OPS

Manual

A Guide to **O**lympic **P**eninsula **S**olar

Pre Release Draft

July 12, 2008

Prepared by

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Abstract

The industrial age of the past three hundred years is identifiable by its explosive growth in human population and standards of living, marked by consumption of vast amounts of stored fossil fuel energy and other resources of the earth, often characterized by enormous waste. We have been spending our energy savings. The post-industrial age is identifiable for its explosive growth in technology and reliance on renewable energy and lower overall energy consumption per capita. We will have little choice but to begin to spend our energy income from the sun. A transition is unfolding and inevitable.

As the world transitions from the industrial age to the post-industrial age, questions begin to arise as to how a more sustainable and healthy world will be achieved and who will manage it. Indeed, we are all involved in the transition, and we all will have opportunities to contribute, but what are the governing principles? What is the basic structure and strategy for moving ahead in a fair and judicious manner, with protection for the remaining resources of the earth? The answers are already emerging, as free market capitalism is embraced on a supranational scale, with globalization of commerce and ideas becoming more and more under the control of corporations. Nationalism is giving way to corporatism. Can we maintain democracy with this reality?

A previously published report, *The Power Trick Report*, takes a regional look at the emerging renewable energy industry. As corporations continue to influence our lives, generally in a good way, there is a tendency for abuses to creep into the economic processes under way. Corporate self-interests are increasingly intertwined with public interests. As a result of advanced industrialization, we seem to embrace the technological solutions presented by corporations before fully understanding how the public domain is served and protected. Whether the general public knows it or not, their future is under less and less control by governments and elected officials, and more and more control by corporations. There is a need for populism to arise to assure a balance and ultimate accomplishment of goals for sustainability.

This manual is provided as a guide to going solar for the general public and the contracting community (of electricians, general contractors, plumbers, heating professionals, and others) on the Olympic Peninsula. The potential for real change toward sustainable energy consumption is dependent on education and long term personal planning, as well as available and emerging technology. A populist movement toward solar energy, essential in a post-industrial age of intense technology focus, provides for a cost effective transition to a sustainable lifestyle, balancing social, ecological, economic, and technical factors. This manual is a tool for use in the populist movement.

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Foreword

Perspective

Corporatism, though perhaps a legitimate approach to economics on the one hand, tends to see the public as an entity to be manipulated and used for gain. Corporatism plays on the ignorance and fears of people. The only "truth" is the public perception of reality...which can and often is defined by corporate interests. Energy is a subject with which the general public has limited knowledge and understanding, for it is vast, esoteric, scientific, and technical. The dizzying aspects of "spinning your meter backwards":

- Do not account for the embedded energy content of renewable energy (solar) systems; embedded energy represents the non-renewable energy used in making it
- Betray sustainable economics and economy of scale
- Put emphasis on energy production rather than conservation…there are for more ecological products and approaches to spinning your meter backwards than solar

Further Perspective

"Tackling Climate Change in the U.S." – Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030, released from ASES, Charles F. Kutscher, Editor, January 2007

This report should be read by anyone interested in the science and strategy of dealing with the link between our energy regime and climate change. The report is compiled from several papers presented at the Solar 2006 conference in Denver, Colorado, and represents ideas, plans, and goals, but not predictions per se.

Here are some numbers that represent reasonably thought out plans for reducing carbon emissions, on the path to more reductions by 2050, with the renewable source and resulting **reductions** by 2030:

[**Million Tons of Carbon** per year]

Energy Efficiency	**688**
Concentrating Solar	**63**
Solar PV	**63**
Wind	**181**
Biofuels	**58**
Biomass	**75**
Geothermal	**83**

It will take a 500 fold increase in the installed PV by 2030…250 GW, above industry predictions of 200 GW. Notice how important efficiency will be!

The original and still ongoing goal of Olympic Energy Systems, Inc. is the development of a renewable energy industry on the North Olympic Peninsula. By encouraging the involvement of a large number of licensed contractors (electrical and general contractors for Solar PV installations), the public has more choice and more potential to save on installation costs. The process for developing solar electric grid-tied systems is actually straightforward, as equipment is off the shelf, while the solar knowledge required involves basic geometry, not rocket science. The solar energy system basics involve:

Solar knowledge: Assessing solar access at sites for performance predictions
Equipment knowledge: Solar PV panels, mounting structure, and inverters [specs on-line]
System knowledge: Solar PV array basics, in forming series and parallel strings and keeping within the parameters of the inverters; knowing impacts of roof orientations
Electrical Code knowledge: Familiarity with NEC 690; knowing how to interpret code
Utility knowledge: Familiarity with Net Metering agreements

Before ever doing solar projects, contractors have most of the basic knowledge needed to develop and install systems. Olympic Energy Systems fills in the rest, until the contractor becomes experienced enough to call itself a solar firm. Most technicians would say that it is easier than you think. In fact, Olympic Energy Systems has helped homeowners develop solar electric and hot water systems themselves, in a consultant role (helping only with economic and technical decisions).

Jonathan A. Clemens
Port Townsend, Washington USA
May 2008

Introduction

In 1950, nearly 100% of the electricity used in Washington State was sourced from large-scale hydropower plants. Since that time, increases in demand have been largely met by fossil fuel fired electric plants. About 2/3 of the electricity sold by Puget Sound Energy (the utility for East Jefferson County and Port Townsend, and of course, much of the Puget Sound area) is sourced from coal and natural gas fired power plants.

In the U.S., about 10% of the nation's electricity is derived from hydropower and 20% from nuclear power, with about 50% sourced from coal fired electric power plants.

In 2001, the US Department of Energy predicted an average 1.4% annual increase in the consumption (of all forms) of energy through 2020, even with expected conservation measures. That is an increase of about 30% in total energy consumption from 100 to 130 Quads (where 1 Quad = 1 Quadrillion BTUs), which despite alternative energy development, will mostly be met by fossil fuels.

Though energy price hikes will do a lot to spur innovation and conservation, there will still be enough vested interests in the energy industry to allow consumption of energy to remain high. Corporate interests will generally benefit from high energy consumption. Corporatism will likely result in continued construction of coal fired power plants and a resumed construction of dozens of nuclear power plants.

