bpp+

tech overview

applicable building types
all buildings
implementation
anytime, at roof replacement, mid-cycle or refinance
fast facts
- reduces GHG emissions
- provides free electricity
- supports peak-shaving
- supports energy demand response and management

tech primer

Solar Photovoltaics & Batteries

Clean, renewable electricity generation and storage to dramatically reduce utility costs.

En-Power Group

cost & benefits

GHG savings

Tenant Experience Improvements

Utility Savings

Capital Costs

Maintenance Requirements

*ratings are based on system end use, see back cover for details.

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Building Performance Exchange

A program of Built Environment Plus

Getting to know solar PV systems

Solar photovoltaic (PV) systems provide clean, renewable electricity that can be used to meet a building's immediate energy needs, stored in batteries for future use, and in some cases, sold back to the electric grid for utility cost savings.

How does solar PV work?

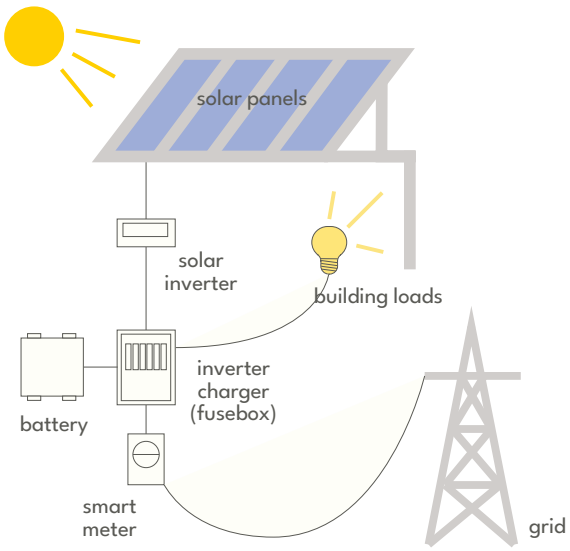
A solar photovoltaic (PV) system is an energy generating technology that absorbs and converts sunlight into clean and renewable electricity. This technology can be used to provide onsite electricity generation for buildings and dramatically reduce electricity costs.

A solar PV system is comprised of modular solar panels made up of solar cells that harvest energy from sunlight, a solar inverter that converts DC to AC, as well as mounting and cabling equipment. Electricity generated by a solar PV array can be used for a building's energy demand, stored in batteries (if included), or in some cases, sold back to the grid. Standalone, or "islanded" PV systems are not connected to the grid and require special equipment and additional wiring. These systems can create a more resilient building by providing electricity during a grid blackout.

Most PV systems are installed on rooftops, however systems can also be integrated into building facades, mounted on car-park roofs, installed at ground level, or in other configurations. Rooftop solar PV systems may include a battery storage system if electricity storage is desired.

This tech primer will outline design considerations for a roof mounted solar PV installation for all building types. Considerations include determining the number of panels needed to meet the desired level of electricity generation, assessing the available roof area as well as its condition, structural strength and other requirements, determining how the solar array will be mounted on the roof, and whether or not the system will incorporate battery storage.

Fig 1. In a typical solar PV system, solar energy is harvested by the solar panels, converted into usable energy by the solar inverter, and applied to various end uses through the inverter charger.



Assess
Always consult a qualified service provider before undertaking any building upgrades.

Coordinate Upgrades for Maximum Savings
Any roof upgrades or retrofits should be performed before, or in conjunction with, solar PV installation in order to prevent conflicts and reduce construction costs.

PV installers should be contracted to coordinate with roof installers and manufacturers in order to ensure compliance with the roof warranty during a PV retrofit.

Community Shared Solar
For buildings that do not have roof space to install PV panels or have significant shading on their roof, electricity can be purchased from a community shared solar program where solar energy is generated offsite.

Buildings that have a suitable roof but do not wish to purchase a PV system can rent the roof to a solar developer who will install and maintain a PV system.

How to implement a solar PV system

Solar PV systems complement other high-performance building upgrades by supporting net zero energy goals and significantly reducing utility costs.

Retrofit solutions

There are multiple steps to installing a solar PV system:

A **Size the System –** Rooftop PV panels must be sized to the electric load requirement of the building. Panels should be installed on all available roof area with allowances for shade, mechanical equipment access, and walkways.

- If the electric load requirement of the building demands a larger PV system than the roof can accommodate, any electricity reducing measures (such as installing LED lighting) can help lower the system requirements.
- If the electric load requirement of the building demands a smaller PV system than the roof can accommodate, consider converting a base building system (such as domestic hot water) to electric in order to increase the number of panels required.

