International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization on TPE (IOTPE)

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

March 2011 | Issue 6 | Volume 3 | Number 1 | Pages 24-29

REVIEW OF ARCHITECTURAL DAYLIGHTING ANALYSIS OF PHOTOVOLTAIC PANELS OF BIPV WITH ZERO ENERGY EMISSION APPROACH

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Abstract- Daylighting is the illumination of building interiors with sunlight or sky light and is known to affect visual performance, lighting quality, health, human performance, and energy efficiency. Nowadays, sustainable design because of the energy efficient is one of the major subjects of architecture around the world which is better that the buildings are renovated with building-integrated photovoltaic (BIPV) cells and collectors because of saving energy sources are the maximum use of daylighting. Energy conservation refers to efforts made to reduce energy consumption in order to preserve resources for the future and reduce environmental pollution. It can be achieved through efficient energy use (when energy use is decreased while achieving a similar outcome), or by reduced consumption of energy services.

Keywords: Architecture, Sustainable Design, Daylighting, BIPV, Energy Efficiency, Renovation.

I. INTRODUCTION

Direct or diffuse sunlight shining on the solar cells induces the photovoltaic (PV) effect, generating unregulated DC electric power. Building-integrated photovoltaic (BIPV) is a relatively recent new application of PV energy technologies involves combining solar photovoltaic electricity technologies with those of building construction. This subject is of great interest to those in the fields of energy conservation and building design. Building BIPV systems are considered to be multifunctional building materials, and they are therefore usually designed to serve more than one function. For example, a BIPV skylight is an integral component of the building envelope, a solar energy system that generates electricity for the building, and daylighting element. BIPV can affect every aspect of the design process such as: layout and orientation, energy strategies, appearance and architectural expression.

Most of BIPV systems can be grouped into two main categories: facade systems and roofing system. The fundamental first step in any BIPV application is to maximize energy efficiency within the building's energy demand or load. The efficiency of each BIPV product is specified by the manufacturer.

Meanwhile PV in building renovation is not the prior measure to reduce the high energy demand of the existing building stock. But, as part of a well balanced renovation concept (thermal insulation, improved windows, improved ventilation system and solar collectors) it marks a further step towards sustainable housing. The objective of this paper is to enhance the architectural quality, the technical quality and the daylighting issues of PV systems in the built environment and to assess and remove non-technical barriers to their introduction as an energy-significant option. BIPV research and development should therefore focus on achieving these cost reductions, by optimizing integration concepts, by developing new building products and by the development of standardized products.

Primary issues are studied in this paper. In particular, we perform nonlinear modeling and analysis, controllers design, and validate the theoretical results [3].

II. ZERO ENERGY EMISSION AND DAYLIGHTING MILESTONES

A. Daylighting and Windows Visible Transmittance

The potential for daylighting buildings is directly related to the amount of fenestration area installed on the building envelope. It is also related to the amount of light allowed through those systems into the building. The ability of a fenestration product to transmit daylight is called visible transmittance (VT). There are three important categories of light energy within the solar spectrum: ultraviolet (UV), visible, and infrared (IR). The visible transmittance of a fenestration system depends upon: 1) the amount of the visible light segment of the solar spectrum that is transmitted through the glass, and 2) the ratio of frame to glass, which depends upon the window design and frame type [2].

B. Photovoltaic Module

A photovoltaic module or photovoltaic panel is a package interconnected assembly of photovoltaic cells, also known as solar cells. Solar photovoltaic cells are small, square-shaped panel semiconductors manufactured in thin film layers from silicon and other conductive materials. When sunlight strikes the PV cell, chemical reactions release electrons, generating electric current. The small current from individual PV cells, which are installed in modules, power individual homes and businesses, or can be plugged into the bulk electricity grid. There are two basic commercial PV module technologies available on the market today:

1. Thick crystal products include solar cells made from crystalline silicon either as single or poly-crystalline wafers and deliver about 10-12 watts per ft^2 of PV array (under full sun).

2. Thin-film products typically incorporate very thin layers of photovoltaic active material placed on a glass superstrate or a metal substrate using vacuum-deposition manufacturing techniques similar to those employed in the coating of architectural glass. Presently, commercial thin-film materials deliver about 4-5 watts per ft^2 of PV array area (under full sun). Thin-film technologies hold out the promise of lower costs due to much lower requirements for active materials and energy in their production when compared to thick-crystal products [3].

