



Evolving residential energy storage systems

The need for robust and reliable connectors

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Learn more about

- The basics of residential energy storage systems (RESS)
- Key features to consider when selecting an RESS
- The importance of choosing the correct to meet the RESS's needs

The All Electric Society (AES)

The vision of AES propels us toward a future where renewable electrical energy is universally accessible, abundant, and economically viable as the predominant energy source. This transformation necessitates the widespread electrification, interconnection, and automation of all economic sectors and infrastructure.

Residential energy storage systems (RESS) are one of the growing ways to realize this vision. Designed for use in homes, an RESS stores excess energy generated by renewable sources, such as solar panels, for use on demand when a residence truly needs it.

Introduction to residential energy storage systems



Residential Energy Storage

Typically, RESS are comprised of a renewable energy source, batteries, inverters, and control systems. The synergy of these components enables the complete system to generate energy, store that energy efficiently, and utilize it strategically during periods of high demand, power outages, or when renewable sources are not actively generating electricity. ■

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The impacts of climate change

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The renewable energy source for residential systems, predominately solar panels, harnesses energy from the sun and converts it into electrical energy. That energy can then be pushed into an energy storage system located in the residence. The heart of the system, batteries, stores the excess energy efficiently. Lithium-ion batteries, known for their high energy density and cycle life, are commonly used. Other technologies, such as lead-acid or lithium-iron-phosphate batteries, may also be utilized based on specific requirements.

Inverters play a critical role in converting the direct current (DC) stored in batteries into alternating current (AC) used in homes. This conversion is vital for the seamless integration of stored energy into the existing electrical grid. Sophisticated control systems manage and optimize the flow of energy within the RESS. These systems ensure efficient charging, discharging, and overall performance, contributing to the reliability and longevity of the system.

The RESS facilitates a significant reduction in reliance on the grid by empowering users to store excess energy for later use. This enhances energy independence, offering homeowners greater control over their energy consumption. In the event of a power outage, RESS serves as a reliable backup power source, ensuring essential appliances and devices continue to operate. This not only provides convenience but also enhances the resilience of the household. Some advanced RESS can actively participate in demand response programs, contributing to the balancing of electricity demand and supply on the grid. This support enhances the stability and efficiency of the broader electrical infrastructure.

Utilizing stored energy during peak times or high electricity rate periods enables users to save money on their energy bills. Moreover, homeowners with excess energy have the option to sell it back to the utility company, creating an additional revenue stream. When coupled with renewable energy sources, RESS actively contributes to a reduction in greenhouse gas emissions and minimizes environmental impact. This aligns with global efforts towards sustainability and combating climate change.

The demand for RESS is experiencing rapid growth due to several reasons. Increased awareness of vulnerabilities in traditional energy infrastructure has driven a growing interest in reliable, resilient renewable energy solutions. RESS provides a decentralized approach, reducing dependence on centralized power grids and enhancing overall energy resilience. The potential for financial savings through reduced reliance on the grid during peak times and the ability to sell excess energy back to utility companies make RESS an attractive long-term investment for homeowners, offsetting initial costs over time.

As environmental concerns become more prominent, there is a growing emphasis on sustainable living. Coupling RESS with renewable energy sources allows homeowners to actively contribute to environmental conservation, reducing their carbon footprint and promoting eco-friendly practices. Advancements in battery technology, system design, and control algorithms have significantly improved the efficiency and effectiveness of RESS. These technological strides have enhanced the overall performance and attractiveness of residential energy storage solutions, making them more accessible and appealing to a broader audience.

RESS emerge as essential components in realizing the vision of the All Electric Society. The multifaceted benefits of energy independence, backup power, grid support, financial savings, and environmental impact position RESS as a pivotal solution in the evolving energy landscape. The rapidly growing demand for these systems is propelled by increased awareness, cost-effectiveness, environmental consciousness, and ongoing technological advancements, collectively steering the transition toward a more sustainable, resilient, and decentralized energy future. ■

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Supporting a sustainable future

System needs in the market for residential products

A good residential energy storage system combines key features and characteristics to ensure optimal performance, reliability, and user satisfaction. In addition to these expectations, a system should be aesthetically pleasing, installation-friendly, expandable, and affordable.

Aesthetics

The visual appeal and design of RESS play a crucial role in system adoption. These systems are often installed in visible areas of homes, such as garages, sidewalls, and living spaces. Therefore, considerations for space requirements, design, and appearance are vital. Consumers are more likely to invest in technologies that seamlessly blend with their existing home decor and design.



Garage installed RESS

Installation-friendly

Complex installations result in higher costs due to increased labor expenses stemming from lengthy installation times. Therefore, an essential requirement for residential energy storage systems is ease of installation. This involves compatibility with existing infrastructure, including solar panels, inverters, and home electrical systems. A system that seamlessly integrates with these components reduces the need for extensive modifications and time for installation, making the technology financially feasible for a broader range of homeowners.

Expandable

Modular energy storage systems that are easy to install offer homeowners the flexibility to start with a smaller capacity and scale up as needed. This adaptability is particularly appealing to consumers who prefer to gradually invest in an energy storage solution or adjust their

system to changing energy requirements. Furthermore, modularity plays a crucial role in the maintenance of battery energy storage systems, allowing for easier repair or replacement of individual components.

Affordable

Cost is a significant factor in the adoption of RESS, as it usually represents the most substantial portion of the complete system. To encourage widespread adoption, manufacturers and developers must ensure that RESS is highly cost-competitive. This involves optimizing manufacturing processes, utilizing cost-effective materials, and exploring innovations that reduce overall system costs without compromising efficiency and reliability. ■

Stackable energy storage system

The most common style of residential energy storage system is the stackable energy storage system (SESS). These systems are modular, scalable, and stackable. Within these systems, the electrical connectors serve as the linchpin for seamless integration, efficiency, and safety across various parts of the energy storage system. Careful consideration in selecting connectors is pivotal in addressing the system's requirements.



