

# Shading Studies

A Pacific Energy Center Factsheet



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## Introduction

The sun brings warmth and sparkle to architecture, but when its potential is misunderstood or not addressed, it may cause extreme discomfort for building occupants and excessive energy and retrofit costs for building owners. Throughout the history of architecture and technology, designers of the most comfortable and energy-efficient buildings have utilized knowledge of the sun and its predictable paths across the sky. Societies have developed charts, graphs, sundials, even entire structures to study solar patterns and mark recurring solar events. The heliodon at the PG&E Energy Center is a relatively new addition to the archives of solar instruments. An effective tool for assessing shading and solar radiation patterns, the heliodon is available to designers for projects within the PG&E service territory. It is intended to assist in locating opportunities for energy savings and increased occupant comfort through solar-responsive architecture.

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## What is a Heliodon?

The heliodon, named after the Greek term for sun-machine, is an effective tool for studying shading patterns, solar access and incident solar radiation. The table-top of the heliodon, which represents the ground plane of the Earth, can be tilted and rotated about different axes to adjust for site latitude, time of year, and time of day. These adjustments change the relationship of the table-top to an electric light representing the sun, allowing assessment of solar issues for a site at any location, season, or time of day.

An architectural model is an effective tool for designing and evaluating shading devices, building form, courtyards, siting/orientation of buildings, location of landscape elements and potential for solar electricity (photovoltaics). Assessment of interior sun patterns is also possible. With only a small investment of time, a design can be tested, modified, and re-tested early enough in the design process to allow modification of the building's details, envelope, and form to best respond to solar conditions, maximizing energy efficiency.

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## Types of Studies

The heliodon can reveal what parts of a model are in sun or shade for a particular time of day during the year. What you do with this information determines the potential of the heliodon. Through observation, one can determine times of day when the sun's rays will fall on building surfaces. This type of analysis is known simply as a Shading Analysis. For this type of

analysis, the model can range from a portion of an urban landscape for determining the shading effects of a proposed building onto a site, or a single window for examining the performance of a shading device.

A solar radiation study determines the performance of a shading device by measuring the percent shading on a window for different times of day and year. For this type of study, build a facade model of a representative bay or two including window openings. On a piece of paper, outline the window opening and draw a grid with each unit equal to 5% of the total window area. Tape this paper onto the window opening. During the heliodon study, the number of squares in shadow indicate the percent shading at a given time. By entering this data into an existing Energy Center solar radiation spreadsheet, you can calculate heat gains due to solar radiation. Taking this one step further, you can run an informal cost analysis to determine the payback period for shading devices and other proposed design elements.

For either type of study, the Energy Center recommends analyzing the model at a minimum of three simulated times of year: the summer and winter solstices (June and December) — to assess conditions when the sun is highest and lowest in the sky, and the Spring/Fall equinox (September and March) — to assess the mid-point between these extremes.

It is important to note that while the heliodon is an excellent tool to study shading, the potential for glare, and solar radiation, it does not simulate daylighting conditions or illumination levels. Daylighting concerns the light qualities and light levels in a space rather than simply what is in direct sun and what is in shade. Because the heliodon at the Energy Center is located indoors and relies on an electric light source, it cannot accurately mimic illumination from the blue sky or the actual intensity of sunlight. To assess light levels and light quality issues, the Energy Center provides other tools and methods. If you are interested in conducting a daylighting study, please see the “Daylight Model Studies Factsheet” or contact Bill Burke at (415) 973-9951 or WxB0@pge.com.

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## **Building the Model**

Here are some guidelines for constructing shading models.

- Models should not weigh more than 25 pounds or be larger than 2.5' x 3.5' in plan. The heliodon table-top measures 2' x 3' with the 3' dimension being the north-south axis. The heliodon may accommodate larger models. However, be sure to contact the Energy Center ahead of time if your model exceeds either limit.
- Use standard materials such as basswood, foam core, matte board, or cardboard. Color and materials do not matter, but correct dimensions are crucial.
- Construct your model with reasonable care and strength. The model and its components should be able to withstand tilts of up to 90°.

- Build the model to precisely represent the geometry of the building and building site with correctly scaled windows, large mullions, wall depth, overhangs, neighboring buildings, trees, etc. The accuracy of the analysis results are directly proportional to the accuracy of the model.
- Build your model to allow for quick modifications for comparison of different building, window or shading strategies (i.e., build alternative pieces of the model that can be ‘plugged’ into place). Consider how to pin or tape the parts in place to withstand tilting of the table-top required for simulation of different conditions.
- Mount the model on a stiff base with clearance for clamping the base to the heliodon— at least 2” around the building footprint.
- Label true north directly on the model or bring detailed orientation information.

Contact the Energy Center before building your model if you have any questions.

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## **Documentation Options**

A heliodon session is typically recorded to allow for subsequent study and analysis of the results and/or sharing the information with others. The Energy Center offers three methods for recording a heliodon session: digital images (both still and video) through a “point-of-view” camera, VHS video (through the same camera), and photography using a standard digital or film camera.

The most popular approach is to position the PEC’s miniature “point-of-view” video camera inside or outside a model to record shading patterns. The camera, about the size of a lipstick tube (5/8” in diameter), is usually small enough to place through existing model windows and doors. A Macintosh computer is then used to capture digital images (still and/or moving). The images are labeled according to the simulated date, time and location at which they are taken, and can be saved to a CD or disk. Still images are generally saved in .tif or .jpg format, which can be viewed on most computers. Images can then be manipulated, if desired, with editing software such as Adobe Photoshop™.

Alternatively, one can use the same “point-of-view” camera to capture VHS video footage of the sun’s impact on a model throughout the day. The video footage, paired with an audio track to record comments and the hours of the day, has proven to be an excellent method for documenting a model’s performance. Each simulated day takes about 30 seconds of video tape.

A third option is to use a standard digital or film camera to photograph the model at regular intervals throughout the simulated day or at times of particular interest. In this case, if interior photos are desired, the model must have sufficiently large openings (2 3/4” diameter) to accommodate the camera’s lens.

For each of the above options, the Energy Center supplies the recording equipment, but the user needs to bring the storage medium. For digital still images or video, bring a writable CD or USB flash drive. For VHS video, bring a standard VHS video tape. If you would like to bring your own camera to take photographs or slides, you are welcome to do so.

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### **Using the Heliodon**

Please contact us at least three days in advance to make an appointment. A heliodon session can take less than one hour, but usually lasts around two hours, and may take longer depending on the number of views, level of discussion, and documentation method(s). Bring your model, any additional model pieces for alternate strategies, materials for modifications, recording media, and information regarding exact orientation and latitude of the project.

To schedule an appointment, please use the "Request to Use the Heliodon" form on the Pacific Energy Center web site at: <http://www.pge.com/pec/heliodon>.