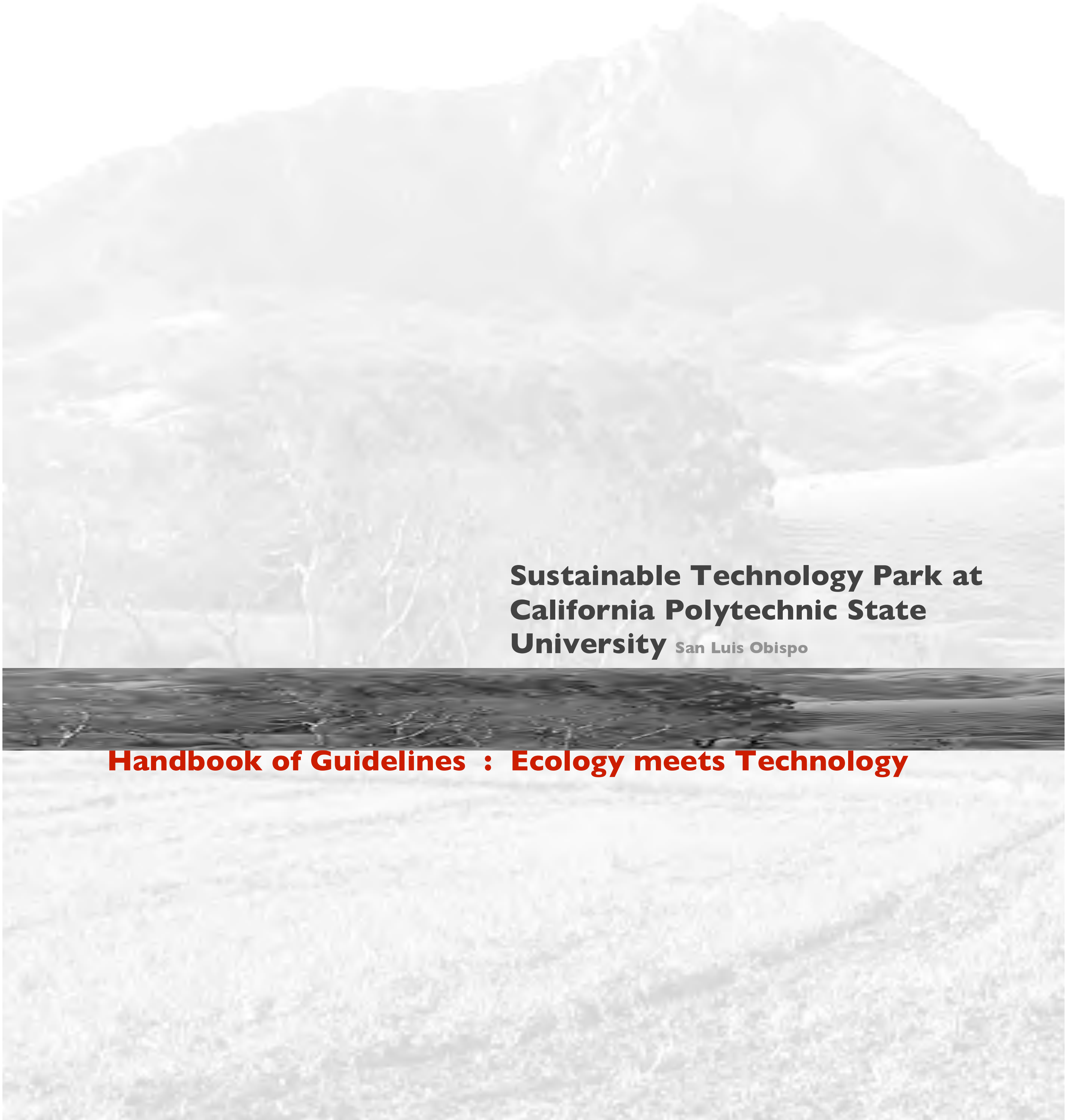

Sustainable Technology Park at California Polytechnic State University San Luis Obispo

Handbook of Guidelines : Ecology meets Technology

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Renewable Energy

Several forms of renewable energy can be developed at the Technology Park site. These include:

1. Solar photovoltaic electricity production

2. Solar thermal heat production

3. Wind electricity generation

4. Biomass generated electricity from animal waste on the Cal Poly campus

There are also financial incentive programs available from the California Energy Commission and the Pacific Gas and Electric Company which may be applicable to this project to assist in paying capital costs. Net metering is also available from Pacific Gas and Electric Company to generate an income stream to the Technology Park in the form of reduced electricity payments.

