SOLAR SEBASTOPOL

A Feasibility Study
for the Sebastopol City Council

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May 7, 2002

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EXECUTIVE SUMMARY

The present study finds that the production of solar electricity with photovoltaics (PV) on residential and commercial rooftops in the City of Sebastopol is technologically and economically viable. We see a technical potential of roughly 1,000 to 1,500 kilowatts (kW) installed on various rooftops with net metering arrangements, of which we can readily imagine 500 kW to be realized in practice. The up-front cost of 500 kW of PV arrays can be expected to fall in the neighborhood of $3 million, which could conceivably be raised through a municipal revenue bond issue.

Given the substantial rebates and net metering agreements currently available to consumers in California, the installation of PV systems on the rooftops of utility customers is close to cost-neutral in terms of recovering the initial capital investment through utility bill savings. In the near term, we estimate that the annual bill savings would fall in the range of 6.4 to 7.2% of the initial PV cost, which we expect to be slightly above the bond interest rate, thus making the project fundamentally feasible. Depending on the specific assumptions made, especially with respect to utility rate escalation, PV electricity has a simple payback time in the neighborhood of 11 years and can produce savings over a 25-year project life of several times the initial investment.

Still, even under the most favorable conditions, undertaking such a long-term investment with significant up-front costs presents a financial and psychological hurdle to many customers. Solar electricity is virtually assured to produce long-term financial savings, and it is also certain to hedge the risk of future price variability. At the same time, PV electricity is certain not to produce any immediate windfall — whether for residents or the City. The key issues are the time horizon of planning and the value assigned to risk hedging as well as environmental benefits.

Our study concludes that City Government may play an important role as a facilitator for investment in PV electricity by reducing the financing and transaction costs for participating customers, thereby promoting and realizing clean energy as a public good. Our survey of Sebastopol residents found mainly positive attitudes, indicating that a majority of respondents either would be interested in participating or thought that a City-sponsored PV program was generally a good idea. We believe that were Sebastopol to proceed with a solar electricity program of some kind, this would be in keeping with the interests and priorities of residents and voters.

INTRODUCTION

1.1 Background and Scope

The present report presents the results of a research project conducted during the spring semester 2002 by students in Prof. von Meier's course, "Small-Scale Energy", in the Department of Environmental Studies and Planning at Sonoma State University. This research project was inspired by a group of Sebastopol activists and City Council Members who met in late 2001 to discuss the how the City of Sebastopol might support clean, renewable electricity.

Specifically, the group entertained the idea whether it might be feasible to replicate some variant of what the City of San Francisco is undertaking (see Section 6).

In thinking about how solar or other renewable electricity could work for Sebastopol, several questions present themselves:
•How could an effective program be designed in which the City of Sebastopol would in some way, through financing or otherwise, assist building owners to implement solar electricity production?

•How large an amount of electricity are we potentially talking about?
•What sums of money are involved, and how much of a subsidy, if any, is still needed to make the investment in solar electricity economically realistic for property owners?

•What is the interest level among Sebastopol residents and business owners?
•How would a revenue bond issue be designed to most effectively meet the City's needs and goals?

The present report addresses a subset of these questions, namely, the physical feasibility, the economics, and resident attitudes. Without making policy recommendations, it is intended as a practical reference to assist the City Council in its fact finding and decision making process regarding whether to launch such an initiative and how best to design it.

Rather than presenting an exhaustive study of renewable energy options, this report focuses only on photovoltaic (PV) solar electricity, which can be generated by roof-mounted panels that produce no noise, emissions, or other hazards. This choice results from the assumed constraint that electricity generation be installed *within* city limits (which may ultimately not turn out to be a legal requirement and for which there is certainly no technical imperative).

This report thus excludes wind power (which, in many locations, is far more cost effective than solar power) because of the comparative paucity of wind resource in Sebastopol itself as well as the more complicated issues pertaining to zoning and liability that arise from the aesthetics and the small but not negligible physical hazard associated with wind turbines. The report also excludes micro-hydroelectric power for lack of a viable hydroelectric resource. Finally, the report does not address energy efficiency and conservation measures, which represent arguably the single largest and most cost-effective resource for reducing reliance on conventional energy, but whose significance and scope require a separate study and analysis. We are limiting ourselves, then, to examining solar electricity from photovoltaic (PV) arrays that are "grid-connected" or "utility-interactive", feeding electricity into the utility's (PG&E's) power distribution system from various locations. These sites may include homes, businesses, and public buildings such as schools. As discussed in more detail below, a cornerstone for the economic analysis of PV is the availability of *net metering*, in which the solar electricity flows backwards through a customer's utility meter and is accordingly subtracted from that customer's consumption. Because the credit is taken at the *retail* electric rate, the economics are much more favorable than for a solar power plant considered as an electric “generator” selling electricity at wholesale market rates.

This means, however, that the City of Sebastopol cannot simply install, say, a one-megawatt solar power plant and realize the same financial bottom line as the aggregate of many smaller systems scattered about rooftops throughout the city. Rather, implementing a large amount of solar power generation in an economically smart way requires the cooperation of numerous participants, i.e., numerous utility customers with individual meters. The question then becomes how the City and its residents can most effectively work together to produce the greatest economic — and environmental — benefit for the community as a whole.

1.2 Scenarios

While it is relatively straightforward for the City to finance and install solar power on public buildings, and while the electric grid doesn’t care whose rooftop the power comes from, the accounting becomes more complicated when the City provides money for solar installations but the financial savings accrue to individual utility customers in the form of bill reductions. Future analysis will be needed to identify the best contractual arrangement between the City and program participants, which would include residential homeowners as well as small and medium-sized businesses.

For the sake of the preliminary analysis in this report, we considered two scenarios which we called Plan I and Plan II. Each plan has several conceivable variations, which are discussed in Section 4 below.

Plan I	The PV system belongs to the building owner. The City pays cash to the vendor and installer for the system and its installation, and the property owner repays the city over time with the money they saved on their utility bill.
Plan II	The PV system belongs to the City. The property owner makes their roof space available and sees a reduction of their utility bill. The property owner shares these utility bill savings with the City.

In the sections that follow, this report will address the questions of overall technical feasibility, economic feasibility, and public attitudes regarding a City-sponsored solar energy project.

2 THE SOLAR RESOURCE

Sebastopol is situated in an area with relatively abundant sunshine. The map shown in Appendix I, produced by the National Renewable Energy Laboratory (http://rredc.nrel.gov/solar/), illustrates the measured solar resource for different regions throughout the United States. It indicates that most of California, with the exception of the far northern coastal areas, enjoys favorable sunshine conditions that tend to make solar power generation economically attractive (yellow and orange regions).

