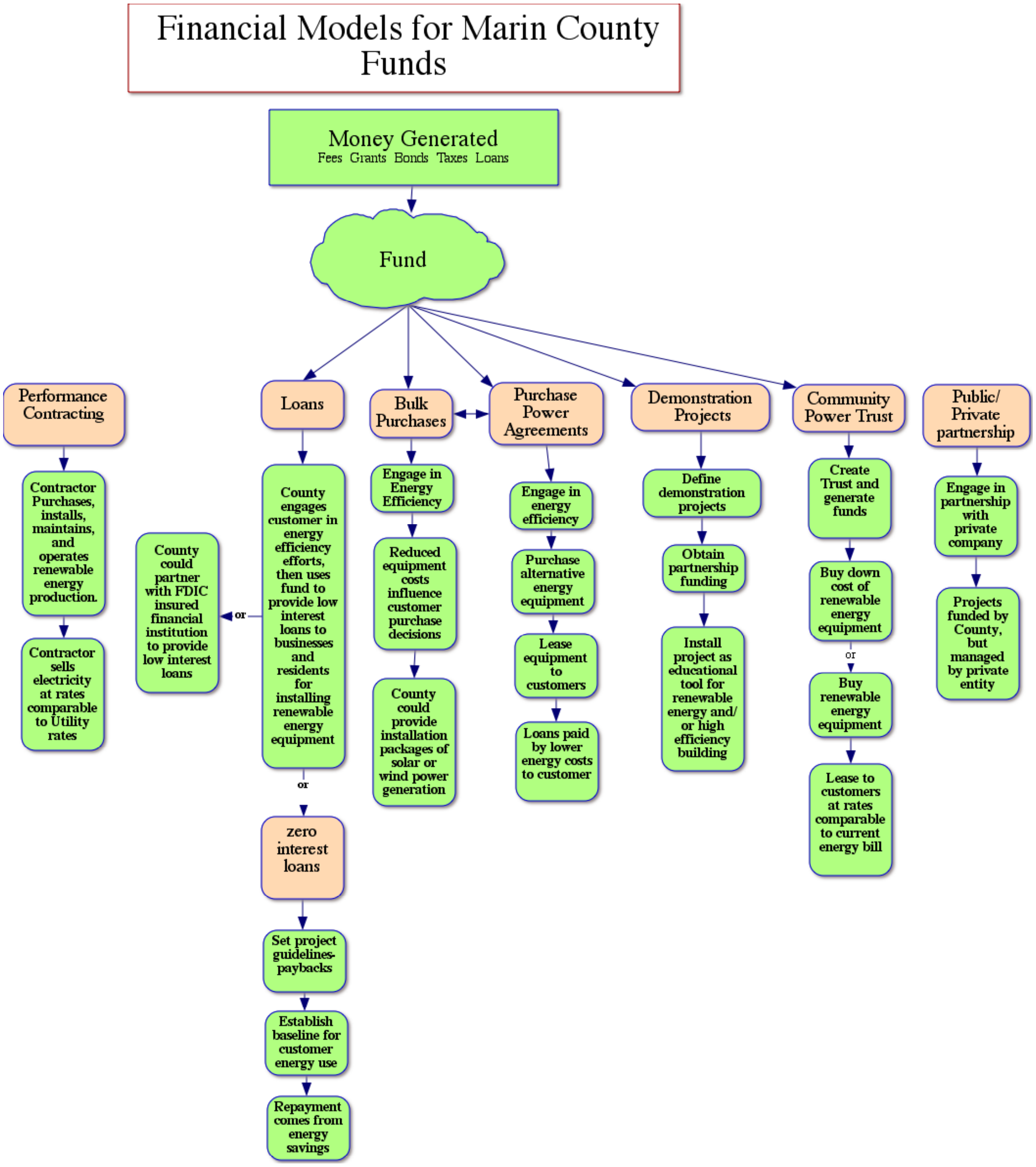
a. Customer enters agreement with a private energy service company (performance contractor);
b. The contractor evaluates energy savings opportunities and provides a detailed recommendation of systems and energy savings performance;
c. The contractor guarantees savings over terms of approximately ten years;
d. Contractor installs, maintains, and operates system.

Because the transaction is between the performance contractor and the end-use customer, no County funds are required. This can make performance contracting an attractive way to facilitate renewable energy and energy efficiency implementation within the County. While this is a viable option, performance contracting would likely be one part of a much larger strategy for reaching Marin County's goal for greater renewable energy production and a lower emissions profile.

Benefits of performance contracting include zero cost to the County, parity in electricity rates for customers (performance contractors finance projects based on money saved through reduced utility expenditures from energy efficiency equipment installed), and there are environmental benefits from the installation of renewable technology. Issues to consider include potential legal concerns around equipment and property ownership, a reduction in County control over achieving renewable energy goals, and funding sources for the performance contracting program.

## 7. Public-Private Partnership

A public-private partnership might be an effective vehicle for increasing alternative power generated in Marin County. A public-private partnership is a system in which a government service or private capital venture is funded and operated through a partnership of government and one or more private sector companies. A Marin County – private sector partnership would benefit the County by taking advantage of the financial, business, and management acumen of a private company. A partnership could allow a private entity access to new sources of capital, and could put the responsibility of project management on the private company.




## B. *Options For Raising Capital*

There are a variety of options for the County to generate funds for the program structures described above. While not all of the options listed below will be feasible for Marin County, this provides an extensive list of how other municipalities have raised funds for their projects. Some of these financing options will be more applicable to certain types of projects than others.

### 1. Taxes

**General Tax** - A general tax is a tax whose burden falls upon a very broad section of the general public, such as wage earners or property owners, but may require legislative action. General taxes for revenue can include:

- Corporate Gross Receipts Taxes
- Corporate Income Taxes
- Death and Gift Taxes
- Individual Income Taxes
- Local Sales Taxes
- Personal (Tangible) Property Taxes
- Real (Ad Valorem) Property Taxes
- State Sales and Use Taxes
- Value-Added Taxes

**Carbon Tax –** At this time, the only city to successfully implement a carbon tax is Boulder, Colorado. Boulder's carbon tax was approved by voters in November 2006, and became effective on April 1, 2007. It is based on the number of kilowatt-hours used, and is expected to add $16/year to the average residential bill, and $46/year for the average business bill. The carbon tax is expected to raise $6.7 million by 2012, and the programs it will fund are expected to have reduced carbon emissions by 350,000 metric tons in that same timeframe. Boulder's carbon tax is collected by the local electric utility, which provides the funds collected to the City's Office of Environmental Affairs. This is similar to how municipal utilities collect other user fees. See Appendix A for a more detailed description of Boulder's carbon tax.

### 2. Fees

**General Fees** - A fee is a financial charge for services rendered, or activity undertaken. Fees can be based on the service provided or benefit received, including potential negative environmental impacts. Fees establish direct links between the demand for services and the cost of providing them. Fees typically used by counties include:

- Access Rights
- Bond Issuance Fees
- Connection Fees
- Construction Fees
- Franchise Fees
- Inspection/Monitoring/Testing Fees
- Licensing and Recreational Fees
- Local Aquifer Protection Fees
- Local Water/Wastewater Utility User Fees
- Permitting Fees
- Product Registration Fees
- Professional Certification Fees
- Septic System Impact Fees
- Solid Waste Disposal Fees (Tipping Fees, Septage/Sludge Fees)
- State Public Water Supply Withdrawal Fees
- Tolls
- Transporter Fees
- Water Rights Application Fee
- Well Permit/Pumping Fees

**Fee for (renewable energy) service –** Under a fee for service program for renewable energy, the County would lease the property on which the renewable technology (i.e., solar) is installed. The County would own the renewable energy system, and would sell the electricity to the property owner at an agreed-upon rate under a standard contract.

**Special Charges**- Special charges apply to specific types of transactions or activities which impose unique environmental or development costs. Special charges are not placed on the general population or upon the sale of a particular good or service, such as many taxes, and they are not fees for administrative services. Special charges can include:

- Direct Water Use Charges
- Effluent Charges
- Emission Charges
- Exactions
- Feedstock Charges
- Impact Fees
- Severance Taxes
- Special Assessments
- Waste-End Charges (Special Industry Fees)

**Fines and Penalties –** Violators of federal and/or State environmental laws and regulations are frequently subject to the payment of monetary fines and penalties. These fines and penalties can often take the form of environmental benefit projects, monetary payments, or reimbursements (i.e., superfund liability cost recoveries).

**Fee-Bates –** The "fee-bate" concept, which was introduced in the California Legislature in Assembly Bill 493 (2007), would establish a one-time rebate at time of purchase for customers who purchase "clean" vehicles. The rebate would be funded through one-time fees paid by customers who purchase vehicles higher emissions of greenhouse gas pollutants. The County could establish a similar program, with or without state action.

### 3. Bonds

**Clean Renewable Energy Bonds ("CREBs")** **–** The legislative intent of the federal CREBs program is to provide an incentive for publicly owned projects that do not qualify for federal Production Tax Credits. These bonds are available to any governmental or public entity, not just utilities. One cannot use dollars raised by CREBs to support privately owned projects. Marin County, and some cities and towns within the County, have applied for CREBs for municipal solar projects, and could apply for a CREB for other alternative energy projects. The first round of applications for CREBs funded 401 government photovoltaic system projects in Marin. The County has recently applied for a second round of CREBs funding for additional buildings.

**Private Activity Bonds**[33] **-- Private activity bonds are tax-exempt securities** issued by or on behalf of local government. Private activity bond authority in California is managed by the

[33] Gust Rosenfeld, P.L.C., as published by the Arizona Department of Commerce, "Financing With Private Activity Bonds," January 8, 2007.

California Debt Limit Allocation Committee. The Committee allocates bond authority to cities, counties, and state agencies, which then issue the bonds. The bonds are purchased and used by the private sector. Private activity bonds may only be used by the private sector for projects and programs that provide a public benefit. These bonds require strict compliance to Internal Revenue Service codes. The federal government limits the amount of private activity bond authority for each state on an annual basis. California's limit for 2006 was $2.8 billion.[34] Tax-exempt status is jeopardized if an issuing authority exceeds the volume cap limit. In Marin County, Private Activity Bonds could be defined as local furnishings of electricity and power and would be subject to a volume cap limit.

**Municipal Bonds -** Municipal bonds are attractive to many investors because the interest income is exempt from federal income tax, and in many cases, state and local taxes as well. In addition, municipal bonds often represent investments in state and local government projects including schools, highways, hospitals, housing, sewer systems, and other important public projects, such as renewable energy.

**Other bonds –** Other types of bonds that municipal entities can access are listed below. These bonds are not likely to be useful for the renewable energy investments the County wishes to make.

- Advance Refunding Bonds
- Anticipation Notes
- Appropriation-Backed Bonds
- Asset-Backed Revenue Bonds
- Capital Appreciation and Zero Coupon Bonds
- Certificates of Participation
- Derivatives
- Double-Barrel Bonds
- General Obligation Bonds

[34] California Department of Finance, "0959 Debt Limit Allocation Committee: Mission Statement," from *Governor's Budget, 2007-2008 – Enacted Budget Detail.*

- Mandate Bonds (Environmental)
- Moral Obligation Bonds
- Mortgage Lease-Back Revenue
- Private Activity Bonds
- Revenue Bonds
- Short-Term Municipal Bonds
- Special Assessment Bonds
- Special Tax Bonds
- State Revolving Fund (SRF) Revenue Bonds
- Structured Municipal Bonds
- Tax Increment Bonds

### 4. Loans

The County could take out a loan to help finance a renewable energy program. A loan is the temporary provision of a specific amount of funds up-front for an expenditure that must be repaid in a set amount of time, typically with interest. The rate of interest is established prior to the loan or, in the case of commercial loans, determined through negotiations. Different types of loans include:

- Agriculture: Rural Business-Cooperative Service -- Economic Development Loans
- Agriculture: Rural Housing Service (RHS) – Community Facilities Loans
- Agriculture: RHS – Housing Site & Self-Help Housing Land Development Loans
- Agriculture: Rural Utilities Service -- Water and Waste Disposal Systems Loans
- Co-Bank (National Bank for Cooperatives Loan Program)
- Co-Funding
- Commercial Loans
- Direct Source (Equipment) Financing
- EPA: State Revolving Funds - Clean Water
- EPA: State Revolving Funds - Drinking Water
- Federal Financing Bank
- Federal Loan Programs
- North American Development Bank
- Private Investment
- State Loan Programs
- State Revolving Fund (SRF) Pre-Financing and Short-Term Loans
- SRF Private Beneficiary Loans - Clean Water

### 5. Grants

A grant is a sum of money awarded to an eligible entity without a requirement for repayment. Typically, grants are awarded by the federal government to state or local governments, or by states to local governments, for the purpose of financing a particular activity or facility. Grants are also available from non-profit organizations and foundations. The County should consider pursuing relevant grant opportunities.

# III. Technology Options

This section discusses various renewable resource technology options that might be considered in Marin County – solar, wind, bioenergy, and ocean power.[35] This report does not look at energy efficiency or conservation (using less energy through the use of more efficient equipment and operating practices) which is the most cost-effective option for reducing energy-related emissions, because it is too large of a topic to be addressed here. A separate report examining these opportunities is pending. Each section below provides a description of the viable potential renewable energy technology, including how it works, average cost, and an estimate of the generating potential in Marin County.[36] Summaries of the various technologies and local generating potentials are provided in Table 1.

Marin County used 1421 GWh in 2005[37], so 717 GWh of renewable power in-County could readily meet 50% of the electricity demand using solar, biomass, and on-shore wind power. If ocean power and off-shore wind power are included in this sum (bringing the total to 1247 GWh), the County could meet as much as 87% of its electricity needs through alternative

[35] Geothermal and small hydroelectric power (under 30 MW) also are considered to be renewable energy resources. Marin County does not have a geothermal resource. And while there may be opportunities for very small-scale hydropower, that was considered beyond the scope of this project.
[36] For details on calculations, see Appendices E through H
[37] California Energy Commission.

energy. The table below summarizes the power that could be generated with alternative energy technologies.

**Table 3. Summary of Renewable Energy Potential in Marin County**

| Technology | Rated MW | GWh/yr | Million Therms/yr | Deployment Potential[38] |
|---|---|---|---|---|
| Solar | 220 | 316 | 6.7 | High |
| Small Wind | 11 | 20 | NA | Medium |
| Large Wind | 182 | 280 | NA | Low |
| Off-Shore Wind | 260 | 400 | NA | Low |
| Methane Capture (Landfill gas, dairies) | 6.5 | 49 | NA | High |
| Biomass (Waste to fuel) | 7 - 16 | 52 - 120 | NA | Medium |
| Ocean Power | 150 | 130 | NA | Low |
| **TOTAL** | **837 -846** | **1247 – 1315** | **6.7** | |
| **For reference, Marin County used 1,421 GWh in 2005 and 81.7 million therms** | | | | |

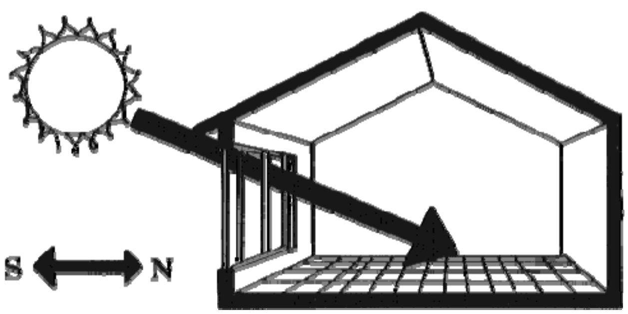
[38] Deployment potential levels were determined based on the state of the technology and current policy, permitting and cost constraints.

## A. Solar

### 1. How Solar Technology Works

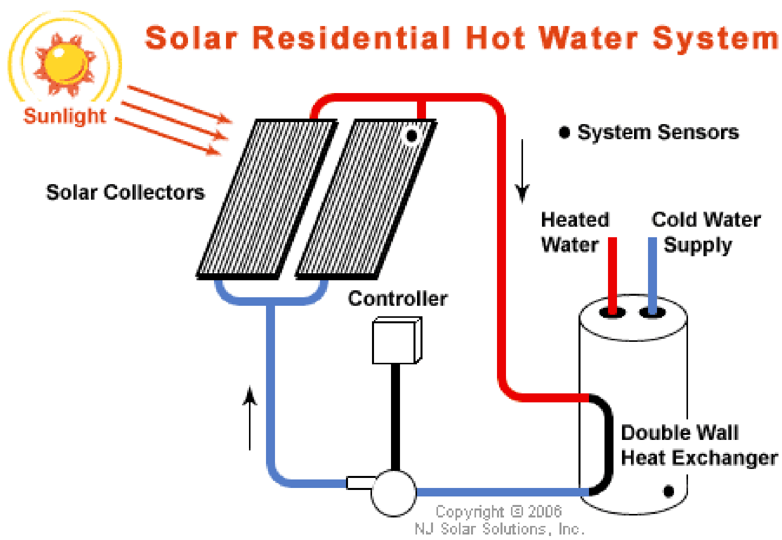
Solar power is divided into four categories. The most basic of the four types is **passive solar**, which uses building design to take advantage of natural light and heat from the sun. Buildings of any size can be designed to reduce power consumption by utilizing the sun's energy. Passive solar does not generate electricity, but it does reduce the amount of energy that is consumed by a building. Examples of passive solar design include use of natural sunlight to reduce the need for electric lights during the day, and use of sunlight to heat a building space (Figure 1). The cost of passive solar varies between buildings and based on the complexity of the design. Because it is a function of building design, and therefore a building standards issue, passive solar's energy saving potential was not included in the resource potential calculations in this report.