III. SOLAR BUILDING DESIGN GUIDELINES

These guidelines provide guidance to property owners, architects, contractors and others who may be interested in creating a solar building to save energy and create a more comfortable home environment. The guidelines include techniques for designing solar buildings that use solar energy.

A. Solar Heating Techniques

1. Orient buildings or additions to maximize winter sun exposure:

• Place buildings or additions on the site where they receive the most winter sun and are blocked from cold winter winds.

• Elongate the building or addition on its east-west axis for increased winter sun exposure.

• Minimize north-side building or addition exposure.

• Place habitable rooms on the south side and rooms with minimal heating and lighting requirements (closets, corridors, laundry, garage, utility rooms, etc.) along the north side.

2. Choose top-quality windows and place them strategically:

• Locate major window openings on the southeast, south, and southwest. Keep windows small on the north and west.

• Select top-quality windows. Optimize building glazing by evaluating R-value, visible light transmittance and solar heat gain coefficient of the glass [8].

B. Passive Cooling Techniques

Minimize Direct Sun Exposure and Heat Absorption:

• Give priority to exterior sun controls, such as trees, awnings or trellises - as opposed to interior controls, and heat before they penetrate the building skin.

• Shade south windows with overhangs sized to keep the sun out in the summer and early fall. Shading devices can take on many attractive forms, such as trellises and awnings.

• Try to minimize west-facing glazing. Shade west glazing by strategically locating shade trees, trellises, awnings, exterior blinds or shutters. In hillside areas, east-facing glazing may require shading as well. Vertical shading devices work best on east-west orientations because of the low sun angle.

• Minimize the size of skylights and use them mostly for natural lighting. Sky lids can be used for direct heat gain, or skylights can be indirect (solar tube) to eliminate overheating and glare.

• Make the roof a light color if appropriate. Always take into account the context of the project; for example, earth tones are preferred in hillside areas to minimize visual impact.

• Use light-colored, non-reflective finishes balanced with glare control for outdoor sidewalks, driveways, patios, and parking areas and shade them whenever possible.

• Use high-performance glazing selected for your climate and purpose to optimize heat transfer between the interior and exterior [7].

IV. INDOOR VENTILATION

Indoor ventilation refers to the exchange of air inside the home, in the space inhabited by human occupants. It is separate from attic or roof ventilation and has a very different purpose. It has two essential functions: to exhaust pollutants, moisture, and odors from inside the house to the outside, and to bring in outdoor air to mix with the indoor air. This guide is designed to help homeowners understand the need for indoor ventilation, the options for achieving a satisfactory ventilation system, and how to operate the system effectively. It is intended for both buyers of newly constructed homes and for those thinking of installing a ventilation system in their present home.

A. Why Ventilation?

Homes today require specific strategies to maintain a healthy and comfortable living environment. Ventilation reduces excess moisture and unhealthy indoor air pollutants. Properly designed and installed ventilation increases comfort and security. Today's homes are more energy-efficient because they follow standards mandating better insulation and airtightness. However, without an appropriately designed, installed and maintained ventilation system, the benefits of these better-built homes can become liabilities. When we think of buying, building or updating a home, we all too often focus on aesthetic features rather than factors such as the quality of the indoor air. In fact, according to the American Lung Association, 85 percent of Americans didn't realize the air in their homes posed a possible health hazard. The good news, however, is that we are becoming increasingly aware of the importance of indoor air quality and its direct relationship to good health. We are demanding better comfort and healthier air. Mechanical ventilation is simply a system that moves stale, tired air out of the home, replacing it with an inflow of fresh air. A properly designed and installed home ventilating system provides a wide array of benefits not only to the homeowner, but also creates healthier, more comfortable and satisfied customers for mechanical installers and builders.

B. Selecting a Ventilation System

For new construction there are a number of choices for supplying ventilation and makeup air. The options include a combination of a balanced system (where powered exhaust air is equal to powered supply air) and exhaust only (air is exhausted by fan and supply air is not fan-powered). The most important factor in the choice of a ventilation system is the type of combustion appliances operating in the house (see Protection Against Depressurization sidebar). Following is a description of the various types of ventilation systems and the conditions in which they should be used.

Balanced ventilation. Balanced systems use power both to expel indoor air and its pollutants and to bring in fresh air to supply basic, round the clock ventilation. A variety of balanced ventilation systems are available and are described below. The department recommends a balanced system such a heat recovery, or energy recovery ventilator. In most instances, these systems will be the most available, effective and easily understood equipment.