As shown in the map, the amount of solar energy collected in a typical Northern California location by a south-facing panel, tilted at an angle that corresponds to latitude, is between 5 and 6 kilowatt-hours per square meter per day (kWh/m^2-d). This represents the incident solar radiation (also called “in**sol**ation”), of which some percentage — typically in the neighborhood of 10% — can be converted into electricity by photovoltaic (PV) cells.

We were unable to obtain empirical solar energy data specific to Sebastopol's micro-climate, but general experience from operating PV systems confirms this range. Accounting for occasional fog, 5 kWh/m^2-d is a reasonable estimate that we used in our economic calculations.

This figure does not assume the solar panel's tilt angle to be exact; indeed, the total incident solar energy does not change dramatically if the tilt angle or southerly orientation is varied by ±15 degrees. Sebastopol's latitude is about 38^o, which is conveniently similar to the pitch of most standard roofs (for example, an 8 in 12 roof has an angle of 33.7^o).

To illustrate what the insolation value means in practice, consider a rooftop PV module measuring one square meter, or roughly 10 square feet. If it is converting 10% of the incident 5 kWh/m^2-d of solar energy into electricity, it will produce 0.5 kWh per day on an annual average basis.

A typical rooftop PV array might be rated at 2 kilowatts of peak output (kW_p). This means the array will produce 2 kW of electric power at the peak insolation that would typically be encountered at noon on a sunny California day, 1000 watts per square meter (1000 W/m^2 or 1 kW/m^2), which is the factory rating standard. At 10% efficiency, this array will have to occupy 20 square meters. (A less efficient type of PV module could produce just as much power, but it would have to be bigger.) Over the course of an average day, the 2 kW_p array will produce 10 kWh of electric energy. This amount roughly meets the needs of a typical household with a $40/month electric bill.

3 ON LOCATION: SEBASTOPOL ROOFTOPS

3.1 Technical Aspects of Rooftop PV

The installation of photovoltaic (PV) modules on residential and commercial rooftops has, over the past several decades, become a standard and routine procedure. In many cases, it is possible to perform the installation without roof penetrations (and thus concern over roof warranty). Modules are readily mounted on pitched roofs to fill the available unshaded space, and flat roofs may be covered with panels either laying flat or mounted on tilted supports for greater energy production. The typical residential roof with composition shingle and a 4-in-12 or 8-in-12 pitch presents no obstacle to a straightforward installation of PV panels.[1]

In addition to standard rectangular modules, various products with innovative installation approaches are on the market. These will, in the near future, include PV roofing tiles. Some of the diverse products that are already available and qualify for California State rebates include, for example:

- "PowerGuard" square assemblies designed for flat commercial roofs that double as thermal insulation and roof protection (http://www.powerlight.com/)
- PV modules designed for standing-seam metal roofs (http://ovonic.com/unisolar/)
- "PowerShade" carport structures for shading parking lots (http://www.powerlight.com/)

PV arrays can also be placed on tilted supports or even passive tracking systems on the ground. This option has the benefit of easy access, maximal energy production from solar tracking, and non-interference with roof maintenance. However, in urban areas, rooftop installation is generally preferred for compelling reasons of space use and aesthetics. For the same reason we also chose not to examine the carport option in this report, recognizing that PV carport structures seem a more likely choice for larger commercial complexes than for Downtown Sebastopol.

In this report, we made no specific assumptions regarding which PV product would be used, recognizing that this choice will depend on the compatibility with specific sites and on the City's ability to negotiate competitive offers with individual suppliers.

3.2 Sebastopol Roofs

An aerial photograph, shown in Fig. 3.1, provides an initial impression of the considerable solar rooftop potential in Sebastopol. The overview of a portion of Downtown suggests that while tree shading is fairly common in the residential neighborhoods, there appears to be ample unobstructed roof area on a number of commercial buildings.

[1] While installation on ceramic tile roofs is possible, it can be more difficult, and we conservatively excluded tiled roofs from our selection of "feasible" rooftops.

Figure 3.1: Aerial View of Downtown Sebastopol
Courtesy of Sonoma State University, GIS services

To assess the physical potential for rooftop solar electricity, especially in the residential sector, we found it necessary to examine each individual building at least in a cursory manner. Thus we examined every address within the Sebastopol city limits on foot or bicycle. On a street map, we noted those addresses that have, at first glance, a rooftop on which the installation of a PV array appears generally feasible — i.e., there are no immediately obvious reasons why it should be infeasible.

The criteria for a "feasible" rating are as follows:

- Facing within 15 degrees of south
- No shading obstructions (poles, trees, etc.)
- No major obstructions on the roof itself (skylights, air units, tile, etc.)
- Solid roof construction (no plastic or tin roofing).

While roofs obviously vary in size and available square footage for PV installation, we believe that most of the "feasible" roofs would support at least a 2 kW_p installation, which measures in the neighborhood of 250 sq.ft.