**Figure 2. Passive Solar Heating and Lighting**



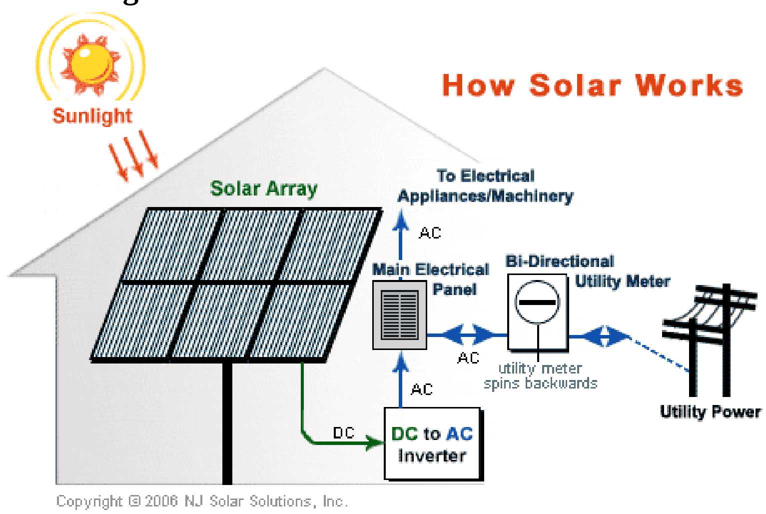

Another type of solar power is **solar thermal hot water heating**. This technology uses the sun's energy to heat water, which is stored in a tank for use in swimming pools, domestic hot water, or radiant heating systems. There are many ways to use the sun to heat water, but most systems use piping, filled with water or another working fluid, inside of a glass or plastic casing to collect the sun's heat. A small pump or natural convection drives the water through the solar collectors to raise the temperature (Figure 2). Thermal solar panels do not generate electricity directly but reduce the use of gas or electricity previously used for heating water. For Marin County, solar thermal systems relying on natural convection have been shown to be operable all 12 months of the year. Solar thermal water heating is most commonly used on individual residential or small commercial sites. Solar thermal heaters usually require approximately 6 square meters of panels to heat a 100 gallon tank, and it is generally cheaper to implement than solar electric systems. Legislation passed California in 2007 requires the California Public Utilities Commission to study and implement a pilot program to promote greater deployment of solar hot water heaters, with a goal of 200,000 solar hot water heaters statewide by 2017 (Assembly Bill 1470, Huffman).

**Figure 3. Solar Residential Hot Water System**




**Photovoltaic solar power** uses the sun's energy to excite electrons in a multilayer semiconductor, which emit electrical energy when they "fall back down" to their ground state. The electrical energy is collected by electrodes in the solar panel and sent through wires to the power storage unit. Photovoltaic power can be used on a wide range of scales, from handheld devices of less than 1 watt, to electric systems for residential buildings that produce 4 to 5 kW, to power plants that produce more than 10 MW.[39] The power per area for photovoltaic panels is approximately 10 Watts per square foot for polycrystalline solar cells, which are the type commonly used for rooftop installations. Solar photovoltaic power is mostly distributed, meaning that it is located in small clusters on rooftops (Figure 3), but can be centralized in the case of a solar farm power plant. Because of its distributed characteristic, transmission lines are usually not a cost or logistical issue because the buildings on which the panels are placed are already connected to the grid.

**Figure 4. Photovoltaic Solar Power**

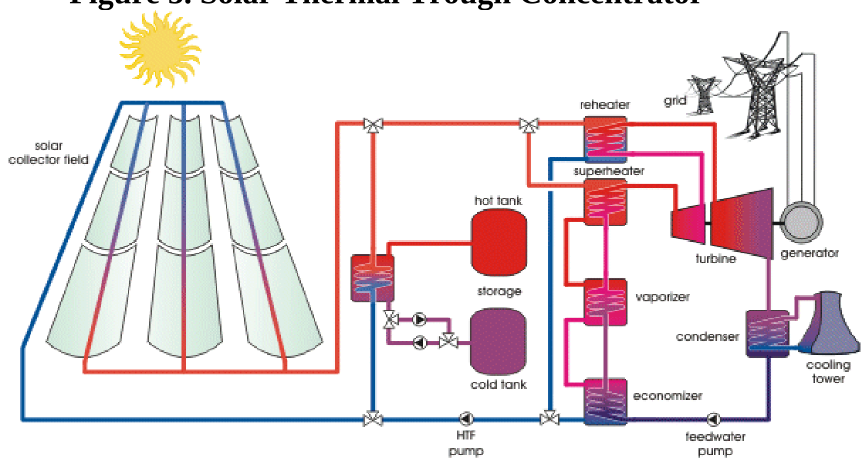



**Concentrated solar power** can be in the form of photovoltaic or thermal conversion. Photovoltaic concentrators use small, expensive, but extremely efficient, solar cells and focus many times the Sun's light on the cell using mirror arrays. This technology is still in the late testing phases and has yielded promising results. Thermal concentrating solar power (CSP) can be accomplished with parabolic trough (Figure 4), parabolic dish, or power tower systems (Figure 5). Parabolic trough and dish both use arrays of curved mirrors to focus sunlight on a

[39] Power plant output is measured in multiples of watts. Output from small facilities is measured in kilowatts ("kW"); output from larger facilities in measured in megawatt ("MW"). The average natural gas power plant has a generating capacity of about 300 MW.

tube of fluid to turn it into steam used to turn a generator. Trough technology is ideal for utility scale use at several megawatts, while dish can be used in smaller units of 10 to 25 kW or combined to create a larger system. Power towers use an array of mirrors to focus light up to a tower, where a working fluid is heated and turned to steam to turn a generator. These solar power tower plants typically provide tens to hundreds of MW capacity, and occupy a land area ranging from tens to hundreds of acres. Thermal CSP technology has been used for power plants since the 1980s, and can be combined with traditional fossil fuel technology to form a hybrid power plant that can provide baseload power generation.[40] Hybrid CSP systems can have lower investment risk than non-hybrid systems and can reduce the amount of fossil fuels burned compared to traditional natural gas plants.

**Figure 5. Solar Thermal Trough Concentrator**




[40] The U.S. Department of Energy, Energy Information Administration defines baseload as: "The minimum amount of electric power delivered or required over a given period of time at a steady rate." A baseload power plant is one that can run continuously to meet minimum load requirements. In California today, much baseload power is met by nuclear power plants.

**Figure 6. Solar Thermal Power Tower Concentrator**[41]

## 2. Reliability Issues

Photovoltaic power is not a baseload power source because it depends on the sun, which is a variable power supply. Although photovoltaic power is not predictable hour to hour, weather averages give a very good estimate of what power can be expected from the panels on a monthly or yearly basis, which greatly reduces the risk in investing in photovoltaics. One way to mitigate the uncertainty in a solar system due to variable solar insolation (the intensity of the sun on a horizontal surface) is to combine the solar with fossil generation such as natural gas as in the hybrid CSP systems, thereby reducing rather than eliminating the dependence on fossil fuel. Another way to reduce the negative impacts of weather variation on the accuracy of projected power output of a solar power system is to have solar plants installed in geographically diverse locations such that if the sun is not shining in one location, it is likely to be bright in another. This is a technique practiced by the wind power industry, and can be thought of as diversifying investments rather than putting all the "eggs in one basket."

[41] Photo source: TREC-UK.

The standard in the power industry is that no more than 20% of a region's power can come from solar without causing instability in the power system. Currently, solar accounts for only about 0.2% of the power produced in California so there is room to grow before the 20% value is reached.[42] One positive aspect of solar power is that most of the technologies have been shown to perform remarkably well as they age. A well-made solar photovoltaic panel bought today is guaranteed by the manufacturer to maintain its efficiency for 20 to 25 years. Solar thermal systems last as long, if not longer, as photovoltaic systems.

### 3. Where Solar Technology is Best Used

All types of solar power are best suited for an environment that experiences many hours of direct sunlight each year. High humidity and high temperatures have a negative, but not disastrous, impact on solar photovoltaic performance, and do not usually adversely affect the performance of solar thermal systems. Sunny, moderately dry conditions exist for most of the year in Marin County, which is ideal for solar photovoltaic and solar thermal systems. However, CSP technology requires flat (slopes of less than 1%) areas with annual-average direct normal solar radiation of 6 kWh/day.[43] Unfortunately, Marin County does not have the level of direct solar radiation to support this technology.

Solar power is one of the most flexible sources of renewable power due to the fact that solar can be installed as small, distributed systems or large plants. This characteristic allows home and business owners to personally support renewable power. As long as there is roof or land area in a moderately sunny area, solar panels can be installed in nearly any size scale.

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[42] Bodzin, Steven, "Schwarzenegger, Hedge Funds Invest in California Solar Power," July 7, 2006, www.Bloomberg.com.
[43] California Energy Commission, *California Solar Resources: In Support of the 2005 Integrated Energy Policy Report*, April 2005, Report #500-2005-072-D.

### 4. Typical Costs

Solar thermal installations have a wide price range because there are many different types of systems available. The typical price range for a complete installed solar thermal residential water heating system is between $5,000 and $12,000.[44] Solar thermal water heating does not directly provide electricity (rather, it displaces the use of gas or electricity) so a price per watt value does not make sense to report. However, 50% to 80% of the water heating needs for a residence can be provided by such systems, and solar thermal hot water systems are the most cost-effective of the solar technologies.

Solar photovoltaic installations currently cost approximately $7 to $10 per watt, including the site assessment, balance of system equipment required for grid connection, and the installation.[45] This cost varies with the quality of the solar panels, the type of mounting device, the difficulty of the installation site, and the number of watts being installed. The general "economies of scale" rules apply, making larger installations more economical than smaller ones. Electricity from the panels averages between 20 and 25 cents per kWh. Currently this cost is offset by state and federal subsidies and tax credits.[46] Also, as the price of electricity from the grid rises, the relative cost of electricity from solar panels decreases. Many customers view a solar electric system as a hedge against electricity price increases. Lastly, solar photovoltaic panels and equipment are dropping in price each year, promising less costly options in the near future.

Maintenance costs for solar photovoltaic panels are nearly zero and involve simply cleaning the panels once or twice a year. However, it is necessary to replace the inverter after

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[44] Bennett, Matthew, "Exploring the Basics: Solar Photovoltaic, Solar Thermal, and Wind Energy Systems," as posted on website of Green Energy Ohio.
[45] Bennet, "Exploring the Basics."
[46] Information on all current incentives, rebates and tax credits are available at the Database of State Incentives for Renewables & Efficiency (DSIRE), www.dsireusa.org

about 10-15 years at a cost of about $700/kW.[47] Photovoltaic panels themselves most often come with a 25-year warranty from the manufacturer. Maintenance needs vary for solar thermal systems depending on the system design and components. Solar thermal systems, like photovoltaic, generally have a lifetime of approximately 25 years, and possibly longer if the system is well-maintained.

## 5. Opportunities within Marin County

Solar power presents a significant, viable renewable energy for Marin County, particularly the photovoltaic and solar thermal technologies. Marin County should proactively pursue the use of solar photovoltaic technology on commercial, industrial, government, and residential rooftops, and solar thermal systems for pool and domestic water heating. The County of Marin has identified approximately 29.2 million square feet of rooftop and parking areas located in solar accessible areas. Three potential scenarios were examined in estimating solar build out potential of this area – 100% solar photovoltaic; 100% solar thermal; and a combination of the two.[48] Summaries of all estimates are provided in Table 4.

**Table 4. Solar Build Out Potential In Marin County**

| Scenario | Rated MW | GWh/yr | Million Therms/YR |
|---|---|---|---|
| 100 % Photovoltaic | 220 | 316 | NA |
| 100% Thermal | NA | NA | 3.7 |
| Combination Photovoltaic and Thermal | 130 | 190 | 3.5 |

As noted in the previous section, thermal CSP systems are not suitable for Marin County. Photovoltaic concentrating systems are still in testing phases and Marin County should continue to monitor the progress of this technology as it develops.

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[47] Black, Andy, "Payback on Residential PV Systems with Performance Based Incentives and Renewable Energy Credits," On Grid Solar, 2006.
[48] For details on methodology and calculations, see Appendix E

Of all alternative power sources, solar power is one of the best to implement immediately because of its well-demonstrated success in distributed applications. Other types of alternative energy technologies, such as geothermal, ocean, hydroelectric, or some forms of biomass and biogas, need to be installed in multimillion or multibillion dollar projects and take up large tracts of land. Many projects, such as transportation or vehicle fuel reforms, require the cooperation of several bureaucracies and/or massive infrastructure that is not currently in place. Solar's ease of implementation and scalability make it among the easiest renewable energy resource to install in a short timeframe.

### 6. Greenhouse gases saved

Three of the most common greenhouse gases are carbon dioxide ($CO_2$), sulfur dioxide ($SO_2$), and nitrous oxides ($NO_x$). Using PG&E's current energy mix, the greenhouse gases that would be avoided by installing solar photovoltaic panels on all available rooftop area totals 170 million pounds of $CO_2$ per year, 0.019 million pounds of $SO_2$ per year, and 0.13 million pounds of $NO_x$ per year. If solar thermal panels instead of photovoltaic panels were installed on all available rooftop area, only natural gas would be displaced, resulting in 250 million pounds of $CO_2$ per year, 0.0076 million pounds of $SO_2$ and 0.19 million pounds of $NO_x$ per year saved.[49]

### 7. Local Economic Benefits

Proactive installation of solar photovoltaic and solar thermal systems in Marin County would create green jobs and stimulate the types of local businesses that have been identified by Marin County's 2005 *Targeted Industries Study*.[50] Experts are needed to do site assessments, design, sales, panel installation, and maintenance. Equipment for the system, including the solar

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[49] Please see Appendix E for details on calculations.

[50] Eyler, Robert, *Marin County Targeted Industries Study Economic Impact Supplement*, Final Report, December 31, 2005, prepared for The Marin Economic Commission and Community Development Agency.

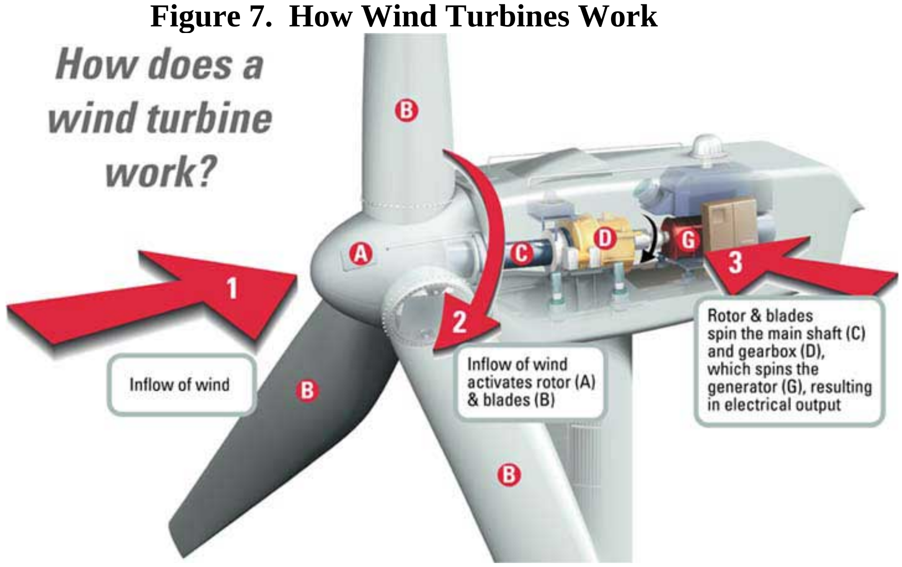
cells, batteries, wiring, invertors, tracking system, and other components also could be purchased from local companies.

## C. *Wind Energy*

### 1. How Wind Technology Works

Wind turbines create power when wind blows at high enough speeds to turn a rotor, which thereby spins a generator and produces electricity (Figure 7). Wind turbines can range in peak output capacity from about 1 kW to 5 MW, with turbines as large as 6 and 10 MW under development. Turbines can be used individually or in an array (wind farm) to produce as much power as desired. Wind power can be a central source, in the form of several multi-MW wind turbines, or a distributed source, consisting of single small or large turbines scattered on rural or urban property.