Solar Photovoltaic Electricity Generation

Electricity production with photovoltaic solar panels is the most mature renewable energy technology. It offers the advantages of minimal maintenance and reliability. Two types of systems are in use. Off-grid systems use solar panels and batteries to store electricity for use at night and on cloudy days. On-grid systems are connected to the existing power grid. They only generate electricity during day light hours.

Off-Grid Photovoltaic Systems - These systems are complex and include batteries and battery chargers. This reduces net energy production by approximately 10%. Batteries also add significantly to the cost and have a limited lifespan and require significant maintenance. Since the Technology Park is located on campus, the extra cost and complexity of an off-grid system is not warranted. Additionally off-grid systems are not eligible for financial incentives offered by the California Energy Commission and the Pacific Gas and Electric Company.

On-Grid Photovoltaic Systems – These systems are relatively simple compared to off-grid systems. There are no batteries for on-site energy storage. When solar electricity generation can't supply the load, electricity is supplied from the grid. Solar produced power in excess of building requirements flows into the electrical grid and the building owner is given credit through net metering. Figure 1 is a schematic of a typical off-grid system.

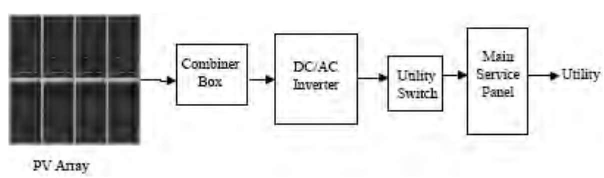

Figure 1 - On-Grid Photovoltaic Electrical Generation System

After California Energy Commission, Energy Technology Development Division, "A Guide To Photovoltaic System Design And Installation," *Version 1.0, June 14, 2001.*

Estimating Power Production – The National Renewable Energy Laboratory (NREL) has developed Internet-based computer models that estimate power production, PVWATTS. Two versions are available; Version 1 uses solar data from a predefined database, and Version 2 is linked to an extensive solar GIS database.

Use of the Version 2 Model requires a broadband Internet-connection. Both Versions are located at the NREL website:

http://rredc.nrel.gov/solar/calculators/PVWATTS/

Figure 2 is output (PVWATTS Version 1) for an off-grid 30 kW system located in Santa Maria, California (about 30 miles away from the Cal Poly campus). Default values were used for energy prices.

The California Energy Commission also has an internet-based computer model, for estimating the economics of photovoltaic systems. It is available on their website at:

http://www.consumerenergycenter.org/renewable/estimator/index.html

PVWatts

AC ENERGY & COST SAVINGS

Station Identification	
City	Santa Maria
State:	CA
Latitude:	34.90° N
Longitude:	120.45° W
Elevation:	72 m
PV System Specifications	
AC Rating:	10.0 kW
Array Type:	Fixed Tilt
Array Tilt :	33.9°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	10.3 ¢/kWh

Energy Production		
Month	Energy (kWh)	Energy Value ($)
1	1304	134.31
2	1354	139.46
3	1658	170.77
4	1809	186.33
5	1935	199.31
6	1767	182.00
7	1932	199.00
8	1940	199.82
9	1730	178.19
10	1610	165.83
11	1379	142.04
12	1404	144.61
Year	19822	2041.67

Figure 2 - PVWATTS Version 1 Model Output

Solar Thermal Heat Production

Solar energy can be used to heat the buildings of the Technology Park. Either passive solar architectural design elements or active solar heat collectors can be used. Passive solar design is discussed elsewhere in this report. This section will discuss active solar heat collector systems. At this time there are no financial incentives available for the installation of solar thermal heating or hot water systems so a detailed financial analysis will need to be performed to justify the capital cost of the system on energy savings alone.