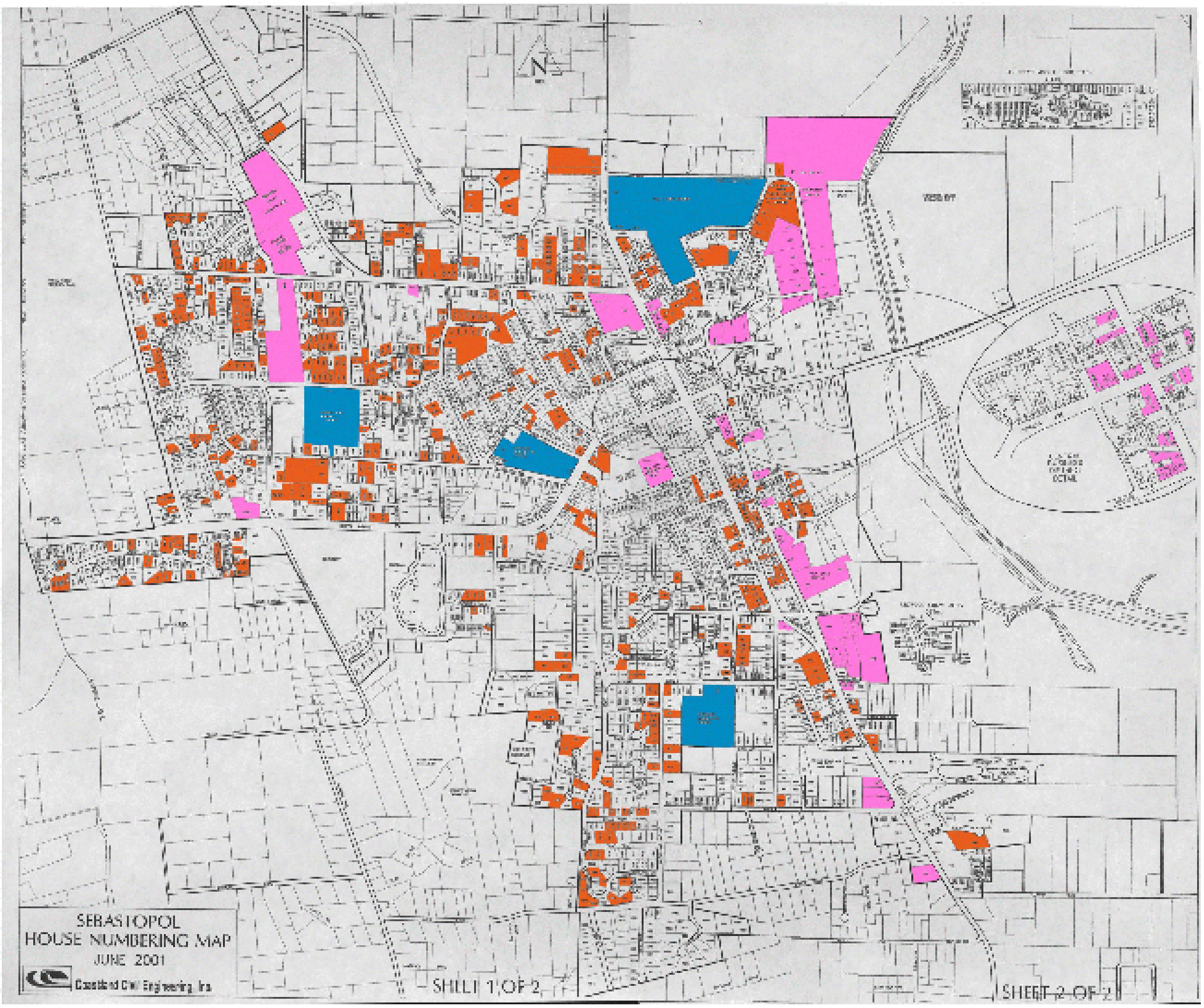

Figure 3.2: Street Map with Feasible PV Locations

The legend for the map is as follows:

Orange	Sites that could readily accommodate a 2 kW system. This includes residential sites, some small commercial, and some public buildings.
Pink	Sites that could accommodate a 3 kW or larger system. This includes commercial and nonprofit sites (grocery stores, gas stations, and the downtown area). Many of these roofs are flat and all have minimal obstructions.
Blue	School sites that could accommodate a 3 kW or larger system.

One large (3' x 4') hardcopy of this map is being submitted to the City Council.

The actual addresses for “feasible” sites are listed in Appendix I.

3.3 Noteworthy Sites

Several sites stand out because their roof area and electric demand may support a large PV installation, or because of high public visibility.

Palm Drive Hospital A prime candidate for a large, 100 kW PV installation. Substantial electric demand (approx. 5,000 kWh/d) that could absorb up to one megawatt (MW) of PV generation if roof space and eligibility rules permitted, but likely constrained by roof space and 100 kW limit (as of December 2002, see E-Net Rules below).

Whole Foods Market Extensive flat roof space. The electricity consumption of this store could be offset by up to 100 kW_p of PV generation.

Other Grocery Stores Albertson's, Fiesta Market, Fircrest, and Safeway also have mainly flat roofs and significant electric demand.

Ives Pool Potential for both PV electricity and solar water heating; expressed interest (see Appendix II).

Gas Stations Flat rooftop space covering pumps seem ideal for 2-4 kW systems for small commercial customers. Perhaps an interesting public relations angle.

The Masonic Center 373 N. Main St. has a large flat rooftop with space for a 4-7 kW system.

Sebastopol Garden Apts. 7983 Healdsburg Ave. has a mix of south-facing and flat rooftops and covered parking with room for 5+ kW system.

Schools Four schools within the city limits have a potential for PV that needs to be further analyzed. It seems likely that each site could support at least a 10 kW system.

City Water Utility The City's main electric load of over 2,000 kWh/day could be offset by up to 400 kW of PV. However, this electricity is now bought at a low rate, so that there are no near-term economic savings. Installation options require further study.

Powerhouse Brewing Co. A perfect PV site in almost every respect: South-facing orientation; large, unobstructed roof with just the right pitch; a location with top visibility — but alas, the building's National Historic Landmark status likely prohibits mounting any PV modules on the roof.

3.4 Discussion of Data

We have identified approximately 500 residential and small commercial sites that would appear suitable for PV installations of 2 kW in size. If somewhere between 60 and 80% of these sites turn out, on professional inspection, to be indeed well-suited for PV, this implies a technical potential of 600-800 kilowatts of installed PV capacity (300-400 sites @ 2 kW).

In addition, 60+ sites appear feasible for PV systems of 3 kW or more, of which some could accommodate on the order of tens of kW and several up to 100 kW. If 30 of these sites hosted between 3 and 10 kW each and 4 sites hosted 100 kW each, this would correspond to about 500-700 kW of installed capacity.

The technical potential for both small and large rooftop PV systems, within the Sebastopol city limits, thus appears to be on the order of 1,100-1,500 kilowatts or 1-1.5 megawatts (MW).

Obviously, the entire technical potential will not be realized in practice because not all property owners with feasible sites will choose to participate in the program. With residential sites in particular, owner-occupied properties seem more likely participants, yet these account only for an estimated 60% of Sebastopol households. If half of the owner-occupied residences opted to participate, this would mean roughly 100 sites (350 x 0.6 x 0.5) or 200 kW of installed PV.

If we assume the lower end of the estimated feasible PV generation at the larger public and commercial sites (500 kW) and suppose that 60% of this potential were actually installed, we can envision another 300 kW from these larger systems, making a combined total of 500 kW or half a megawatt of installed PV in Sebastopol.