**Figure 7. How Wind Turbines Work**




Typical utility scale wind turbines are between 700 kW and 2.5 MW in capacity and occupy only a few square meters per turbine base. In an array of wind turbines, it is crucial to make sure that the turbines are spaced out enough that the rotors are not in danger of coming into contact with each other and that the turbines do not experience turbulence from nearby units. The standard spacing between turbines is about 4 times the rotor diameter in the direction parallel to the rotor plane and 10 times the rotor diameter in the direction perpendicular to the rotor plane. This guideline dictates the number of wind turbines that can be installed in a given area.

Standard residential wind turbines are between 1 and 10 kW in capacity and have an area requirement of only the space needed for the tower pole. Sometimes guy wires are used to hold up the tower, which extend diagonally away from the tower to the ground and increase the area needed. About one-fourth of an acre of land is recommended in order to install a wind turbine of this size. *Say why* However, it is technically possible to install a wind turbine on much less land if a strong monopole tower is used and if the tower is tall enough to put the turbine above the air turbulence created by trees and buildings on the ground.

One unique advantage of wind turbines over other types of power generators is that, even in the case of a wind farm that requires hundreds of acres of land area, the land can still be used for its original purpose. For example, farming can continue on land that is occupied by wind turbines with the sacrifice of only the area the tower pole requires.

## 2. Reliability Issues

Wind power technology today is very well tested and reliable, and is used by countries such as Denmark and Germany to provide up to about 20% of their electrical power generation. The only significant problem that still exists with converting wind into power is that wind speed is variable and unpredictable on a local basis and a short time frame. Wind variability prevents the turbines from generating a constant power output, which limits wind power to non-baseload power supply. PG&E currently uses wind power for only 1.3% of total power to northern

California.[51] Only when 10-20% of all power used in a region is generated by wind will the intermittent generation characteristic of wind energy become an issue.[52]

Despite the problems created by wind variability, several successful strategies exist for reducing its impact on wind turbines and on the grid. One low-tech, easily implemented way to mitigate the negative effects of varying wind speed is to install wind turbines in geographically diverse locations. If the wind is not blowing at one location, it is likely to be blowing at another, and so the net average of the power output is more likely to remain in the same range than the power output from one turbine alone. This concept is similar to that behind having diversified investments or a diverse stock portfolio.[53]

A more technical way to deal with the problem of wind variability and varying output is to store excess energy by either pumping water uphill into reservoirs or producing hydrogen. This stored energy can then be used at times when the demand for electricity is greater than the amount that the turbines are producing. These strategies all help to make wind power a robust energy source despite the impact of wind variability.

### 3. Where Wind Is Best Deployed

Small wind power systems are another renewable energy option for residential or small business use because they have minimal ground space requirements and can generate energy at low wind speeds (Class 2 wind resource).[54, 55] Siting suburban wind turbines must be done carefully to ensure the safety of people and property, and to ensure that the turbine performance

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[51] Pacific Gas & Electric, "PG&E's 2006 Electric Delivery Mix."

[52] Community Environmental Council, "*Santa Barbara County Renewable Energy Blueprint*," Chapter 3: Wind Power, August 2007.

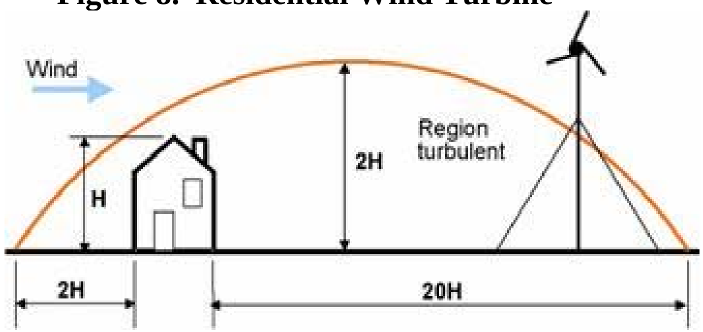
[53] A study published in the Journal of Geophysical Research found that it is viable to use geographic diversity to reduce variability of utility scale wind farms. Archer and Black, *Spatial and Temporal Distributions of U.S. Winds and Wind Power at 80m Derived from Measurements,* 2003. Stanford University.

[54] National Renewable Energy Laboratory, "Classes of Wind Power Density at 10 m and 50 m."

[55] Potential wind power sites are evaluated on the wind power density, measured in watts per square meter, which indicates how much energy can be generated at a given site. Wind power density is categorized into classes from 1 to 7, with Class 1 being the least powerful, and Class 7 being the most powerful. Wind speed generally increases with height above ground.

will be optimized. For example, wind turbines must be installed at high enough elevations that the air flow is not obstructed by houses or trees (Figure 8). Marin County is in the process of developing a wind code that is designed to facilitate installation of residential wind turbines.[56]

**Figure 8. Residential Wind Turbine**




Source: Segen Renewables

There are wind turbines currently being tested and audited for compliance by the British Wind Energy Association that are designed specifically for rooftop use in low wind, urban environments. As soon as the audits show the turbines to be useful, which should be within one or two years, Marin County could consider this option and develop wind codes that adapt with the development of the technology.

Large wind turbines are typically installed on farms or in other unobstructed windy areas, including the ocean, and require a wind resource of approximately Class 3 or higher. Many countries in Europe already use offshore wind power to obtain electricity including Denmark, Sweden, Holland, UK, and Ireland, with a total capacity of 587 MW.[57] Future projects are planned in many other locations, including Spain, USA, and Belgium.

As with small wind turbines, it is critical to power output from large wind turbines that the turbine rotor be mounted high enough to be in an area with smooth, undisturbed air flow.

[56] Marin County has an ordinance that governs wind energy installations, Title 22.32.180 of the Development Code. It is in the process of being revised. The current wind ordinance can be found online at http://municipalcodes.lexisnexis.com/codes/marincounty/.
[57] British Wind Energy Association, "Offshore Wind: Worldwide."

Wind turbines have a very small footprint compared to traditional fossil fuel power plants and, as mentioned previously, the land under the turbines can usually be utilized for other purposes while the turbines are in operation. Farmers have had a great interest in having turbines built on their property because they can continue to use the land for grazing or growing while at the same time making a profit from lease or royalty payments for a wind turbine.[58] The County could explore partnerships with private property owners, including farmers and the Marin Agricultural Land Trust, to promote the installation of wind turbines on their property.

Another important factor to consider when siting wind turbines is proximity to the electricity grid. Transmission lines are very expensive to install, ranging from around $175,000 per mile for low voltage lines to $5 million per mile for high voltage underground lines.[59] Because of this cost, it is desirable to install wind turbines near a grid connection with adequate capacity.

### 4. Typical Costs

The approximate cost, before rebates or tax incentives are taken into account, for residential wind turbines between 1 and 10 kW is $3 - $6 per watt installed.[60] The larger the turbine capacity, the lower the price per watt, making a 10 kW wind turbine generally cheaper per watt than a 1 kW turbine. State and federal rebates, incentives, and tax credits are available for wind generation systems that can bring down the net installed cost.[61] The National Renewable Energy Laboratory reports that incentives for small-scale wind projects can reduce

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[58] Community Environmental Council, *Energy Blueprint*, Chapter 2: wind power.

[59] Chester, Mikhail, R. Plevin, D. Rajapogal, D. Kammen, *Biopower and Waste Conversion Technologies for Santa Barbara County,* February 2007, report prepared by University of California, Berkeley for Community Environmental Council.

[60] Bergey, Mike, "Out of the Shadows: the Bright Future for Small Wind Power," presented at 2002 California Wind Energy Consortium Forum.

[61] Information on all current incentives, rebates and tax credits are available at the Database of State Incentives for Renewables & Efficiency (DSIRE), www.dsireusa.org

capital costs by $6/kW, between three percent and nine percent of capital costs.[62] Maintenance costs for residential wind turbines are minimal, since these turbines are designed to be hassle-free, and they have a lifetime of 20-30 years, depending on the manufacturer.[63]

Large scale wind turbines, with a capacity ranging from 50 kW up to several MW, can have a price as low as $1 per watt, assuming that more than one turbine is being installed for economies of scale and excluding the cost of power transmission lines to the site. Well-sited utility scale wind turbines can generate power that costs between 3 and 6 cents per kWh, not including tax credits.[64] By comparison, a new natural gas plant generates electricity at about 8 cents per kWh.[65] Finally, wind turbines have a lifetime of at least 20 years, and maintenance costs during that time average $0.01 per kWh.[66]

## 5. Opportunities within Marin County

Marin County has the potential to obtain about 450 MW of rated power from small, large, and offshore wind turbines in the County (see Table 5 below). This capacity translates into providing about 700 GWh/year of power. Additional wind resource exists within many parks and wilderness preserves in Marin County, but those regions are excluded from this study because of the improbability of installing wind turbines in those locations. Small turbines are projected to be able to contribute 11 rated MW, while large turbines could contribute 182 rated MW. Offshore turbines could add 260 MW of power.[67]

[62] Kandt, A., E. Brown, J. Dominick, T. Jurotich, *Making the Economic Case for Small-Scale Distributed Wind – A Screening for Distributed Generation Wind Opportunities*, June 2007, p. 3., NREL/CP-640-41897.
[63] Bergey Windpower, "Small Turbines for Homes and Businesses: Frequently Asked Questions."
[64] Wiser, Ryan, M. Bolinger, *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006*, May 2007, p. 11, prepared for the National Renewable Energy Laboratory.
[65] Community Environmental Council, *Energy Blueprint*..
[66] Danish Windpower Association, "Operation and Maintenance Costs for Wind Turbines," May 12, 2003.
[67] Please see Appendix E for details on calculations.

**Table 5. Summary of Wind Potential Estimates for Marin County**

| | Rated MW | GWh/yr |
|---|---|---|
| Small Wind | 11 | 20 |
| Large Wind | 182 | 280 |
| Offshore Wind | 260 | 400 |
| TOTAL | 453 | 700 |

a) ***Short term pilot projects, power output potential:***

Small wind turbines could be installed on any sites within the County that have ample land area and are located in a Class 2 or higher wind region. There are already coarse resolution wind maps to provide general wind data, however, a more fine scale analysis of the wind potential across the County would give a much better idea of localized micro-climate wind potentials.[68] Marin County could offer incentives to encourage residents and farmers to install turbines, or implement a program in which Marin County owns and installs the turbines on residents' property. The small wind capacity of 11 rated MW (20 GWh/year) referenced in Table 5 is based on a rough analysis that one percent of the residential properties in the County have the land and wind required for a 10 kW wind turbine. The County should consider installing a small wind turbine at any of its facilities with adequate wind to serve as a model. It is important to remember that small wind turbines are very low profile, quiet, and non-intrusive compared to utility scale systems, which makes them easy to install in a backyard, or in a park.

It is recommended that Marin County adopt building codes and policies that allow for the future use of rooftop wind turbines as they come online and prove effective. In the past, rooftop wind turbines have shown a high rate of property damage, mostly from vibrations caused by the turbine, but newer rooftop designs are dealing with these problems and have the potential to be excellent power producers. Several companies, including Quietrevolution, OY Windside, and

[68] The wind maps included in Appendix F of this report are for wind resource at 50 meters, which is much higher than residential wind turbines. Therefore, the maps in this report are not to be used for estimating small wind potential

Blue Green Pacific all have developed vertical axis wind turbines designed for urban environments with turbulent wind flows. Blue Green Pacific is a San Francisco based company that offers small turbines.[69] Marin County should continue to monitor how these companies' wind turbines perform and should install them on local buildings if they prove successful.

Large wind turbines onshore in Marin County have the potential to provide 182 rated MW[70] of power annually. Wind power is a well-proven technology, so there are no technological reasons to not start pilot projects immediately. The GIS maps for Marin County's wind resource will be able to provide a good starting point for specific siting of turbines, although a much finer resolution map will ultimately be needed[71]. Utility scale wind turbines require a Class 3 wind resource at minimum, while large residential turbines can potentially operate in a Class 2 wind resource.

Marin County also should undertake a public education campaign to gain support for wind power development. Giving people accurate knowledge on statistics about bird deaths, comparison of the "eyesore" and environmental effects of wind turbines compared to new fossil fuel power plants, and other such information could have a positive impact on public perspective. The California Energy Commission in September 2007 adopted "Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development." The new guidelines are intended to encourage the development of wind resources in California while mitigating impacts on bird and bat populations.[72]

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[69] "Taking Tiny Steps Toward Capturing The Power Of Wind: San Francisco Startup Offers Small Turbines As One Way To Offset The Cost Of Electricity," San Francisco Chronicle, June 24, 2007.
[70] Please see Appendix F for details on calculations.
[71] Please see Appendix F for GIS wind maps.
[72] California Energy Commission and California Department of Fish and Game, *California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development,*" p. E-1,2007, CEC-700-2007-008-CTF.

### b) ***Long term projects, power output potential***

The most basic long term project is to maximize the utility scale on-shore wind capacity. In addition, Marin County should begin to investigate the potential of installing off-shore wind turbines. Conservative calculations estimate that if wind turbines are installed on 2% of the ocean area, 260 MW (400 GWh/year) will result. Wind maps of Marin County show that coarse resolution velocity data indicated a high potential for offshore wind power in Marin County[73]. Studies concerning the marine environmental impact of an ocean wind turbine could be undertaken immediately and a partnership with the National Marine Sanctuaries could be established to ensure protection of ocean ecosystems and habitats. Offshore wind turbines are a well developed technology and there is already research being conducted on ways to anchor off-shore wind turbines in deep water, which will reduce the impact a turbine could have on the environment, as well as make it feasible to install wind turbines in waters deeper than 30 meters. Deep water installations can also ensure that turbines are far enough offshore that they are not visible from land and can utilize the higher winds often found further offshore.

Generally, distances greater than 50 nautical miles offshore are considered too far to be economically viable due to transmission line costs and difficulty of maintenance. Offshore distances between 0 and 5 nautical miles historically have also been excluded from wind installations due to the impact on coastal marine ecosystems and visibility issues. Depths greater than 30 meters are typically not feasible for offshore wind turbines, although technology improvements will likely allow an increase in the maximum depth for offshore wind in the future. Installing multiple turbines at one time is less expensive than installing each one at a time due to economies of scale in construction costs. Finally, it would be wise to combine an offshore

[73] Please see Appendix F for GIS wind maps.

wind project with a facility that generates electricity using ocean power so money could be saved by sharing use of sea-to-land transmission lines. (See section on ocean power.)

### 6. Greenhouse Gases Saved

Greenhouse gases that could be saved by using wind power to replace the current PG&E energy mix would total 370 million pounds per year of $CO_2$, 0.044 million pound per year of $SO_2$, and 0.28 million pounds of $NO_x$.[74] These values were found by taking the average of the high and low estimates for small wind, large wind, and offshore wind and adding the three average values.

### 7. Local economic benefits

As with any large project, jobs would be created from the project research, site inspections, and construction of wind turbines. Local construction companies could be used and materials could be purchased from local suppliers whenever possible. Also, because wind turbines are so visible compared to solar power or biomass facilities, Marin County may gain recognition as an environmentally progressive county.

### 8. Potential Barriers to Installation

#### a) Public Opposition

Public opposition is perhaps the most easily anticipated barrier to installing wind turbines in Marin County. Several high-potential wind projects have been slowed by opposing residents, such as the Cape Wind project in Massachusetts, which is making progress towards receiving its permit to install, but has had to overcome obstacles due to opposition. The major public concerns tend to be interruptions to the viewshed, sound pollution, and avian deaths. Education programs are useful in helping the public to understand differences between older wind technology that is noisy, poorly sited, and hazardous to birds, and new wind technology that is

[74] Please see Appendix D for details on calculations.

quiet and sited with much more careful intent. A report by the National Wind Coordinating Committee calculated that commercial scale wind turbines accounted for only 0.01% - 0.02% of all avian fatalities. Collisions with communication towers, buildings, vehicles, and power lines each individually account for more bird fatalities than wind turbines.[75] The National Audubon Society has also voiced its support for wind power saying that "as the threats of global warming loom ever larger, alternative energy sources like wind power are essential."[76] As noted above, the California Energy Commission in September 2007 adopted *Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development*. The new guidelines are intended to encourage the development of wind resources in California while mitigating impacts on bird and bat populations.[77]

Concern about sound pollution should diminish when residents experience how quiet the new turbines are during operation, and the changes to the view shed will have to be accepted with the mindset that seeing wind turbines is better than seeing the smoke stacks of a fossil fuel fired power plant. The presence of wind turbines signifies power being produced without pollution, and hopefully will eventually become as easily accepted as power lines.

