

Powering the Future: Grid Modernization and Microgrid Trends

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The central power grid is commonly portrayed as an aging web of smaller power networks, stitched together via technologies from different decades.

At the same time, many of the electric loads on today's grid look nothing like what the grid was originally designed to support, from electric vehicle charging stations to localized energy storage systems. In an era of electrification and growing concerns about climate change, the transformation of traditional power grids has become imperative. It's time for an upgrade.

Microgrid technology is emerging as a viable solution to grid modernization, electrification of everything, increasing reliability, and overall energy efficiency. This article highlights the latest trends in microgrid technology and demonstrates its potential to reshape our energy landscape.

Grid Modernization

Microgrids represent a key element of grid-modernization efforts, enabling the integration of renewable energy sources, energy storage systems, and advanced control technologies. These localized power systems can operate independently or in conjunction with the main grid, enhancing reliability, resilience, and flexibility. Microgrids help reduce downtime, improve grid operations, and smooth the transition to a clean-energy future by intelligently managing energy flows using [current sensing](#) in power-conversion systems (PCS) that focus on [renewable energy](#).

Electrification of Everything

The electrification of various sectors, from transportation to heating and industrial processes, is gaining momentum. Microgrid technology plays a vital role in enabling this transition by providing localized, on-demand energy solutions. Electric-vehicle charging infrastructure can be seamlessly integrated into microgrids, allowing for efficient and intelligent charging while reducing the strain on the main grid. Additionally, microgrids facilitate the adoption of electric heating systems and electrified industrial processes, decreasing reliance on fossil fuels and promoting sustainability.

Bidirectional Energy

Traditionally, power grids have operated on a unidirectional flow of electricity, delivering energy from centralized power plants to end consumers. However, with the integration of distributed energy sources, bidirectional power has emerged as a defining feature of modern microgrids. Microgrids enable the two-way flow of electricity, allowing excess energy generated by renewable sources or from energy storage systems (ESS) within the microgrid to be fed back into the main grid (as shown in Figure 1).

This bidirectional capability streamlines the use of renewable energy resources, supports demand response programs, and promotes energy sharing and collaboration among interconnected microgrids.

