

HARNESSING THE POWER OF THE SUN

INTEGRATING BATTERY ENERGY STORAGE SYSTEMS WITH PHOTOVOLTAIC SYSTEMS

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IN THE QUEST for sustainable and resilient energy solutions, the integration of Battery Energy Storage Systems (BESS) with Photovoltaic (PV) systems has emerged as a game-changer for building electrification. This synergy not only enhances energy efficiency but also ensures a reliable power supply, even during grid outages.

BACKGROUND AND DRIVERS FOR BUILDING ELECTRIFICATION

Moving building operations to all-electric systems is driven by a combination of environmental, economic, technological, and policy factors. Electrification makes sense even in regions reliant on coal or gas for power generation because electric systems, like heat pumps, are highly efficient and reduce overall energy use. It prepares buildings for future grid decarbonization as renewable energy sources grow, while centralizing emissions at power plants makes them easier to manage and potentially capture. Electrification also eliminates methane leaks from gas systems, improves indoor air quality by avoiding combustion, and simplifies infrastructure by eliminating the need for gas pipelines. Over time, it aligns with global goals for cleaner energy, reduces costs through economies of scale, and enhances resilience with options for onsite renewable energy integration.

The Illinois Stretch Energy Code encourages all residential and commercial building construction to design to this strategy which requires buildings be solar PV ready, electric appliance ready, and electrical vehicle charging ready.

THE ROLE OF PHOTOVOLTAIC SYSTEMS

Photovoltaic systems convert sunlight directly into electricity using solar cells. These systems can be installed on rooftops, ground-mounted, or as canopy structures over parking lots. The versatility of PV systems makes them suitable for residential, commercial, and industrial applications. Modern PV cells have achieved remarkable efficiency converting nearly 50% of sunlight into usable electricity.

BATTERY ENERGY STORAGE SYSTEMS: THE BACKBONE OF RELIABILITY

Battery Energy Storage Systems store excess energy generated by PV systems during peak sunlight hours. This stored energy can be used during periods of low sunlight or at night, ensuring a continuous power supply. Lithium-ion batteries are the most common choice for BESS due to their high energy density and long cycle life. Other options include lead-acid and flow batteries. Battery storage is also prominent for mission critical buildings since they can provide a temporary source of power during a utility outage.



500 kWh (125/250/500 kW)

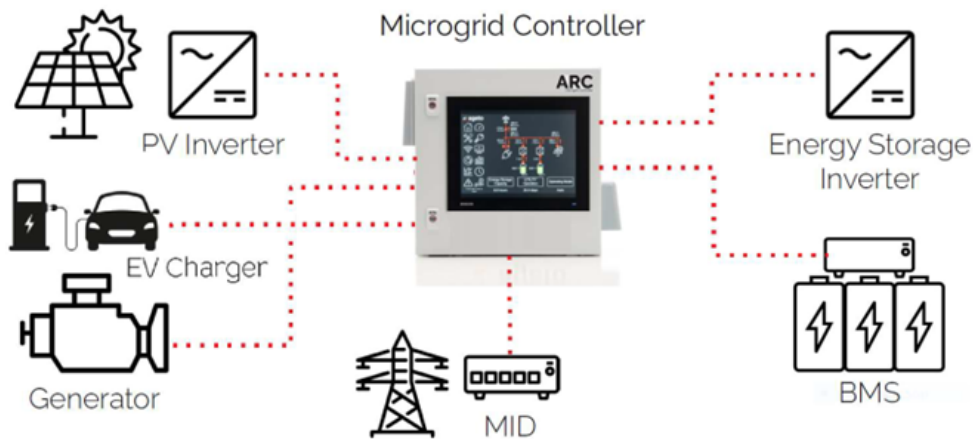


1000 kWh (250/500/1000 kW)



BENEFITS OF INTEGRATION

- 1. ENERGY INDEPENDENCE:** By combining PV systems with BESS, buildings can reduce their reliance on the grid, leading to greater energy independence and resilience.
- 2. COST SAVINGS:** Stored solar energy can be used during peak demand times when electricity rates are higher, resulting in significant cost savings.
- 3. ENVIRONMENTAL IMPACT:** Utilizing renewable energy sources reduces greenhouse gas emissions, contributing to a cleaner environment.
- 4. GRID STABILITY:** BESS can provide ancillary services to the grid, such as frequency regulation and peak shaving, enhancing overall grid stability.



SYSTEM COSTS

The costs of battery energy storage systems (BESS) and photovoltaic (PV) systems can vary significantly based on several factors, including system size, technology, and location. Here's a comparison of the costs for these systems:

BATTERY ENERGY STORAGE SYSTEMS (BESS)

- 1. Utility-Scale Systems:** The cost of utility-scale BESS, particularly lithium-ion batteries, has been decreasing. As of 2024, the installed capital costs for a 4-hour duration system are approximately \$1,200 per kWh[1]. These costs can vary based on the duration and capacity of the storage system.
- 2. Residential Systems:** For residential applications, the cost of a BESS can range from \$500 to \$1,000 per kWh[2]. This includes the cost of the battery pack, inverter, and installation.