#### b) ***Technical/environmental obstacles***

Transmission lines must connect the wind turbines to the grid, and they are costly to install if the wind turbine is in a remote location. This can also be a complicating factor for off-shore wind. In the case of off-shore wind, although it may not be possible to reduce transmission line cost drastically, the turbines can be made larger and have higher velocity, providing an uninterrupted wind resource that can yield a power output great enough to make the

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[75] National Wind Coordinating Committee, *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States*, National Wind Coordinating Committee Resource Document, August 2001.
[76] Testimony of Audubon Director of Conservation Policy before the Committee on Natural Resources Subcommittee on Fisheries, Wildlife and Oceans, May 2007.
[77] California Energy Commission and California Department of Fish and Game, *California Guidelines*.

installation costs worthwhile. Transmission lines can be bundled into a cable that is dropped on the ocean floor.

Another environmental obstacle is that offshore wind in Marin County will require turbines to be erected within National Marine Sanctuaries because all of Marin County's coastline is sanctuary. This is not an insurmountable issue, although it is a difficult one. The wind power industry must continue development of technologies to moor the turbines to the seabed in a minimally intrusive or non-intrusive manner if offshore wind power is to be used in Marin County. However, based on the wind maps in Appendix F, the offshore wind resource is tremendous. It should be emphasized that serious research is already well underway to develop techniques for deep-water offshore wind turbines, which would be beneficial in that they would be far enough off the coast that they would not be very visible, and they would not be fixed to the ocean floor, eliminating the environmental concern of ocean habitat damage.

### D. *Biomass and Biogas*

#### 1. How Biomass and Biogas Work

Biomass and biogas are both considered bioenergy, a category of renewable energy technology that uses waste that otherwise would go into landfills or decompose to the environment. Biomass works by destroying waste from agriculture, forest residues, and municipal wastes (i.e., landfills) in boiler-steam turbines. Biogas is the combustion of methane gas from landfills and agriculture, particularly dairy manure ponds.[78, 79] Destroying methane, which is a potent greenhouse gas, can be useful in achieving greenhouse gas reduction goals. A 2006 Executive Order establishes targets for California to increase the production and use of

[78] California Bioenergy Interagency Working Group, *Recommendations for a Bioenergy Plan for California*, April 2006, p. 13, publication CEC-600-2006-004-F.
[79] Organic-based materials may also be used as vehicular fuels, as in ethanol and biodiesel. A brief discussion of biofuels is provided in a following section.

bioenergy, including bio-diesel fuels made from renewable resources.[80] The Executive Order sets a target of 20 percent of state goals for renewable electricity resources from biomass between 2010 and 2020. A consortium of state agencies has been developing and implementing a Bioenergy Action Plan.

Biomass and biogas systems can range greatly in size and capacity based on what amount of feedstock is available to consume. They can be on the order of tens of kW to tens of MW. The space needed for a biomass system varies depending on the capacity, type of feedstock, and type of conversion used.

### 2. Reliability Issues

Biomass and biogas conversion processes are proven and reliable and provide a baseload power supply. This means these technologies can be operated and relied upon much like conventional fossil fueled or nuclear power plants, an advantage over wind or solar power.

### 3. Where Biomass and Biogas Are Best Used

An important factor to consider in siting a biomass or biogas generator is the transportation distances that will be required. It is ideal to install a biomass facility as close to its source fuel as possible in order to cut down on the costs and emissions from trucking fuel from the source to the generator facility. As with other renewable energy systems, biomass and biogas systems should be sited near existing power lines to avoid the high costs of installing new transmission lines.

Other factors that should be considered when siting a biomass or biogas facility are the local air quality regulations and the accessibility by existing roads. Building new access roads can disrupt local ecosystems as well as cause erosion, dust particulates, and additional air pollution due to construction machinery. Permits, including regional air and water quality

[80] Executive Order S-06-06, April 25, 2006.

permits to build a biogas generator, can be difficult to obtain. Marin County may want to work more closely with regional air and water regulators to overcome these challenges.

### 4. Typical Costs

Biomass and biogas conversion technologies produce electricity at a cost between that of solar and wind technologies. Fossil fuels are still cheaper than biomass, but if the entire life cycle and all externalities of biomass and fossil fuels are compared, including air pollution and the energy required to burn and transport the fuel, biomass is cheaper.[81] Biomass systems typically have a lifetime of about 20 years. Biomass conversion systems range dramatically in installation cost and maintenance cost, due to the diversity of possible feedstock, location, conversion process, size, capacity, construction materials, and emissions.

California has a number of programs in place for subsidizing biomass technologies. The CPUC Self-generation Incentive, the Federal Renewable Energy Production Incentive (REPI), Renewable Resources Trust Fund, Dairy Power Production Program, Supplemental Energy Payments (SEP), and the Rice Straw Tax Credit Program all currently provide rebates, incentives, or tax credits for installing biomass technology.

### 5. Biomass and Biogas Opportunities within Marin County

Marin County has the ability to harness several bioenergy sources including landfill gas, dairies, and municipal waste. A summary of the extraction potentials for these sources is presented in Table 6.

**Table 6. Summary of Bioenergy Potential in Marin County**

| | **Rated MW** | **GWh/yr** |
|---|---|---|
| Methane Capture or Biogas (landfill gas and dairies) | 6.5 | 49 |
| Biomass (municipal solid waste to fuel) | 7.0 - 16 | 52 - 120 |
| **TOTAL** | **13 – 22** | **100 – 170** |

[81] Community Environmental Council, *Energy Blueprint*, Chapter 5: Biopower and Waste Conversion Technologies.

Methane Capture (Biogas) Potential:

There are 29 dairies in Marin County that together house 16,000 cows.[82] Averages from analyses of methane digesters installed on dairy farms across California show that each cow produces approximately 2.5 kWh per day from its methane emissions, assuming that the gases are converted into energy rather than flared into the atmosphere.[83] This means that there are about 1.7 MW available to be utilized in Marin County from dairies alone. The Straus Family Creamery has already installed a methane digester[84] that has been very successful and could serve as an example for other dairies.

The Redwood Sanitary Landfill has indicated interest in installing a 4-5 MW landfill gas to energy project. The project would produce approximately 34 GWh/yr.[85] The County should work with the landfill to make sure that the plans are carried out and that rigorous emissions standards are followed. Wastewater treatment plants, another source for methane capture energy projects, should also be considered. Biogas facilities already exist at some local treatment plants including the Central Marin Sanitation Agency. However, wastewater treatment plant biogas energy potential estimates were not calculated as part of this report.

Biomass (Waste-to-Fuel):

Facilities may be built to accommodate all municipal solid waste in waste-to-energy processes. Based on statewide estimates from 1999 and 2004, the California Integrated Waste Management Board reports that Marin County produces 203,701 tons of paper and organic waste

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[82] Marin County, *Greenhouse Gas Reduction Plan*, 2006.
[83] California Energy Commission/Public Interest Energy Research reports on the Dairy Power Production Program: Straus (CEC-500-2005-114), Edenvale (CEC-500-2006-083), Van Ommering (CEC-500-2006-084), Koetsier (CEC-500-2006-085), Hilarides CEC-500-2006-086), Lourenco (CEC-500-2006-100).
[84] California Energy Commission, Dairy Power Production Program, *Dairy Methane Digester System 90-Day Evaluation Report: Blake's Landing (Straus) Dairy*, June 2005, CEC-500-2005-114.
[85] Waste Management, "Keeping Marin County Clean: Landfill Gas Collection," 2004.

per year. If used as fuel for biomass processes, that amount of waste could produce between 6.9 and 16 MW of capacity for the County, assuming a low conversion rate of 300 kWh/ton and a high rate of 700 kWh/ton.[86]

### 6. Greenhouse gases saved

The calculation of potential greenhouse gases saved from implementing biomass technologies is not straightforward. This is due to the fact that biomass produces emissions as it operates that must be taken into account to understand the net impact each biomass process has on greenhouse gas levels. The amount of emissions produced by a biomass conversion process depends on many factors, including the type of waste used as fuel and the purity of the waste material, the efficiency of the process itself, and the filters used to prevent pollutants from reaching the atmosphere. Because of the variation and complexity of these issues with each different biomass generator, it was not within the scope of this study to take generator emissions into account.

*Without* including the emissions produced by the biomass process, the greenhouse gases saved if landfill gas displaced PG&E's electricity energy mix would be 18 million pounds of $CO_2$, 0.0021 million pounds of $SO_2$, and 0.013 million pounds of $NO_x$.[87] Similarly, the greenhouse gases saved if other biomass displaced PG&E's electricity energy mix would be 54 million pounds of $CO_2$, 0.0064 million pounds of $SO_2$, 0.041 million pounds of $NO_x$.

### 7. Local economic benefits

Biomass and biogas power plants can stimulate local farms, reduce the volume of material in local landfills thereby reducing the rate at which the current landfills reach their maximum capacity, improve local air quality, create jobs, and reduce the dependence on out-of-county electricity. Local companies can also be supported by purchasing construction materials

[86] Please see Appendix G for details on calculations.
[87] Please see Appendix D for details on calculations.

locally and using local experts for technical support. Biomass and biogas resources are recognized as important to helping California achieve its renewable energy and greenhouse gas reduction goals, as evidenced by the Governor's Executive Order on Biomass.[88]

### 8. Technical Obstacles

Methane capture technologies for biogas are fairly well established and successfully deployed. A series of reports on installed dairy methane digesters in California, done by the California Energy Commission and its Public Interest Energy Research ("CEC/PIER") program, found that the digesters generate much more power than the dairies can use, so the farmers often flare the excess fuel rather than feeding it back into the grid as free power for the utility.[89] In some cases, as much as 40% of the fuel was being flared. This not only wastes fuel, but also reduces the amount of energy that could be produced by the generator, even though the system is perfectly capable of performing better. The six farm owners surveyed in the CEC/PIER study expressed satisfaction with most aspects of their methane digesters, but all expressed frustration with the lack of compensation provided to them for putting excess electricity onto the grid. As mentioned earlier in the report, the California Public Utilities Commission in July 2007 ordered PG&E and Southern California Edison to enter into contracts with small, renewable distributed generators (under 1.5 MW) such as biogas digesters to purchase excess electricity (CPUC Decision 07-07-027).

Waste-to-fuel technology for biomass has been used for decades and cleaner, more efficient technologies are currently in development and testing

### 9. Environmental obstacles

The impact of biomass and biogas technologies on air, water, and soil quality must be carefully assessed before undertaking a project. Different types of feedstock produce different

[88] Executive Order S-06-06, April 25, 2006.
[89] CEC/PIER Dairy Power Production Program reports, cited above.

byproducts, some mostly benign but others very toxic. Therefore, the type of feedstock and method of conversion should be well understood. Because of the potential emissions of the conversion processes, it can be difficult to obtain permits to proceed with projects. However, if done properly, the conversion process is safe and results in byproducts much less harmful than the inputs.

Biomass and biogas technologies are environmentally cleaner than using fossil fuels, but they still produce emissions and therefore are not an end-all solution to the problem of greenhouse gas pollution. For example, biogas technology can be used to obtain power from the gases that are produced inside a landfill or wastewater treatment plant that would otherwise be flared into the atmosphere, creating emissions without producing power. Also, some gases, such as methane, are much more damaging to the environment than the gases that are byproducts of the conversion process. The more harmful gases are transformed into less harmful ones while generating energy.[90] Biomass and biogas themselves are generally considered carbon neutral, although the operations for a biomass plant, such as transportation vehicles, emit carbon, too. Even so, the net carbon from these technologies is less than that from fossil fuel plants. In addition to carbon dioxide, many biomass processes emit gasses such as NOx, SOx, CH4, CO, hydrocarbons, heavy metals, and particulates. The levels that are emitted vary from plant to plant but are consistently much lower than emissions from fossil fuel plants and can be further reduced with filtering technologies.

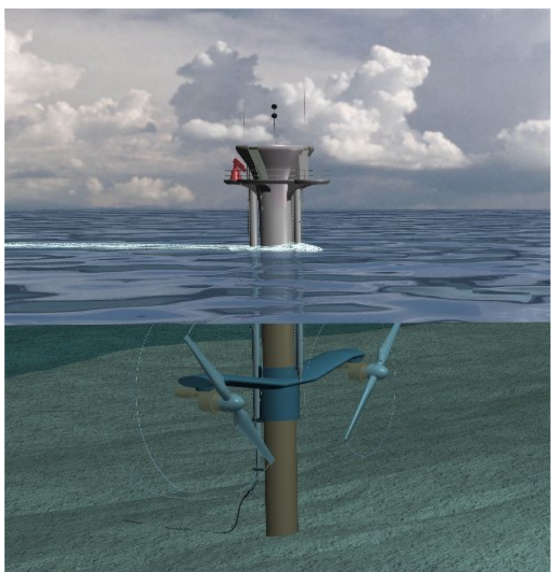
[90] California Bioenergy Working Group, *Recommendations for a Bioenergy Plan for California*, p.21.

## E. *Ocean Power*

### 1. How Ocean Power works

Ocean power is broken into the four subcategories of current, tidal, wave, and ocean thermal power. The distinction is important because each type of technology operates uniquely. **Current power** works like an underwater wind turbine anchored by tension legs or a monopile, using the ocean water flow to spin a turbine (Figure 9). Water off the coast of California only moves at about .03 to .07 meters per second. Given these speeds, ocean current power is probably not suitable for Marin County.

**Figure 9. Current and In-Stream Tidal Power Device**[91]

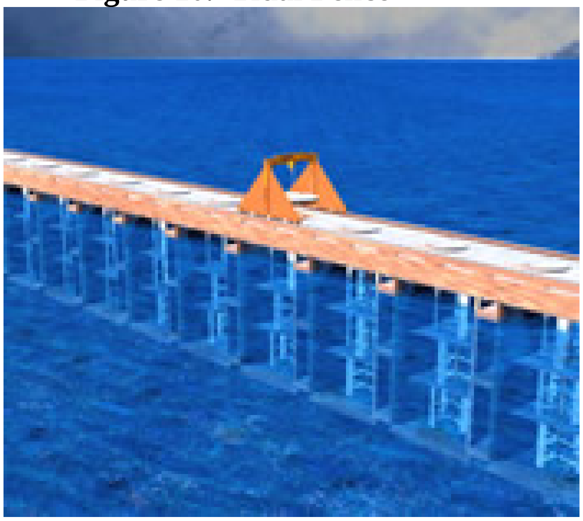


**Tidal power** systems come in two forms, barrage and in-stream. Barrage systems generate energy much like a small hydroelectric plant, trapping water at high tide and releasing it during low tide, when the water spins turbines as it cascades downhill. This older style of tidal power plant was nearly as environmentally intrusive as a hydroelectric plant because it required that a dam be built to hold water during high tide. However, modern in-stream tidal power

[91] An example of Marine Current Turbines device that could be used in either ocean current or in-stream tidal power projects.

plants are designed specifically to alleviate the environmental impact. Two examples of these concepts are called tidal fences (imagine a giant turnstile, similar to a revolving door, that stretches across a channel but does not retain the water – Figure 10) and tidal turbines (operates like a current power device – Figure 9). There is a 240 MW barrage system in France and a 20 MW barrage system in Canada which have both been operating since the 1980s. According to a study done by the Electronic Power Research Institute (EPRI), approximately 1-2 watts per square meter are available in the San Francisco Bay from tidal power. EPRI's preliminary report estimates that this could result in approximately 35 MW of extractable power.[92] Additional engineering analyses are being performed by the City of San Francisco and Pacific Gas & Electric to further assess the tidal power resource in the Bay and estimates of extractable power may change as a result.

**Figure 10. Tidal Fence**[93]



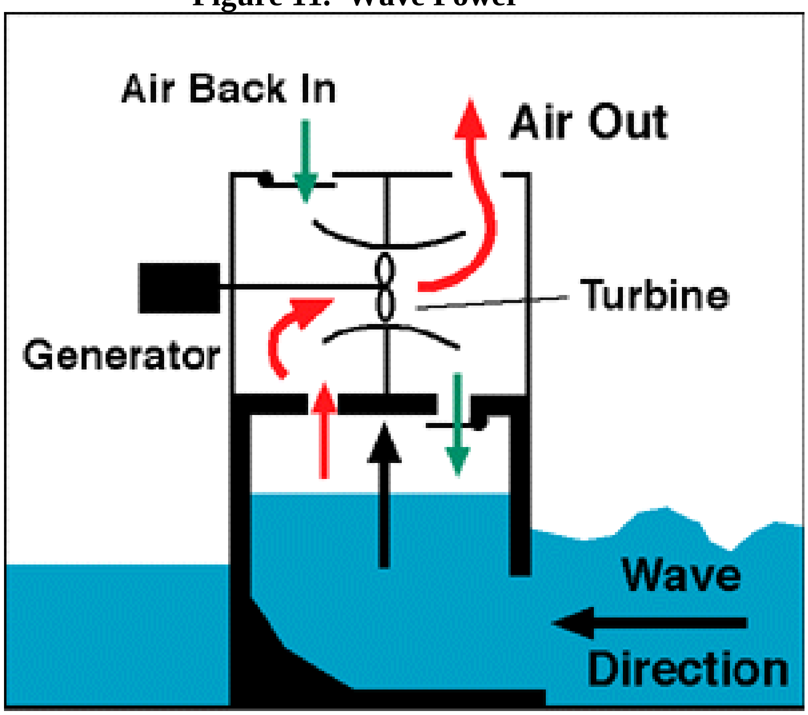
**Wave power** technologies capture energy from horizontal displacement, vertical displacements, or using an oscillating water column to cyclically compress air (Figure 11).