Active solar thermal systems circulate water or antifreeze through a flat plate collector system. NREL has written a design manual, "Solar Radiation Data Model for Flat Plate and Concentrating Collectors," which is available for download on the NREL website:

http://rredc.nrel.gov/solar/pubs/redbook/

Solar data tables by state are also available at the same website.

Flat plate collectors with water as a fluid, are more efficient but require a dump valve, which drains the collectors to avoid freezing. This type of collector is suitable for the San Luis Obispo area, which has relatively few days a year when freezing temperatures are recorded. Antifreeze based collectors employ a heat exchanger when potable water is heated. Antifreeze based systems can be also be used to circulate hot water through radiators for space heating.

Wind - Electricity Generation

Electrical generation with wind turbines is a mature renewable energy technology. On-grid wind energy systems are eligible for financial subsidies from both the California Energy Commission and Pacific Gas and Electric Company. They are also eligible for net metering subsidies.

The siting of a wind turbine is dependent on the availability of adequate wind over the course of the year. The National Renewable Energy Laboratory has developed a Wind Energy Resource Atlas of the United States, which is available for downloading on their website:

http://rredc.nrel.gov/wind/pubs/atlas/maps/chap3/3-55m.html

Figure 3 is the map for southern California. It can be seen that San Luis Obispo County is largely located in Wind Energy Class 1 and 2. Class 1 is considered unsuitable for wind energy development and Class 2 is marginal. Wind resources are highly site dependent on elevation, topography, vegetation, and the blocking effect of nearby buildings, so the Technology Park site could be in a higher Wind Energy Class than indicated on Figure 3. The actual wind resource would need to be determined by an on-site study over a number of months.