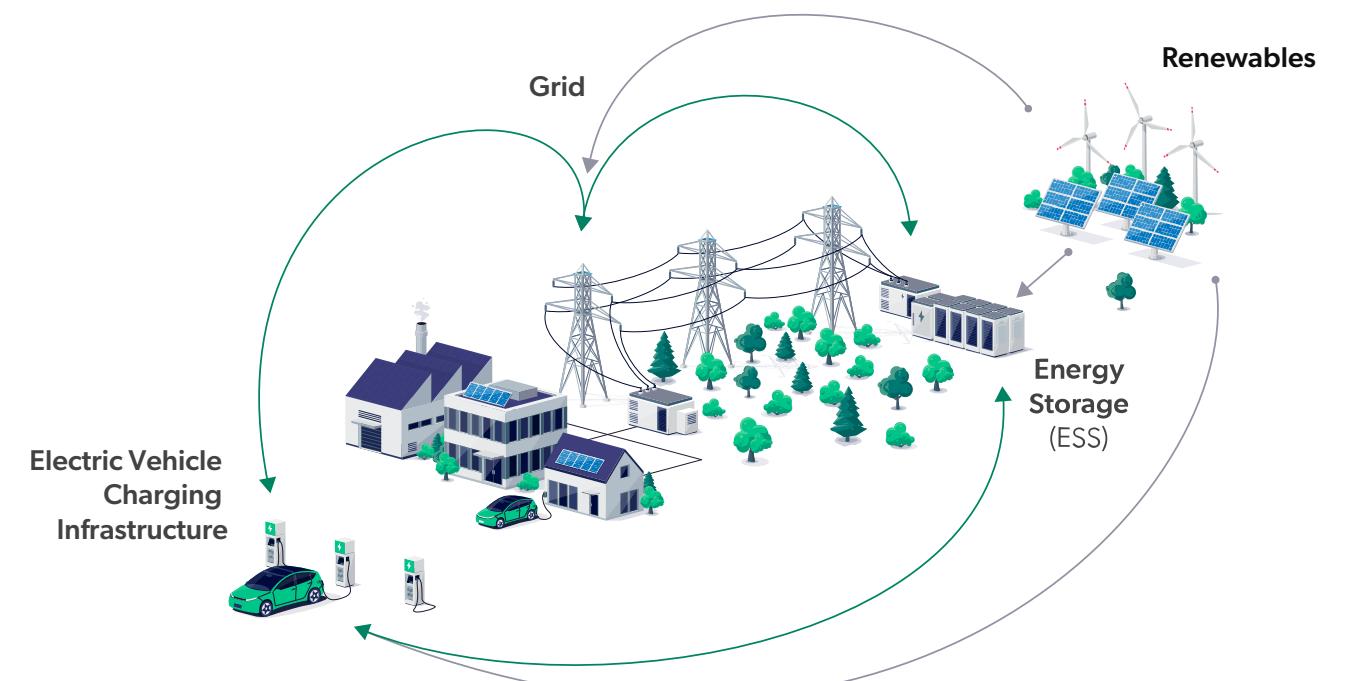


Figure 1: Bidirectional flow of energy in a microgrid

Energy Efficiency

Efficiency is a critical aspect of sustainable energy systems and is key to the success of microgrid technology. By employing advanced energy management systems, microgrids can intelligently balance energy supply and demand, optimize generation and storage resources, and reduce overall energy waste.

Current sensors, like those offered by Allegro MicroSystems, play a crucial role in monitoring and controlling the flow of electricity within microgrids. With the proliferation of current measurement functions and frequent power conversions found in microgrids, solutions with [low power loss](#) are needed to maintain overall efficiency.

These sensors provide real-time data on current levels, enabling precise load monitoring plus fast fault detection to protect people and equipment. By accurately measuring and analyzing current data, microgrids can make informed decisions to maximize efficiency and minimize operational costs. Furthermore, the localized nature of microgrids reduces transmission losses, enhancing overall system efficiency.

Energy Storage Solutions

Integrating energy storage systems, mainly in the form of batteries, into microgrids enables efficient energy management. Excess energy generated during peak production periods can be stored and used during periods of high demand or low generation. Energy storage systems help balance supply and demand, reduce reliance on the main grid, and improve the overall efficiency of microgrids.

For any energy storage system, it is important to consider how to keep components cool. Lower system temperatures are directly related to longer equipment lifecycles, higher reliability, and more up time.

Cooling approaches vary between residential systems and larger, container-sized solutions. A residential storage system uses fans to keep the chassis and battery cells cool, while a larger system is likely to incorporate a heat pump. The heat pump solution provides cooling and environmental control for the entire container. In addition to the heat pump, it is common to find a fan on each cell.

Regardless of the deployment, choosing a [reliable fan controller](#) is critical to maintaining battery temperature, measurement accuracy, and therefore battery health.

Power Density

Power density, or the amount of power output in a given volume, is an important element in the design of microgrid components. Some benefits of higher power density in microgrid equipment are provided in Table 1.

Application	Benefit(s) of High Power Density
PV Inverters	Space Efficiency, Lower Installation Cost and Increase ROI, Improved Performance and Power Utilization, Enhance Reliability and Less Heating
Energy Storage Systems (ESS)	Space Efficiency, Maximize Energy Transfer, Increase Lifespan, Improve scalability and versatility
EV Charging	Fast Charging Time, Space Efficiency Improvement, Improve Reliability by having less heat generated, Cost Effectiveness
Power Conditioning Systems (PCS)	Reducing footprint of power conversion systems (PCS) makes room for more batteries in the same floor plan.

A common path to higher power density is to increase the switching frequency of power-conversion systems, thus allowing the use of smaller, passive components.

Allegro offers designers current sensors with fast step response (shown in Figure 2) and wide bandwidth ([up to 1 MHz](#)), as well as fully integrated, isolated gate drivers that support gallium-nitride (GaN), metal-oxide-semiconductor (MOS), and silicon-carbide (SiC) technologies to support these higher speeds while reducing switching losses.

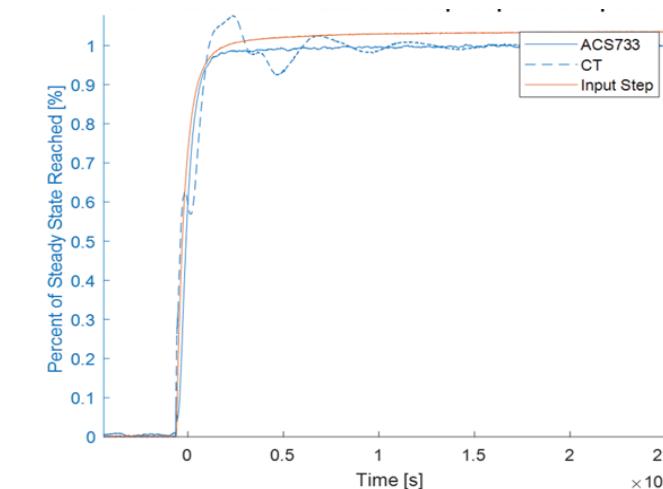


Figure 2: Step response of 1 MHz current sensor from Allegro vs. a current transformer (CT)