Populism is a necessary component of our modern, corporate-oriented capitalistic system, if there is to be a reasonable balance between private and public interests. Loosely organized now in the form of disparate groups of environmental, social, political, and non-profit organizations, populism must be expanded in a way that the public is made aware of the corporatism v. populism dynamic and has confidence in its ability to effect positive change. And we mean a change in the energy realm. Education is a key activity, along with carrying out reasonable goals and objectives.

Objectives:

1) Reduce Energy Consumption – direct and indirect (embodied)
2) Finance or subsidize Renewable Energy investment with energy efficiency measures
3) Learn to become Energy Managers, on a personal level, not merely consumers
4) Develop an Energy Plan – Short and Long Term
5) Ultimately consider Embodied Energy in the products and services we buy or use
6) Build up the local Solar Energy Industry
7) Invigorate a Populist Movement toward Solar Energy

Solar Potential on the North Olympic Peninsula

3.5 Peak Sun Hours per Day on an annual basis for a fixed PV panel facing south at the latitude angle. OES has observed weather conditions that indicate a significant difference in cloudiness between the years 2002 and 2007: 165 cloudy and 200 sunny days in 2002 versus 237 cloudy and 128 sunny days in 2007. Cloudy includes mostly cloudy and partly sunny. Sunny includes mostly sunny and partly cloudy. Energy production of a PV panel in a day can actually be higher on a partly cloudy day than a clear sunny day, as reflected energy intensifies at the PV panel.

System Architect Role

A system architect looks at all factors of development and will work to meet system goals for performance and cost effectiveness through a systematic approach, putting emphasis on processes, which are not a part of typical consumer transactions. The system architect is customer-oriented, independent, and diligent. The system architect augments the tendencies of contractors to limit their time and effort in upfront process work and pursues more cost-effective solutions. A system architect does not profit from the materials or labor in a solar energy project, when truly independent. The fees constitute the value provided by the consultations of the system architect.

Energy Management

We manage our careers, our families, and our money, but do we manage our energy?

As we tend to merely buy our energy, and perhaps respond to price changes or cues, we typically have not seen ourselves as energy managers. Managing energy means looking beyond the paying for energy, by looking at:

Sources
Uses
Impacts
Economics
Life Cycle Costs
Technology Trends
Science (e.g., Principles and Efficiency)

An understanding of the TRANSFORMATIVE nature of energy improves our ability to advance energy efficiency. Advancing energy efficiency is a precondition for effective solar energy systems.

An understanding of equipment and associated science and principles of operation improves our ability to make wise decisions about maintaining our existing equipment (such as furnaces or heat pumps) or procuring new equipment or systems (such as solar energy systems – PV, solar hot water, etc.).

Solar Energy System Development

The life cycle importance of solar energy systems necessitates a “development” approach rather than a mere purchase decision. Development means process. One does not have to be “mired down in process”, which would imply that one is either ignorant of the process, ignorant of the importance of process, or following the wrong (or less than optimum) process.

PLANNING – Goals, Requirements & Objectives, Constraints

SPECIFICATION – Options, Trade Studies (on components and configurations)

INSTALLATION – Contractor Team Selection, Project Management

COMMISSIONING – Functional Test, System Familiarization

Given the importance in reducing our energy consumption and carbon emissions, based on the emerging threats posed by over-consumption, an engineering approach to the development process, as opposed to the marketing approach, is not excessive and is necessary.

Economics

Many people may not be aware that costs, in general, reflect embodied energy in the products and services we acquire. If sustainability in energy, environment, and economics is to be achieved, then cost effectiveness must be apart of the equation. When a solar energy system returns on the initial investment, there is also an implied return on the energy invested in the system. With embodied energy deriving mostly, if not entirely, from non-renewable energy sources, a positive economic return (i.e., a Payback less than the Service Life, or a positive Present Worth) is mandatory.

Olympic Energy Systems has developed its Renewable energy Cost Model (RCM) for assessing various solar energy system configurations and economic conditions for System Cost and Present Worth.

The following RCM printout represents a system that was actually developed in early 2008. The 2660 Watt grid-tied solar electric system cost of $17,200 installed (actual price), given the economic conditions and incentives at the time, will translate to a positive payback, that is, a positive Present Worth, considering its expected Service Life of 25 years.

This 2660 Watt system is the **first** solar electric system installed on the North Olympic Peninsula, since Clallam County's first grid-tied solar electric system in 2003 (by an Olympic Energy Systems, Inc. client), to actually have a positive Present Worth. The payback is possible due to incentives, including a $500 per Kilowatt utility rebate, a $0.18 per KWh production incentive through 2014, and an uncapped 30% federal tax credit (as the site is deemed commercial).

These systems must be developable without incentives, while still providing a positive Present Worth, to ensure that embodied energy is low enough to provide for a positive return on energy investment. A Populist Movement will be critical in this endeavor.

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General Instructions	!	**Renewable Energy Cost Model (RCM)**	
Choose Simplified or General Input MODEL	!	Developed by: Olympic Energy Systems, Inc.	
Select New System TYPE	!	Original Date: 6/4/04 Rev A 9/15/05 jac	
Specify New System SIZE	!	Revision History:	
Specify New System Basic SPECS	!	Simplified Input Model Complete 6/10/04 jac	
Enter Relevant Energy COSTS	!	Solar Hot Water Model In Work 7/12/04 jac	
Enter Existing System DATA	!	Solar Hot Water Model Complete 8/25/04 jac	
Specify Model PARAMETERS	!	General Input Model In Work	