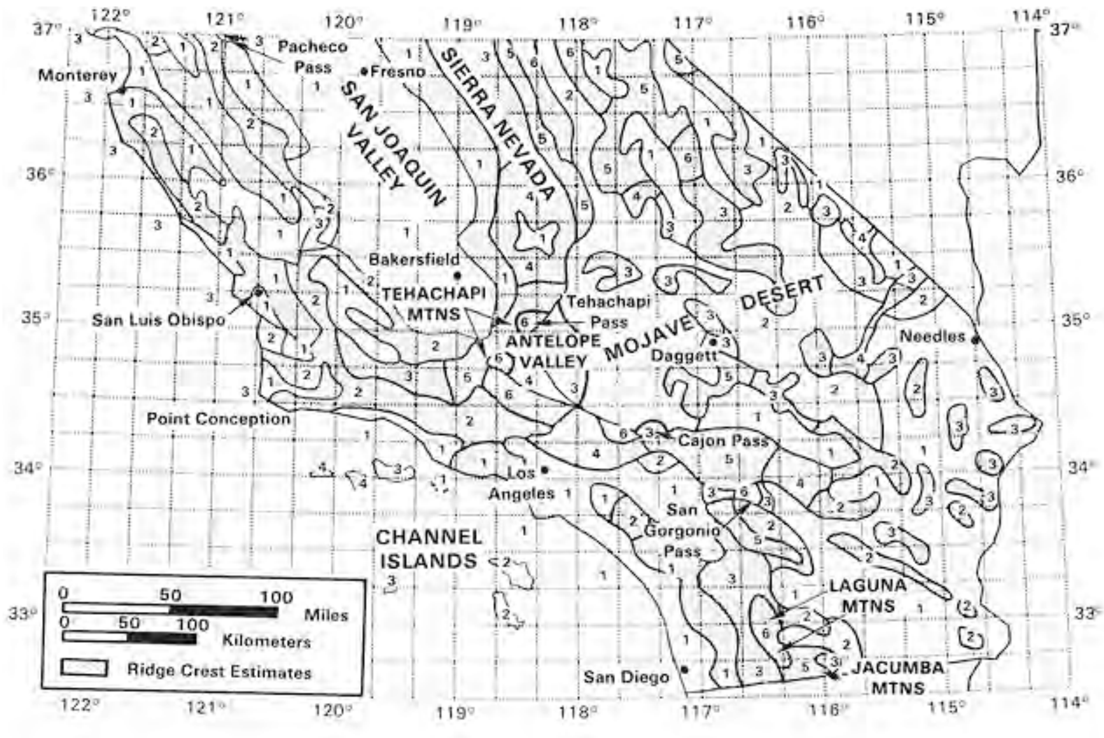

Figure 3 – Wind Energy Resource Map for Southern California

After National Renewable Energy Laboratory, *"Wind Energy Resource Atlas of the United States",* Southern California, 1986.

Other siting issues include the visual impact of the system. Typically an effective wind energy system should be on a 80 to 100 foot tower, depending on local wind conditions. Wind systems generate noise, which may be an issue to both Technology Park occupants and neighboring buildings.

Wind energy systems require periodic maintenance, which involves climbing the windmill tower. Such work is potentially dangerous and requires a specialty contractor.

According to the article 'Climate' (p.20 of this handbook) there is insufficient wind speed for wind turbines. In the surrounding area there are suitable sites, though.

Biomass Renewable Energy

Conversion of biomass to electrical energy is the largest source of renewable energy in the United States, about 47% according to the U.S. Department of Energy. The majority of this generation is in the form of large-scale conversion of forestry and crop residues by combustion. The biomass energy plant in Soledad, north of San Luis Obispo in Monterey County, is a typical example.

Even though there is no room for lagoons on the site for the Tech Park, there are biomass resources available on the Cal Poly campus that have been developed on a smaller scale, animal wastes from the Cal Poly dairy herd. The Bioresources and Agricultural Engineering Department (BRAE) have operated a covered dairy lagoon digester and 30 kW microturbine system since July 2002 (see Figures 4 and 5). At the Cal Poly dairy, about 90 percent of the manure is deposited on concrete, flushed through a solids separator, and pumped into a 14,400 cubic meter covered lagoon digester. Approximately 300,000 to 400,000 liters of flushed manure is loaded daily into the lagoon. Naturally occurring anaerobic bacteria convert the dairy waste into biogas, a mixture of approximately 30% carbon dioxide and

70% methane. The project is described in detail in Williams, D.W. and D. Gould-Wells, 2003.

The biogas is captured by a floating membrane cover on the top of the lagoon and piped to the micro-turbine and electrical generation system. The generator is on-grid and is participating in the Pacific Gas and Electric Company net metering program.

The environmental benefits of a covered lagoon digester system, although not quantified in a measurable economic value, are considerable. By virtue of the cover capturing the gas emissions from the dairy manure, both odor and the release of greenhouse gases are considerably reduced. Methane has twenty one times the greenhouse gas generation potential of carbon dioxide. Conversion of the dairy waste methane to carbon dioxide in the microturbine is a substantial environmental benefit.

A microturbine fueled by biogas may be eligible for a grant from the California Self Generation Incentive Program, as described in the next section. Plans have been developed by BRAE for a more efficient packed bed-heated digester, which would produce more biogas and allow the generation of more electricity for on campus use. The new digester design could serve as a prototype for the commercialization of this promising technology. The point of contact for the project is Dr. Doug Williams of the Bioresources and Agricultural Engineering Department at 805-756-6153.

Figure 4 – Cal Poly Covered Dairy Lagoon Digester
After Williams, D.W. and D. Gould-Wells, 2003

Figure 5 – Cal Poly 30kW Microturbine Installation
After Williams, D.W. and D. Gould-Wells, 2003

Financial Incentive Programs for Renewable Energy

There are several financial incentive programs available for renewable energy projects including grants for construction and operating subsidies in the form of net metering which will reduce the cost of electricity to the Technology Park. Eligibility for these programs should be confirmed with the granting agencies before making financial commitments.