[92] Electric Power Research Group, Presentation on Ocean Energy Systems to the International Energy Agency, November 2005.
[93] Conceptual drawing of multiple tidal turbines linked together to form a tidal fence. Source: Bluenergy.

Wave buoys and reticulators capture wave energy from horizontal and vertical displacement by floating on the surface of the ocean and bobbing and swaying in the waves. Wave generators built into the shoreline utilize the wave surges as an oscillating water column to compress air cyclically.

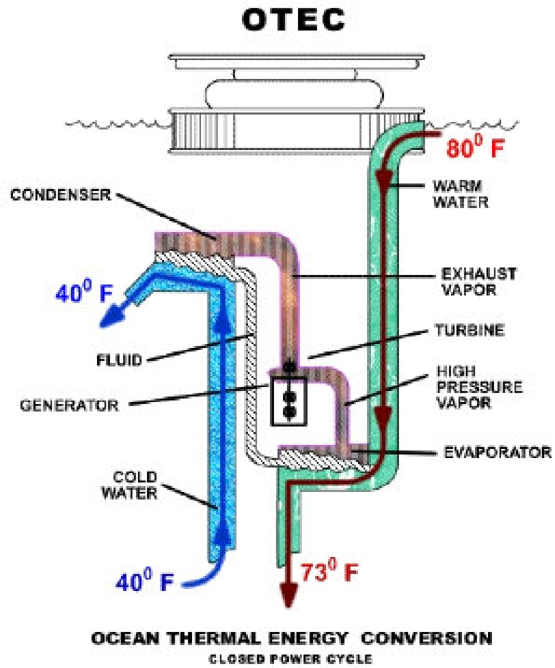
Wave power technologies use the waves to compress air or another working fluid, or use water falling from high to low, to turn a turbine in order to generate power. There are currently wave power plants being built in Scotland, Portugal, Australia, and the United States (Oregon), as well as many projects around the world that are in planning phases. Most of the wave power stations are small-scale commercial pilot projects of around 500 kW, but the wave power devices are suitable for scaling up the power plants to hundreds of MW.

**Figure 11. Wave Power**




**Ocean thermal** energy devices use approximately a 20 degree Celsius temperature difference in the water to convert a working fluid into gas, which, in turn, spins a turbine to generate electricity (Figure 12). These machines function similarly to any heat engine. There are several working facilities around the world, one of which is in Kona, Hawaii. Temperature gradients along the California coast are typically not large enough to use this type of technology.

**Figure12. Ocean Thermal Energy**




### 2. Ocean Power Opportunities within Marin County

The most feasible ocean power technology for Marin County, as described below, is wave power.

**Table 7. Wave Power Potential in Marin County**

| SUMMARY [94] | Rated MW (low-high) | GWh/yr (low - high) |
|---|---|---|
| Wave Power | 150 | 130 |

Based on wave data from research buoys near San Francisco and Monterey, Marin County is likely to have significant wave power potential.[95] A single wave plant could provide

[94] For details on how these numbers were calculated, please see Appendix H.

[95] Previsic, Mirko, et al., *System Level Design, Performance, and Costs for San Francisco Pelamis Offshore Wave Power Plant*, December 11, 2004, prepared for the Electric Power Research Institute, EPRI Report E2I EPRI Global – 006A – SF.

around 150 MW (130 GWh/year) of power.[96] Most wave power units can be used individually or strung together to scale the system up or down depending on local available resource. A wave plant of 150 MW capacity could require anywhere from 2 to 10 square miles, depending on the spacing necessary for devices and on the local wave resource. It is not recommended that Marin County pursue current power or ocean thermal power because the ocean current velocities are too slow and the thermal gradient is too small.

Although there are already a handful of successful ocean power plants installed in European waters and many pilot projects in progress, ocean power in general is not yet a mature field and it is recommended that Marin County refrain from ocean power installations until they are well-proven. A wise course of action is to ensure that ocean depths, average current velocities, average tide and wave frequency and heights are well-documented so that implementation steps can be taken quickly when ocean power technologies mature. Siting studies could also be initiated. Ocean power projects around the world should be tracked carefully to learn from their successes and mistakes. Within the decade, many projects that are in progress will have been completed and Marin County will be able to proceed with those projects as examples.

There are three ocean power feasibility studies underway in San Francisco. One is for tidal power, involving turbines deep underneath the Golden Gate Bridge that would generate power as the tides rush in and out of the San Francisco Bay. The other two are for two different types of wave power devices. The City and County of San Francisco has an application pending before the Federal Energy Regulatory Commission for a feasibility study of a tidal power installation. Marin County is supporting San Francisco's application, and, should it proceed, may wish to participate in the development of the project. Marin County should continue its

[96] Please see Appendix H for details on calculations.

involvement with that project to identify ways that energy from such a tidal power plant could be shared. PG&E is working with the City and County of San Francisco on a study of ocean power potential in San Francisco Bay. PG&E also is looking at ocean power potential off the coasts of Mendocino and Humboldt Counties.

In the future, ocean power technologies are expected to be much more proven and well-developed as alternative energy sources. A pilot ocean power facility could be installed within fifteen years, with larger scale installations following. An offshore ocean power facility should be combined with offshore wind projects to share transmission cable costs, because transmission cables are a significant percentage of the cost of both installations.

As with offshore wind power, despite the fact that many people view ocean power as a far-off energy option at best, there are many pilot ocean power devices that are already delivering electricity to cities in Scotland, France, Portugal, USA (Oahu, Atlantic City, and New York City), Ireland, and a handful of others. It is expected that today's research will bring ocean power to the point of economic feasibility in the next decade.

### 3. Greenhouse gases saved

Replacing PG&E's electricity energy mix with 150 MW of ocean power would save 70 million pounds of $CO_2$, 0.0083 million pounds of $SO_2$, and 0.053 million pounds of $NO_x$ per year. Ocean power technologies do not produce any emissions during operation.[97]

### 4. Typical Costs

Because so few ocean power plants exist, it is difficult to say what the costs are for installation and operation. There are many small scale pilot projects underway and many are successfully producing power already, but the price of installation, maintenance, operation, and cost of electricity are much higher for small scale projects than for utility scale. Also, each site is

[97] Please see Appendix D for details on calculations.

very different and poses unique challenges which alter the cost. Projected price per kWh for ocean power projects in development range from about 4.5 cents to 11.2 cents.[98] A company operating in Scotland sold ocean power to the grid for 7 cents per kwh in 2005,[99] and analyses done in 2004 for the pricing of an ocean power plant off the coast of San Francisco arrived at cost of electricity ranging from 9.2 – 11 cents per kWh.[100] The same analysis estimated the operations and maintenance costs for a utility scale wave power plant to be about 1.3 cents per kWh.

### 5. Local Economic Benefits

As mentioned earlier, there are economic and energy security benefits from locating an ocean power facility off of the coast of Marin County. Power generated within the County increases Marin's energy security and control over price fluctuations, if the County has an ownership share and/or access to power generated from the facility. Also, construction of a power facility could provide local jobs and could benefit local businesses if materials needed for construction were bought within County.

### 6. Technical or environmental obstacles

The largest obstacle to using ocean power to generate electricity is that any object placed in the ocean has an impact on the marine ecology. Therefore, siting, construction, and operation of ocean power facilities must be done with extreme care. The proposed site must be thoroughly studied in order to understand the ecosystems in the surrounding area. The utmost concern for seals, fish, corals, and all other marine creatures must be exercised. Precautions must be taken to ensure that the facility or device will not leak any hazardous materials into the water, and to ensure that marine life is not put at risk. One of the most challenging aspects of an offshore

[98]Community Environmental Council, *Energy Blueprint,* Chapter 7: Ocean Power.
[99] Community Environmental Council, *Energy Blueprint.*
[100] Previsic, *San Francisco Pelamis Offshore Wind* Plant, p. 5.; Previsic, Mirko, *System Level Design, Performance, and Costs – San Francisco California Energetech Offshore Wave Power Plant*, December 20, 2004, p. 5, EPRI Report E2I EPRI-006B-SF;

ocean power facility is how to anchor it to the seafloor so that it stays where it is supposed to, without causing any damage to the living creatures on the ocean floor. However, unlike utility scale wind power, most ocean power installations are not very visually intrusive, which makes them more acceptable to the public.

### F. *Transportation*

The transportation sector is responsible globally for 14% of greenhouse gas emissions. In the San Francisco Bay Area, however, the transportation sector contributes 50% of greenhouse gas emissions.[101] Controlling emissions from the transportation sector is challenging for several reasons, the primary of which is the vast number of sources and owners. Transportation patterns are strongly driven by local zoning and development policies. While this report does not address the question of how to reduce emissions from the transportation sector, it would be irresponsible to not recognize that the County's success in reducing its greenhouse gas footprint will require policies and action in the transportation sector, most likely working in conjunction with other regional, state, and national entities to develop solutions.

Prior to the development of any transportation strategy or policy aimed at integrating renewable fuels for transportation (and, thus, displacing conventional fossil fuels) in Marin County, the County should first focus on reducing aggregate fuel consumption. One thing the County could initiate on a local level is the development of a biofuels infrastructure for fleets and private vehicles in Marin. Initial research on this topic was conducted as part of the process of developing this report, and has been transmitted separately to County staff in rough draft form.

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[101] Presentation by Terese McMillan, Deputy Executive Director, Policy, Metropolitan Transportation Commission, to Women Energy Associates, May 15, 2007.

### G. *Energy Efficiency*

Government agencies in the United States spend $10 billion on energy. Energy can represent as much as 30% of a building's operating cost.[102] According to Flex Your Power, undertaking energy efficiency measures can reduce energy costs by $25,000 per year for every 50,000 square feet of office space.[103] Implementing energy efficiency measures – equipment and technology that use less energy, as well as behavioral shifts – has been shown to have positive effects on the comfort and attractiveness of interior spaces and produce better worker productivity and morale. Energy efficiency also can include examining building operation and maintenance to identify opportunities to replace equipment and alter practices so that the building uses less energy, a practice known as "retro-commissioning."

As noted in the introduction, California highly prioritizes energy efficiency, placing it first in the loading order for new electricity resources. Between 2006 and 2009 California's investor-owned utilities will spend about $2 billion on energy efficiency programs, at an average cost of $0.03018/kwh of electricity saved and $0.21255/therm of natural gas saved.[104] This money otherwise would go toward the purchase of electricity from power plants or the construction of power plants.

Included in the study of community choice aggregation being developed for the County by Navigant Consulting is a section on the energy efficiency potential in the County. That potential is expected to be significant, and the results from the energy efficiency section of the CCA study should be included in any further action the County takes to increase its energy independence. In particular, the County should look at a range of policy and financial incentives it can provide to create greater private sector investments in energy efficiency. For example, the

[102] Flex Your Power, "Best Practice Guide: Local Governments."
[103] Flex Your Power, "Best Practice Guide."
[104] CPUC Decision 05-09-043, Table 1.

County could condition any financing program on the property owner receiving and implementing an energy efficiency audit, as is being done in Santa Monica. Another option would be a requirement that before a property can be sold, it be upgraded to meet or exceed current energy and water efficiency standards.

## IV. Program Recommendation

Marin County should begin developing short-, medium-, and long-term plans to facilitate installation of more renewable energy resources within the County. In the short-term, the County should establish a power purchase agreement ("PPA") program. The County will need to identify private entities with which it can partner to provide financial and technical services, including a low-interest loan program, energy efficiency audits and implementation activities, and appropriate solar and small wind technologies. This program should be targeted at residential, small commercial, and large commercial property owners. Also in the short-term, the County should coordinate with operators of the County's landfill and water and wastewater treatment facilities to determine what is required for them to initiate or increase the amount of electricity they generate using biogas. The County also should consider developing incentives to facilitate development of a biofuels infrastructure for private and fleet automotive vehicles. Finally, the County should expand energy efficiency standards that exceed current state Title 24 standards, as well as consider adopting an ordinance that requires upgrade upon sale of a property. The County then should work with local building and planning departments to ensure that these energy efficiency requirements are maintained.

In the medium-term, the County should identify and facilitate development of larger scale wind and solar installations. The County will need to identify property owners and other stakeholders, including state and federal agencies and non-profit entities with property suitable for development. The County concurrently should further study options for funding larger scale renewable energy projects, such as a community power trust. A key consideration in developing larger scale projects should be providing opportunities for County residents to have opportunities to participate in the project, either by purchasing output from the facility or somehow contributing to it. The County should continue working to identify opportunities for projects within Marin County, as well as develop stronger relationships with state and university research programs that may be looking for opportunities to demonstrate innovative technologies.

In the long-term, the County should monitor technological developments and regulatory progress of various ocean technologies and rooftop wind technology, as well as off-shore wind potential.

# APPENDIX A
# CASE STUDIES

## Solar Santa Monica

The City of Santa Monica has a stated goal of becoming “energy self-sustaining” by 2020. A key step in achieving this goal is Solar Santa Monica, a program that is designed to simultaneously reduce demand for energy in the City and deploy more renewable energy. The Solar Santa Monica program will in a two-year pilot be first geared towards 50 residential and business “demonstration sites.” It is estimated that the typical residential application will be approximately 2 kW and cost about $15,000 to install. Most commercial applications would be much larger and have a fixed price of $6.86 per watt of delivered electricity.

Santa Monica offers four pre-designed packages. Two of these packages are focused mainly on efficiency. These packages are designed for apartment/condos, or for those who are not ready to make a large financial investment (packages are expected to cost around $1,000 or $2,000 respectively). The other two pre-designed packages are much more expensive (approximately $15,000 or $22,000 respectively), but the takeaway is a solar PV or thermal system.

### *PROGRAM ANALYSIS*

Solar Santa Monica uses **financial incentives, site specific evaluations, pre-designed packages, and demonstration projects** to encourage PV and Solar Hot Water.

#### Financial Incentives

Santa Monica residents and businesses that install photovoltaic systems are waived the cost of the permitting for PV and solar hot water. Santa Monica also encourages business owners to use Federal and State investment tax credits and accelerated depreciation options that help the economic return on investment.

Santa Monica has also taken the approach of partnering with local businesses to facilitate transactions (such as installation, and rebates/financing).

- Santa Monica issued an RFP to find a number of companies willing to do both the efficiency work and install solar panels. Bids were evaluated by in-house staff with the assistance of outside experts. These contractors will warranty their equipment and installation for 10 years.
- Santa Monica is also developing a group of preferred lenders, which will guarantee favorable financing to qualifying applicants and/or systems

### Site Specific Evaluations

Energy efficiency upgrades, while not as glamorous as a new PV or solar thermal systems, can be very inexpensive and offer competitive returns on investment with low initial investment. Santa Monica recognizes this fact and bundles energy efficiency with their other solar programs. This can average different payback periods for energy efficiency technologies, many of which have paybacks of less than 18 months, with renewable technologies. Under this program, before a building receives a finalized design for PV or thermal, staff assesses the appliances, building envelope, lighting, water, and HVAC. By reducing a building's load requirements the size, and therefore cost, of a system is reduced. Only after this step has been completed does the program assess roof-top solar potential.

The assessment for roof-top solar potential includes the orientation of the roof, available roof space, type of roof, current electrical usage (for PV) or current water usage (for Thermal).

### Pre-designed Packages

Santa Monica offers four fixed, pre-designed packages for homes (commercial sites are treated differently). The packages are:

- Solar Standard package
- Super Solar package
- Single family home/ condo package, and
- Apartment package

**Solar Standard Package**
Gross cost: $22,800
Discounted cost: $14,900
Typical savings over 5 years (current rates): $7,230
Simple rate of return on investment: 9.8%

This package begins with 2 kW PV system with design advisor and resident deciding on the best size for that particular home. Gross costs include the purchase of equipment plus the cost of expert installation. Discounted costs are calculated by subtracting state, city and utility rebates plus a $2,000 Federal income tax credit. Tax credits and rebates are estimated, as these areas are subject to considerable uncertainty pending specific system parameters.