It should be emphasized that this is a conservative estimate based not on the maximal available roof space or total electric usage, but on a guess as to the confluence of various technical and human factors that make PV installation at a given site practical and desirable. Thus the one-half megawatt estimate counts only that fraction of potential sites that we estimate to be both particularly convenient and amenable to solar electricity — in other words, the "low-hanging fruit". For a population of 8,000, a total installed 500 kW or 2,500 kWh/day of solar electricity would represent about one-third of a kilowatt-hour per person per day, which is on the order of one-tenth of the typical residential electricity consumption. Though still far from 100 percent renewable, this "Half-a-megawatt-of-PV" scenario could be said to make a significant dent in Sebastopol's dependence on traditional energy resources.

4 SOLAR ECONOMICS

4.1 PV Costs: Hardware, Installation, and Rebates

A working photovoltaic array has many components. These can either be bought individually at a high price, or in bulk at a somewhat lower price. The core of the system consists of the PV modules, which tend to account for the major portion of the overall cost. The remainder — electrical wiring, inverter, installation labor, etc. — is referred to in the industry as "balance-of-systems" cost.

PV modules come with a peak watt (W_p) rating. This is the amount of power a PV device is capable of producing at noon on a cold, clear day under full sun. To obtain the electric energy output in kilowatt-hours (kWh), we multiply the peak watts of the system by the equivalent number of hours of full output expected on an average day. Recognizing that the average day is 12 hours long but that some of these hours receive less than full sunshine, a typical Northern California location would receive approximately 5 equivalent daily hours of full sun. Thus, a 2 kilowatt peak PV system would be expected to generate 10 kilowatt-hours per day (2 kW x 5 hrs/day = 10 kWh/day) in this location.

Prices listed below on a "per installed peak watt" basis rely on informal quotes from a number of sources (see Appendix II). It is quite conceivable that the City of Sebastopol could negotiate a more favorable deal with a supplier based on a volume purchase of both materials and installation.

Important factors that will contribute to lowering prices are system size and contractor fees. The cost of the PV modules *per se* is essentially independent of the installed system size, although a manufacturer or distributor may well be able to offer a discounted price on the purchase of a large number of modules, which may then be installed in any combination on a number of roofs. However, there are also certain fixed labor costs associated with designing and installing a PV system on a given roof, and these costs will appear less on a per-kilowatt basis if each installed system is larger. If a standard package is designed that can be installed with only minor modifications on a large number of buildings, this reduces the time spent on engineering analysis and thus further reduces cost.

Finally, substantial rebates are available through the *Emerging Renewables Buydown* programs, administered by the California Energy Commission and the Public Utilities Commission. Requirements for this program are discussed in more detail below, but it is generally possible to receive a rebate of half the purchasing price or $4.50 per peak watt, whichever is less. Based on these factors, estimated costs of PV installations are discussed for various scales below.

Small residential: Provides for a portion of the electric loads. The size of such a system would typically be 1 to 1.5 kW, which only makes up for about half of the electric needs of a typical home. The cost for a system of this size might be $12 per watt. After the rebate of $4.50/$W_p$ this comes to $7.50/$W_p$, which brings the total installed price per home within the range of $7,000-$12,000.

Medium residential: Provides for nearly all of the electric loads. One of these systems would typically be 2 to 5 kW. The 2 kW system will tend to fall short of providing all of the electric usage for most residences, while the 5 kW system would nearly always provide excess electricity on a year-round basis. Because net metering does not allow payment for excess electricity, 2 kW seems a good choice for a standard package that would fit most residential sites. Cost for these systems declines with increasing wattage, but taking as a conservative estimate $11 per watt would bring the cost of a complete installed 2 kW system, after rebate, to $13,000.

Small/medium commercial: A system in the10 -20 kW range that might go on an apartment building or a retail store. Installed costs would be $10/W_p$ or less, or in the neighborhood of $5/W_p$ installed after rebate, which comes to $50,000 for a 10 kW system.

Large commercial: A system greater than 30 kW that might go on a large grocery store. The price falls to $9/W_p$ or less. For example, a 100 kW system procured at $8.50/W_p$ receives a rebate of half the purchase price or $4.25/W_p$ and costs $425,000.

The California Energy Commission offers a cash rebate for qualifying renewable energy systems as part of their Emerging Renewables Buydown Program. The rebates amount to $4,500 per kilowatt, or 50% of the purchasing price, whichever is less. Applicants for a cash rebate must meet the following requirements:

•You must be and remain on the electric grid.

•The photovoltaic system electrical production must not exceed 200% of the site's historical or current energy needs.
•The system components must be on the CEC's published list of eligible products, and the retailer of the PV system must provide a minimum five-year warranty.
•The photovoltaic system can be installed by yourself or by a contractor, but if you do it yourself, you may not include your labor cost as part of the total eligible system cost.
•Some systems must meet national standards.

More information is available at www.consumerenergycenter.org/buydown/program .

In addition to rebates, there are State and Federal solar tax credits applicable to residential photovoltaic system installations. For the State Tax Credit, the amount credited is 15% of the total cost of the system, to be applied over up to five years, after deducting the value of any municipal, state, or federal incentive for the purchase and installation of a solar energy system. This credit can be claimed on California Tax Form 3508. The Federal Tax Credit amounts to 10% of the system's cost and is explained on Instructions and Form 3468 for Federal Income Tax. Both of these forms can be found online at the following addresses: www.ftb.ca.gov/forms/index (State Tax Form 3508) and www.irs.gov (Federal Tax Form 3468 and Instructions).

4.2 Where the Savings Are: Utility Interconnection, Rate Schedules and Net Metering

Photovoltaic arrays can supply the electric utility grid much like regular power plants, or they can feed through an electric customer's service connection and meter (see diagram in Appendix I), offsetting some of that customer's demand at times and supplying whatever is left to the grid. Physically, a PV power plant and rooftop PV are similar, but the accounting mechanisms and economic incentives are different. In the former case, the PV array is considered a "generator", and as such is subject to the market rules under which competing generators sell their output at wholesale prices. In the latter case, the PV generation is thought of as a reduction of demand and credited to the customer at the same *retail* rate they pay for electricity.

When Sebastopol customers install their photovoltaic system, they sign up for the E-NET program with PG&E. (There are other programs for larger PG&E customers, but E_NET focuses on residential and small commercial customers.) Under E-NET, energy generation by the PV system and use of energy by the customer will be metered through the same meter, and credits or charges will be applied to the customer's PG&E account. If the customer is using more energy than the system is putting out, then they will be charged, and if the system is putting out more energy than the customer is using, then they will be given a temporary credit that can offset consumption during the same billing period. For each billing cycle, the cumulative number of kilowatt-hours (kWh) represents the *net* consumption (actual consumption minus PV generation), and this is what the customer is billed for.