PHOTOVOLTAIC (PV) SYSTEMS

1. Residential Systems: The average cost of a residential PV system in 2024 is around \$2.84 per watt[3]. For a typical 10 kW system, this translates to approximately \$28,241 before incentives, and about \$19,873 after applying the federal solar tax credit[3].
2. Commercial Systems: Commercial PV systems tend to have lower costs per watt due to economies of scale. The cost can range from \$1.50 to \$2.00 per watt[4], depending on the size and complexity of the installation.

BUILDING ELECTRIFICATION SYSTEMS

1. Whole-Home Electrification: The cost of fully electrifying a home, which includes replacing gas appliances with electric ones and adding systems like heat pumps, can range from \$10,000 to \$15,000 in colder climates[5]. In warmer climates, the cost is slightly lower, ranging from \$4,000 to \$11,200[5].
2. New Construction: For new residential buildings, all-electric construction is often more cost-effective than mixed-fuel homes. The cost savings come from avoiding gas infrastructure and using efficient electric appliances[6].

SUMMARY

- BESS: \$500 to \$1,200 per kWh
- Residential PV: \$2.84 per watt (before incentives)
- Commercial PV: \$1.50 to \$2.00 per watt
- Whole-Home Electrification: \$4,000 to \$15,000

These costs are influenced by various factors, including technological advancements, market demand, and regional incentives.

COST REFERENCES

[1] Utility-Scale Battery Storage | Electricity | 2024 | ATB - NREL

[2] Cost Projections for Utility-Scale Battery Storage: 2023 Update

[3] How Much Do Solar Panels Cost? (Dec 2024) - ConsumerAffairs

[4] Solar Panel Cost in 2024: How to Estimate The Cost of Solar | Solar.com

[5] How Much Does Whole-Home Electrification Cost? | NAHB

[6] The Economics of Electrifying Buildings: Residential New Construction



FINANCIAL INCENTIVES

There are several incentives available for BESS, PV systems, and building electrification systems. These incentives can significantly reduce the upfront costs and make these technologies more accessible. Here are some key incentives:

BATTERY ENERGY STORAGE SYSTEMS (BESS)

- 1. Federal Investment Tax Credit (ITC):** The ITC provides a 30% tax credit for the cost of installing a BESS, whether or not it is paired with a solar system. This credit applies to residential systems over 3 kWh and commercial systems over 5 kWh[1].
- 2. State-Level Incentives:** Many states offer additional rebates and incentives. For example, California’s Self-Generation Incentive Program (SGIP) provides rebates for energy storage systems, with higher incentives for low-income customers and those in high fire threat districts[1].
- 3. Utility Programs:** Some utilities offer incentives for installing BESS, often in exchange for the ability to use the stored energy during peak demand times[2].

PHOTOVOLTAIC (PV) SYSTEMS

- 1. Federal Solar Tax Credit:** Also known as the Residential Clean Energy Credit, this provides a 30% tax credit for the cost of installing a solar PV system [3].
- 2. State and Local Incentives:** Many states offer additional incentives such as rebates, tax credits, and property tax exemptions. For example, New York offers the NY-Sun Incentive Program, which provides rebates for residential and commercial solar installations[4].
- 3. Net Metering:** This allows solar PV system owners to sell excess electricity back to the grid, effectively reducing their electricity bills. Net metering policies vary by state[5].

BUILDING ELECTRIFICATION SYSTEMS

- 1. Home Energy Rebates:** The Home Efficiency Rebates and Home Electrification and Appliance Rebates programs, funded by the Inflation Reduction Act, offer up to \$14,000 for home electrification projects. These rebates can cover costs for electric appliances, heat pumps, and other energy efficiency improvements[6][7].
- 2. Weatherization Assistance Program:** This federal program provides grants to improve the energy efficiency of low-income homes, which can include electrification measures[7].
- 3. State-Specific Programs:** States like California and New York offer additional incentives for building electrification, including rebates for heat pumps and electric appliances[6].

These incentives can significantly reduce the costs of installing BESS, PV systems, and electrifying buildings, making it easier for homeowners and businesses to adopt sustainable energy solutions.

INCENTIVE REFERENCES

- [1] Solar Battery Incentives and Rebates - EnergySage
- [2] Guide to solar battery tax credits, rebates, and other incentives
- [3] Homeowner’s Guide to the Federal Tax Credit for Solar Photovoltaics ...
- [4] Solar Tax Credit By State In 2024 | A Complete Guide
- [5] Solar incentives by state - ConsumerAffairs
- [6] How to Upgrade and Electrify Millions of US Homes and Buildings
- [7] Home Energy Rebates Programs | Department of Energy

WHAT ABOUT THE RETURN ON YOUR INVESTMENT?