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	Kailin	**Insolation Level**	**0.98**
SOLAR PV - Simplified Input	Enter here:	Note: Sales Tax = 0.082; **Peak Sun Hours = 3.5**	
GRID (enter 0) or Standalone (enter 1)	0	Default is 0 (Grid) **IL x PSHD x 365 = PSH/Year**	
SIZE (300, 600, 1200, 1500, 2000, 3000)	2660	Watts, Array (Select value)	**1252**
MOUNT (Roof (0), Ground (1), Pole (2))	0	PV Install Location (Roof, enter 0)	3330
ECONOMIC INTEREST RATE (0.xxx)	0.03	Interest on Savings, Annual	
FINANCE INTEREST RATE (0.xxx)	0.09	Interest on Loan, Annual	
FINANCE PERIOD (# of Years)	5	Assumes Annual Payments on Loan	
DOWN PAYMENT (Fraction, ie, 0.xx or 1)	1	Fraction paid upfront; Default is all down (enter 1)	
GREEN (Premium Price) TAGS ($/Kwh paid)	0.18	0.05 from NWSC; **Production Payments (utility)**	
GREEN (Premium Price) TAGS DURATION	7	In YEARS (Example, WA State Incentives = 10)	
STATE SALES TAX EXEMPTION (1 or 0)	1	**1 if exempt**, 0 if not exempt	
REBATE (Discount off System Cost), fraction	0.3	0.20 off, if Off Grid (in WA); **Tax Credit of 30%**	
REBATE (Discount off System Cost), cap	100,000	Example, $2000 federal cap	
UTILITY RATE (current rate, example 0.08)	0.08	$/KWh; Model assumes a 4% increase per year	
If Standalone:	!	**Utility Rebate:** 500 (Dollar$/KW)	
SYSTEM VOLTAGE (24, 48)	24	Volts	
BATTERY CAPACITY (350, 700, 1400)	350	Amp-hours	
Solar PV SYSTEM COST (w/out Rebate)	**$17,417**	**Solar PV Model OUTPUT $2004 'Should Cost'**	
Energy Savings per Year ($)	652	Annualized Savings plus Subsidy, if applicable	
Solar PV System PRESENT WORTH	**$484**	PW of (Savings + Subsidy) at EIR - Loan at FIR	
PAYBACK PERIOD (Years)	*see below*	Number of Years to get a Present Worth of ZERO	
Enter **Operating Time** (Life), years n = xx	**25**	Increment/Decrement by 1 until PW = or > 0	
Note: Service Life DEFAULT = n = 25	*reset default*	If done computing Payback Period, enter Default	

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Lessons Learned

Taking heed to lessons allows problems to be avoided in the development process. Lessons can be gleaned from scientific endeavor and industry, but when it comes to solar energy system development, mostly from the experiences of system developers and owners. In the ideal world (and actually in the engineering world), lessons learned are documented and shared. The local solar energy industry has a few lessons to offer, mainly in these general categories:

Permits/Inspections
Performance
Quality
NEC Code
Utilities
Customer Expectations

Your solar architect will freely share those lessons learned from all aspects of and all participants in the solar industry.

Most lessons learned pertain not so much to solar but to the art of contracting.

Strategies

The OES favorite: Finance solar energy systems with the returns from investing in energy efficiency and conservation measures. Case in point is the Parks solar project in Sequim, Washington, whereby the owner first invested in an electric heat pump upgrade, realized significant energy savings, then invested in a solar electric system.

Other favorites: Deferred Gratification (buy later improved technology, in order NOT to subsidize old technology). For residential prospective clients, the Thin Film soon versus Crystalline PV now decision is an important one, both for personal (cost effectiveness) and public (carbon emission reduction) benefits.

The vast majority of current PV production is sold overseas and will be increasingly used in large scale commercial projects in the US in the next few years, spurned mainly by state mandated Renewable Portfolio Standards. RPS mandates require the sourcing of electricity production from renewable sources, like wind and solar. The challenge to residential PV development is two-fold…too much demand for the limited production and too high a price for most residential households and small businesses. It is when the large scale solar farms have been developed to meet mandates will there be a redirection of supply from commercial to smaller scale commercial and residential applications. So, to incorporate crystalline PV on homes now, though commendable from a philosophical standpoint, is less than optimum for economic and environmental reasons.

Projects

The American Solar Energy Society (www.ases.org) has hosted a tour of solar sites for many years, done on the first Saturday of October. The tour is a tribute to solar energy owners who have a story to tell about how and why they went solar. For review of existing projects and sites, you should contact your regional solar energy developers.

Olympic Energy Systems, Inc. has developed solar electric (on grid and off grid) and solar hot water systems in several cities and counties throughout the region, from Port Townsend, Blyn, Sequim, and Port Angeles, to Port Orchard, Bremerton, Bainbridge Island, Kirkland, Marblemount, and Forks.

Conclusions

Going solar is a process that will involve a lifetime of learning and decision making. Reactive and conditioned response thinking will give way to informed and proactive thinking. A populist movement is a conceptual, but very real, approach to working side by side with corporate interests in our democratic-governed capitalistic-driven system, where all can share in the progress and all can live and work in a sustainable fashion.

References

These references are not exhaustive by any means, nor should they be considered priorities. It is just that a manual should contain some starting points for further research.

Web Links [favorites include www.solarwashington.org, www.ases.org, www.doe.gov]
Utility Contacts [Clallam County PUD, Puget Sound Energy, City of Port Angeles, etc.]
One Line Diagrams [Available upon request from Olympic Energy Systems]
Contractor Directory [See www.olympicenergysystems.com]