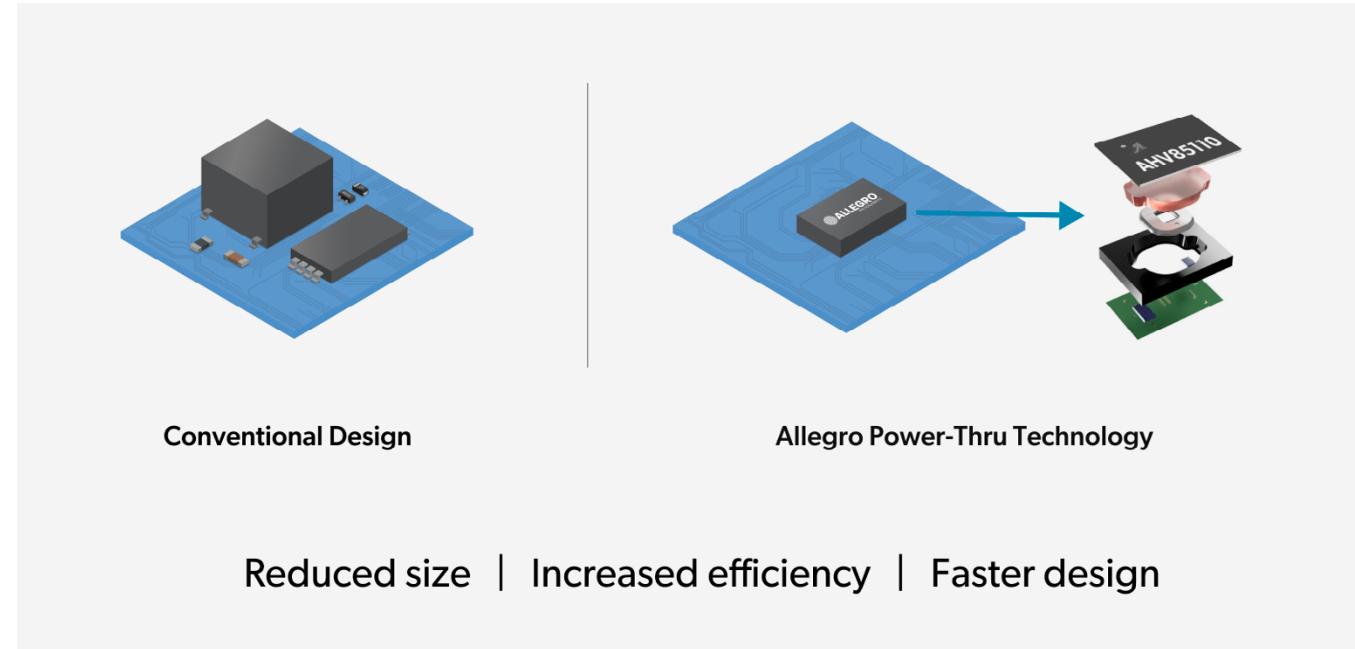


Figure 3: Solution size of competing solution vs. Allegro's solution with Power-Thru technology

Another common strategy for higher power density is to choose up-integrated solutions that incorporate value-added features, reducing the bill of materials (BOM) and board space.

The size reduction achievable using Allegro's fully integrated, isolated gate drivers with Power-Thru technology is shown in Figure 3.

Whether your design focus is speed, up-integration, or both, [high-speed, fully isolated gate drivers](#) and [wide-bandwidth current sensors](#) from Allegro are perfect for either approach.

Distributed Generation

Microgrids enable the integration of distributed generation sources, such as solar panels and wind turbines, at the local level. By generating electricity closer to the point of consumption, transmission losses are minimized, resulting in improved system efficiency. Leveraging renewable energy sources within microgrids not only reduces reliance on centralized fossil fuel-based power plants but also enhances the overall sustainability and efficiency of the energy system.

Allegro Power-Thru Technology

Reduced size | Increased efficiency | Faster design

Conclusion

Microgrid technology represents a transformative force in the pursuit of grid modernization, electrification of everything, bidirectionality, and energy efficiency. By embracing the latest trends in microgrid technology, we can create a more sustainable and resilient energy infrastructure.

As renewable energy adoption continues to accelerate, microgrids offer a decentralized and flexible solution, empowering communities, businesses, and individuals to actively participate in the clean-energy transition. With ongoing research and development, policy support, and collaboration among stakeholders, microgrids hold immense potential to shape the future of energy and foster a greener world.

To learn more about clean-energy solutions and how Allegro is helping move the world toward a more-sustainable future, visit allegromicro.com/cleanenergy.