APPLICATIONS OF RESOURCE ASSESSMENT FOR SOLAR ENERGY

Joseph McCabe PE
ASES Fellow
PO Box 270594
Littleton, CO 80127
energyideas@gmail.com

ABSTRACT

There are many data sets and numbers quantifying the potential for solar energy. These numbers are now being expressed graphically, and in useful formats enabling informed solar decision making. This paper explores the use of new computer tools facilitating market assessment of specific solar sectors like distributed generated photovoltaic (PV) systems. State wide, community wide and individual building tools which evaluate the location specific potential of solar energy are presented. We describe a project being worked on with Google's computer aided design (CAD) software package SketchUp that evaluates solar energy, and the technical potential for new building integrated PV (BIPV) projects around the world. These tools can guide decision making for the most appropriate utilization of solar technologies and are simplifying the evaluation of distributed generated energy from PV.

1. INTRODUCTION

There are many excellent solar resource assessment activities creating data around the world. These include but are not limited to Typical Meteorological Year (TMY2, TMY3), and World Radiation Data Centre (WRDC) formatted data sets. Solar resource assessment tends to include three areas of focus: data gathering, forecasting, and characterization. Forecasting tools like SolarAnywhere® which is a web-based service providing hourly, satellite-derived solar irradiance data, is not included. Instead we discuss the characterization and decision making tools that further quantify and create understanding out of historic resource assessment information.

A historic example of using solar resource information is when in 1971 Richard Britz surveyed the state of Oregon for all southern exposure land suitable for solar energy utilization creating "The Edible City Resource Manual". Today, many national, state, local and individual building analysis tools exist which help to define the potential performance from solar electric systems. Some of these tools are included in the following discussion.

2. CALIFORNIA SOLAR ENERGY, CEC PIER

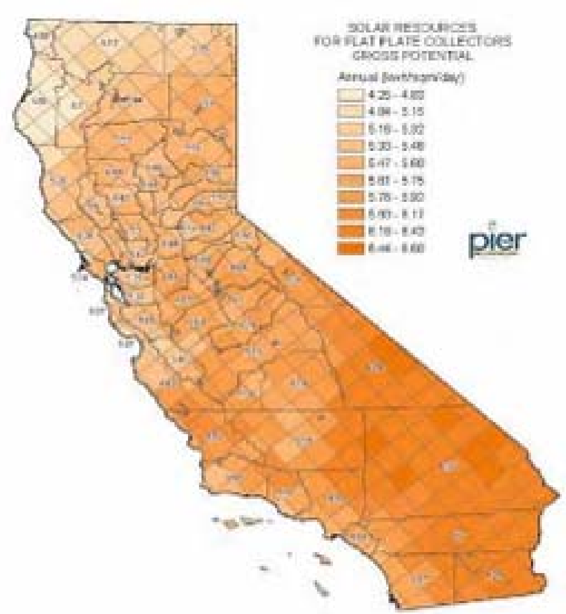

Fig. 1: Gross PV Potential in California

During the most recent energy crisis in California it was asked, where are our renewable energy resources and how should the state best utilize these resources? In 2005 the California Energy Commission Public Interest Energy Research (CEC PIER) department's research in strategic value analysis (SVA) investigated the state of California's opportunities for electricity from PV. Renewable resource information, climate zones, environmental information and certain types of demographic information were transferred into a geographical information system (GIS) database for

 first published in the SOLAR 2010 Conference Proceedings

the analysis. Gross, technical and distributed PV opportunities for residential and commercial building integrated PV (BIPV) opportunities were explored.

Gross potential, as shown in Figure 1, overestimates the true feasible electrical generation from PV. Gross potential considers all land use; technical potential excludes technically impossible locations. More realistic technical potential assumptions were evaluated in the SVA. First, PV systems were assumed to have 10% solar to electric efficiencies and it was assumed that systems were only used in practical locations. In order to accurately estimate practical land use, filters excluded large bodies of water, and pristine areas of the state. Forests (due to shading), agricultural lands, reserves, parks, areas with sensitive habitats (e.g., coastal sage scrub, wetlands, coastal zone and riparian management areas), and north slopes greater than 5% were also excluded.