Customers can decide if they want to be billed monthly or yearly. With yearly billing, extra solar electricity generated in the summer can be applied to offset consumption in the winter. With monthly billing, the PV generation can only offset consumption in each month, but cannot roll over to the next billing period. Any electricity produced above and beyond the customer's consumption does not receive any payment, so that the net electricity bill, monthly or yearly, can never be less than zero. This constraint follows logically from the "PV as demand reduction" concept.

Net metering has two important advantages: It makes small-scale power generation both relatively simple and economically attractive. Standard analog kilowatt-hour meters can do the metering job, as they simply spin forward whenever electricity is consumed by the customer and backward whenever the production exceeds the customer's demand and electricity flows into the grid. As retail electric rates are generally higher than wholesale market prices, the effective "revenue" from the saved electricity is considerably more than what it would be for a standard "generator".[2]

Most residential PG&E customers are on the simple E-1 Residential Service tariff, which presently charges $0.116/kWh and $0.133/kWh for consumption above the baseline (baseline tiers vary seasonally and depending on whether the home has electric heating). For this tariff, only the cumulative amount of electric energy consumed during a billing period matters, not the time at which it was used — owing to the fact that the traditional analog kilowatt-hour meters installed in most homes have no way of keeping track of when the consumption took place. The A-1 Small General and A-10 Medium General Service tariff for commercial customers work the same way, only with the different rates shown in Appendix I.

With a more sophisticated meter that records *when* each kilowatt-hour was consumed, Time-of-Use (TOU) metering is available — for example, as E-7 Residential TOU or A-6 Small General TOU Service. Under TOU billing, different rates apply to different hours of the day and different seasons, with rates higher during the summer and mid-day hours when the electric grid faces higher demand (see table) and it is thus effectively more expensive to provide service.

Because demand in California is summer-peaking (driven primarily by air conditioning loads) and because this peak inevitably occurs while the sun shines, solar electricity is ideally matched to relieve this demand, and TOU metering allows a PV system to receive economic credit for delivering during "prime-time". Summer on-peak rates are as high as $0.315/kWh for residential customers. The TOU meter still works as a net meter, recording the difference between generation and demand, but accounts for the net consumption at a different rate depending on the hour and date on which it occurred. On-peak and off-peak rates may vary by a factor of three, in which case each on-peak kWh would economically offset three times that amount of off-peak electricity.

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[2] There is good technical rationale for paying distributed generation at the retail rather than the wholesale price, as it tends to relieve the load on the transmission and distribution system.

While time-of-use metering is mostly popular with commercial customers, it is available for residential customers as well. The customer has to bear the one-time cost of installing the TOU meter, which is $277 for residential and $530 for commercial customers. This cost is worthwhile in the context of PV generation because it allows for the bulk of the solar electricity to be sold to the grid at higher on-peak rates.

Larger commercial customers (A-10 Medium General and E-19 Medium General TOU) are furthermore charged a separate rate for their maximum instantaneous power demand, known as the demand charge, in addition to the energy charge for cumulative consumption.[3] This demand charge can be as high as $6.70/kW in the summer, meaning that a customer with a peak electric demand of 100 kW would be charged $670 per summer month in addition to the electric energy charges. The demand charge will also be reduced to the extent that PV generation coincides with the time of heaviest electric demand and reduces the maximum amount of power drawn.

PG&E's Interconnection and net metering requirements are listed in more detail at http://www.pge.com/gen/retail_gen_net_metering.shtml.

California State Assembly Bill 29X sets limits for the size of the installation under the E_NET program. Allowed installation sizes (given in terms of the capacity in watts) depend on the date of application for the E_NET program. The critical date is December 31, 2002.

E-NET Eligibility Requirements

	Prior to and including December 31, 2002	After December 31, 2002
Customer class	Any residential, commercial, industrial or agricultural	Any residential or small commercial
Load requirement	None	20 kW or less
Installation size	1 MW or less of PV, wind or PV/wind hybrid	10 kW or less of PV, wind or PV/wind hybrid

Required components of the E_NET application process are the following:

- Completed application form
- Single_line diagram with the project details (an example of this is given at the website)
- Interconnection Agreement with PG&E
- Proof of insurance coverage
- Approved building permit for the installation with the inspection done by local authorities
- Final inspection of the system by PG&E prior to operation
- Written final approval from PG&E before system operation commences.

Further requirements:

E_NET is a subset of what is called "Rule 21 Generators". All the interconnection requirements specified in Rule 21 must be met.

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[3]This is a logical charge to impose on large customers because the instantaneous power demand dictates the size and thus the cost of the distribution equipment such as power lines and transformers that are required to serve these customers.

•The system's inverter must have both PG&E and UL1741 certifications.
•Approved disconnect switches in accordance with Rule 21.
•Protection equipment installed by PG&E as necessary to ensure safe and reliable operation of PG&E facilities.
•A Local Authority Clearance from the jurisdiction where the PV/wind system is installed.

While these technical requirements may sound intimidating, meeting them is routine practice for qualified professional installers of PV equipment.

4.3 Financing Scenarios for Sebastopol

The general concept is that the City of Sebastopol raises cash by issuing a revenue bond and uses this cash to purchase or help finance PV systems on Sebastopol rooftops, including residential and commercial customers' roofs and those of public buildings. As stated in the Introduction, we considered two basic scenarios:

Plan I — The PV system belongs to the building owner. The City pays cash to the vendor and installer for the system and its installation, and the property owner repays the city over time with the money they saved on their utility bill.

Plan II — The PV system belongs to the City. The property owner makes their roof space available and sees a reduction of their utility bill. The property owner shares these utility bill savings with the City.

These savings could be shared in different ways:

II A — After some number of years, when the initial cost of the PV system has been recovered by the City, ownership of the PV system is transferred to the property owner, who continues to receive free electricity for the remaining lifetime of the system, or

II B — The property owner continues to make payments to the City throughout the life of the PV system, but at a rate lower than the monthly utility savings. (Once the system has paid for itself, the continuing revenue stream will be used by the City to fund other renewable energy projects.)