Heat recovery ventilator (HRV). These systems consist of a fan or fans to provide for the intake and exhaust of air, a duct system, and a heat exchanger. In the winter, the heat exchanger recovers the heat from the exiting air and transfers it to the incoming air. In the summer, this process can be reversed. Most models operate between 70 and 80 percent efficiency. HRVs can run continuously and also be controlled with timers or dehumidistat.

Energy recovery ventilator (ERV). The main difference between an HRV and an ERV is the way the heat exchanger works. In an ERV, a certain amount of water vapor is transferred along with heat energy, while in the HRV, only heat is transferred. Transferring water vapor across the heat exchanger core is desirable. In winter, household humidity stays more constant because some of the moisture from the exhaust air is transferred to the less humid incoming winter air. In the summer, the water vapor in the incoming air is transferred to the drier air leaving the house. If you use an air conditioner, an ERV generally offers better humidity control than an HRV and is usually a better choice. Talk to your contractor about whether the advantages of an ERV are right for your particular situation.

Central intake and exhaust fans with their own duct system are similar to the heat recovery ventilator without the heat recovery feature. The system also can be run continuously or by automatic controls. The initial cost is significantly less than that of a heat recovery ventilator or energy recovery ventilator.

Powered exhaust powered supply intake. This system has a number of variations, all of which call for some form of mechanical exhaust and supply. In one case a centrally located exhaust fan is installed; in another case spot exhaust fans are used along with a whole house exhaust installed in the main living space. Still another variation uses a central exhaust duct system feeding one central fan, installed in the basement or a location away from the living space that exhausts air from the kitchen range, bath, and other selected areas. In all of these cases air is brought in with fans or other mechanical equipment through inlet vents, mixed with household air to temper it, and then distributed through the home. All of these systems can be controlled automatically.

Exhaust only. Exhaust only systems use fans to remove moisture and pollutants from the house, but do not use fans or other mechanical means to bring in air from outdoors. They are, therefore, not balanced ventilation systems. Exhaust only systems include central exhaust systems (a central exhaust fan connects to individual exhaust ducts) and point source units that use fans at multiple sites such as bathrooms and kitchens to remove moisture and pollutants. These systems bring in replacement (makeup) air from outdoors either through vents (also called passive inlets) or by relying on infiltration leaks, around rim joists, windows, and doors, for example. In a newly constructed home built to high standards of air tightness, exhaust only systems - especially those that rely on air leakage - may create a significant imbalance in air pressure in the home. This imbalance can lead to dangerous back drafting of the furnace, water heater, fireplace, and other combustion appliances. For this reason, exhaust only systems should be used only under certain conditions [1].

V. THERMAL SOLAR COLLECTORS

There are basically three types of thermal solar collectors: flat-plate, evacuated-tube and concentrating. Flat-Plate collectors comprise of an insulated, weatherproof box containing a dark absorber plate under one or more transparent or translucent covers. Water or heat conducting fluid passes through pipes located below the absorber plate. As the fluid flows through the pipes it is heated. This style of collector, although inferior in many ways to evacuated tube collectors, is still the most common type of collector in many countries. Evacuated Tube solar water heaters are made up of rows of parallel, glass tubes. There are several types of evacuated tubes (sometimes also referred to as Solar Tubes).

- Type 1 (Glass-Glass) tubes consists of two glass tubes which are fused together at one end. The inner tube is coated with a selective surface that absorbs solar energy well but inhibits radiative heat loss. The air is withdrawn ("evacuated") from the space between the two glass tubes to form a vacuum, which eliminates conductive and convective heat loss. These tubes perform very well in overcast conditions as well as low temperatures. Because the tube is 100% glass, the problem with loss of vacuum due to a broken seal is greatly minimized. Glass-glass solar tubes may be used in a number of different ways, including direct flow, heat pipe, or U pipe configuration. Apricus uses a high efficiency heat pipe and heat transfer fin design to conduct the heat from within the evacuated tube up to the header.

- Type 2 (Glass-Metal) tubes consist of a single glass tube. Inside the tube is a flat or curved aluminum plate which is attached to a copper heat pipe or water flow pipe. The aluminum plate is generally coated with Tinox, or similar selective coating. These types of tubes are very efficient but can have problems relating to loss of vacuum. This is primarily due to the fact that their seal is glass to metal. The heat expansion rates of these two materials. Glass-glass tubes although not quite as efficient glass-metal tubes are generally more reliable and much cheaper.
- Type 3 (Glass-Glass-Water flow path) tubes incorporate a water flow path into the tube itself. The problem with these tubes is that if a tube is ever damaged water will pour from the collector onto the roof and the collector must be "shut-down" until the tube is replaced.