**Super Solar Package**
Gross cost: $32,900
Discounted cost: $21,905

Typical savings over 5 years (current rates): $8,125
Simple rate of return on investment:  7.4%

(Assumes 5300 kWh/year saved at $.15/kWh, with 5% annual increase in electricity costs, plus 120 therms saved/year, at $2/therm, with 5% annual increase in gas rates)

This package is designed to ensure all efficiency improvements are completed, adds solar for electricity, and also puts an emphasis on heating water via a roof-top solar thermal system and an instantaneous hot water heater.  The package also recommends a high-efficiency (horizontal axis) clothes washer and dryer.

**Single Family Sample Package**
Total cost after utility and city incentives:  $2,100
Typical savings over 5 years (current rates):  $3,150
Simple rate of return on investment:  30%

Something of an energy-efficiency sample pack, this program is aimed at providing valuable return on investments while minimizing upfront costs.  The package focuses on appliances (such as low-flow showerheads, CFL lighting, pipe insulation, and a new refrigerator). Under this program, participants are essentially buying energy efficiency upgrades at a reduced cost. Additionally, the home is tested for building envelope leaks, which may point to further cost-effective measures not included in the package. This package is also designed to allow participants the option of "going solar" by purchasing shares of a community solar system.

**Apartments/Condos**
Total cost after incentives -- $925
Typical savings over 5 years (current rates) -- $1,620
Simple rate of return on investment:  20%

Similar to package above, yet slightly smaller due to typical size of participating dwelling.  Also allows purchase of shares in a community solar system.

## Demonstration Projects

Santa Monica will select 50 sites (both residential and commercial) during the first two years of the program to serve as Demonstration Sites.  Santa Monica will facilitate work at all these sites, and is assembling and managing a team of experts for the 50 demonstration buildings. In addition to actively participating in generating renewable energy, these sites have the added value of promoting all Solar Santa Monica programs. Additionally, this program will also help Santa Monica collect local, verifiable data to analyze the effectiveness and accuracy of various program aspects.

### Startup Funding

During the 2000-2001 energy crisis, Santa Monica collected surplus revenues through the utility fee assessed as part of its franchise agreement with the local utility. The City Council encumbered these funds -- $1 million -- for a future renewable energy project. This $1 million is covering staff time and outside consultants during the two-year demonstration phase. After the initial two years, the City will need to identify a new funding source, which could come from program operating costs and fees or from other sources to be identified.

# Alameda County's Energy Management Program

**Project Summary**

Since 1995, the County of Alameda has undertaken several large renewable energy projects, the largest of which is a rooftop solar photovoltaic on the County's Santa Rita Jail. At the time it was installed in 2002, the project integrated the largest rooftop solar photovoltaic system in the U.S. with energy efficiency upgrades and state-of-the-art energy management software. The County brought in both a solar energy company and an energy services vendor to design the project. Building upon a legacy of innovation in energy efficiency, Alameda County was able to access an array of financial incentives offered by state agencies and utilities. The County is able to reduce peak power consumption by 20% without any expenditure from its general fund. Annual energy savings from the solar system and new efficiency investments are estimated to be $190,000 at a minimum and may exceed $400,000 given recently approved retail electricity rate hikes.[105] This marriage between solar PV and intelligent energy efficiency provides public benefits to the community-at-large in the form of significant reductions in demand upon the grid in a region where existing transmission line constraints pose reliability challenges.

Alameda County financed the Santa Rita Jail project in large part through the California Energy Commission's low-interest loan program. The County has financed other large projects this way. The County often incorporates energy efficiency technology with its renewable energy projects.[106] Alameda County was an early participant in PG&E energy efficiency programs, enrolling in a program in the early 1990s that realized $3 million in savings over 10 years. The County established a policy of using those funds to establish a special revolving fund that helps finance energy projects. Interest from this revolving fund is directed to the County's General Fund.[107]

[105] Energy Services Coalition, Case Study. "Alameda County's Santa Rita Jail." See also, Alameda County, "County of Alameda, Santa Rita Jail Case Study," April 2002.
[106] Telephone interview with Matt Muniz, Energy Program Manager, County of Alameda, October 8, 2007.
[107] Muniz interview, October 8, 2007.

# Idaho Low-interest loan program

Since 1987, the Idaho Department of Water Resources has administered low-interest loan programs for energy efficiency projects, and for active solar, wind, geothermal, hydropower, and biomass energy projects. The interest rate is 4% with a 5-year repayment term. Loans are available for retrofit only, with the exception of some renewable resources.

Initial money for the revolving loan fund was $3 million from Idaho's petroleum violation escrow account (PVEA). The program funds more conservation projects than renewable energy projects. According to staff, the program usually is undersubscribed – funds allocated for loans are not fully drawn down every year. When renewable projects are funded through the loan program, it is usually photovoltaic projects.[108]

Residential customers may choose one of two loan options: the standard Residential Loan Program or the Home Performance with Energy Star program. Eligible energy efficiency improvements for residential customers under both programs include insulation, electric and gas heating upgrades, and water heating system improvements. The Home Performance with Energy Star loan program also provides funds for improvements to windows and air conditioning. The maximum residential loan amount is $15,000.

Non-residential customers may undertake projects to improve insulation, windows and doors, heating systems, building commissioning, or custom-designed projects. Specific energy-efficient agricultural equipment may also be eligible. The commercial and industrial loan has a minimum lending amount of $1,000, but loans for the agricultural and public sectors do not have a minimum loan amount.[109] The maximum loan amount for other sectors is $100,000.

**Eligible Efficiency Technologies:** Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, CHP/Cogeneration, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Windows, Motor-ASDs/VSDs, Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval

**Eligible Renewable/Other Technologies:** Solar Water Heat, Solar Space Heat, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Heat Pumps, CHP/Cogeneration

**Applicable Sectors:** Commercial, Residential, Schools, Local Government, State Government, Agricultural, Institutional, Hospitals

[108] Telephone interview with Renee Arellanes, Idaho Department of Water Resources, October 5, 2007.
[109] The Database of State Incentives for Renewables and Efficiency.

## Boulder, Colorado

Boulder, Colorado has adopted several municipal finance policies to help achieve climate change policy goals. One of the most interesting features of the Boulder programs is the establishment of a Renewable Energy Fund. Monies from this fund are steered towards renewable energy systems for low- and medium-income households, with a smaller amount used to offer rebates on city taxes for eligible solar system. Separately, the city has partnered with a local non-profit to offer energy audits at a reduced price.

**Renewable Energy Fund**

The Renewable Energy Fund is a portion of the City of Boulder's general unrestricted sales and use taxes collected on eligible solar system installations. A portion of the renewable energy fund will be used to provide rebates on installation of qualifying systems. The remainder of the renewable energy fund will be dedicated to rehabilitation or installation of renewable energy systems – especially focusing on low or moderate-income housing and site-based non-profit organizations.

The source of the seed money for the "Renewable Energy Fund" is a set-aside from sales and use taxes collected on solar system components and installation costs. Instead of waiving costs associated with renewable technology, Boulder is using the fees collected as a long-term development tool.

**Solar Rebate Program**

The Solar Rebate Program, implemented by ordinance, provides a partial sales and use tax rebate (approximately 15%) on qualified photovoltaic (PV) or solar thermal (Thermal) systems installed within the city of Boulder. The rebate is available to residents or businesses who install a PV or Thermal system in the city of Boulder. Rebates are based on city of Boulder tax paid on materials and/or permits.

**Renewable Energy Audits**

The County of Boulder and some participating cities have partnered with the Center for Resource Conservation to offer discounted energy audits. For residents of participating areas, costs range from $100-$250 (based on size); while for non-participating areas, costs range between $200-350.

**Program Funding**

When Boulder's carbon reduction program started in 2004, if was funded by a one-time appropriation of $100,000 from the City Manager's contingency fund for greenhouse gas and energy programs. This money allowed the city to determine what it needed to do to achieve its climate change goals. During 2005 and 2006, Boulder researched and debated how to fund its program over the longer term. In 2006, Boulder adopted a carbon charge that is assessed on electric utility customers by industrial sector, so that each sector is charged in proportion to what it will receive back in services from the program. The tax is collected by the local utility, Xcel Energy, which entered into a special arrangement with the City. The budget for the program from 2007 to 2012 ranges from $860,265 in 2007 to $1,342,000 in 2012.[110]

[110] Brouillard, Carolyn, and Van Pelt , Sarah, *A Community Takes Charge: Boulder's Carbon Tax*, February 2007.

# Aspen, Colorado

## Community Office for Energy Resources

The community of Aspen, Colorado, including County government, cities and towns, and local utilities, participate in the non-profit Community Office for Energy Resources (CORE). CORE was founded in 1994 to promote renewable energy, energy efficiency, and green buildings in western Colorado. CORE works with the utility companies to offer rebates and incentives for energy efficiency projects and renewable technology installations. CORE operate a program through which utility customers can enter into a loan with a local bank for solar hot water or photovoltaic equipment, and CORE will pay the interest on the loan. Alternatively the customer can just receive a rebate on the equipment.

CORE also operates a grant program, the Renewable Energy Mitigation Program, which since 2000 has given our $8 million to projects in the Aspen County area that help reduce greenhouse gas emissions, reduce energy consumption, or promote renewable energy and sustainable energy management. Grants are made on an annual cycle, by application from community groups.

The CORE program is managed on a budget of about $130,000 annually, with funds being provided by the sponsoring municipalities and utilities.[111]

[111] Information on the CORE program was found on the group's web site, www.aspencore.org, and by telephone interview with Gary Goodson, CORE staff, September 27, 2007.

# APPENDIX B:

# Resources For Further Research

Education Programs:

- **Solar Energy International** - A comprehensive education program specifically for understanding solar photovoltaic energy production. An easily adopted program that would serve to incite residential and commercial customer interest in solar energy.
  http://www.solarenergy.org/docs/SEIcatalog_07.pdf
- **US Department of Energy** - Energy Efficiency and Renewable Energy Education and Training. A comprehensive guide to energy program ideas. Programs could be easily adopted for use by Marin County.
  http://www1.eere.energy.gov/education/lesson_plans.html#higher
- **Texas State Energy Conservation Office** - While this curriculum focuses more on energy efficiency, many aspects are applicable to an education program for alternative energy generation.
  http://www.seco.cpa.state.tx.us/energy-ed_curriculum.htm

Performance Contracting:

- **Energy Services Coalition** - This resource details many complex issues surrounding performance contracting. It is a good resource for state and federal programs in contracting and is a resource for case studies.
  http://www.energyservicescoalition.org/resources/whatis.htm
- **Alliant Energy** - A comprehensive list of performance contractors and other pertinent information.
  http://www.alliantenergy.com/docs/groups/public/documents/pub/p014587.hcsp
- **US Department of Energy** - A detailed information database for energy performance contracting. Provides a list of approved contractors and case studies.
  http://www1.eere.energy.gov/femp/financing/superespcs.html

Low Interest Loans:

- **DSIRE –** Database for State Incentives for Renewables & efficiency. A list of municipal and utility programs offering low interest loans to residential and commercial customers for implementing alternative energy or energy efficiency.
  http://www.dsireusa.org
- **Oregon Energy Loan Program** - A detailed description of a low interest loan program specifically for alternative energy production.
  http://www.oregon.gov/ENERGY/LOANS/selphm.shtml
- **Brownfields Clean Up Revolving Fund Washington State** - While not a loan program for alternative energy, this revolving fund low interest loan example is

similar to a program that Marin County could use to provide low interest loans for alternative energy. http://cted.wa.gov/portal/alias__cted/lang__en/tabID__85/DesktopDefault.aspx?init

Bulk Purchasing:

- **Berkeley Lab and the Clean Energy Group** - Using Bulk Purchase Commitments to Foster Sustained Orderly Development and Commercialization of PV http://72.14.253.104/search?q=cache:BVtbTtOf-D4J:www.cleanenergyfunds.org/Innovative%2520Practices%2520Report/Bulk_Purchases.pdf+how+to+bulk+purchase+solar&hl=en&ct=clnk&cd=4&gl=us

Zero Interest Loans:

- **The Green Campus Loan Fund** - Harvard University's loan program that offers zero interest loans to qualified energy efficiency and alternative energy generation projects. Extensive case studies available on this site. http://www.greencampus.harvard.edu/gclf/
- **Harvard Resource Conservation Incentive Program 1993-1998** - This is the first effort from Harvard to use a revolving fund to provide zero interest loans. http://www.greencampus.harvard.edu/gclf/startup.php#RCIP
- **Western Massachusetts Electric** – Zero interest loan program of up to $75,000 to businesses for energy conservation projects. This could easily be adopted to use for alternative energy generation projects. http://www.wmeco.com/Business/SaveEnergy/EnergyEfficiencyPrograms/ZeroInterestLoan.aspx

Community Power Trust

- **Central Indiana Community Power Trust Inc**. While this program serves a purpose other than generating money for alternative energy, it provides a framework for consideration. http://72.14.253.104/search?q=cache:hzTTDwDhj_UJ:www.cipower.com/documents/library/ORU%2520Guidelines.pdf+community+power+trust&hl=en&ct=clnk&cd=6&gl=us

Public-Private Partnerships

- **Cooperative Community Energy** is a co-op in Marin County that assists businesses and residents to purchase alternative power equipment. http://www.cooperativecommunityenergy.com/co-op/index.html
- **U.S. Department of Transportation –** Public private partnerships information. http://www.fhwa.dot.gov/ppp/defined.htm#2

# APPENDIX C:

# References


Online:

Alternative Fuels Comparison Chart. (2005). (3.12.2007). www.communityfuels.com

Biofuels: An industry overview. (2007) First Research. (3.19.2007). www.firstresearch.com

Fuel Comparison Chart. (3.12.2007).
http://www.eere.energy.gov/afdc/pdfs/afv_info.pdf

McCarl, Bruce A. & Schneider, Uwe, A. Economic Potential for Biomass Based Fuels for Greenhouse Gas Emission Mitigation

McCormick, Robert. (2005) Beyond Diesel – Renewable Diesel. (3.12.2007). www.ctts.nrel.gov

Michigan Renewable Fuels Commission
http://www.renewablefuelscommission.org/

National Biodiesel Board
http://www.biodiesel.org

Renewable Energy Access
http://www.renewableenergyaccess.com/rea/news/story?id=42813

Subsidizing Big Oil. (3.22.2007)
http://www.ucsusa.org/clean_vehicles/fuel_economy/subsidizing-big-oil.html

Sauer, Amanda. (2005) Global Competitiveness in Fuel Economy and Greenhouse Gas Emission Standards for Vehicles. World Resources Institute

**Boulder**
http://www.bouldercolorado.gov

**SMUD**
http://www.smud.org/residential/saving/advantage/index.html

**California Energy Commission**
http://www.energy.ca.gov

**Department of Energy**
Zero Energy Homes Program
http://www.eere.energy.gov/buildings/info/documents/pdfs/35317.pdf

Marin County solar map and rooftop area study:
http://www.votesolar.org/resources/downloads/tools_Marin_GIS_Case_Study.pdf

eGRID excel file:
http://www.epa.gov/cleanenergy/egrid/index.htm

CEC/PIER dairy farm reports
http://www.energy.ca.gov/2006publications/CEC-500-2006-083/CEC-500-2006-083.PDF
http://www.energy.ca.gov/2006publications/CEC-500-2006-086/CEC-500-2006-086.PDF
http://www.energy.ca.gov/2006publications/CEC-500-2006-085/CEC-500-2006-085.PDF
http://www.energy.ca.gov/2006publications/CEC-500-2006-084/CEC-500-2006-084.PDF
http://www.energy.ca.gov/2006publications/CEC-500-2006-100/CEC-500-2006-100.PDF
http://www.energy.ca.gov/2005publications/CEC-500-2005-114/CEC-500-2005-114.PDF

Marin county crop report 2004:
http://www.co.marin.ca.us/depts/AG/Main/2004cropreport.pdf

CIWMB website:
http://www.ciwmb.ca.gov/Profiles/County/CoProfile1.asp

NREL offshore wind report:
http://www.nrel.gov/docs/fy04osti/36313.pdf

TrueWind Solutions wind maps:
http://www.awstruewind.com/inner/windmaps/California.htm

Green Energy Ohio:
http://www.greenenergyohio.org/page.cfm?pageID=1326

NREL wind class:
http://rredc.nrel.gov/wind/pubs/atlas/tables/A-8T.html

EPRI San Francisco reports (pelamis, energetech OWC):
http://www.epri.com/oceanenergy/attachments/wave/reports/006_San_Francisco_Pelamis_Conceptual_Design_12-11-04.pdf

http://www.epri.com/oceanenergy/attachments/wave/reports/006_San_Francisco_Energetech_Conceptual_Design_RB_12-20-04.pdf

http://www.ndbc.noaa.gov/ wave buoy data
http://www.awea.org/ American wind energy association
http://rredc.nrel.gov general renewable energy info
http://www.quietrevolution.co.uk/engineers.htm new rooftop low wind option
http://www.stanford.edu/group/efmh/winds/2002JD002076.pdf Jacobson and Archer
http://www.bwea.com/offshore/worldwide.html list of offshore projects
http://www.windpower.org/en/tour/econ/oandm.htm o & m
http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2004/05/14/BAGJG6LG3R15.DTL Straus Dairy
http://cemarin.ucdavis.edu/Agriculture_and_Natural_Resources123/Dairies.htm biomass

**Technology Section:**

WRITTEN REFERENCES

Brouillard, Carolyn, & Van Pelt, Sarah. (2007), "A Community Takes Charge: Boulder's Carbon Tax"

"City of Santa Monica Solar Energy Resource, Co-Generation, and Energy Efficiency Program Development", 2003

Community Environmental Council, Santa Barbara County Renewable Energy Blueprint, August 2007.