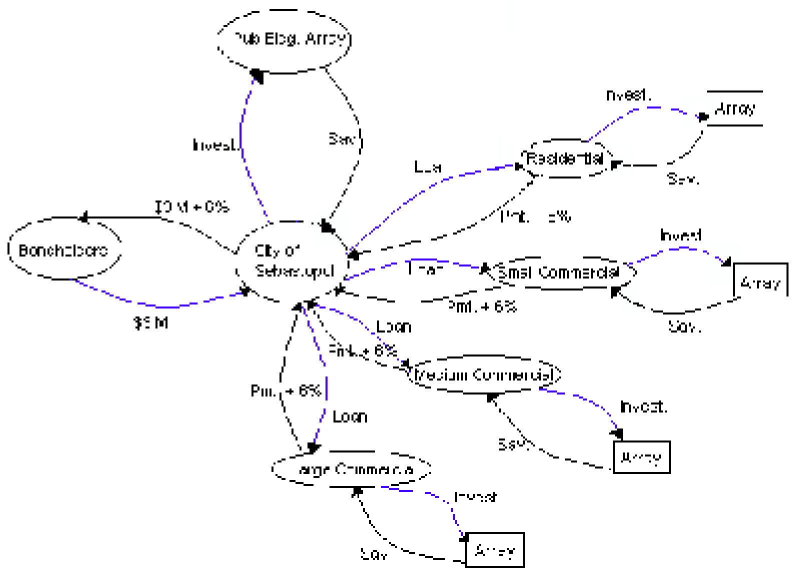
In both Plan I and II, the payments made by the property owner to the City could be specified in different ways, including:

(a) a flat monthly or bi-annual payment,
(b) a payment based on the *estimated* utility savings each month, or
(c) a payment based on the actual utility savings computed with the help of an additional meter that measures only PV output.

Note that in versions (a) and (b), the property owner assumes the financial risk associated with variable electricity production, whereas in (c) the City assumes this risk. Given standard warranties for PV products and dependable sunshine, this solar production risk is probably very small compared to the risk of utility rate increases (against which the customer is now protected).

In the broadest general terms, the flow of money can be visualized as in Fig. 4.1 below, using the hypothetical figures of $3 million and 6% interest for a Municipal bond issue. The City receives $3 million in cash from bondholders, which it repays over time plus 6% interest. The City invests these $3 million in a number of PV systems of various sizes, in various locations, and conceivably with various contractual arrangements as to ownership. (At a conservative average post-rebate cost of $6/W, this would buy a total 500 kW of PV generation.)

Regardless of the ownership status, the City recovers a revenue stream from each installed PV system, whether from its own utility savings (PV on public buildings) or from a payment made to the City by participants hosting the PV. This revenue stream must be sufficient and timely to



pay off the bondholders.

Figure 4.1: Simplified Financial Flow Diagram

From the perspective of the program participant, the situation looks essentially as follows: A PV system appears on their roof, paid for with cash from the City. This cash is either transferred directly from the City to the PV vendor and installer, or it changes hands twice by going first as a loan to the participant who then pays it to the PV vendor and installer. (Another possible variant is that the inspired participant opts to contribute some additional cash of their own, but we will ignore this scenario as it does not affect the remainder of the analysis.) Each month, the participant finds a lower PG&E bill than before. The participant pays an amount of money approximately equal to this electric bill savings to the City as a "loan repayment" or an "exchange for savings". Thus the program is essentially revenue neutral for the participant.

After some time period, the PV system will have paid for itself and electric bill savings will continue to accrue, which may be divided among the program participant and the City in whatever way deemed appropriate. With a lifetime upward of 20 or 25 years for PV systems, and with utility electric rates unlikely to go *down*, it is a safe assumption that the PV systems will eventually pay for themselves and generate a positive net present value. There is no doubt that with a sufficiently long time horizon, solar energy is a good investment. The key questions concerning the financial viability, however, have to do with time.

Thus, to assess the viability of this general scheme, we would like to know:

- Would the revenue stream from utility savings be sufficient and timely enough to meet the City's obligations toward the bondholders?
- How long until the PV systems have paid for themselves?

4.4 How Will It Pay? Economic Analysis for Sample Cases

The key variables in assessing the financial viability of PV systems are

- Initial cost of PV system (minus rebates, tax credits, etc.)
- Interest rate or terms of borrowing agreement
- Projected output from PV system
- Utility tariff and projected future rate changes (escalation factor)
- Discount rate, if future savings are to be discounted to compute net present value (NPV).

The variables related to the PV system per se, cost and output, can be estimated with relative confidence. Thus, the solar component of the equation presents the least of the uncertainty.

The present utility rates vary considerably depending on the particular tariffs for different customers, especially whether TOU rates are in effect. Future savings depend greatly on future electricity prices, projections of which are notoriously difficult and unreliable.[4] Nevertheless, the standard procedure in financial analysis is to assume that prices increase exponentially by some constant percentage rate, the escalation rate, which may be equal to whatever inflation is expected, or it may be greater than inflation (for example, if there is reason to believe that energy will become a scarcer commodity as compared to other goods).

Finally, the discount rate, which determines to what extent future savings are less valuable in terms of today's money, can be based on market interest rates (seeing that if I had the money today, I could invest it), though as an implicit statement of preference (i.e., how much better is money today than money tomorrow) it is essentially a subjective decision. Despite their subjective nature, both the escalation and the discount rates can have very significant impacts on the outcome especially of longer-term calculations and should therefore always be treated with healthy skepticism.

Having made these disclaimer statements, we may consider some illustrative cases of PV investment. The investment appears most attractive when considered over the course of the project life, generally taken to be 25 years. If annual savings from PV generation are added up over 25 years, the net present value (NPV) of these savings will exceed the initial investment by

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[4] As one old-timer in the utility industry put it, "If you predict future energy prices, the one thing you can be sure about is that whatever number you say is going to be wrong."

a considerable amount. For example, a 2 kW PV system with an initial cost of $8,250 will produce a revenue stream totaling about $14,800.[5]

Depending on escalation and discount rates chosen, the lifetime savings can be estimated substantially higher: for example, an escalation rate of 10% and a discount rate of 2% (not entirely unreasonable assumptions) yields an NPV for the $8,250 project of over $42,000, or five times the initial investment. While we believe that such calculations qualitatively make a correct statement — that is, solar energy is a good long-term investment — the lifetime savings are, unfortunately, not the correct figure of merit for the purpose of evaluating project feasibility in this case. Rather, we must stick to the near-term questions of payback times and cash flow.