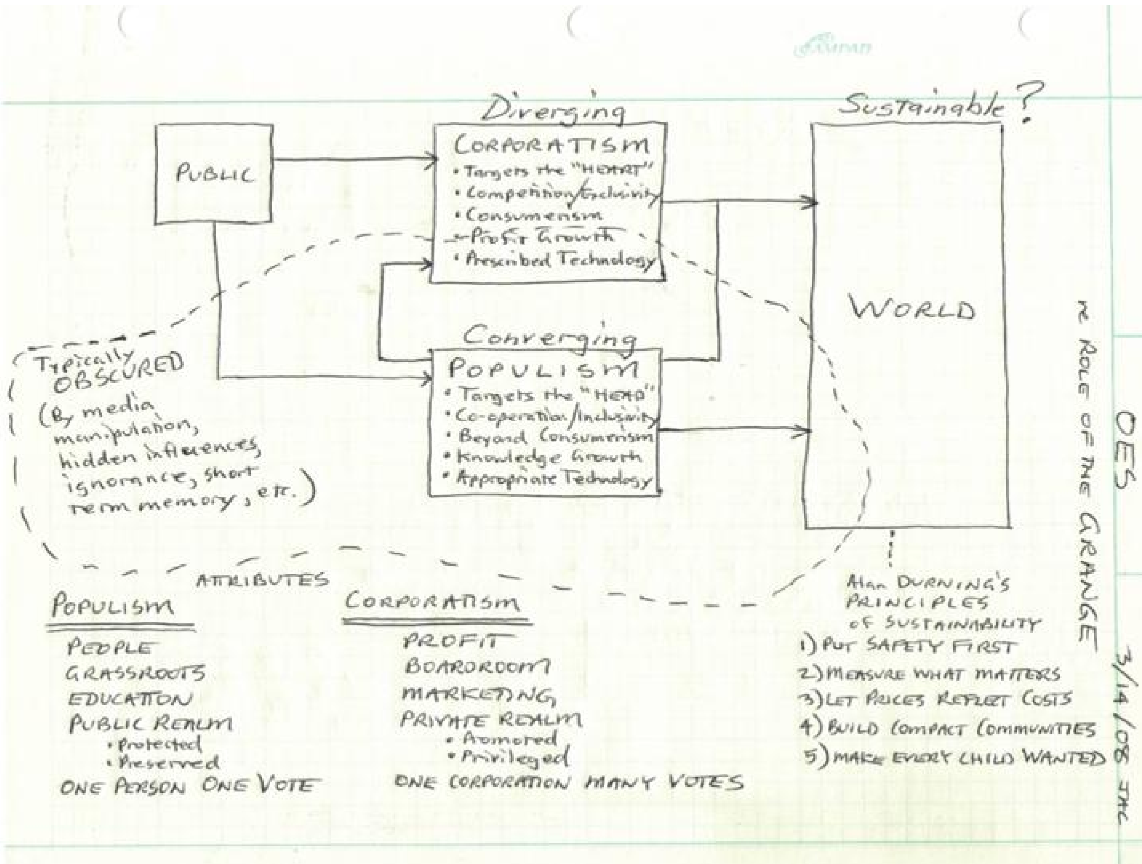
- Hanson Electric & Networks
- Current Electric (of Port Townsend)
- Jarmuth Electric
- Lang's 'Lectric
- Cascade Electric
- Extra Mile Tech & Electric
- Black Point Electric
- West Sound Electric
- Greenspace Design & Landscaping Ltd (www.greenspaceltd.com)
- Alpha Builders Corporation
- Sunrise Heating
- Air-Flo Heating
- H2O Plumbing Contractors
- Precision Plumbing
- NW Gas Supply & Plumbing

Operational Solar Sites [See your regional solar systems developer]
Recommended Reading

“Living on Less – An Authoritative Guide to Affordable Food, Fuel, and Shelter”
“The Urban Homestead: Your Guide to Self-Sufficient Living in the Heart of the City”
“The World Without Us”, by Alan Weisman

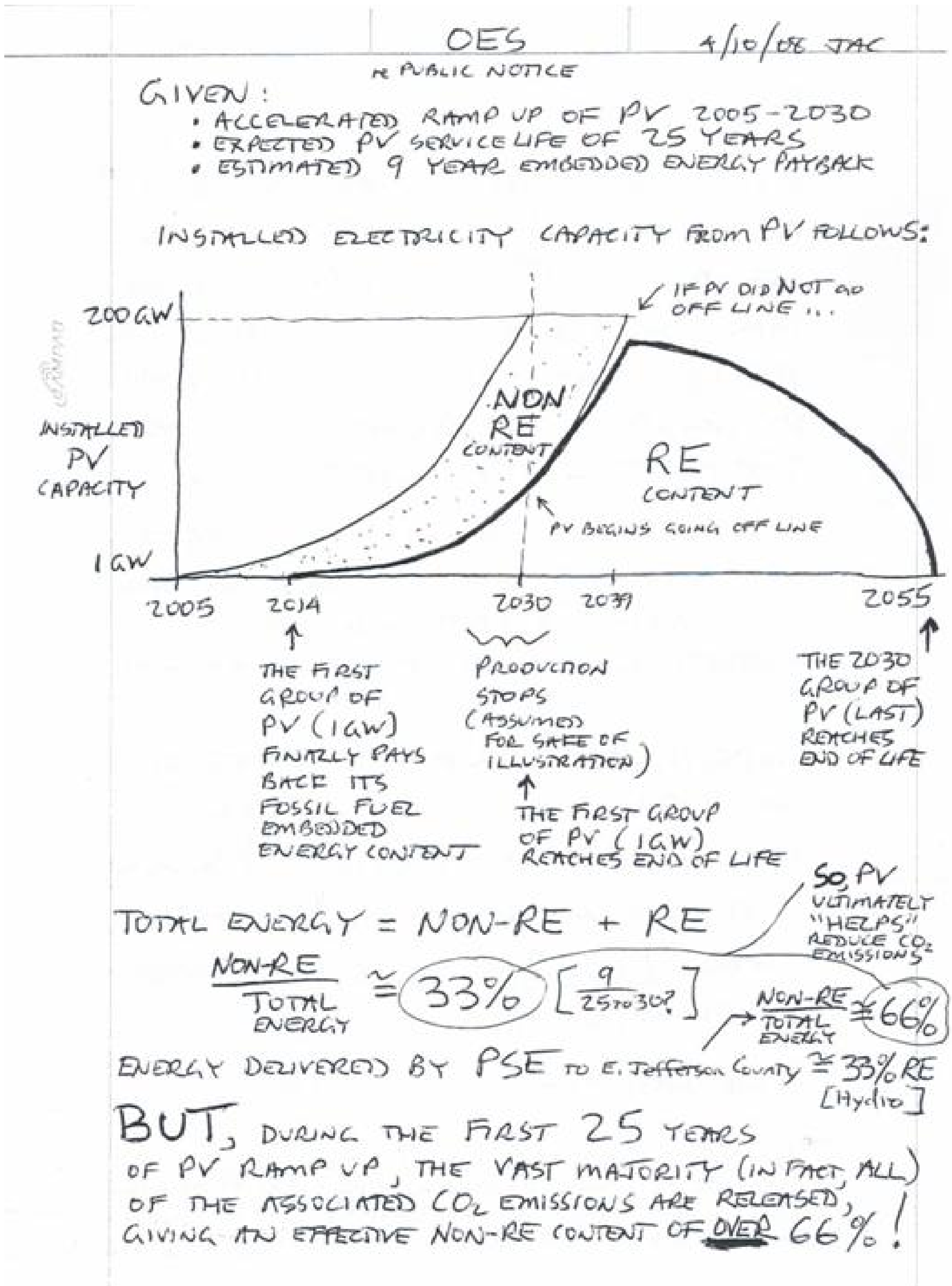
Supporting Data

Corporatism v. Populism
PV Embedded Energy
Project Summaries
Solar Insolation Data