If you have a site or project that can consider this electrification approach, modeling is essential to determine a range of ROIs. Equipment manufacturers such as Generac have modeling software that requires east-to-obtain information such as:

- Utility tariffs and location
- Technology to deploy such as solar PV, BESS, hydrogen fuel cell, Electric Vehicle (EV) charging, microgrid
- Load information (address if existing site or load profile if a new site)

With this information, the analysis will summarize available incentives for your location, optimize the size of the system and equipment, and provide the ROI data with estimated first costs and annual savings.

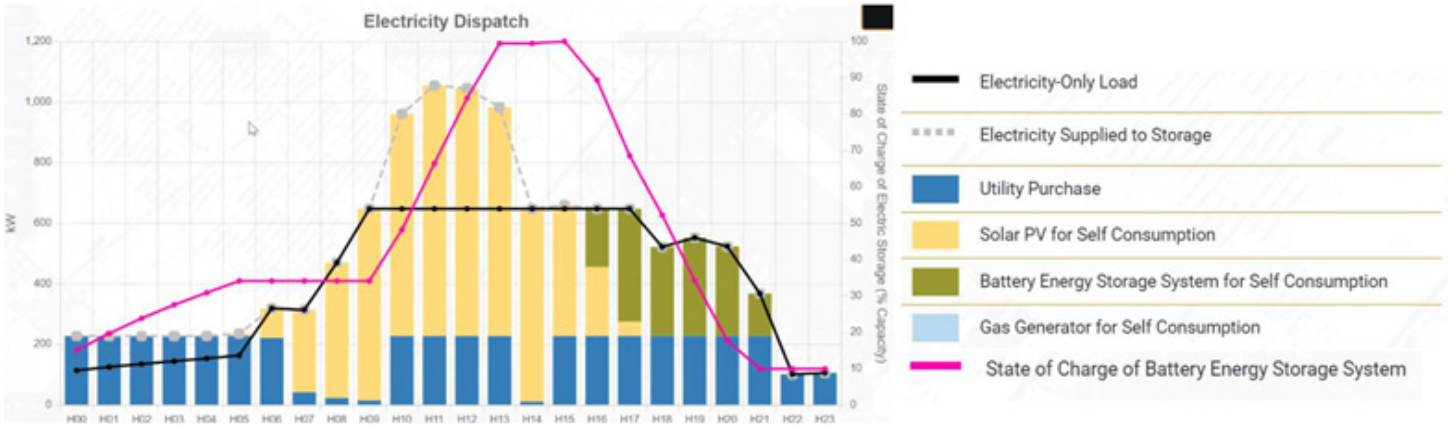
A NOTE ABOUT HYDROGEN FUEL CELL APPLICATION

Hydrogen Fuel Cells (HFC) can be used as part of the overall electrification strategy because it's essentially an on-site source of electrical power generation similar to a gas or diesel generator. The benefit of the HFC uses hydrogen as the fuel and produces heat and water as the waste product while producing electrical energy. It is a scalable technology that works at better efficiencies than a normal gas or diesel generator. If your application is looking for additional reliability and peak shaving opportunities, integrating the HFC is worth considering.

GOOD CANDIDATES FOR PV, BESS, HFC

Good candidate sites and projects will have 1) high utility demand charges (>\$15/KW/Month), high energy charges (>\$.15/kWh), a large spread of time of use (ToU) rates during peak and off peak times, can deploy a good size solar PV system, has good local and state financial incentives, offers demand response incentives, and has sensitive site operational and resiliency requirements.





FUTURE OUTLOOK

As technology advances and costs continue to decline, the adoption of integrated PV and BESS solutions is expected to grow. Innovations in battery technology, such as solid-state batteries, promise even greater efficiency and safety. Additionally, policy support and financial incentives will play a crucial role in accelerating the deployment of these systems.

The integration of Battery Energy Storage Systems with Photovoltaic systems represents a pivotal step towards sustainable and resilient building electrification. By harnessing the power of the sun and storing it for future use, we can create a more reliable, cost-effective, and environmentally friendly energy landscape.

ABOUT THE AUTHOR



KEN PANUCCI, PE, CEM leads the buildings division team at Primera Engineers. His expertise is the result of nearly 40 years of experience in design/construction engineering environments and over 25 years of experience in project management. His technical background includes building mechanical systems, including building central plant and power plant systems. His work includes the planning and implementation of short and long-term business unit strategic plans and management of staff responsible for all of Primera's energy services, commissioning services, HVAC, plumbing, electrical, lighting, life safety, architectural,

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