Residential Example		
Simple Payback	**Flat Rate**	**TOU Rate**
System Size (kW)	2	2
Savings		
Average Sun Hrs (h/d)	5	5
Energy Production (kWh/y)	3650	3650
Average Applicable Utility Rate ($/kWh)	0.12	0.162
Annual Utility Savings ($/y)	438	591
Costs		
PV Cost ($/kW)	10,000	10,000
CA Rebate ($/kW)	4,500	4,500
Federal Tax Credit	0.10	0.10
CA Tax Credit	0.15	0.15
System Cost after rebate ($)	11,000	11,000
System Cost after Tax Credit ($)	8,250	8,250
Payback		
Simple payback (y)	18.84	13.96
Payback with 5% utility rate escalation	13	11

In the residential example above, which first assumes an E-1 residential flat rate of $0.12/kWh (averaged below and above baseline), the simple payback time comes to about 19 years — not a foolish investment considering that the PV systems are typically expected to last for 25 years or more, but also not particularly attractive.

5 Assuming 5% utility escalation, 5% discount rate, 5kWh/d output, and $0.162/kWh initial utility rate as discussed below.

The payback calculation changes somewhat if utility rate escalation is taken into account. If the flat electricity rate, and thus the savings due to PV, increases by 5% per year (a plausible assumption considering there will be inflation), the simple payback time shrinks to below 13 years.

A key change in the calculation comes about if the customer switches to time-of-use metering. Estimating the utility savings requires estimating how much of the PV output is produced during each of the summer and winter, on- and off-peak time periods.
For the E-7 Residential TOU tariff, the on-peak periods are weekdays from noon-6pm, with summer on-peak rates of $0.315/kWh. The table in Appendix I shows an estimation of how many kWh would be produced by a 1 kW_p PV system during each hour, multiplying this production by the applicable rate and adding the contribution from each hour of the day for a total daily revenue. As the on-peak rates only apply to weekdays, it is then necessary to calculate a weighted average over the week in order to obtain a weekly and seasonal average revenue. Combining winter and summer, we obtain an annual average revenue of $0.81/day for a 1 kW_p PV system, or an average rate per energy produced of $0.162/kWh. This average rate is skewed toward the on-peak rate because so much of the PV production occurs on summer afternoons.

If we insert the new average rate of $0.162/kWh into the simple payback calculation as above, the annual utility savings increase from $438 to $591, and the payback time with unescalated rates comes to 14 years. With a 5% utility escalation rate, the payback is reduced to 11 years. This last scenario, TOU rates combined with 5% escalation, while being the most favorable also seems the most plausible. Thus, we estimate a simple payback time for residential PV under the given assumption to be in the neighborhood of 11 years.

While the payback time undoubtedly plays an important role in consumer decisions, it also is not the figure of merit that should decide the feasibility of a PV initiative. Indeed, it can be argued that precisely *because* investment in solar energy requires a longer time horizon than most consumers are able to consider that this is an appropriate area for government initiative.

With regard to economic feasibility for the City of Sebastopol, the crucial figure is the monthly revenue from utility savings. Assuming that residential participants will switch to TOU metering, the question is: Does $590 per year suffice as a return on an $8,250 investment? As an annual return on investment (ROI), this represents 7.15%. With utility rate escalation, this $590 and thus the rate of return can be expected to increase. A 7.15% rate of return is thus a conservative estimate. In relation to a hypothetical bond interest rate of 6%, we would conclude that the project is close, but feasible.

Also shown in Appendix I is an illustrative example for commercial customers under TOU rate schedules. With net metering, these customers will also receive a majority of their PV savings at the higher on-peak rate; in addition, their demand charge will be reduced. We analyzed a hypothetical case of a medium commercial customer on the E-19 tariff (“medium” here is PG&E’s definition; for Sebastopol, this would be very large) with an electric usage of 10,000 kWh/day and with a 250 kW PV system installed. At $4/$W_p$ installed (after rebate and tax credits) this PV system would cost $1 million. The monthly savings, using our assumptions as to the PV output profile and including savings on both energy and demand charges, come to approximately $8,300/mo. in the summer and $2,600/mo. in the winter, given an estimated annual savings of $65,400/yr. This represents just over 6.5% return on the investment — again, close, but feasible.

While the direct economic benefits are modest in the near term, it is important to recognize the intrinsic value of the risk-hedging provided by solar electricity, as it protects the consumer against potential future price increases. (While the long-term investment conversely denies the consumer the chance of enjoying dramatic future price reductions, few would consider this a likely scenario.) Reducing financial risk has an economic value in and of itself, just as we are willing to pay an insurance premium greater than the statistical expectation of claims (and thus allow insurance companies to stay in business). Given the proven reliability of PV technology and the dependable solar resource in California, solar electricity has pronounced benefits to risk-averse investors.

5 IN THE EYES OF THE PUBLIC: PROJECT SUPPORT AND PREFERENCES

5.1 Survey Procedure

Our main goals were to determine Sebastopol residents' general interest level in the project and to identify whether they had any strong preferences about alternative implementation approaches. Secondary information we set out to obtain was the number of homeowners who believe they have suitable rooftops for PV installation, and their estimated monthly electric bill. Our survey questionnaire, printed on postcards, is shown below.[6]

SOLAR SEBASTOPOL Survey

1. Are you a homeowner with a house inside the Sebastopol city limits and willing to take part in an environmentally progressive study that may bring solar electricity (photovoltaics, or PV) to Sebastopol?

   Y N

2. Is the roof of your building flat or south-facing and free of shading? Could you estimate the square footage available for solar panels?

The City is examining the possibility of supporting the installation of PV systems on utility customers' rooftops, which feed into the utility grid through the customer's electric meter in a "net metering" arrangement. Two options are being considered:

Plan I The homeowner provides a portion of the total cost (downpayment) of the system and installation. The City assists the homeowner with the procurement process and low-interest financing. The PV system belongs to you, the homeowner, and your power bill goes down immediately.

Plan II You as the homeowner make no financial contribution, but allow the City of Sebastopol the use of your roof until the system has paid for itself (we estimate around 10 years), after which the system components are yours to keep and your power bill starts going down. The roof never stopped being yours.

3. Which plan is more appealing to you? Plan I Plan II

4. How much was your last electric utility bill, in dollars or kilowatt-hours (kWh)?

5. Please note any questions, comments, or concerns:

Throughout the month of April, teams of students set up in front of various stores in downtown Sebastopol, asking customers as they were leaving if they would like to participate in our survey. With kind permission from store management, we administered the survey in front of Safeway, Fiesta Market, and Whole Foods. While most respondents completed the

[6] We thank Sprint Copy Center for their support of this project.

questionnaire on the spot, they were given the option to mail it in postage-paid. The survey's main limitation, which quickly became apparent, was the low proportion of store patrons who own homes within the city limits (the overwhelming majority either rent or live outside city limits). Thus also we began going door to door in residential neighborhoods to better serve our target population.

