

F R O S T & S U L L I V A N

FROST & SULLIVAN BEST PRACTICES AWARD

INDUSTRIAL POWER ELECTRONICS - GLOBAL

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Technology Leadership 2019

**TMEiC**  
*We drive industry*

FROST & SULLIVAN

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2019

BEST  
PRACTICES  
AWARD

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## Background and Company Performance

### *Industry Challenges*

We are in a day and age where digital transformation has taken center stage in all industries leading to a fourth industrial revolution. Industry 4.0 implies that industrial machinery will have smart product processing capability and will also have the ability to communicate with other machinery without human aid by bridging the physical and virtual worlds. While various industries embrace this trend, it is crucial that ICT semiconductors, central processing units, digital signal processors, integrated circuits etc. are not only highly advanced, but also offer high quality and reliability. This highly depends on the production processes of these devices as they are extremely sensitive to the power supply disturbances and require fine manipulation, strict room conditions, detailed process line control and so on. The key to addressing this challenge is advanced power electronics solutions.

On the other hand, demand for solar power systems are increasing, as economics vs. conventional power continue to improve and the global need to limit emissions becomes more urgent. Key components play a role in this and project developers are looking for solar inverter solutions that enable farms to maximize electrical output (harvest) and therefore revenues. One main challenge in the solar inverter industry is the potential differential harvests that can be achieved. The string and central inverters face a challenge from the perspective of partial shading, which can cause a reduced energy harvest. Partial shading can be caused by dust, debris, a chimney, and branches of trees, which may come between sunlight and the solar panel.

In order to increase the use of renewables, the power transmission/distribution networks are required to be more flexible in operation considering the generation power variations. In addition, they are also required to be more resilient to the disasters, which are increasing in numbers and in strength due to global warming. Once again, power electronics technology is best placed to address these challenges.

### *Technology Leverage and Business Impact*

#### **Commitment to Innovation & Creativity**

Innovation and creativity is embedded in the DNA of TMEIC and forms the core of its innovative capabilities. One of the key success factors of the company is its ability to envisage visionary scenarios by constantly analyzing mega trends and applying its technology brilliance to address those developments. The company has developed a revolutionary technology concept called “modular power electronics (PE) system”, with which it is set to transform the landscape of industrial power electronics. TMEIC has developed three path breaking products based on its modularity concept; Universal Power Conditioning System (U-PCS), Multiple Power Compensator (MPC) and Modular multilevel converters (MMC). When it comes to anticipating market gaps, technology voids and more importantly customers anticipated future needs, TMEIC has time and gain maintained its position at the forefront of the industry. Furthermore, it has gained a reputation of raising the bar higher every time with its innovations, making it difficult for its competitors to

catch up. Its recently launched Solar Ware Universal Power Conditioning System (PCS), the latest evolution of the highly successful Solar Ware family of inverters, is a vivid testament to this. It is intriguing to see TMEIC's level of commitment and dedication to thoroughly engage with the market stake holders (customers, utilities, developers, technicians and so on) to get their inputs/feedback while developing the Universal PCS. The result of this meticulous product development and R&D process is a product that will prove to be a boon to the end users. It addresses legacy market unmet needs such as ease of installation and maintenance, increase in energy harvest etc. and also addresses evolving customer needs such as flexibility, scalability, smart features and so on.

### **Industry Leading Design**

TMEIC's excellence in industrial power electronics can be attributed to its deep rooted and sophisticated technology know-how gained over the course of several years. Its focus and efforts to continually innovate and ensure that its product offerings are state of the art is highly commendable. The company's modular PE system is the epitome of technology innovation, born out of relentless pursuit of groundbreaking ideas, contributing to the betterment of various industries. The products born out of this concept are embedded with a wide range of features and functionalities that are unique in the industry and ultimately enhance end user value multi-fold.