Stackable energy storage system

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An SESS offers a flexible and scalable solution for renewable energy storage. The modular stacking concept allows for easy expansion, as the number of battery modules or packs can be adjusted to meet the specific needs of a particular application. A consumer can start with a small system, and as the needs increase, can add more battery modules to the existing system to provide more backup capacity. ■

Addressing the connector needs of the RESS

Battery modules are the most crucial component of residential energy storage systems. They are a collection of battery cells connected in series or in parallel. The combined cells are responsible for storing electricity as chemical energy, most commonly Lithium-ion, so it can be used when needed. The battery modules are coupled with a battery management system (BMS), to help support and maintain efficient operation of the battery system.

Together, these components monitor the battery cells to ensure they are operating within their prescribed operating windows for the state of charge, voltage, current, and temperature. They also monitor and control charging, discharging, and safety features like temperature regulation. To manage the signal and data transmission of the

monitoring and controlling functions of these devices, high-quality connectors are needed. Due to the compact size and limited space within these devices, robust and reliable connections like the Phoenix Contact FQ series board-to-board connectors are ideal.

Board-to-board connectors

The pin headers and sockets are available with 1.27 and 2.54-mm pitch. The series makes it easy to implement mezzanine, coplanar, and mother-daughter connections.

Facilitating communication and power transmission between stacked battery modules are intermodule connectors. These connectors are integral to the modular design, allowing for the dynamic expansion or reduction of the system based on energy storage requirements. The physical stacking mechanism requires specialized connectors to maintain a secure and stable alignment and arrangement of battery modules.

The ideal connectors should incorporate features such as sealing to provide weather and corrosion resistance, which contributes to the longevity and reliability of the system; float, to address the possible misalignment that can occur when stacking the battery modules; and possibly disconnect/connecting under load, which could be required for safety during maintenance and system conditioning.

To support power requirements, a connector similar to Phoenix Contact's Battery Pole Connector (BPC) offers a reliable and robust power connection option. Rated for voltages up to 1500 V DC and up to 350 A, the BPC meets UL 4128 and provides IP67 degree protection. Once plugged in, it offers the flexibility to freely rotate 360 degrees.

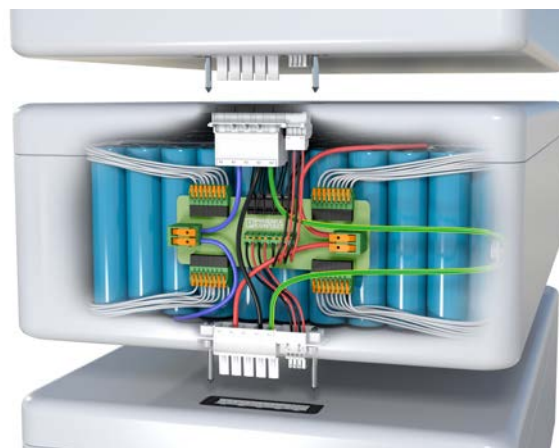
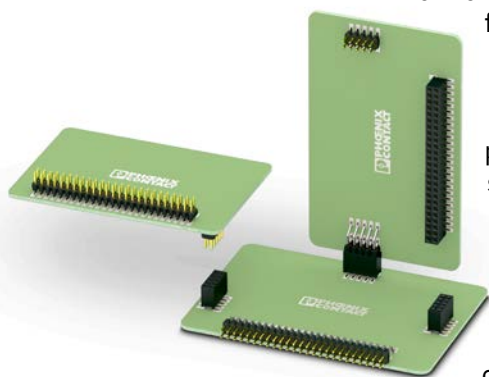
Battery pole connectors

Residential storage systems will use one of several data protocols to communicate within the system. The most commonly used protocols are Modbus, CAN bus, and RS-485. These protocols communicate and transmit data between the BMS and other components of the system. Instead of using an individual connector for power, another for data, and yet another for signal connections, there is a growing trend toward using a hybrid connector.

A hybrid connector, capable of handling power, signal, and data communication within a single interface, offers several benefits that can enhance the versatility of stackable RESS. These connectors streamline the overall system setup, reducing complexity, optimizing space, and contributing to cost savings.

Finally, consideration should be given to the utilization of UL-certified connectors, compliant with standards such as UL 9540 for energy storage systems and UL 4128 for intercell connectors. These approvals underscore safety and reliability, which ensures adherence to industry standards and regulations. ■

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Stackable hybrid connectors

Conclusion

Addressing connector needs with the key features and requirements mentioned is essential for the successful development and deployment of residential energy storage systems. Manufacturers and developers must consider critical factors such as aesthetics, easy installation, scalability, customization, and cost competitiveness. By meeting these requirements, they can create efficient, reliable, and well-suited RESS solutions that align with the evolving needs of homeowners and the dynamic energy market. This strategic approach ensures the continued growth and integration of residential energy storage systems in the pursuit of sustainable and independent energy solutions.

Learn more at www.phoenixcontact.com/energystorage



About Phoenix Contact

Since 1923, Phoenix Contact has created products to connect, distribute, and control power and data flows. Our products are found in many industrial markets, including energy, infrastructure, process, factory automation, and e-mobility. Together with our customers, we are empowering a smart and sustainable world for future generations.

For more information about Phoenix Contact or its products, visit www.phoenixcontact.com, call technical service at **800-322-3225**, or email us-info@phoenixcontact.com.