Fig. 2: Technical PV Potential in California

Figure 2 shows the PV technical potential in California based on the preceding assumptions. Comparison between the technical and gross PV potential maps shows a much higher technical potential exists in the southeastern part of the state than in other areas. The technical potential for PV is massively large at nearly 17 million MW state wide. Obviously, the entire state will not be covered with PV, but buildings provide an attractive subset of opportunity for distributed electrical generation opportunities in California. Limiting applications to residential and commercial building rooftops provides a smaller technical PV potential analysis.

Estimates of the number of commercial and residential units were developed using housing projects data from the Department of Finance and geographically located via Zip Codes.

Fig. 3: Residential BIPV Potential in California.

Fig. 4: Commercial BIPV Potential in California. (Fig 1 - 4 courtesy of CEC)

Figure 3 shows the technical potential associated with locating PV systems on residential rooftops. The technical potential associated with installing PV systems on California's 15 million homes exceeds 38,000 MW. Note, this is close to the total installed convention electrical generating capacity of the state of California at the time. Figure 3 shows PV potential associated with residential housing to fall predominately around the Bay area, Los Angeles and San Diego metropolitan areas. These are coincidently the areas with the greatest peak generating needs.

Figure 4 shows similar generating capacity for commercial BIPV buildings. Roof top areas were estimated from CEC Efficiency Division forecasting data. The potential for locating PV systems on commercial buildings using 2005 building numbers indicates the state wide potential at 37,000 MW.

3. SOLAR MAPPING ON ROOFTOPS IN OSNABRÜCK GERMANY

An example of successful mapping of existing buildings for the feasibility of electricity production from solar was performed by the "Sun Area" team in Germany. Mapping the solar potential of rooftops in Osnabrück Germany has found that 20% of the country's rooftops are suitable for solar power production using a freely available web based tool located at the web address: www.osnabrueck.de/sun-area. With project "Sun Area", building owners can evaluate whether the roof of their house is suitable for the construction of a PV system. The tool includes roof angle, alignment of the roof, the sun's path across the sky, shadows cast by a chimney or shadows from another rooftop over the course of the day and the seasonal change in hours of sunlight.

Fig. 5: Osnabrück Germany Building by Building PV Suitability (Image courtesy of SUN-AREA).

Home owners can search for their own buildings. Surfaces can be interactively configured for an area of PV in square meters, and the achievable electrical production in kWh per year is displayed. As shown in Figure 5, there is a solar suitability legend of red for very good at 95% appropriate for a solar system; orange is well suited for 81 – 94% appropriate; and grey is not suitable for PV installations. Step by step instructions for residence of the community are included in the website: http://geodaten.osnabrueck.de/website/SunArea/viewer.htm (http://translate.google.com/ is quite helpful for those non-German speaking communities looking to replicate this service for their constituents).

The SUN-AREA method was developed at the University of Applied Sciences Osnabrück. The Town Osnabrück was the first town in Europe, to get a solar potential roof survey, which began in November 2007. In the past two years, the number PV-installations have increased about 150%. More than 4,000 kW of PV has been installed compared to about 2,200 KW peak in 2007.

The study found that PV could cover the complete power requirement of homes throughout Germany. This corresponds to more than 100 times the solar that is used today.

SUN-AREA calculates the solar power potential of each roof area, each city and each county or district. With geographical information systems, the solar potential of all roof areas are precisely calculated automatically on the basis of aircraft scanner data. This is done by calculating the angle of the roof, its alignment and shade factors. Solar suitability, potential power output, CO_2 reduction as well as investment volume are calculated for each sub area of a roof and made available to all in an interactive map on the Internet.

More than 100 municipalities have been surveyed by SUN-AREA. For example:

City of Osnabrück ~70,000 roofs inspected
www.osnabrueck.de/sun-area
City of Braunschweig ~80,000 roofs inspected
www.braunschweig.de/sun-area
City of Bielefeld ~100,000 roofs inspected
www.bielefeld.de/de/un/klen/sfb
City of Wiesbaden ~120,000 roofs inspected
www.wiesbaden.de/solarkataster

4. OPTIMIZE SOLAR SYSTEMS PERFORMANCE

Existing buildings can benefit from detailed surface analysis software. Individual building services are now available like precigeoSolar™, an overhead imagery service, which provides individual building and PV system analysis. This software provides “what-if” calculations for interactive comparisons of PV technologies, inverter optimization and shading analysis. Outputs include: monthly insulation maps, interactive PV module selection, monthly kWh outputs, monthly savings, a roof diagram, a shade file summary, inverter-module string outputs, module specification sheet, financial analysis, environmental benefits from the State of California, and annual solar kWh for selected roof surfaces.