The Universal PCS is a modular inverter system which is designed to perform both energy generation and energy storage functions while offering high efficiency, cutting-edge features, and unparalleled reliability. It is an amalgamation of multiple modular inverters that can operate independently. Each inverter module is a self-contained with same hardware components regardless of inverter capacity. So, if one modular inverter fails, the others continue to generate power from the PV panels without any impact, thus increasing availability and optimizing power generation of the total system. It is noteworthy that the Universal PCS leverages its proven and highly successful 3 level circuit technology highly reliable IGBT based power conversion system. Its fully modular design offers enhanced individual Maximum Power Point Tracking(MPPT) for greater energy yield and it leverages advanced controls system loaded with value added features and functionalities to meet not only today's smart inverter requirements, but also anticipated new requirements as they evolve. It also significantly reduces the maintenance time as it allows seamless replacement of the faulty inverter module without disrupting the operation of the rest of the inverter modules. This modular approach leverages multiple layers of flexibility that allow designers a vast array of design and installation options for every project. It is also highly customizable where up to six units can be placed on the same skid and it also has the bi-directional ability to combine PV and ESS inverters in the same lineup.

### **Technology Incubation Excellence**

TMEIC' power electronics products based modular technology represent the next generation of industrial solutions that not only offer superior reliability and efficiency but are also highly cost effective. This is a significant step forward in the industrial power electronics market which marks a corner stone in the evolution of the forth industrial

revolution and digital transformation. The company has a well thought out and perfectly streamlined technology incubation process in place; this can be broadly segmented in to three categories. The first one is “development plan approval system” where its management board performs a thorough business and technological feasibility analysis. This is followed by a “product release approval system” where it carries out a second level feasibility analysis on cost of production, components availability, production facilities, parts procurement and assembly lead time, delivery, and so on from a business perspective and performance, the quality, the reliability, the maintainability, and so on from a technical perspective. The third one is the design review system which closely monitors the progress at each milestone between the two approval stages.

One of the innovative products developed through TMEIC’s technology incubation excellence is the “Multiple Power Compensator (MPC)”. The company has developed this product specifically to enhance the critical processes in ICT component manufacturing such as semiconductors, liquid crystal products and films. Even though TMEIC started off by delivering MPCs in excess of 600,000kVA in its home market (Japan), it was quick to identify a trend in China where factories were increasingly facing power drops. In an effort to address this trend, the company developed an MPC with maximum capacity of 16,000kVA that that can be connected directly to China’s distribution voltage (10kV systems). This MPC topology is based on parallel connections to a full voltage compensation type converter that utilizes a low-loss high speed switch (HSS) on the direct supply circuit used during standard power supply. When there is a power dip, the MPC disconnects the affected equipment from the system in a record time of 0.001 seconds and the power is supplied from the converter ensuring continuous operation. TMEIC’s MPC offers highly advanced value added functionalities when compared to similar offerings and technologies in the market. To highlight a few features that make it truly unique – it offers high speed and high voltage disconnection capability; it offers high speed control capability; it provides high power output capability; it offers compensation capability even when the voltage drops to zero and it offers high system efficiencies and simplifies installation to a high magnitude. It is Frost & Sullivan’s finding that TMEIC’s MPC significantly increases the reliability of power supply to the factories, avoids production loss and improves the overall production quality.

### **Excellent Financial Performance**

TMEIC’s tremendous focus on power electronics has propelled it to one of the leading positions in the global market in terms of market share. The company achieved above market average growth rate by registering 10% year-on-year revenue growth rate; it is also noteworthy that TMEIC recorded a 10% growth rate on its operating income in 2018 compared to the previous year. It is also noteworthy that the company has achieved a total cumulative PV inverter shipment of 20GW for utility-scale PV systems where it has recorded an impressive 35% CAGR over the past five years. TMEIC also currently holds the largest market share in the large-capacity PV inverters (100kW and above) and is taking serious measures to increase its overall global market share, where its main strategy is to increase its overseas sales percentage. In an effort to strengthen its

