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**Final Report**

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## Background

A small research group at the Florida Solar Energy Center has been working for several years to perform research and other work in support of U.S. Department of Energy and State of Florida energy efficiency objectives in the area of windows, skylights, clerestories, and other glazed apertures in buildings, generically called fenestrations. This work includes not only thermal energy transfer through fenestration systems but also the controlled introduction of daylight illumination for the displacement of electric lighting energy.

Work in the last few years has focused almost entirely on providing technical support to the National Fenestration Rating Council's program to introduce energy performance rating and labelling of windows into the United States. This work has included a variety of activities.

- Annual energy performance simulations aimed at determining the relative performances of a variety of residential window and glazing options for different climates.
- Evaluation of Lawrence Berkeley Laboratory reports and software products in the area of fenestrations.
- Development of better computational tools for predicting the solar spectral irradiance incident on fenestration systems and contributing to solar radiant heat gain, and the effects of exterior shading.
- Service on various committees and task groups of the NFRC as well as participation in and technical support for ASHRAE's technical committee 4.5 on fenestrations.
- Evaluation of the daylighting potential of commercial buildings in hot humid climates.

## Accomplishments

- We have given papers at several meetings of the American Solar Energy Society, ASHRAE, and the ACEEE Summer Study Conference over the years. These are in the areas of annual window energy performance and window physics and optics. A publications list is available on request.
- We have worked with Dariush Arasteh and Elizabeth Finlayson at LBL on their "Window" computer program and have identified some problems and made additional suggestions for improvements in the program.
- We have developed computer programs SUNSPEC and SMARTS2 that calculates clear sky solar spectral irradiance distributions and broadband irradiances and illuminances on

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arbitrarily oriented planes and have made it available for general use. Another program, SUNPATH, is available that calculates the position and path of the sun in the sky. A third program has recently been made available, called AWNSHADE, that determines the unshaded fraction of a window shaded by awnings, sidefins, overhangs, or combinations of these, for any position of the sun in the sky and also for diffuse radiation. All three programs are useful for characterizing the clear sky solar irradiance incident on fenestrations in any climate in the U. S.

- We have been very active with NFRC, ASTM, and ASHRAE committees and in providing technical support for these committees, chairing the NFRC Solar Heat Gain Subcommittee since its inception.

- We performed tests and prepared a report analyzing the window design for our new, showcase, energy-efficient office building, occupied this past summer.

- New, user-friendly versions of AWNSHADE, SUNPATH, and SUNSPEC, written in Visual BASIC, were completed and a new program, SPECVIEW was started. The program provides a rapid way of displaying multiple Window 4 glazing spectral datafiles on a screen, for direct visual evaluation and selection.

- A new solar calorimeter for indoor and outdoor tests of the solar radiant heat gain of fenestration systems was designed and portions of it were procured. It will take advantage of a new indoor, high output Vortek solar simulator recently purchased by FSEC for installation in one of its high-bay lab areas. The calorimeter project has also been provided with a dedicated portion of a building at our auxiliary site for conventional outdoor tests and to introduce a new test never before performed anywhere. The latter is an indoor test in which the calorimeter is held fixed in place, with a fixed angle of incidence, and with real solar radiation irradiating the aperture. This is possible through the use of a heliostat to the north of the building, tracking the sun and sending a fixed-path, reflected beam of solar radiation horizontally into the building and onto the calorimeter.

- We participated in an ASHRAE Task Group to develop the United States standard procedure for the calorimetric measurement of fenestration solar heat gain. A number of group meetings were attended, and a draft procedure was prepared. A goal of this work on which we have insisted is that the new standard permit a variety of incident irradiance geometries and test article orientations giving maximum freedom to the sponsoring organization to specify the particular kind of test it desires, whether it be indoor testing with a solar simulator or outdoor testing with the sun as a source.

- The NFRC standard for determining solar heat gain differs considerably from the methods specified in the ASHRAE Handbook of Fundamentals. Considerable work was performed to modify the ASHRAE Handbook procedures so that they more accurately handle the new angularly selective and spectrally selective fenestration systems on the market and so that they will better harmonize with NFRC procedures. A considerable amount of technical analysis and text was provided to ASHRAE Technical Committee 4.5's Handbook Subcommittee in support of this work.

- In connection with the previous item, we developed a new method of calculating solar gain through spectrally selective fenestration systems, a comprehensive advancement in the practice which will be incorporated in a future version of the ASHRAE Handbook of