Concentrating collectors for are usually parabolic troughs that use mirrored surfaces to concentrate the sun's energy on an absorber tube (called a receiver) containing a heat-transfer fluid, or the water itself. This type of solar collector is generally only used for commercial power production applications, because very high temperatures can be achieved. It is however reliant on direct sunlight and therefore does not perform well in overcast conditions [5].

VI. INSULATIONS

Inadequate insulation and air leakage are leading causes of energy waste in most homes. Insulation:

- saves money and our nation's limited energy resources;
- makes your house more comfortable by helping to maintain a uniform temperature throughout the house;
- makes walls, ceilings, and floors warmer in the winter and cooler in the summer.

The amount of energy you conserve will depend on several factors: your local climate; the size, shape, and construction of your house; the living habits of your family; the type and efficiency of the heating and cooling systems; and the fuel you use. Once the energy savings have paid for the installation cost, energy conserved is money saved - and saving energy will be even more

A. How Insulation Works

- **Conduction:** through solid material or gas, the more insulate the material, the less the conduction (Figure 1(a)).
- **Convection:** the heat "travels" thanks to air movements, because of temperature and density gradient. Hot air moves up and heat dissipates. The quieter the air, the less the convection (Figure 1(b)).
- **Radiation:** each material absorbs or emits thermal radiations depending on its temperature and its emissivity. Heat exchange is function of propagation media (vacuum or air). When radiation is absorbed or reflected, there is less thermal transfer (Figure 1(c)).

(a) (b) (c)

Figure 1. The heat transfer methods:
(a) Conduction, (b) Convection, (c) Radiation

Thermal insulation stops conduction, convection and radiation effects: by creating a thermal barrier against conduction, suppressing air movements and limiting radiation effects (Figure 2).

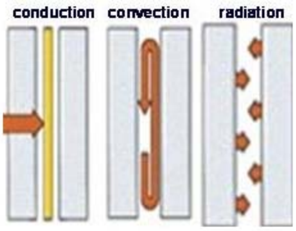

Figure 2. Insulation stops

Heat flows naturally from a warmer to a cooler space. In winter, the heat moves directly from all heated living spaces to the outdoors and to adjacent unheated attics, garages, and basements - wherever there is a difference in temperature. During the summer, heat moves from outdoors to the house interior (Figure 3).

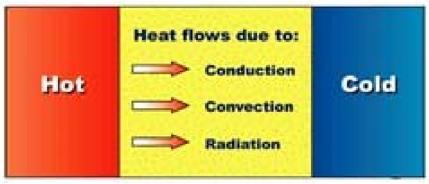

Figure 3. Direction of air movement

To maintain comfort, the heat lost in winter must be replaced by your heating system and the heat gained in summer must be removed by your air conditioner. Insulating ceilings, walls, and floors decreases the heating or cooling needed by providing an effective resistance to the flow of heat [2], [8].

B. What is R-Value?

- Insulation is rated in terms of thermal resistance, called R-value, which indicates the resistance to heat flow. The higher the R-value, the greater the insulating effectiveness. The R-value of thermal insulation depends on the type of material, its thickness, and its density. In calculating the R-value of a multi-layered installation, the R-values of the individual layers are added.

• The effectiveness of an insulated ceiling, wall or floor depends on how and where the insulation is installed.
• Insulation which is compressed will not give you its full rated R-value. This can happen if you add denser insulation on top of lighter insulation in an attic. It also happens if you place batts rated for one thickness into a thinner cavity, such as placing R-19 insulation rated for 6 1/4 inches into a 5 1/2 inch wall cavity.
• Insulation placed between joists, rafters, and studs does not retard heat flow through those joists or studs. This heat flow is called thermal bridging. So, the overall R-value of a wall or ceiling will be somewhat different from the R-value of the insulation itself. That is why it is important that attic insulation cover the tops of the joists and that is also why we often recommend the use of insulation sheathing on walls. The short-circuiting through metal framing is much greater than that through wood-framed walls; sometimes the insulated metal wall's overall R-value can be as low as half the insulation's R-value.
• This standard measure is made in laboratories according ISO 8301 norm and is declared at 10°C temperature and expressed in W/m.K. Here are some examples of thermal conductivity for usual building materials:
It is admitted that materials are thermal insulants if their conductivity is less than 0,065 W/m.K (Figure 4).