5.2 Survey Results

As of May 1, we have 204 completed survey questionnaires. Responses were as follows:

Residence	
Homeowners within City Limits	107
Renters within City Limits	23
Outside City Limits	74
Plan Preference	
Plan I	124
Plan II	80
Roof	
South facing	142
Not south facing	62
< 200 sq.ft.	13
300-400 sq.ft.	13
500-800 sq.ft.	23
1,000-1,500 sq.ft.	16
> 1,500 sq.ft.	9
Electric Bill	
$0-50/mo.	27
$51-100/mo.	65
$101-150/mo.	37
$151-300/mo.	22
> $300/mo.	9

Comments	
General positive, “Pro-Green” remarks	47
Support of the Initiative	42
Questions about the funding source	11
Question about being renter, not owner	9
Comments about no south-facing roof	4
Questions about PV maintenance	2
Question about roof warranty	1

5.3 Discussion of Results

Although we have not reached our desired number of survey responses, so far we have found that

•A high percentage of people shopping in Sebastopol either rent or are not Sebastopol residents;
•A majority of those who completed the survey were interested in this project, and many quite enthusiastic;
•Not many people felt that they could estimate their roof space very well;
•There is no clear majority of the residents' votes in favor of either financing option Plan I or PlanII

At this point we feel it is safe to conclude that a majority of Sebastopol residents would be in favor of an initiative as presented to them in the survey, and many are very enthusiastic about it. Although we must be cautious about response bias in our sample (i.e., people with negative attitudes didn't complete the survey and therefore weren't counted), the positive feedback we have received far outweighs the negative or indifferent reactions. We came across some residents who were simply not interested in participating, but not nearly as many as those who were in support of it.

Concerning the payment plans, we have not discerned a clear favorite of the residents. That possibly proves the viability of offering homeowners more than one option in how the project is financed. The question of houses having enough roof space or facing in the right direction would probably have to be determined by a project assistant or professional viewing the home of each interested homeowner. The data we have received on residents' monthly electric bills confirms our rough estimates of typical residential electricity consumption levels, but could be enhanced with more specific information about their energy use patterns, needs, and willingness to conserve.

6 PIONEERS AND PARTNERS

The first to implement utility-connected photovoltaics on a large scale has been the Sacramento Municipal Utility District (SMUD), in a programmatic effort initiated over a decade ago. It is noteworthy that the "Solar PV Pioneers" program for residential rooftop photovoltaics is so popular that SMUD has a large backlog of participation requests. More information can be found at http://www.smud.org/pv/index.html.

San Francisco's Proposition H, approved by voters in November 2001, offers a new vision for initiative on renewable energy at the municipal level even in the absence of a municipal utility. Prop H gives The City unlimited revenue bond authority to build solar, wind and conservation on residences, businesses and government buildings (see http://www.local.org/sfproph.html). Projected to result in the installation of tens of megawatts of solar generation, this project is indeed large enough to motivate investment in additional manufacturing capacity on the part of the PV industry.

Related in part to efforts to reduce greenhouse gas emissions at the local level, seeing the absence of Federal policy in this direction, other local governments are beginning to consider encouraging investment in renewable energy in various ways. For example, the Fairfax Town Council passed a resolution by unanimous vote on April 16th, 2002, to create a joint powers authority called the "Marin Local Energy Council" to develop and fund renewable and conservation projects on a countywide scale. The goal of the Energy Council is to reduce Marin's net greenhouse gas emissions by 20 percent by the year 2020 (the Toronto Target), which represents the most ambitious standard to date for a local government. The Marin Local Energy Council can be reached at 415.258.9198.

Albeit on a smaller scale, municipalities across California have chosen to invest in solar energy at least for public buildings. The following are some examples:

Santa Monica, CA As of July 1, 1999 the City uses 5MW (megawatts) of renewable electricity for its municipal buildings, including its airport and City Hall. The City has also installed a solar electric car charging station with a 2.1 kW PV system. After the success of this demonstration, Santa Monica built a 31.2 kW port at their Civic Auditorium. Another prized system is the 50 kW solar powered Ferris wheel. Perhaps the most relevant accomplishment is the City's solar housing, which includes 44 units that feature 20 kW of PV electricity and a 28 kW gas_powered microturbine system that uses waste heat for all domestic hot water.

Santa Cruz, CA As of July 2001, Santa Cruz City Hall will produce 7% of the building's electricity with a 14 kW PV system. The total cost came to $9 per peak watt.

Alameda County The Santa Rita Jail has achieved a 20% reduction in their energy consumption due to energy saving tactics, which included the installation of a 642 kW PV system comprising 5,700 modules. The system is expected to pay for itself over the course of about 11 years and realize a lifetime savings of $7 million.

CONCLUSION

Our study finds that City Government may be able to play an important role as a facilitator for investment in PV electricity by helping reduce the financial costs for participating customers, thereby promoting and realizing cleaner energy as a public good. Our survey found mainly positive attitudes among Sebastopol residents, indicating that a majority of respondents either would be interested in participating or thought that a City-sponsored PV program was generally a good idea. We believe that were Sebastopol to proceed with a solar electricity program of some kind, this would be in keeping with the interests and priorities of residents and voters.

While City-sponsored rooftop PV with net metering promises no substantial economic gain for either the City or participants in the near term, it appears feasible as an approximately revenue neutral program with substantial long-term public benefits. These benefits include long-term cost savings, risk reduction with respect to future utility rate increases, support of the local transmission and distribution infrastructure, the reduction of greenhouse gas emissions and other air pollution, and unquantifiable benefits relating to public education and political precedent. A $3 million bond issue could be expected to finance approximately half a megawatt of installed PV. By proceeding with such an initiative, Sebastopol would join other City and County governments at the cutting edge of forward-thinking, fiscally and ecologically responsible policymaking.

We recommend that the City of Sebastopol undertake the following further steps:

- Obtain professional assistance for designing and drafting a specific solar bond measure;
- Perform a more detailed financial analysis including program specifics such as payment contracts and administrative costs to verify the financial viability of such a program;
- Issue a Request for Bids to solar vendors and contractors towards a bulk purchase and installation rate;
- Obtain improved data on expected participation, possibly preparing an advance list of interested candidate building owners; and
- Examine in detail the potential for PV installation at public sites, including school buildings and the City's water pumping facility.

Students and faculty of the Energy Management and Design Program at Sonoma State University will be happy to discuss possibilities for further collaboration.

APPENDIX I: DATA