Americas operations and market share, TMEIC has built a second power electronics factory in Houston, Texas as a supplement to its already existing factory. This new factory became fully operational in August 2017. These production facilities will not only manufacture PV inverters but also other high-quality competitive products such as inverters for driving motors by leveraging its power electronics technology. With the addition of this new factory, the company aims to increase its production capacity of its PV inverters by nearly 300%. It is Frost & Sullivan's finding that TMEIC is poised for a steady growth over the next two to three years which will be primarily driven by its innovative PEiE concept backed by an extremely strong product/technology innovation strategy and manufacturing excellence with a strong focus on quality and reliability.

### **Customer Acquisition Strategy**

TMEIC was quick to identify the power electronics related challenges in various industries and converted them in to opportunities to acquire new customers with its innovative modularity concept, which is perfectly placed to address customer pain points. Frost & Sullivan firmly believes that TMEIC's innovative modular PE system solutions will be highly successful in helping industries improve the reliability and efficiency, optimize overall operations, and pave the way to attain their sustainability goals. Significant strides made by TMEIC in this space demonstrate its relentless pursuit of enhancing the overall customer ownership experience. The company's highly successful customer acquisition strategy is driven by four core areas of excellence – product excellence, innovation excellence, manufacturing excellence and customer service excellence. With equal focus on all four aspects, TMEIC has carved a unique and special place in this highly competitive market and has gained a highly respectable reputation of developing futuristic products that enhance customer value substantially.

A fitting example for this is its newly developed Modular Multilevel Converter (MMC) technology, which significantly enhances the performance of extra-high voltage power transmission systems. With its unique mechanical, electrical and anti-seismic design, this technology addresses the evolving requirements of modern day power networks such as higher flexibility in power exchanges among distributed renewables and cities (load centers), better resilience against increasing natural disasters and so on. The MMC comprises of high voltage and high power modular cells (consisting of power semiconductor devices) connected in series. It is designed to generate quasi ideal AC voltage from the DC voltage suitable for the power transmission rated at several hundreds of MW and at several hundreds of kV. There are several features and functionalities which make the MMC stand out from conventional technologies. Its black start capability is a perfect example for this. The black start capability allows the MMC to continue operation as a DC to AC inverter and output the AC voltage even while the AC transmission system faces a forced shut down (by a natural disaster, or any other reason). It is able to supply the power to the local AC power network while rest of the AC power system is in black out. This black start function will play a crucial role in increasing the resilience of the transmission power network. Some of the other value adding functionalities of the MMC include, a wide operational capability, power reversal capability with constant DC voltage

polarity and with its AC voltage control capability, it is able to control both the active and reactive power. In simple terms, the MMC is capable of addressing the gaps and shortcomings of the conventional AC transmission technology; it offers advanced features and enhanced capabilities to stabilize the power transmission networks and improve resilience against natural disasters multi fold.

### **High Growth Potential**

With a clear understanding of the evolving market needs, TMEIC continually innovates to ensure that its product offerings are ahead of its time. This is clearly evident from the significant strides it has made in its product generation evolution curve. A vivid testament to demonstrate TMEIC's thought leadership is its conception of a visionary concept called Power Electronics in Everything (PEiE) which it developed to capitalize on the fourth industrial revolution, Industry 4.0. It is a well-known fact that TMEIC is the pioneer of three-level inverter technology which has been leveraged in its PV inverters, UPS systems and in the motor drive inverters. This is a key driver for high product penetration and high growth potential. This combined with its revolutionary PEiE concept and modular PE system solutions such as Universal Power Conditioning System (U-PCS), Multiple Power Compensator (MPC) and Modular multilevel converters (MMC) is expected to significantly accelerate its growth potential in the coming years.

### *Conclusion*

Frost & Sullivan firmly believes that TMEIC's modular PE system technology is truly one of a kind and it will bring about dramatic enhancements to every industry's critical processes and provide much needed relief from the power supply disturbances. It is a revolutionary technology that is not only unique and visionary, but it is also likely to be disruptive to existing technologies. The company's aspiration for continuous development of best-in-class products through visionary innovation has provided it with a unique edge in the market.