Green Energy Ohio, "Bowling Green Wind Power Assessment," 2001

Marin County Community Development Agency, "Marin County Greenhouse Gas Reduction Plan," October 2006

Miller, Fletcher, "Winds of Change: Wind Power for the 21st Century," Green Energy Ohio, Presentation to the American Society of Mechanical Engineers at Case Western Reserve University, October 20, 2005

Previsic, Mirko, "Overview of Wave and Tidal Energy", Electronics Power Research Institute, 2007

Simons, George , and Joe McCabe, "California Solar Resources" for the California Energy Commission, 2005 (CEC-500-2005-072-D)

# APPENDIX D:

# CALCULATION OF GREENHOUSE GAS EMISSIONS

The pounds per megawatt hour of $NO_x$, $SO_2$, and $CO_2$ that are emitted by electricity production in northern California were calculated based on the Environmental Protection Agency's eGRID data from 2004[112] and PG&E's energy mix. The eGRID dataset contains the actual emissions data from natural gas and coal power plants in the United States. The $NO_x$, $SO_2$, and $CO_2$ emissions in pounds of gas per MWh of power production from California coal plants and natural gas plants were separately averaged to obtain the values summarized in the Table D.1. PG&E's energy mix[113] includes 40% of power from natural gas power plants and 1% of power from coal power plants. The rest of the power comes from nuclear, large hydroelectric, and renewables. The final values for calculating greenhouse gases saved by implementing renewable energy sources was found by weighting the emissions values based on how much natural gas or coal is used in PG&E's energy mix.

**Table D.1. Greenhouse Gas Emissions (lbs/MWh)[114]**

| EMISSION TYPE | CA NATURAL GAS PLANT | CA COAL PLANT | EMISSIONS WEIGHTED FOR PG&E ENERGY MIX |
|---|---|---|---|
| **$CO_2$** | **1,300** | **2,200** | **530** |
| **$SO_2$** | **0.039** | **4.8** | **0.063** |
| **$NO_X$** | **0.99** | **0.77** | **0.40** |

To calculate the greenhouse gases saved, the MWh per year values for each renewable technology were multiplied by the pounds of gas emitted per MWh of electricity produced (530, 0.063, or 0.40 for $CO_2$, $SO_2$, and $NO_x$, respectively). The greenhouse gases saved by implementing alternative energy sources are summarized in Table D.2.

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[112] "The Emissions & Generation Resource Integrated Database for 2006 (eGRID2006)," U.S. Environmental Protection Agency. www.epa.gov/cleanenergy/egrid/index.htm

[113] Pacific Gas & Electric 2006 Electric Power Mix Delivered to Retail Customers, http://www.pge.com/education_training/about_energy/how_electric_system_works/2006_energy_mix.html

[114] California coal and natural gas power plant emissions were averaged to obtain average plant emissions for each technology. PG&E's mix of 40% natural gas and 1% coal was used to obtain emission estimates for PG&E's specific energy mix.

**Table D.2. Estimated Greenhouse Gas Savings per Renewable Energy Type (Millions of lbs per year)**

| | $CO_2$ | $SO_2$ | $NO_X$ | ENERGY TYPE DISPLACED |
|---|---|---|---|---|
| SOLAR 100% PV* | 170 | 0.019 | 0.13 | PG&E MIX |
| SOLAR 100% THERMAL[115] | 250 | 0.0076 | 0.19 | NATURAL GAS |
| WIND | 320 | 0.038 | 0.24 | PG&E MIX |
| BIOMASS[116] | 18 | 0.0021 | 0.013 | PG&E MIX |
| OCEAN | 70 | 0.0083 | 0.053 | PG&E MIX |

It is important to note that these are not the only greenhouse gases emitted by burning natural gas or coal, however, these gases are emitted in high quantities and represent a large portion of greenhouse gases. Methane, for example, is more harmful for the environment than the three gases listed here, but it is released in a smaller quantity.

[115] 100% solar PV and thermal scenarios are mutually exclusive: cannot have both at the same time.
[116] These numbers do not include any emissions created by the biomass conversion process itself.

# APPENDIX E:

# CALCULATION OF SOLAR POTENTIAL

The available rooftop area of residential and commercial/industrial buildings that is accessible for solar power was estimated by the County of Marin at 29.2 million square feet. It is assumed that there is not any land area suitable for a utility-scale solar farm. The available square footage was reduced by 25% to account for installation limitations such as roof obstructions and localized shading (reduction factor of 0.75). It should be noted that the amount of rooftop area, for either solar photovoltaic or solar thermal panels, is finite. If a given area is calculated as being used for solar photovoltaics, it cannot also be used for solar thermal. Calculations were carried out for three scenarios:

a) 100% solar photovoltaic panels

b) 100% solar thermal panels

c) A combination of solar thermal panels for residential hot water heating and photovoltaic panels in remaining rooftop area

**A) 100% Solar Photovoltaic**

The power per area for solar photovoltaic panels installed is estimated at 10 Watts per square foot. The conversion factor for changing the electricity from direct current to alternating current was assumed to be 82% in previous studies done by the County of Marin and will also be used in this analysis. This value means that only 82% of the power generated in DC is collected after conversion to AC. The capacity factor, which is a value accounting for the percentage of the time that electricity is actually being produced by the panels, is estimated to range between 18% and 22%, which is a range that has been demonstrated by many installed solar power systems. For this analysis a value of 20% was used.

To calculate the potential rated capacity for Marin County, the total area available was multiplied by the reduction factor for area (0.75) and the power per square foot of 10 Watts[117] to yield 220 MW of solar photovoltaic power. To find the number of GWh, 220 MW was multiplied by the power conversion reduction factor (0.82), the capacity factor (0.20), 8760 (hours in a year), and then divided by 1000 to give a range of 316 GWh per year.

$$29.2 million\ ft^2{}_{AvailArea} * \frac{10Watt}{ft^2} * 0.75_{Area\,ReductionFactor} = 220MW_{Rated}$$

$$220MW_{Rated} * 0.82_{AC/DC\,ConversionFactor} * 0.20_{CapacityFactor} * \frac{8760Hr}{Yr} * \frac{1GW}{1000MW} = 316GWh/yr$$

$$200MW_{Rated} * 0.82_{AC/DC\,ConversionFactor} * 0.20_{CapacityFactor} = 36MW_{Actual}$$

[117] 10 W/ft$^2$ is the average power per area that can be obtained with typical silicon solar cells used for residential systems as has been demonstrated by numerous solar installations.

**B) 100% Solar Thermal Hot Water**

It was assumed that the demand for heated water in Marin County is higher than the amount of heated water that could be delivered with solar thermal panels if units were installed on all of the available rooftop areas.[118] In this scenario, no solar photovoltaic panels are used because solar thermal panels are assumed to be occupying all available space. It was also assumed, based on empirical data from the Sunlight and Power website, that 64 square feet of solar thermal panels can heat about 80% of the hot water demanded by an average residence. The hot water demand was assumed to be 80 gallons of water per day, based on a study conducted at Lawrence Berkeley National Laboratory.[119] The same study used an input water temperature of 14 C (about 60 F) and a heater thermostat temperature of 54 C (about 130 F), yielding a temperature change of 40 C. However, because a typical hot shower is around 110 F, a temperature change of 50 F (110 F – 60 F) was used for calculations.

To calculate the rated potential for solar thermal water heating in Marin County, the total available area was multiplied by the area reduction factor (0.75) and divided by 64 square feet per unit to find the number of units that could be installed. That value was then multiplied by 80 gallons per day and by an 80% efficiency, a value typically used in industry to estimate solar thermal performance, to give the number of gallons that could be heated each day with solar thermal panels. The power required to heat that amount of water was then calculated by converting the gallons of water to pounds and multiplying the pounds of water by the temperature change of 50 F, then multiplying by 365 days per year, the capacity factor (0.20) and dividing by 100,000 BTU per therm to obtain a value of 6.7 million therms per year.

$$29.2 million\ ft^2{}_{AvailArea} * 0.75_{Area\,ReductionFactor} * \frac{1unit}{64\,ft^2} * \frac{80gal}{unit/day} * 0.80_{EfficiencyFactor} = 2.2 million \frac{gal}{day}$$

$$2.2 million \frac{gal}{day} * \frac{8.34\,lb}{gal} * (110^\circ F - 60^\circ F) * \frac{365days}{yr} * \frac{1therm}{10^5\,BTU} * 0.20_{CapacityFactor} = 6.7 million \frac{therm}{yr}$$

**C) Combination Solar Thermal For Residential Hot Water, Solar Photovoltaic In Remaining Area**

The number of residences in Marin County was estimated from the California Integrated Waste Management Board 2004 database as 71,998 single-family units and 30,699 multifamily units. The number of families residing in a multifamily unit was not specified, so it was assumed that multifamily means two families and hence two units. This assumption causes the calculation to err on the conservative side because most multifamily units probably have four or more families in residence. It was assumed that

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[118] This includes water used by commercial, industrial, and residential needs, as well as any other heated water use in the county. Estimates based on the number of residences in Marin County and their average hot water consumption support this assumption even before including non-residential consumption.

[119] Lutz, James, *Estimating Energy and Water Losses in Residential Hot Water Distribution Systems*, 2005, Paper LBNL '57199.

each family uses 80 gallons of hot water per day (160 gallons for multifamily residences) and 64 square feet of solar thermal panels are able to heat 80% of the hot water used (128 square feet for a multifamily unit).[120] The other factors assumed are the same as in Scenarios A and B.

The area needed to heat residential water with solar power was estimated by multiplying the number of families (remember that multifamily units are assumed to be two families) by 64 square feet and dividing by the area reduction factor of 0.75. It could be argued that the area reduction factor is not necessary for this case since the 64 square feet is the literal area required by the panels, but it is included because it deals with rooftop obstructions and shading.

From this point, the method of Scenario B was used to calculate how much energy is required to heat the water used by residences, while the method of Scenario A was used to calculate the potential photovoltaic capacity after subtracting out the rooftop area required for residential solar thermal heating. This resulted in a rated capacity of 130 MW of photovoltaic power. Multiplying by appropriate reduction factors, as was shown for Scenario A and B, and the number of hours per year yields 190 GWh and 3.5 million therms per year, respectively.

Solar Thermal Portion

$$1.33E5\ families * \frac{64\ ft^2}{family} * \frac{1}{0.75_{area.reduction.fctr}} = 11.4E6\ ft^2_{\substack{to\ heat\\ resid.\\ hot\ water}}$$

$$11.4E6\ ft^2_{\substack{to\ heat\\ resid.\\ hot\ water}} * \frac{1\ unit}{64\ ft^2} * \frac{80 gal}{unit \cdot day} * 0.80_{effncy.fctr} * \frac{8.34 lb}{gal} * \left(110°F - 60°F\right) * \frac{365 days}{yr} * \frac{1 therm}{10^5 BTU} * 0.20_{capacity.fctr} = 3.5 Million\ Therms / yr$$

Solar PV Portion

$$\left(11.8E6\ ft^2_{nonres.roof} + 17.4E6\ ft^2_{res.roof} - 11.4E6\ ft^2_{\substack{to\ heat\\ resid.\\ hot\ water}}\right) * 10\frac{W}{ft^2} * 0.75_{area.reduction.fctr} = 130 MW_{Rated}$$

$$130 MW_{Rated} * 0.82_{ACDC.conv.fctr} * 0.20_{capacity.fctr} * 8760\frac{hr}{yr} * \frac{1 GW}{1000 MW} = 190\frac{GWh}{yr}$$

$$130 MW_{Rated} * 0.82_{ACDC.conv.fctr} * 0.20_{capacity.fctr} = 21 MW_{Actual}$$

[120] Sun Light and Power, "Solar Hot Water."

# APPENDIX F:

# CALCULATION OF WIND POWER POTENTIAL

Wind power potential was calculated separately for small, large, and offshore wind technologies because the wind resource required and the plausible locations are different for each type. For all scales of wind power, the capacity factor was assumed to be 22%[121] and an AC/DC conversion factor of 80%[122] was used. The capacity factor of wind turbines depends greatly on the individual site, but 22% is on the low end of average values for what has been shown in operation of wind turbines. Also, not all turbines use an AC/DC conversion (they produce AC power in the first place instead of producing DC), but it was included in this study to err on the conservative side and account for power conditioning. Lastly, no array efficiency reduction factor was used because it is anticipated that wind turbines in Marin County will be installed individually or in small clusters rather than large farms.

*Small Wind Capacity*

Small wind generation capability was estimated by assuming that each local government (there are 12 in Marin County), each dairy farm (there are about 29 in Marin County), and 1% of residential buildings would all install one 10-kW wind turbine. Multiplying this resulted in 11 MW of rated power. Taking into account the reduction factors above and converting into power per time resulted in 20 GWh/year. Small wind turbines require a Class 2 or higher wind resource, which exists in Marin County, but site-specific wind measurements should be taken before installing turbines to make sure there is enough wind. The wind maps used in this study are not applicable for small wind power because the wind maps represent wind speeds at 50 meters (164 feet), which is much higher than the hub-height of small turbines.

$$(12_{\substack{government \\ buildings}} + 29_{dairies} + (120,700_{\substack{residential \\ buildings}} * 1\%)) * 10kW_{\substack{system \\ size}} * \frac{1M}{1000kW} = 11MW_{Rated}$$

$$11MW_{Rated} * 0.80_{\substack{ACDC \\ CapacityFactor}} * 0.22_{CapacityFactor} * \frac{8760hr}{yr} * \frac{1GW}{1000MW} = 20GWh/yr$$

$$11MW_{Rated} * 0.80_{\substack{ACDC \\ CapacityFactor}} * 0.22_{CapacityFactor} = 2MW_{Actual}$$

*Large Wind Capacity*

Large wind potential for Marin County was estimated using GIS mapping software to overlay wind resource data on a map of the County, filter out the urban regions, airports, military land, and parks and wilderness preserves (spaces where wind turbines historically have not been installed) (Figure F.1). There are 364 parcels of land identified in a Class 2 or higher wind resource area that are 60 acres or larger. It was

[121] American Wind Energy Association, "Wind Energy Basics."
[122] Iowa Energy Center, "Wind Energy Manual," 2006.

assumed that each of these parcels of land would install 2 wind turbines of 250 kW rated capacity.