An example project roof provides the following performance and system information: kWh per square foot (or square meter) information, 4.66 average sun hours, Qty-36 175 watt Suntech solar modules, in 4 strings of 9 modules each. Each module is 5.25 feet long and 2.69 feet wide. The DC STC system size is 6,300 watts, the AC CEC rated system size is 5,116 watts. The average daily production of 4.66 hours at 5.116 kW/hr is 23.84 kWh per day on average. The annual production is 8,701, kWh per year with an annual calculated savings of 8,701 kWh x $0.44 = $3,828.79.

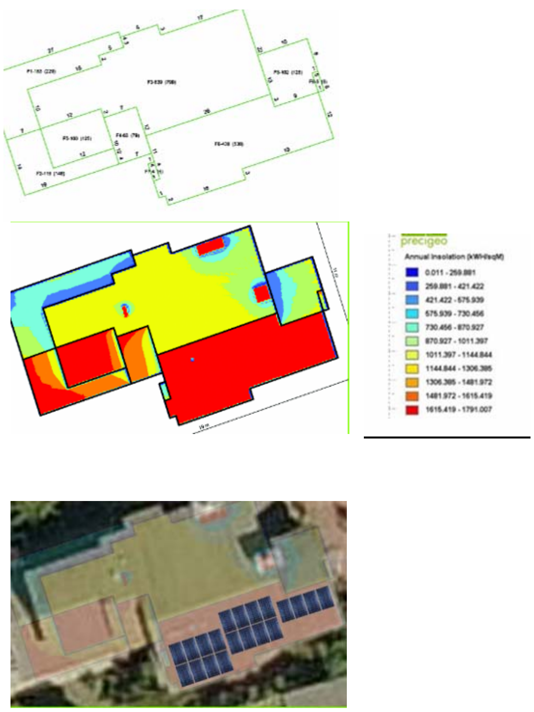

Figure 6: Outline of the building, color coded solar potential and module placement on the roof.

Monthly information can also be output for a particular surface. An example output project for January calculates kWh per square foot for the selected roof surface, 64-85 kWh per square foot at 2.40 sun hours. The average daily production from 2.40 sun hours of 5.116 kW AC CEC watts equals 12.29 kWh per day in January. The production for the month of January is 381 kWh and the bill savings is $167.70.

In addition to proper placement of modules, inverter selection and string management maximize the potential electrical energy from the system.

As seen in Figure 6, there is an outline of the building, and a color coded graphical representation of each surfaces' potential for electrical generation from PV. Solar modules are placed to scale on a satellite image of the actual building for visualization purposes.

Figure 7 shows a different building in 3D, with valuable surface suitability color ranges; red being the best surfaces for electricity generation from PV.

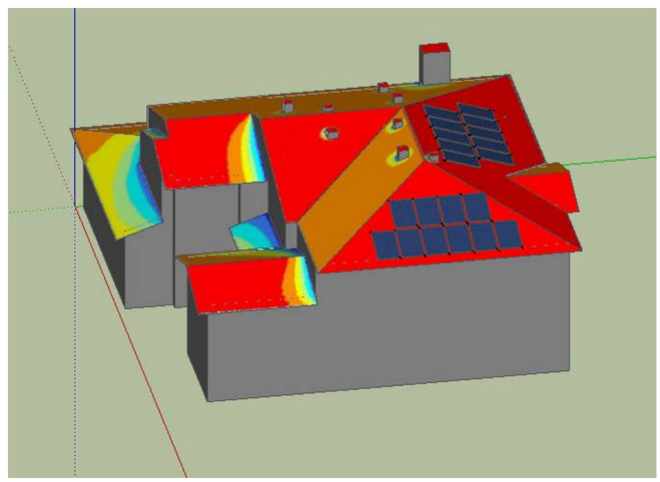

Fig. 7: Valuable 3D information from overhead imagery software service. (Figures 6 & 7 courtesy of precigeoSolar™).