B **Install Panels –** Rooftop PV panels are commonly mounted using ballasted or mechanically fastened systems:

1. A ballasted system mounts PV panels on weighted freestanding racks which do not typically require mechanical attachment to the roof, making installation easy and affordable. Ballasted mounting systems require greater spacing between rows to prevent shade falling on panels, thus requiring more space to install the same number of panels as a mechanically fastened system.
2. Mechanically fastened steel rack systems penetrate the roof to connect to the structural frame of the building. Solar PV panels are raised higher and with greater tilt to allow more density and less risk of shading, leading to superior energy generation potential.

C **Choose a Battery –** A grid connected battery system stores electricity generated by the PV system and discharges it at times of peak demand or high electricity rates. The battery system should be specified to match the building's storage needs and the PV system capacity. Batteries often have safety requirements that can be determined by local fire code. These requirements depend on the building, battery location, and specific battery model, and can range anywhere from setbacks and a non-combustible mounting surface, to active fire suppression systems.

There are several commercial grade battery types available:

- Lead Acid Batteries have long been on the market and can be purchased for a relatively low upfront cost, however they have shorter lifespans than other options and need to be recharged more frequently.
- Aqueous Hybrid Ion or Saltwater Batteries do not contain heavy metals and have a low environmental impact. Compared to Lead Acid batteries, they have a longer lifespan and do not need to be charged as frequently.
- Lithium Ion Batteries offer a very long lifespan, compact installation, and do not need to be frequently charged. They have high safety requirements.
- Flow Batteries are a new market technology that is safe, long lasting, and easily allows for capacity increases. They are bulky and include extra fluid storage tanks and pumps.

D **Install a System Monitor –** A web-connected digital monitor should be installed to give real-time readouts on voltage, current, power output, state of charge, and alerts to notify staff of functional issues.

E **Obtain Green Financing –** The financing marketplace for Solar PV is very mature compared to other energy solutions. Often, government programs are available to help secure incentives and maximize investment.

- Financing options include traditional up-front purchases, low-rate green financing, and third-party power purchase agreements (PPAs), which require no upfront cost and include an agreement to purchase electricity directly from a solar developer, who fully funds and maintains a solar PV system installation.

Costs and benefits of solar PV systems*

Greenhouse Gas (GHG) Savings

GHG savings are significant in any solar PV installation as the conversion to a clean, renewable electricity source dramatically reduces GHG emissions. The amount of GHG savings is dependent on the size and application of the system.

Tenant Experience Improvements

Tenants' everyday experience will likely remain unchanged, however solar PV systems with battery storage reduce electricity bills and can provide backup generation for emergency equipment in the event of a power outage.

Utility Savings

Solar PV systems generate electricity onsite, leading to dramatic utility savings.

Capital Costs

Installing a solar PV system requires a high upfront capital investment. Installation costs tend to decrease as system size increases because the cost for inverters and other system components do not scale at the same rate. Battery costs vary widely by application, and standalone, or "islanded" PV systems require additional electrical work and equipment that can increase costs.

Maintenance Requirements

Solar PV systems are inherently low-maintenance, but staff should be trained to properly clean equipment, check for leaks and corrosion, and check that equipment is within proper operating ranges. Creating a maintenance log is a helpful first step in a successful preventative maintenance program. Knowledgeable staff can identify and address maintenance items independently or know when to engage qualified contractors.

Take Action

This document is one of more than a dozen High Performance Technology Primers prepared by the Building Performance Partnership (BPP) to introduce decision-makers to solutions that can help them save energy and improve comfort in their buildings.

For more information, contact Built Environment Plus.

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The Building Performance Partnership (BPP), created by Building Energy Exchange (BE-Ex) and the Institute for Market Transformation (IMT), supports the creation and operation of local high-performance building hubs that accelerate measurable, equitable, and sustainable action to improve the health, comfort, and performance of buildings. With support from both BE-Ex and IMT, partner hubs serve their respective regions with customized resources that cater to the needs of their communities while benefiting from the existing resources and expertise of our network.

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*The Costs & Benefits rating system is based on a qualitative 1 to 4 scale where 1 () is lowest and 4 () is highest. **Green** correlates to savings and improvements, **dark blue** correlates to costs and requirements. Ratings are determined by industry experts and calculated relative to the system end use, not the whole building.

Note: GHG and utility savings are dependent on existing window conditions and are based on the heating and cooling loads. Assumes existing windows are leaky, un-insulated, and without special coatings.