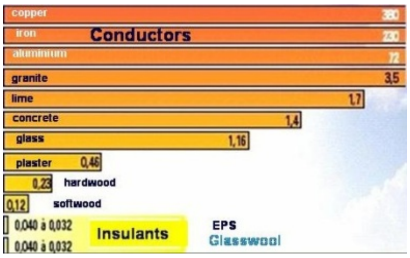

Figure 4. Thermal conductivity levels in different conductors

C. Insulation Product Types

Some types of insulation require professional installation, and others you can install yourself. You should consider the several forms of insulation available, their R-values, and the thickness needed. The type of insulation you use will be determined by the nature of the spaces in the house that you plan to insulate.
• The different forms of insulation can be used together. For example, you can add batt or roll insulation over loose-fill insulation, or vice-versa. Usually, material of higher density (weight per unit volume) should not be placed on top of lower density insulation that is easily compressed. Doing so will reduce the thickness of the material underneath and thereby lower its R-value. There is one exception to this general rule: When attic temperatures drop below 0°F, some low-density, fiberglass, loose-fill insulation installations may allow air to circulate between the top of your ceiling and the attic, decreasing the effectiveness of the insulation. You can eliminate this air circulation by covering the low-density, loose-fill insulation with a blanket insulation product or with higher density loose-fill insulation.
• Blankets, in the form of batts or rolls, are flexible products made from mineral fibers, including fiberglass or rock wool. They are available in widths suited to standard spacings of wall studs and attic or floor joists. They must be hand-cut and trimmed to fit wherever the joist spacing is non-standard (such as near windows, doors, or corners), or where there are obstructions in the walls (such as wires, electrical outlet boxes, or pipes). Batts can be installed by homeowners or professionals. They are available with or without vapor-retarder facings. Batts with a special flame-resistant facing are available in various widths for basement walls where the insulation will be left exposed.
• Blown-in loose-fill insulation includes cellulose, fiberglass, or rock wool in the form of loose fibers or fiber pellets that are blown using pneumatic equipment, usually by professional installers. This form of insulation can be used in wall cavities. It is also appropriate for unfinished attic floors, for irregularly shaped areas, and for filling in around obstructions.
• In the open wall cavities of a new house, cellulose and fiberglass fibers can also be sprayed after mixing fibers with adhesive or foam to make them resistant to settling.
• Foam insulation can be applied by a professional using special equipment to meter, mix, and spray the foam into place. Polyisocyanurate and polyurethane foam insulation can be produced in two forms: open-cell and closed-cell. In general, open-celled foam allows water vapor to move through the material more easily than closed-cell foam. However, open-celled foams usually have a lower R-value for a given thickness compared to closed-cell foams. So, some of the closed-cell foams are able to provide a greater R-value where space is limited.
• Rigid insulation is made from fibrous materials or plastic foams and is produced in board-like forms and molded pipe coverings. These provide full coverage with few heat loss paths and are often able to provide a greater R-value where space is limited. Such boards may be faced with a reflective foil that reduces heat flow when next to an air space. Rigid insulation is often used for foundations and insulation wall sheathing.
• Reflective insulation systems are fabricated from aluminum foils with a variety of backings such as craft paper, plastic film, polyethylene bubbles, or cardboard. The resistance to heat flow depends on the heat flow direction, and this type of insulation is most effective in reducing downward heat flow. Reflective systems are typically located between roof rafters, floor joists, or wall studs. If a single reflective surface is used alone and faces an open space, such as an attic, it is called a radiant barrier. Radiant barriers are installed in buildings to reduce summer heat gain and winter heat loss. In new buildings, you can select foil-faced wood products for your roof sheathing (installed with the foil facing down into the attic) or other locations to provide the radiant barrier as an integral part of the structure. For existing buildings, the radiant barrier is typically fastened across the bottom of joists, as shown in this drawing. All radiant barriers must have a low emittance (0.1 or less) and high reflectance (0.9 or more) [4].

VII. CONCLUSIONS

Energy efficiency is important not only because of the environmental concerns surrounding energy use, but also one of the important goals of sustainable architecture and Zero Energy Emission as an outcome. As a result, Brighter Future of Earth and the Human Future and its architecture depend on both efficiency energy consumption in buildings and also renewable energies.

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