



# Power Electronics in the US Electrical Power Industry - Financing and Value Proposition

*Jim Benke – Mitsubishi Electric Power Products, Inc. (MEPPI)*

# Power Electronics in the US Electrical Industry

## Trends – United States Specific

► Power electronics play a crucial role in the United States electrical industry, impacting various sectors, including renewable energy, industrial applications, transportation, and utilities. Overall, as the US electrical industry continues to evolve, power electronics will be at the forefront, driving advancements in efficiency, reliability, and the integration of new technologies. Here are some key aspects:

1. **Renewable Energy Integration:** Power electronics are essential in integrating renewable energy sources like solar and wind into the grid. They help manage the variability of these sources through inverters and converters that ensure stable and efficient power delivery.
2. **Grid Modernization:** As the US electrical grid modernizes, power electronics technologies are vital for smart grid applications. They enable better demand response, real-time data analytics, and improved efficiency in power distribution.
3. **Electric Vehicles (EVs):** Power electronics are fundamental in the development and operation of electric vehicles. They control battery charging and discharging, manage electric motor drives, and enhance overall vehicle efficiency and performance.
4. **Energy Efficiency:** In industrial environments, power electronics improve energy efficiency through variable speed drives and motor controllers, reducing energy consumption and operational costs.
5. **Advanced Power Conversion Systems:** Innovations in power electronics have led to advanced power conversion systems that allow for more efficient energy storage solutions, including battery management systems and supercapacitors.
6. **Solid-State Transformers:** Emerging technologies like solid-state transformers offer the potential for more adaptable and efficient power distribution and are another frontier for power electronics in the grid.
7. **HVDC and FACTS:** High-voltage direct current (HVDC) systems and Flexible AC Transmission Systems (FACTS) use power electronics to enhance the capacity and flexibility of power transmission networks.



# Power Electronics in the US Electrical Industry

## Trends – United States Specific

- ▶ Several challenges can potentially block the successful implementation and adoption of power electronics in the electrical industry. Here are the top five challenges in using power electronics in new products within the United States electrical industry:
- 1. Thermal Management:** Power electronic devices often generate significant heat, which can affect performance and reliability. Effective thermal management solutions are necessary to dissipate heat and maintain optimal operating conditions.
  - 2. Cost and Investment:** The initial cost of advanced power electronic components can be high, and significant investment is required for research, development, and production. This can be a barrier for companies looking to adopt these technologies in their products. **Traditional existing technology has the advantage of economy of scale.**
  - 3. Complexity and Integration:** Integrating power electronics into existing systems requires specialized design and engineering expertise. The complexity of these systems can pose challenges in terms of design, implementation, and maintenance.
  - 4. Reliability and Durability:** Ensuring long-term reliability and durability of power electronic components, especially in harsh environments or critical applications, is a major challenge. This requires rigorous testing and quality assurance processes.
  - 5. Technical Standards and Interoperability:** The rapid advancement of power electronics technology often outpaces the development of industry standards. Ensuring interoperability and compliance with existing standards can be difficult, especially in applications that require coordination across different systems and devices.



# Power Electronics in the US Electrical Industry

## Trends – United States Specific

► Power electronics are poised to remain a cornerstone of technological evolution in the electrical industry for decades to come. Power electronics are likely to be highly successful in the United States electrical industry over the next 5, 10, 15, 20, and even 30 years. Here's why this technology will continue to play a critical role in the future:

- 1. 5 Years:** In the short term, power electronics will see accelerated adoption due to the growing need for energy efficiency and the integration of renewable energy sources into the grid. The push for smart grid technologies and electric vehicles will drive demand for advanced power electronic solutions.
- 2. 10 Years:** Over the next decade, innovations in semiconductor materials, potentially such as silicon carbide (SiC) and gallium nitride (GaN), will improve the performance, efficiency, and cost-effectiveness of power electronic devices. This will enhance their application in both consumer and industrial settings.
- 3. 15 Years:** By this time, power electronics will be integral to the energy infrastructure, with advances in grid management and distributed energy resources. Widespread adoption of renewable energy and storage solutions will become more prevalent, supported by sophisticated power electronic technologies.
- 4. 20 Years:** Long-term developments will likely focus on further integrating power electronics with advanced technologies like artificial intelligence and machine learning for predictive maintenance and energy optimization. This will enhance the reliability and efficiency of electrical systems.
- 5. 30 Years:** Looking further ahead, power electronics will be central to the transition toward a more sustainable energy system, facilitating significant reductions in carbon emissions and enabling new paradigms in energy generation and consumption.



# Power Electronics in the US Electrical Industry

▶ Power Electronics **value proposition** has the potential to achieve **value-parity** with traditional grid systems.

- **Enhanced Operational Flexibility**
  - Provides superior command and control capabilities for grid management
  - Supports dynamic response to energy demand fluctuations
- **Integration with Renewable Energy**
  - Enables efficient incorporation of solar and wind power
  - Facilitates a transition to cleaner energy systems
- **Improved Grid Reliability and Resilience**
  - Enhances system reliability, reducing downtime and maintenance costs
  - Strengthens grid resilience against outages and disturbances
- **Long-term Economic Benefits**
  - Offers potential for greater efficiency and reduced operational expenses over time
  - Supports sustainable energy optimization strategies
- **Achieving Value-Parity**
  - Focuses on delivering significant value beyond initial costs
  - Aims to meet or exceed the strategic benefits of conventional grid assets through enhanced performance and adaptability



# Power Electronics in the US Electrical Industry – Slide 1

## *Example of a Power Electronics Solution - Achieving Value-Parity*

- ▶ **Hypothetical Example Context:** A regional utility company is looking to integrate a substantial increase in solar and wind power into its existing power grid. The traditional transformers in their substations, while reliable, lack the versatility needed to manage the variable nature of these renewable energy sources effectively.
- ▶ **Solution with Solid-State Transformers (SST):** By employing solid-state transformers, the utility can not only manage the immediate challenges posed by integrating renewable energy but also future-proof its infrastructure to accommodate evolving demands and technologies within the energy landscape. This example underscores the strategic advantages of SSTs in achieving enhanced grid management and energy efficiency. One power electronic product can act like several products (solid state substation).

# Power Electronics in the US Electrical Industry – Slide 2

## 1. Voltage Regulation and Stability:

- SSTs provide precise voltage regulation, which is essential for maintaining grid stability when integrating intermittent renewable sources. They can quickly adapt to changes in input and output voltages, offering better quality power to consumers.

## 2. Frequency Conversion:

- SSTs can convert frequencies, which is particularly useful when connecting diverse power systems or integrating renewable sources that may operate at different frequencies than the main grid.

## 3. Power Quality Improvement:

- By reducing harmonics and compensating for reactive power, SSTs enhance power quality. This is important for protecting sensitive equipment and ensuring efficient operation of industrial processes that rely on consistent power supply.

## 4. Integration with Smart Grids:

- SSTs are designed to integrate seamlessly with smart grid technologies, offering real-time monitoring and control capabilities. This enables the utility company to optimize grid performance, enhance energy management, and support demand response programs.