5. WORLD WIDE CAD AND SOLAR OPPORTUNITIES

In 2007 Google SketchUp was approached to integrate an open source software package for BIPV visualization into their internationally utilized computer aided design (CAD) package. The software called “BIPV Designer” uses solar resource assessments to calculate the monthly performance of user defined surfaces around the world. BIPV Designer lets users interactively calculate how much energy can be produced by various building surfaces covered with BIPV. By using a stylish graphical user interface (see Figure 8), users can choose different locations (including weather data), system sizes, PV technologies, and economic factors for systems analysis. The idea is to integrate this kind of functionality into the Goggle SketchUp product offerings such that a button can be pushed highlighting surfaces that might be appropriate for solar electricity generation. Further refinement of the economics for the particular surfaces is already available in BIPV Designer.

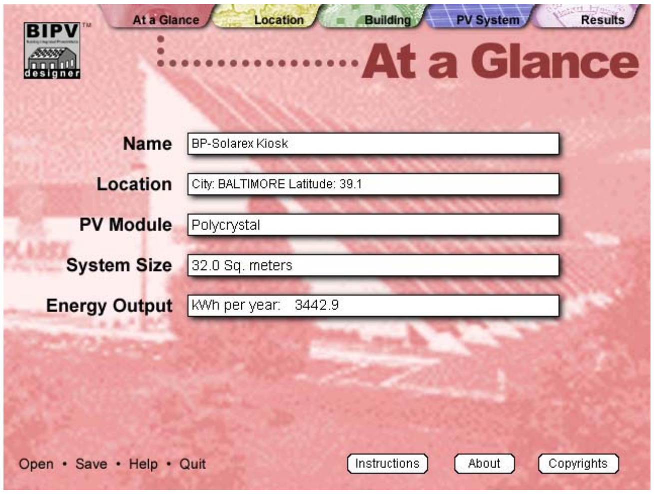

Fig 9: BIPV Designer Graphical User Interface.

In January 2007 the BIPV Designer software was transferred to an open source licensing arrangement. Currently we have a Google Wave project open to look at third party SketchUp plug-ins that could utilize the BIPV Designer engine. Google Wave is a new online tool for real-time communication and collaboration. If interested in being involved with the Wave, please e-mail the author.

5. CONCLUSIONS

Federal governments have a strong role to play supporting resource assessment tools. Resource assessment supports national security interests, electrical supply and transmission infrastructure planning for solar implementation. State governments can facilitate economic expansion, and new energy economic activity from solar energy due to targeted resource assessment visualization tools as seen with the CEC PIER analysis. Local governments can empower citizens with individualized solar resource assessment as seen with Sun-Area. Businesses can provide added value for “what-if” analysis to optimize solar systems performance as seen with precigeoSolar™. Google can provide the world with CAD tools that create a paradigm shift in the way humanity designs buildings, capitalizing on solar resources in the built environment by integrating the visualization of solar resource assessment into their world wide distributed software offering SketchUp.

4. ACKNOWLEDGMENTS

We would like to thank Roy Clausen, Dorothea Ludwig, George Simons, Dr. Cynthia Erickson, John Bacus, Christopher Cronin, Jim Foltz, Robert Flottemesch, Christopher Gronbeck, and the excellent ASES Staff and volunteers.

5. REFERENCES

1. Richard Britz, *The Edible City Resource Manual*, W. Kaufmann, Los Altos, CA 1981.

2. SolarAnywhere® Website: https://www.solaranywhere.com

3. George Simons, Joseph McCabe, *California Solar Resources*, April 2005, CEC Report Number 500-2005-072-D; http://www.energy.ca.gov/2005publications/CEC-500-2005-072/CEC-500-2005-072-D.PDF

4. Personal communications Dorothea Ludwig, February and March 2010.

5. “Mapping the Solar Potential of Rooftops” ArcNews Magazine, Vol. 31, No. 3, Fall 2009 page 30.

6. Personal communications Roy Clausen, February and March 2010.

7. Joseph McCabe, “Designing For Solar” *Home Energy Magazine* Volume 24, 2007; pages 18-19.

8. Joseph McCabe, “An Overview of an Interactive Software Designed to Educate the Energy Production Potential of Building Integrated Photovoltaics”, *American Solar Energy Society (ASES) Annual Conference Proceedings, 2000*.

9. Google Wave Website: http://wave.google.com/

10. Google SketchUp Website: http://sketchup.google.com/