Corporatism v. Populism (the essential dynamic in our free market capitalistic system)

For more information on Populism and the much needed Populist Movement toward solar energy, see the Programs page of the Olympic Energy Systems, Inc. website, at www.olympicenergysystems.com/Programs.html



Indeed, there is long term potential for solar PV to reduce the actual level of carbon emissions, that is, to have a low enough embedded energy content to improve upon our current sourcing of electricity from a mix of sources that include largely coal and natural gas. The "Tackling Climate Change in the U.S." report (ASES 2007) sees the potential for Solar PV to contribute 63 M of the planned 1211 M tons of carbon reductions, or 6%.

Sequim, WA






SOLAR PHOTOVOLTAIC and HOT WATER SYSTEMS

Sanyo HIP-200BA3 PV, 200 Watt, n=16 for 3200 Watts Total
Outback PS1 Inverter System, Grid-Tied, Battery Backup (48 V DC)
S-5! Clamp System (with standing seam metal roof)
Conventional KWh Meter and Base (for production metering), to grid and backup panels
Thermomax Mazdon Evacuated Tube Collector (30 tubes), with tilt kit (stainless steel)
Thermomax Solar Pump Station and SMT100 Differential Temperature Controller
Superstor Ultra, SSU-SE (Solar Edition) 60 gallon tank, w/ heat exchanger (PREHEAT)

The grid-tie inverter provides 120 Volt AC power to the utility grid, per a Net Metering Agreement. In February 2008, the system was already delivering more than 5 KWh per day. An electrical backup panel furnishes backup AC power to receptacles in the house, garage, and pump house, backing up the solar hot water system and well pump system.
The Clallam County PUD is planning to offer renewable energy production incentive payments, per the Senate bills passed in July 2005. This owner should receive over $400 per year through 2014 or later (if the utility chooses) in incentive payments, on top of the avoided retail cost (over $200 per year), a $500 per KW rebate from the PUD, and three $2,000 federal tax credits (PV Year 1, PV Upgrade, and SHW system).
The photovoltaic system was developed by Olympic Energy Systems, Inc. Greenspace installed the PV array and evacuated tube thermal collectors, H2O installed the plumbing, and Hanson Electric performed the electrical installation. Olympic Energy Systems emphasizes energy awareness, conservation, and efficiency measures first and foremost.

OLYMPIC
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Port Townsend, WA

SOLAR PHOTOVOLTAIC SYSTEM

Xantrex GT2.5 2500 Watt Grid-Tie Inverter
Evergreen 180 SL 180 Watt Spruce Line Photovoltaic Panels (8) on detached garage roof
Uni-Rac Solar Mount (flush mount system)
Conventional KWh Meter Base (for production metering; meter supplied by the utility)

The grid-tie inverter provides 240 Volt AC power to the utility grid, per a Net Metering Agreement. The 1440 Watt array is expected to produce about 10 KWh per day at the inverter output in the summer. Provisioning enables capture of incentives in the future, including doubling the PV array size, using the west side of the garage roof. The system is maintenance-free and requires only casual monitoring.

The utility, Puget Sound Energy, offers renewable energy production incentive payments, per the Senate bills passed in July 2005, implemented as REAP (Renewable Energy Advantage Program). This owner should receive over $400 per year through 2014 or later (if the utility chooses) in incentive payments, on top of the avoided retail cost (over $150 per year), a $600 per KW rebate from the utility, and a $2,000 federal tax credit.

The photovoltaic system was developed by Olympic Energy Systems, Inc. Greenspace installed the PV array and Hanson Electric performed the electrical installation. Olympic Energy Systems emphasizes energy awareness, conservation, and efficiency measures first and foremost, above and beyond installation of renewable energy systems.

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Sequim, WA



GRID-TIED SOLAR PHOTOVOLTAIC SYSTEM

SMA Sunny Boy 4000U Inverter, 4000 Watts AC (up to 4800 Watts DC)
Integral DC and AC Disconnects, attached to inverter
Evergreen 190 Spruce Line Solar PV Panels, (12) for 2280 Watts re initial array
Provision for additional PV (12 more PV Panels for a total 4560 Watts in 2008)
UniRac Solar Mount System

The owners live in a beautiful cedar home. The Solar PV array is one of a growing list of energy efficiency projects implemented or in the works. The modest 4/12 pitched roof sections face east and west. A site assessment and follow-on analysis showed that the site will still receive over 80% of its yearly potential. The total system size of 4560 Watts should produce enough electrical energy in a year to ZERO out the utility meter!

Olympic Energy Systems, Inc. developed the photovoltaic system, as consultant and system architect, having met the owners at an OES-sponsored solar energy fair.

Jarmuth Electric (of Sequim) performed their first solar electrical installation with this system, and they did a good job. A General Contractor, Greenspace Landscaping, installed the roof-mounted PV array. Olympic Energy Systems emphasizes energy awareness, conservation, and efficiency measures first and foremost, above and beyond installation of renewable energy systems.

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Port Angeles, WA

SOLAR PHOTOVOLTAIC SYSTEM

Outback PS1 Inverter, Grid-Tied, Battery Backup
Sanyo HIP-200BA3 200 Watt Photovoltaic Panels, (8) on roof, for 1600 Watts Total
Uni-Rac Solar Mount (flush mount system)
Backup Electrical Panel (powered from the PS1)

The grid-tie inverter provides 120 Volt AC power to the utility grid, per a Net Metering Agreement. The entire house power is backed up with a battery and inverter system (Outback PS1). Provisioning enables capture of incentives in the future, including doubling the PV array size, possibly with a pole mount installation in the back yard. The system is maintenance-free and requires only casual monitoring.