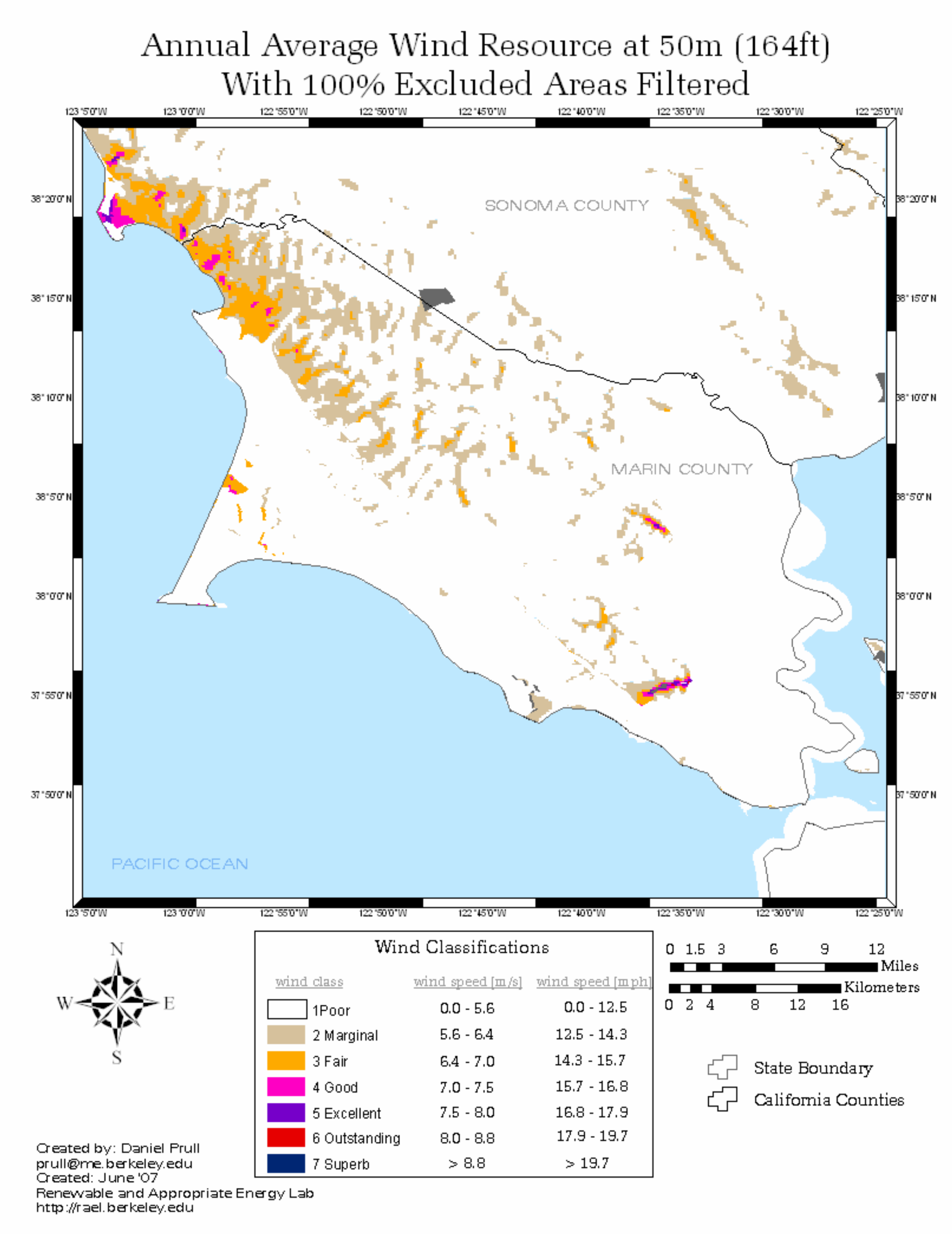
In order to calculate the available GWh per year available from this resource, 364 parcels was multiplied by 0.25 MW per turbine and 2 turbines per parcel to give a total of 182 rated MW.  This value was then multiplied by the capacity factor of 22%, the power conversion factor of 80%, and 8769 hours per year, and divided by 1000 to obtain 280 GWh capacity annually for large wind power.

$$364_{qualifying.parcels} * 0.25_{MW/turbine} * 2_{turbines/parcel} = 182MW_{Rated}$$

$$182MW * 0.80_{ACDC.conv.fctr} * 0.22_{capacity.fctr} * 8760\frac{hr}{yr} * \frac{1GW}{1000MW} = 280\frac{GWh}{yr}$$

$$280\frac{GWh}{yr} * 0.80_{ACDC.conv.fctr} * 0.22_{capacity.fctr} = 32MW_{Actual}$$

**Figure F.1. Average Marin Wind Resource at 50 meters with urban areas, airports, and other excluded zones filtered out. The remaining orange, pink, and purple areas are feasible for utility scale wind turbines**.

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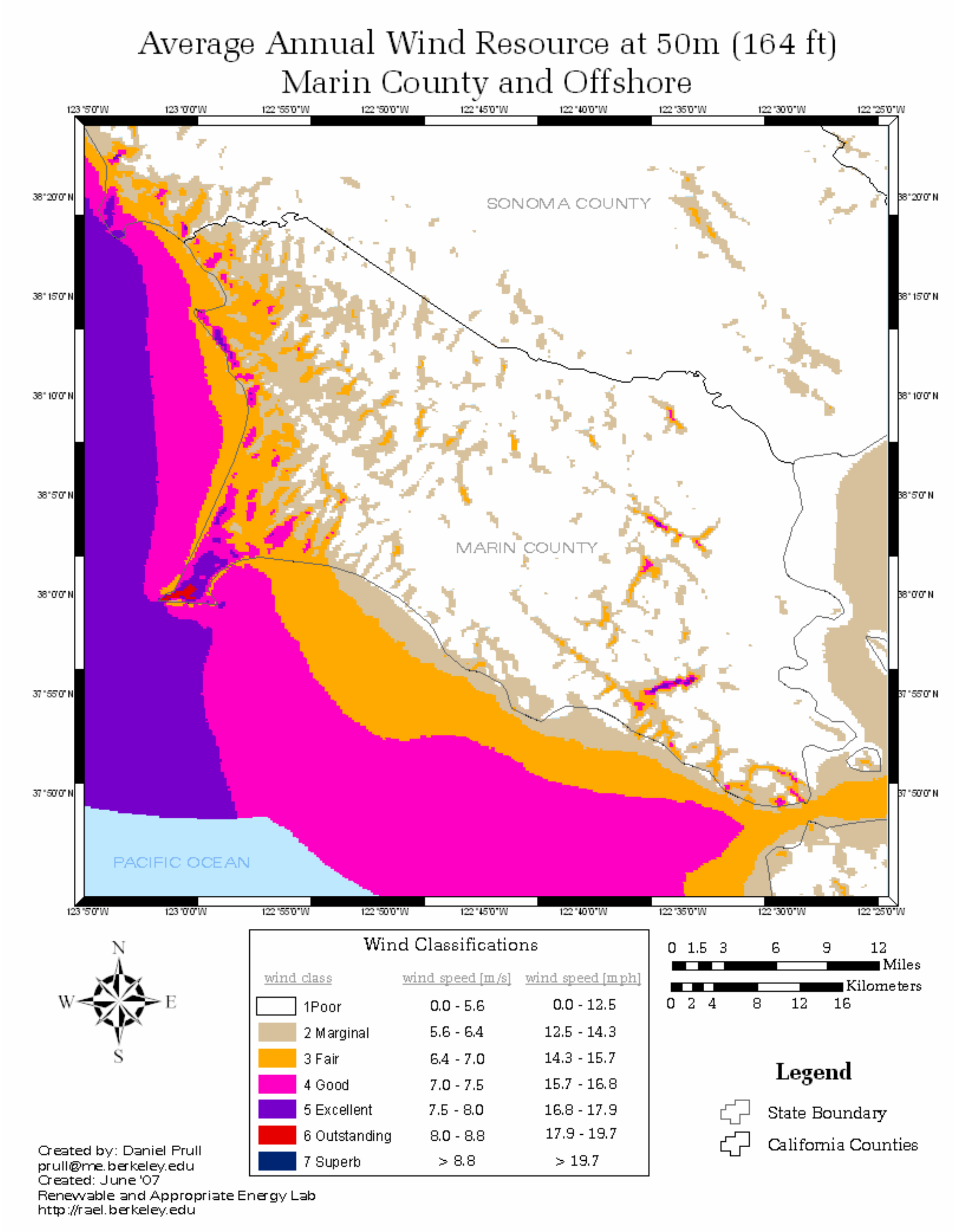
*Offshore Wind Capacity*

Using GIS maps of Marin County with the wind resource overlaid, it was estimated that the ocean surface area off of Marin County that is feasible for wind farms in terms of wind resource and distance from the shore is about 500 square miles. No sites beyond 50 nautical miles offshore are considered feasible due to excessive costs of underwater transmission lines. Also, the present depth limit for easy implementation of offshore wind is 30 meters. Overlaying bathymetry data on the GIS map of Marin County and wind resource shows that the ocean area that is 30 meters deep or less is relatively very small (Figure F.2).

**Figure F.2. Marin Wind Resource Potential at 50 meters, Including Offshore wind resource and Bathymetry.**




In order to perform calculations that result in a power estimate, an assumption must be made about how many square miles will be used for wind power. Because it is out of the scope of this study to do a detailed analysis of the exact area that lies within 50 nautical miles off the shore (but also not too close to the shore), has a high enough wind class, and is less than 30 meters deep, a conservative range of 2% of the 500 square miles was assumed to be available in order to be able to make order-of-magnitude capacity estimates. The power per area was assumed to be 26 MW per square mile, which is based on the power per area of several offshore installations in Europe.[123] Multiplying an area of 10 square miles by 26 MW gives a capacity range of 260 MW. Multiplying by the capacity factor of 22%, the power conversion factor of 80%, 8760 days per year, and dividing by 1,000 yields a power output of 400 GWh per year:

$$500 miles^2 * 2\% * \frac{26 MW}{mile^2} = 260 MW_{Rated}$$

$$260 MW_{Rated} * 0.80_{\substack{ACDC \\ ConvFactor}} * 0.22_{\substack{Capacity \\ Factor}} * \frac{8760 hr}{yr} * \frac{1 GW}{1000 MW} = 400 GWh/yr$$

$$260 MW_{Rated} * 0.80_{\substack{ACDC \\ ConvFactor}} * 0.22_{\substack{Capacity \\ Factor}} = 47 MW_{Actual}$$

[123] Rahmun, Saifur, George Hagerman, Manisa Pipattanasomporn, "Wind Energy: Opportunities and Challenges for Offshore Applications," September 2006.

# APPENDIX G:
# CALCULATION OF BIOMASS POTENTIAL

In this report, the possible fuels for generating power from biomass were broken into the four categories of landfill gas, waste water gas, municipal solid waste paper and organics, and agricultural waste. Different amounts of information are available for each category, so the method of calculating potential power output and assumptions made will be described for each type.

Methane Capture:

Landfill gas potential comes from Redwood Sanitary Landfill, which has stated plans to install a 4.5 MW methane capture project, which would produce 34 GWh per year of power. This power estimate was obtained by multiplying the rated capacity by 8760 days per year and a capacity factor of 85%, and dividing by 1000. The capacity factor is an approximate average of typical biomass generators.

$$Given: \quad 4.5MW_{Rated}$$

$$4.5MW_{Rated} * 0.85_{\substack{Capacity\\Factor}} * \frac{8760hr}{yr} * \frac{1GW}{1000MW} = 34GWh/yr$$

$$4.5MW_{Rated} * 0.85_{\substack{Capacity\\Factor}} = 3.8MW_{Actual}$$

There are four wastewater processing facilities in Marin County. The Central Marin Sanitation Agency, Novato Sanitary District, and the Las Gallinas Valley Sanitary District already collect methane for power production in generators of about 30 – 40 kW capacity. Further investigation is required to determine whether they are generating power to their maximum capability, but preliminary research has suggested that about 40% of the available methane is currently being flared rather than used to produce power. The Sewer Agency of Southern Marin (SASM) has performed feasibility studies on installing methane digesters but so far none of the projects have proved viable due to the fact that SASM is a small facility. No contribution from wastewater facilities was included in biomass calculations because of the speculative nature of the exact power potential, but it is expected that there will be an increase in power available from these facilities in the future. Given their high energy demands it would be unlikely that they could be net energy exporters, but installing more capacity would reduce the amount of energy they purchase.

The biomass feedstock from agricultural waste was calculated only for animal waste from dairy farms due to the available information. In order to compute the potential yearly output from dairy farms, the number of cows in Marin County, about 16,000,[124] was multiplied by the empirically found value of 2.5 kWh/cow/day[125] and then

[124] Marin County, *Greenhouse Gas Reduction Plan*, 2006.

multiplied by 365 days per year. A series of reports following the performance of methane digesters installed on dairy farms across California reported values of averaging 2.5 kWh/cow/day when excess methane was not flared into the atmosphere instead of being used as fuel. It was assumed that this value takes capacity factor and other reduction factors into account since it was reported as an overall output found by dividing the actual power produced by the number of cows.

$$16{,}000 cows * \frac{2.5 kWh}{cow/day} * \frac{365 days}{yr} * \frac{1 GW}{1{,}000{,}000 kW} = 15 GWh/yr$$

$$\frac{15 GWh}{yr} * \frac{1 yr}{8760 hr} * \frac{1000 MW}{1 GW} = 1.7 MW_{Actual}$$

$$1.7 MW_{Actual} * \frac{1}{0.85_{\substack{Capacity\\Factor}}} = 2.0 MW_{Rated}$$

<u>Biomass (Waste-to-Fuel)</u>:

In order to calculate the potential power output from municipal solid waste, the tons of eligible waste must be multiplied by the power output per ton of the waste-to-energy conversion process used, and then the product must be multiplied by the capacity factor, which was estimated at 85%.[126] Detailed information about the tons of municipal solid waste generated in Marin County was obtained from the California Integrated Waste Management Board database.[127] From that data, the tons of solid paper waste and solid organic waste generated in residential and nonresidential sectors per year in Marin County was found. The power output of conversion processes was assumed to range from 300 to 700 kWh/ton.[128] The wide range used in this report is due to the fact that the three common conversion technologies, incineration, gasification/pyrolysis, and anaerobic digestion, each vary in their output capabilities but it is not within the scope of this study to determine exactly how many tons of each waste type would be converted by each specific process. Therefore, a low and a high estimate are made and it is expected that the actual value falls within the range.

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[125] This value was found by averaging the reported kWh/cow/day produced by cows at six different California farms with methane digesters. CEC/PIER Dairy Power Production Program reports.
[126] Community Environmental Council, *Energy Blueprint*.
[127] California Integrated Waste Management Board, California Waste Stream Profiles, Marin County, 2007.
[128] URS Corporation, *Summary Report: Evaluation of Alternative Solid Waste Processing Technologies*. 2005, City of Los Angeles Department of Public Works: Los Angeles.

$$\left(204{,}000\ tons.waste\right)\left(\begin{Bmatrix}300\\700\end{Bmatrix}\frac{kWh}{ton.waste}\right)\left(0.85_{capacity.\,fctr}\right)\left(\frac{1GW}{1{,}000{,}000kWh}\right)=\begin{Bmatrix}52\\120\end{Bmatrix}\frac{GWh}{yr}$$

$$\left(\begin{Bmatrix}52\\120\end{Bmatrix}\frac{GWh}{yr}\right)\left(\frac{1yr}{8760hr}\right)\left(\frac{1000MW}{1GW}\right)\left(\frac{1}{0.85_{capacity.\,fctr}}\right)=\begin{Bmatrix}7.0\\16\end{Bmatrix}MW_{Rated}$$

$$\left(\begin{Bmatrix}7.0\\16\end{Bmatrix}MW_{Rated}\right)\left(0.85_{capacity.\,fctr}\right)=\begin{Bmatrix}6.0\\14\end{Bmatrix}MW_{Actual}$$

# APPENDIX H:
# CALCULATION OF OCEAN POWER POTENTIAL

The approach for calculating the ocean power potential was different than that used for solar, wind, and biomass technologies. Ocean power is the least developed of the four renewable energy technologies presented in this report and so, although there has been fast progress made in the last decade, most ocean power installations are in pilot phases or in late phases of testing. This leads to limited empirical data (as opposed to theoretical data) for ocean power plants. The approach for calculating the ocean power potential for Marin County was to assume that one ocean power plant is installed.

The Electric Power Research Institute (EPRI) estimated that one wave farm off the coast of San Francisco's Ocean Beach could provide about 150 MW of capacity.[129] The wave plant can be scaled up or down depending on the available local resource. The information that was used in the EPRI study was based on wave height and frequency data from research buoys in the waters off of San Francisco (for a deep water location) and Monterey Bay (for a shallow water location). It is assumed that the data from San Francisco is applicable for Marin County because of the close proximity of the two counties, and the similarity of ocean depth (approximately 50 m) for an offshore wave power plant. Because the goal for this report is simply to obtain an order-of-magnitude estimate, it is assumed that wave resource in San Francisco is similar to that in Marin. However, waves are highly dependent on ocean depth and ocean floor topography, as well as local weather conditions, and so the wave data from the San Francisco buoy may not accurately represent the waves in Marin County. A subsequent analysis should be done using data from the buoy off Point Reyes[130] in order to obtain a more accurate wave power resource.

EPRI did an analysis for an oscillating wave column device and a linear hydraulic device, called Pelamis. For each type of technology, EPRI calculated the required number of devices to obtain an ocean power plant with a capacity of about 150 MW. EPRI used a total "effective" reduction factor of 10% to account for wave directionality, power conversion, and wave variability. Therefore, 10% of the rated capacity is actually obtained. Using 150 MW as the rated capacity and then multiplying by 10%, 8,760 hours per year and dividing by 1000 yields a power capacity of 130 GWh per year.

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[129] Between December 2003 and September 2005, EPRI published a series of 17 reports investigating the potential for wave energy projects at various sites throughout the U.S. including off the coast of San Francisco. All reports are publicly available on EPRI's Ocean Energy Website: www.epri.com/oceanenergy

[130] The buoy is called PRYC1. Data can be found at http://www.ndbc.noaa.gov/maps/Monterey_Bay.shtml

$$Given: \quad 150MW_{Rated}$$

$$150MW_{Rated} * 0.10_{\substack{Reduction \\ Factor}} * \frac{8760hr}{yr} * \frac{1GW}{1000MW} = 130GWh/yr$$

$$150MW_{Rated} * 0.10_{\substack{Capacity \\ Factor}} = 15MW_{Actual}$$