***California Energy Commission (CEC)* –** The CEC sponsors the Emerging Renewables Rebate Program. Current funds available from the Program are given in Table 3 below. Since Program requirements are subject to change, the CEC should be contacted to confirm current rebates.

Table 3 – California Energy Commission Emerging Renewables Program Rebates *(Effective January 1, 2005)*

Technology	Size Category	Rebate Offered
Photovoltaic (Solar cells)	Less than 30 kilowatts	$2.80 per watt
Wind	First 7.5 kilowatts Increments above 7.5 kilowatts up to 30 kilowatts	$1.70 per watt $0.70 per watt
Solar Thermal Electric & Fuel Cells	Less than 30 kilowatts	$3.20 per watt

After California Energy Commission http://www.consumerenergycenter.org/erprebate/new_info.html

Details on the program are given in the "Emerging Renewables Guide Book, Third Edition," available online at http://www.consumerenergycenter.org/erprebate/index.html.

Pacific Gas and Electric Company (PG&E) – The California Public Utilities Commission (CPUC) has established the California Self Generation Incentive Program**,** a subsidy program for renewable energy sources serving commercial and institutional users. Technologies supported by the program and rebate levels are given in Table 4 and 5. The program is complementary to the CEC Emerging Renewables Program, but it supports larger systems. In the San Luis Obispo area, the Pacific Gas and Electric Company is the investor owned utility that administers the Program for CPUC.

Table 4 - Technologies Eligible for California Self Generation Incentive Program

Incentive Levels	**Eligible Technologies**
Level 1	• Photovoltaics (PV) • Fuel cells operating on renewable fuel • Wind turbines
Level 2	• Fuel cells operating on non-renewable fuel and utilizing sufficient waste heat recovery
Level 3-R	• Micro-turbines, internal combustion engines and gas turbines operating on Renewable Fuel
Level 3-N	• Micro-turbines, internal combustion engines and gas turbines operating on Non-Renewable Fuel or Waste Gas Fuel, utilizing sufficient waste heat recovery, meeting the reliability and emissions criteria as applicable.

Table 5 – Incentive Levels for Various Technologies – California Self Generation Incentive Program

Incentive Levels	**Eligible Technologies**	**Incentive Offered ($/Watt)**	**Minimum System Size**	**Maximum System Size**	**Maximum Incentive Size**
Level 1	Renewable fuel cells Photovoltaics Wind turbines	$4.50/W $3.50/W $1.00/W	30 kW	5 MW	1 MW
Level 2	Non-renewable fuel cells	$2.50/W	None	5 MW	1 MW
Level 3-R	Renewable fuel microturbines Renewable fuel internal combustion engines and large gas turbines	$1.30/W $1.00/W	None	5 MW	1 MW
Level 3-N	Non-renewable & Waste Gas fuel micro-turbines Non-renewable & Waste Gas fuel internal combustion engines and large gas turbines	$0.80/W $0.60/W	None	5 MW	1 MW

Application requirements and details on the Program can be found in *"Self Generation Incentive Plan Guidebook*," available online at http://www.pge.com/selfgen/. Since Program requirements are subject to change, PG&E should be contacted to confirm current rebates.

Net Metering

Net metering allows grid connected renewable energy systems that "run the meter backwards" , earning credit for electrical energy that they generate in excess of their own usage. Rate schedules for wind and solar systems are given at : http://www.pge.com/suppliers_purchasing/new_generator/solar_wind_generators/index.html#topic1

A separate rate schedule for biogas systems is given at: http://www.pge.com/suppliers_purchasing/new_generator/ebio/

Contact PG&E for current rates and regulations.

Discussion and Analysis

The use of renewable energy will be a benefit to the Technology Park in terms of reducing energy costs and demonstrating state-of-the-art systems to the public. The solar and wind technologies discussed are the most mature and can be designed and purchased in turnkey packages. The biomass energy system discussed is a pre-commercial system that offers some potential for joint research and development between the Technology Park and university researchers.

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