The Clallam County PUD is planning to offer renewable energy production incentive payments, per the Senate bills passed in July 2005. This owner should receive over $200 per year through 2014 or later (if the utility chooses) in incentive payments, on top of the avoided retail cost (over $100 per year), a $500 per KW rebate from the PUD, and a $2,000 federal tax credit.

The photovoltaic system was developed by Olympic Energy Systems, Inc. Eco-Logic installed the PV array and Extra Mile Tech & Electric performed the electrical installation. Olympic Energy Systems emphasizes energy awareness, conservation, and efficiency measures first and foremost, above and beyond installation of renewable energy systems.

OLYMPIC
Energy Systems

Port Angeles, WA

SOLAR PHOTOVOLTAIC SYSTEM

Xantrex GT2.5 2500 Watt Grid-Tie Inverter
Evergreen 180 SL 180 Watt Spruce Line Photovoltaic Panels (8) on roof
Uni-Rac Solar Mount (flush mount system)
Conventional KWh Meter and Base (for production metering)

The grid-tie inverter provides 240 Volt AC power to the utility grid, per a Net Metering Agreement. In May the 1440 Watt array was already producing over 7 KWh per day at the inverter output. Provisioning enables capture of incentives in the future, including doubling the PV array size, possibly with a pole mount installation in the back yard. The system is maintenance-free and requires only casual monitoring.

The City of Port Angeles utility is planning to offer renewable energy production incentive payments, per the Senate bills passed in July 2005. This owner should receive over $400 per year through 2014 or later (if the utility chooses) in incentive payments, on top of the avoided retail cost (over $150 per year), a $500 per KW rebate from the city utility, and a $2,000 federal tax credit.

The photovoltaic system was developed by Olympic Energy Systems, Inc. Greenspace installed the PV array and Hanson Electric performed the electrical installation. Olympic Energy Systems emphasizes energy awareness, conservation, and efficiency measures first and foremost, above and beyond installation of renewable energy systems.

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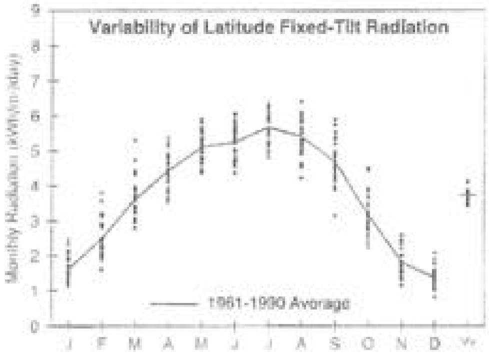

Seattle, WA

WBAN NO. 24233

LATITUDE: 47.45° N
LONGITUDE: 122.30° W
ELEVATION: 122 meters
MEAN PRESSURE: 1001 millibars

STATION TYPE: Primary

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

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	1.0	1.7	2.8	4.1	5.3	5.8	6.1	5.2	3.8	2.2	1.2	0.8	3.3
	Min/Max	0.8/1.2	1.2/2.1	2.4/3.6	3.5/4.8	4.6/6.1	4.8/6.7	5.2/6.7	4.2/5.9	2.9/4.5	1.8/2.8	0.9/1.4	0.6/1.0	3.2/3.6
Latitude -15	Average	1.5	2.3	3.5	4.6	5.4	5.7	6.1	5.6	4.7	3.0	1.7	1.3	3.8
	Min/Max	1.1/2.2	1.5/3.5	2.8/5.1	3.7/5.5	4.7/6.3	4.7/6.6	5.2/6.8	4.4/6.6	3.2/5.8	2.2/4.2	1.1/2.3	0.8/1.8	3.5/4.2
Latitude	Average	1.6	2.5	3.6	4.4	5.1	5.2	5.7	5.4	4.7	3.2	1.8	1.4	3.7
	Min/Max	1.1/2.5	1.6/3.8	2.8/5.3	3.5/5.4	4.4/5.9	4.4/6.1	4.8/6.3	4.2/6.4	3.1/5.9	2.2/4.5	1.1/2.6	0.8/2.1	3.4/4.1
Latitude +15	Average	1.7	2.5	3.5	4.1	4.5	4.5	4.9	4.9	4.5	3.2	1.8	1.4	3.5
	Min/Max	1.1/2.6	1.6/3.9	2.7/5.2	3.2/5.0	3.9/5.2	3.8/5.2	4.2/5.5	3.8/5.8	3.0/5.7	2.2/4.5	1.1/2.7	0.8/2.2	3.2/3.8
90	Average	1.5	2.2	2.8	3.0	3.0	2.8	3.1	3.4	3.4	2.7	1.7	1.3	2.6
	Min/Max	1.0/2.5	1.4/3.5	2.2/4.3	2.3/3.6	2.6/3.3	2.4/3.2	2.8/3.4	2.7/4.0	2.3/4.4	1.8/3.9	1.0/2.5	0.7/2.1	2.3/2.9

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

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	1.2	2.2	3.7	5.2	6.7	7.3	8.0	6.9	5.1	3.0	1.5	1.0	4.3
	Min/Max	0.9/1.8	1.5/3.3	2.9/5.4	4.1/6.3	5.3/8.2	5.8/9.1	6.1/9.0	5.0/8.4	3.4/6.6	2.1/4.2	0.9/2.0	0.7/1.4	3.8/4.8
Latitude -15	Average	1.6	2.7	4.2	5.6	6.9	7.3	8.2	7.3	5.8	3.6	1.9	1.4	4.7
	Min/Max	1.1/2.5	1.7/4.3	3.2/6.5	4.3/7.0	5.3/8.6	5.8/9.3	6.2/9.2	5.3/9.0	3.7/7.6	2.5/5.2	1.1/2.7	0.8/2.1	4.1/5.3
Latitude	Average	1.8	2.8	4.3	5.5	6.7	7.0	7.9	7.2	5.9	3.7	2.0	1.5	4.7
	Min/Max	1.2/2.8	1.8/4.6	3.3/6.7	4.2/6.9	5.1/8.3	5.5/8.9	5.9/8.9	5.2/8.8	3.7/7.7	2.5/5.5	1.1/2.9	0.8/2.3	4.1/5.3
Latitude +15	Average	1.8	2.8	4.2	5.3	6.3	6.6	7.4	6.8	5.7	3.7	2.0	1.5	4.5
	Min/Max	1.2/2.9	1.7/4.6	3.2/6.6	4.0/6.6	4.7/7.8	5.1/8.3	5.5/8.4	4.9/8.4	3.6/7.5	2.4/5.5	1.1/3.0	0.8/2.4	3.9/5.1