With its strong overall performance, TMEIC has earned Frost & Sullivan's 2019 Technology Leadership Award.

## Significance of Technology Leadership

Technology-rich companies with strong commercialization strategies benefit from the demand for high-quality, technologically innovative products that help shape the brand, resulting in a strong, differentiated market position.



## Understanding Technology Leadership

Technology leadership recognizes companies that lead the development and successful introduction of high-tech solutions to customers' most pressing needs, altering the industry or business landscape in the process. These companies shape the future of technology and its uses. Ultimately, success is measured by the degree to which a technology is leveraged and the impact it has on growing the business.

## Key Benchmarking Criteria

For the Technology Leadership Award, Frost & Sullivan analysts independently evaluated 2 key factors—Technology Leverage and Business Impact—according to the criteria identified below.

### Technology Leverage

- Criterion 1: Commitment to Innovation & Creativity
- Criterion 2: Design
- Criterion 3: Technology Incubation
- Criterion 4: Commercialization Success
- Criterion 5: Application Diversity

### Business Impact

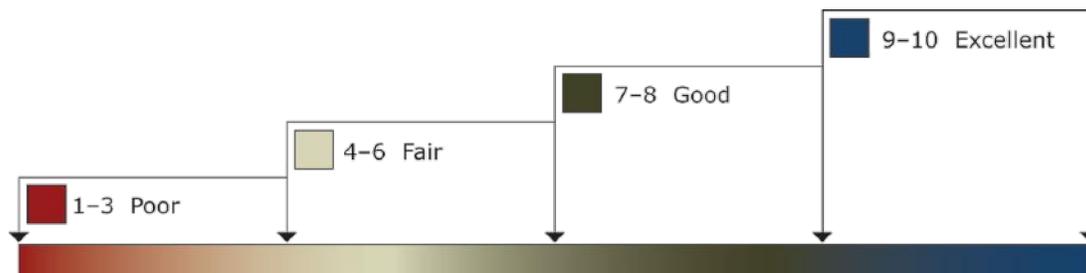
- Criterion 1: Financial Performance
- Criterion 2: Customer Acquisition
- Criterion 3: Operational Efficiency
- Criterion 4: Growth Potential
- Criterion 5: Human Capital

## Best Practices Award Analysis for TMEIC

### Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows research and consulting teams to objectively analyze performance according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation. Ratings guidelines are illustrated below.

#### RATINGS GUIDELINES



The Decision Support Scorecard considers Technology Leverage and Business Impact (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criterion are provided beneath the scorecard). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.

The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, Frost & Sullivan has chosen to refer to the other key participants as Competitor 1 and Competitor 2.

<i>Measurement of 1-10 (1 = poor; 10 = excellent)</i>			
<b>Technology Leadership</b>	Technology Leverage	Business Impact	Average Rating
<b>TMEIC</b>	<b>9.5</b>	<b>9.0</b>	<b>9.25</b>
Competitor 1	6	6	6.0
Competitor 2	6	5	5.0

### *Technology Leverage*

#### **Criterion 1: Commitment to Innovation & Creativity**

Requirement: Conscious, ongoing development of an organization's culture that supports the pursuit of ground breaking ideas through the leverage of technology. Employees rewarded for pushing the limits of form and function by integrating the latest technologies to enhance products.

#### **Criterion 2: Design**

Requirement: The product features an innovative design, enhancing both visual appeal and ease of use.

#### **Criterion 3: Technology Incubation**

Requirement: A structured process with adequate investment to incubate new technologies developed internally or through strategic partnerships.

#### **Criterion 4: Commercialization Success**

Requirement: A proven track record of commercializing new technologies by enabling new products and/or through licensing strategies.

