



## PHOTOVOLTAIC ROOF SYSTEMS

The sun generates enough clean energy in one day to provide a year's supply of energy for your home or office. Why not tap into this abundant resource of clean energy?

One option is the use of a photovoltaic (PV) roof system. Large PV panels, mounted to residential roofs, are very common, especially in the southwestern states. These panels are often unattractive, bulky, and expensive. However, recent breakthroughs in PV design and technology have produced PV modules that replace conventional roof tiles. They come in all shapes, sizes, and varieties and can be used in both residential and commercial applications.

PV preserves the earth's finite fossil-fuel resources—coal, oil, natural gas—and reduces air and noise pollution associated with these energy sources. Also, depending upon where you live and taking into account current utility pricing, state and local incentives offered in some parts of the United States, and other benefits, PV can be competitively priced with traditional energy sources. Also, PV system reliability and durability are outstanding—typical PV systems may last 30 years with minimal maintenance.

## LEED APPLICATION

Leadership in Energy and Environmental Design (LEED) is a program administered by the United States Green Building Council that uses a Green Building Rating System to register and certify the world's greenest buildings.

The LEED credit category that PV Roof tiles apply to is Energy & Atmosphere – Credit 2 – Renewable Energy. There are up to three points awarded for this category, based on the amount of renewable energy the building produces. The requirements are to supply at least 5%(1pt), 10%(2pts), or 20%(3pts) of the building's total energy use through on-site renewable energy systems. These potential renewable energies include solar, wind geothermal, low-impact hydro, biomass, and bio-gas technologies.

Another possible credit category is Energy & Atmosphere – Credit 1 – Optimize Energy Efficiency. There are up to 10 points awarded in this category, based on percentages of energy cost reductions. For example, a 60% reduction will earn the maximum 10 points and is likely attainable with use of an integrated PV roof system.



PV roof shingles

## GREEN BUILDING ISSUES

Few power-generation technologies have as little impact on the environment as photovoltaics. PV technology is ideal for residential applications, providing pollution and noise-free electricity without using extra space. Not only is it great for the environment, but also reduces electricity bills because daylight is free. It doesn't require liquid or gaseous fuels to be transported or combusted. And because its energy source—sunlight—is free and abundant, a PV system can guarantee access to electric power.

Of course, no form of energy production is completely free of effects on the environment. PV production produces small amounts of waste materials, but it is minimal relative to emissions from conventional energy sources.

## DESIGN/CONSTRUCTION APPLICATION

### *How does it work?*

A typical PV system consists of solar cells connected electrically to form a module, which in this case would be a single roofing shingle. All of the shingles connected together make up an array. Since the electricity generated by these PV arrays is direct current, an inverter must be used to convert the electricity to alternating current. Batteries may also be added for emergency backup in the event of power outages or in cases where your PV system is not connected to utility power lines. If you do choose and are able to connect the system to the power lines, it is possible to generate electricity for your power provider and actually make a profit from the system.



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The amount of electricity produced by a PV system is based primarily on the size of the system, but the output of the array will depend on the following:

- Geographic orientation
- Amount of sunlight available at the location
- Tilt – angle from horizontal
- Azimuth – orientation with respect to due south
- Shadowing
- Temperature

Other considerations not affecting the system itself include local utility rates, tax credits, and maintenance.

*How can it be applied to building design or construction?*

Design of the systems is fairly simple since there are very few components. The major design issue is likely deciding the size of system that will be used.

From a construction standpoint, PV roofing systems are easy and ready to install and supplied by numerous distributors. PV roofing installations require a portion of the roof to be exposed by direct sunlight. For North America this would be a south-facing exposure, usually on an inclined roof. Depending on the product, it can be installed by a roofing professional, an electrician, or both. In some cases the manufacturer will also provide installation.

*What types of PV roof shingles are available?*

Even though PV roof shingles are fairly new, there are several different types that can be used for various applications. Pictured below are just a few of the different types available:



Shingled roof

Metal roof

Flat roof panels

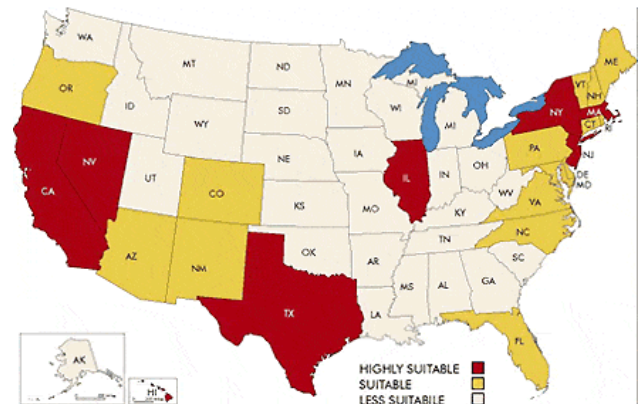
*How much does a PV system cost?*

One disadvantage of a PV system is its high initial cost. A rooftop integrated PV system fully installed costs approximately \$15,000-\$20,000, depending on the size of the system. This is approximately 18¢-25¢ per kilowatt hour, which is significantly more than conventional grid-connected power. But, when considering environmental benefits and available grants and tax incentives, a PV roof system can be comparable to the cost of conventional grid-connected power.

Typically, the energy payback time (the time it takes the system to generate the same amount of energy that it took to manufacture the system) for PV systems is five to 10 years. Given that a well-designed and maintained PV system will operate for more than 20 years, and will often operate for close to 30 years, PV systems produce far more energy over their lives than is used in their manufacture. There are also many grants and tax credits that come with the installation of PV systems. A comprehensive list of these grants/tax credits for the United States can be found at the Database of State Incentives for Renewable Energy (DSIRE) Web site at [www.dsireusa.org](http://www.dsireusa.org).

*Where can a PV system be used?*

In the United States, PV systems are most suitable for the southwestern states which receive the largest amounts of solar radiation. But PV systems can be used anywhere abundant solar radiation is available.



The map above illustrates the relative suitability of commercial photovoltaic projects, by state, using price of electricity, amount of sunlight available, and government programs.

## ADDITIONAL INFO

U.S. Green Building Council [www.usgbc.org](http://www.usgbc.org)  
 U.S. Department of Energy [www.eere.energy.gov](http://www.eere.energy.gov)  
 Database of State Incentives for Renewable Energy (DSIRE) [www.dsireusa.org](http://www.dsireusa.org)

This GreenBuild Tech Bulletin was developed by Jeffrey A. Landreth, a student at Kansas State University. As designers and builders of structural, mechanical, electrical, and plumbing systems in buildings, architectural engineers and constructors have a tremendous opportunity and responsibility to address energy and/or environmental impacts in their work.



# GreenBuild Tech Bulletin



More recently the national grid has proved only 25-30% efficient in providing us with energy from fossil fuels.

Photovoltaics (PV) is an important energy technology for many reasons. As a solar energy technology, it has numerous environmental benefits. As a domestic source of electricity, it contributes to the nation's energy security. As a relatively young, high-tech industry, it helps to create jobs and strengthen the economy. As it costs increasingly less to produce and use, it becomes more affordable and available. And there are many more reasons, as we shall see.

<http://www.osti.gov/dublincore/gpo/servlets/purl/537317-nWTC9G/webviewable/537317.pdf>