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

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	1.8	2.9	4.3	5.6	7.0	7.5	8.3	7.4	5.9	3.7	2.0	1.5	4.9
	Min/Max	1.2/2.9	1.8/4.7	3.3/6.7	4.3/7.0	5.4/8.7	5.9/9.5	6.3/9.4	5.3/9.0	3.8/7.7	2.5/5.5	1.1/3.0	0.8/2.4	4.2/5.5

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

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	0.9	1.4	1.9	2.3	3.0	3.3	4.0	3.5	2.9	1.8	1.0	0.8	2.2
	Min/Max	0.4/1.8	0.6/2.9	1.2/3.8	1.3/3.3	1.5/4.3	1.7/4.9	2.3/5.1	2.0/4.7	1.4/4.2	1.0/3.2	0.3/1.7	0.3/1.5	1.6/2.6
1-Axis, N-S Horiz Axis	Average	0.5	1.1	1.9	2.8	3.8	4.2	5.2	4.4	3.2	1.6	0.6	0.4	2.5
	Min/Max	0.2/1.1	0.5/2.3	1.1/3.8	1.6/4.0	1.7/5.7	2.1/6.4	2.8/6.5	2.4/5.9	1.6/4.8	0.7/2.8	0.2/1.2	0.2/0.8	1.8/3.0
1-Axis, N-S Tilt=Latitude	Average	0.9	1.6	2.5	3.1	3.9	4.1	5.1	4.7	3.9	2.2	1.1	0.8	2.8
	Min/Max	0.4/2.0	0.7/3.4	1.4/4.9	1.8/4.4	1.7/5.7	2.0/6.2	2.8/6.4	2.6/6.3	1.9/5.7	1.1/3.9	0.3/1.9	0.3/1.5	2.0/3.3
2-Axis	Average	1.0	1.7	2.5	3.1	4.1	4.4	5.5	4.8	3.9	2.3	1.1	0.9	2.9
	Min/Max	0.4/2.1	0.7/3.5	1.5/4.9	1.8/4.5	1.8/6.0	2.2/6.7	3.0/6.9	2.7/6.5	1.9/5.7	1.1/4.0	0.3/2.0	0.3/1.6	2.1/3.5

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	4.5	6.4	7.6	9.6	12.8	16.1	18.4	18.6	15.9	11.6	7.4	4.7	11.1
Daily Minimum Temp	1.8	3.0	3.6	5.1	7.9	11.1	12.9	13.2	11.1	7.7	4.5	2.1	7.0
Daily Maximum Temp	7.2	9.7	11.5	14.0	17.7	21.1	24.0	24.0	20.7	15.4	10.3	7.3	15.2
Record Minimum Temp	-17.8	-17.2	-11.7	-1.7	-2.2	3.3	6.1	6.7	1.7	-2.2	-14.4	-14.4	-17.8
Record Maximum Temp	17.8	21.1	23.9	29.4	33.9	35.6	37.2	37.2	36.7	31.7	23.3	17.2	37.2
HDD, Base 18.3°C	429	334	334	263	171	80	32	36	87	210	328	422	2727
CDD, Base 18.3°C	0	0	0	0	0	12	36	45	13	0	0	0	106
Relative Humidity (%)	78	75	74	71	69	67	66	68	73	79	80	80	73
Wind Speed (m/s)	4.1	4.0	4.0	4.0	3.7	3.7	3.5	3.4	3.4	3.5	4.0	4.0	3.8

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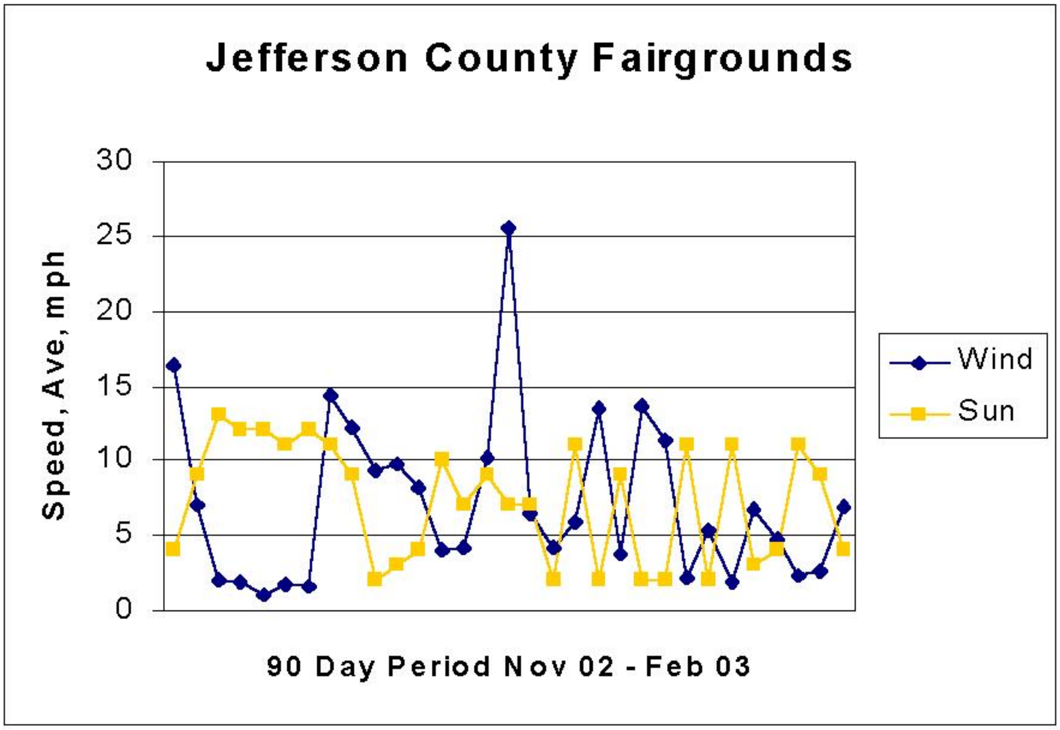
Solar Insolation

This chart shows solar insolation in kilowatt-hours per square meter per day in many U.S. locations. For simplicity, we call this figure "sun-hours per day." To find average sun-hours per day in your area (line 3), check local weather data, look at the map on the previous page or find a city in the table below that has similar weather to your location. If you want year-round autonomy, use the lowest of the two figures. If you want only 100% autonomy in summer, use the higher figure. If you want a utility intertie system, and you have net metering available in your state, use the average figures.