#### **Criterion 5: Application Diversity**

Requirement: The development of technologies that serve multiple products, multiple applications, and multiple user environments.

### *Business Impact*

#### **Criterion 1: Financial Performance**

Requirement: Overall financial performance is strong in terms of revenue, revenue growth, operating margin, and other key financial metrics.

#### **Criterion 2: Customer Acquisition**

Requirement: Overall technology strength enables acquisition of new customers, even as it enhances retention of current customers.

**Criterion 3: Operational Efficiency**

Requirement: Staff is able to perform assigned tasks productively, quickly, and to a high quality standard.

**Criterion 4: Growth Potential**

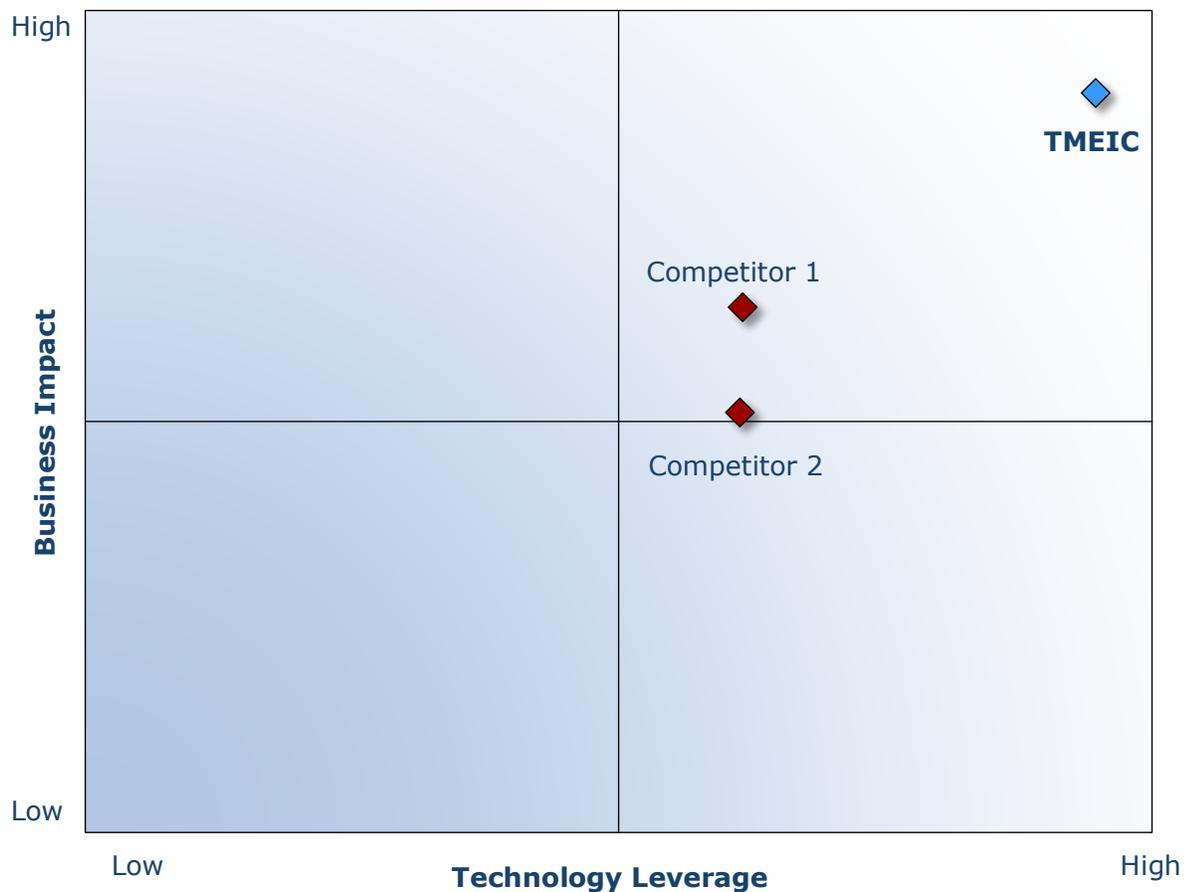
Requirements: Technology focus strengthens brand, reinforces customer loyalty, and enhances growth potential.