State	City	High	Low	Avg
AK.	Fairbanks	5.87	2.12	3.99
AK.	Matanuska	5.24	1.74	3.55
AL.	Montgomery	4.69	3.37	4.23
AR.	Bethel	6.29	2.37	3.81
AR.	Little Rock	5.29	3.88	4.69
AZ.	Tuscon	7.42	6.01	6.57
AZ.	Page	7.30	5.65	6.36
AZ.	Pheonix	7.13	5.78	6.58
CA.	Santa Maria	6.52	5.42	5.94
CA.	Riverside	6.35	5.35	5.87
CA.	Davis	6.09	3.31	5.1
CA.	Fresno	6.19	3.42	5.38
CA.	Los Angeles	6.14	5.03	5.62
CA.	Soda Springs	6.47	4.40	5.60
CA.	La Jolla	5.24	4.29	4.77
CA.	Inyokern	8.70	6.87	7.66
CO.	Grandby	7.47	5.15	5.69
CO.	Grand Lake	5.86	3.56	5.08
CO.	Grand Junction	6.34	5.23	5.85
CO.	Boulder	5.72	4.44	4.87
DC.	Washington	4.69	3.37	4.23
FL.	Apalachicola	5.98	4.92	5.49
FL.	Belle Is.	5.31	4.58	4.99
FL.	Miami	6.26	5.05	5.62
FL.	Gainsville	5.81	4.71	5.27
FL.	Tampa	6.16	5.26	5.67
GA.	Atlanta	5.16	4.09	4.74
GA.	Griffin	5.41	4.26	4.99
HI.	Honolulu	6.71	5.59	6.02
IA.	Ames	4.80	3.73	4.40
ID.	Boise	5.83	3.33	4.92
ID.	Twin Falls	5.42	3.42	4.70
IL.	Chicago	4.08	1.47	3.14
IN.	Indianapolis	5.02	2.55	4.21
KS.	Manhattan	5.08	3.62	4.57
KS.	Dodge City	6.50	4.20	5.60
KY.	Lexington	5.97	3.60	4.94
LA.	Lake Charles	5.73	4.29	4.93
LA.	New Orleans	5.71	3.63	4.92
LA.	Shreveport	4.99	3.87	4.63
MA.	E. Wareham	4.48	3.06	3.99
MA.	Boston	4.27	2.99	3.84
MA.	Blue Hill	4.38	3.33	4.05
MA.	Natick	4.62	3.09	4.10
MA.	Lynn	4.60	2.33	3.79
MD.	Silver Hill	4.71	3.84	4.47
ME.	Caribou	5.62	2.57	4.19
ME.	Portland	5.23	3.56	4.51
MI.	Sault Ste. Marie	4.83	2.33	4.20
MI.	E. Lansing	4.71	2.70	4.00
MN.	St. Cloud	5.43	3.53	4.53
MO.	Columbia	5.50	3.97	4.73
MO.	St. Louis	4.87	3.24	4.38
MS.	Meridian	4.86	3.64	4.43
MT.	Glasgow	5.97	4.09	5.15
MT.	Great Falls	5.70	3.66	4.93
MT.	Summit	5.17	2.36	3.99
NM.	Albuquerque	7.16	6.21	6.77
NB.	Lincoln	5.40	4.38	4.79
NB.	N. Omaha	5.28	4.26	4.90
NC.	Cape Hatteras	5.81	4.69	5.31
NC.	Greensboro	5.05	4.00	4.71
ND.	Bismark	5.48	3.97	5.01
NJ.	Sea Brook	4.76	3.20	4.21
NV.	Las Vegas	7.13	5.84	6.41
NV.	Ely	6.48	5.49	5.98
NY.	Binghampton	3.93	1.62	3.16
NY.	Ithica	4.57	2.29	3.79
NY.	Schenectady	3.92	2.53	3.55
NY.	Rochester	4.22	1.58	3.31
NY.	New York City	4.97	3.03	4.08
OH.	Columbus	5.26	2.66	4.15
OH.	Cleveland	4.79	2.69	3.94
OK.	Stillwater	5.52	4.22	4.99
OK.	Oklahoma City	6.26	4.98	5.59
OR.	Astoria	4.76	1.99	3.72
OR.	Corvallis	5.71	1.90	4.03
OR.	Medford	5.84	2.02	4.51
PA.	Pittsburg	4.19	1.45	3.28
PA.	State College	4.44	2.79	3.91
RI.	Newport	4.69	3.58	4.23
SC.	Charleston	5.72	4.23	5.06
SD.	Rapid City	5.91	4.56	5.23
TN.	Nashville	5.20	3.14	4.45
TN.	Oak Ridge	5.06	3.22	4.37
TX.	San Antonio	5.88	4.65	5.30
TX.	Brownsville	5.49	4.42	4.92
TX.	El Paso	7.42	5.87	6.72
TX.	Midland	6.33	5.23	5.83
TX.	Fort Worth	6.00	4.80	5.43
UT.	Salt Lake City	6.09	3.78	5.26
UT.	Flaming Gorge	6.63	5.48	5.83
VA.	Richmond	4.50	3.37	4.13
WA.	Seattle	4.83	1.60	3.57
WA.	Richland	6.13	2.01	4.44
WA.	Pullman	6.07	2.90	4.73
WA.	Spokane	5.53	1.16	4.48
WA.	Prosser	6.21	3.06	5.03
WI.	Madison	4.85	3.28	4.29
WV.	Charleston	4.12	2.47	3.65
WY.	Lander	6.8	5.50	6.06


Jefferson County Fairgrounds
Speed, Ave, mph
30
25
20
15
10
5
0
90 Day Period Nov 02 - Feb 03
Wind
Sun