**Criterion 5: Human Capital**

Requirement: Company culture is characterized by a strong commitment to customer impact through technology leverage, which enhances employee morale and retention.

*Decision Support Matrix*

Once all companies have been evaluated according to the Decision Support Scorecard, analysts then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.



## Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan analysts follow a 10-step process to evaluate award candidates and assess their fit with select best practices criteria. The reputation and integrity of the awards are based on close adherence to this process.

STEP	OBJECTIVE	KEY ACTIVITIES	OUTPUT
1 <b>Monitor, target, and screen</b>	Identify award recipient candidates from around the world	<ul style="list-style-type: none"> <li>• Conduct in-depth industry research</li> <li>• Identify emerging industries</li> <li>• Scan multiple regions</li> </ul>	Pipeline of candidates that potentially meet all best practices criteria
2 <b>Perform 360-degree research</b>	Perform comprehensive, 360-degree research on all candidates in the pipeline	<ul style="list-style-type: none"> <li>• Interview thought leaders and industry practitioners</li> <li>• Assess candidates' fit with best practices criteria</li> <li>• Rank all candidates</li> </ul>	Matrix positioning of all candidates' performance relative to one another
3 <b>Invite thought leadership in best practices</b>	Perform in-depth examination of all candidates	<ul style="list-style-type: none"> <li>• Confirm best practices criteria</li> <li>• Examine eligibility of all candidates</li> <li>• Identify any information gaps</li> </ul>	Detailed profiles of all ranked candidates
4 <b>Initiate research director review</b>	Conduct an unbiased evaluation of all candidate profiles	<ul style="list-style-type: none"> <li>• Brainstorm ranking options</li> <li>• Invite multiple perspectives on candidates' performance</li> <li>• Update candidate profiles</li> </ul>	Final prioritization of all eligible candidates and companion best practices positioning paper
5 <b>Assemble panel of industry experts</b>	Present findings to an expert panel of industry thought leaders	<ul style="list-style-type: none"> <li>• Share findings</li> <li>• Strengthen cases for candidate eligibility</li> <li>• Prioritize candidates</li> </ul>	Refined list of prioritized award candidates
6 <b>Conduct global industry review</b>	Build consensus on award candidates' eligibility	<ul style="list-style-type: none"> <li>• Hold global team meeting to review all candidates</li> <li>• Pressure-test fit with criteria</li> <li>• Confirm inclusion of all eligible candidates</li> </ul>	Final list of eligible award candidates, representing success stories worldwide
7 <b>Perform quality check</b>	Develop official award consideration materials	<ul style="list-style-type: none"> <li>• Perform final performance benchmarking activities</li> <li>• Write nominations</li> <li>• Perform quality review</li> </ul>	High-quality, accurate, and creative presentation of nominees' successes
8 <b>Reconnect with panel of industry experts</b>	Finalize the selection of the best practices award recipient	<ul style="list-style-type: none"> <li>• Review analysis with panel</li> <li>• Build consensus</li> <li>• Select recipient</li> </ul>	Decision on which company performs best against all best practices criteria

## The Intersection between 360-Degree Research and Best Practices Awards

### Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of the research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often companies make important growth decisions based on a narrow understanding of their environment, resulting in errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry players and for identifying those performing at best-in-class levels.



### About Frost & Sullivan

Frost & Sullivan, the GrowthCompany, helps clients accelerate growth and achieve best-in-class positions in growth, innovation, and leadership. The company's Growth Partnership Service provides the CEO and the CEO's growth team with disciplined research and best practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages nearly 60 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from 45 offices on 6 continents. To join Frost & Sullivan's Growth Partnership, visit <http://www.frost.com>.