L&T SEMICONDUCTOR TECHNOLOGIES LIMITED

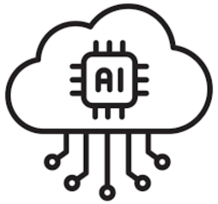
India Smart Utility Week 2025

ANAMIKA BHARGAVA

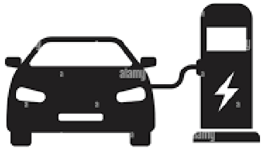
March 2026

Future. Made Together.

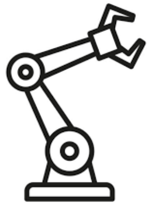
More Demand of Energy Due To the Electrification of Everything



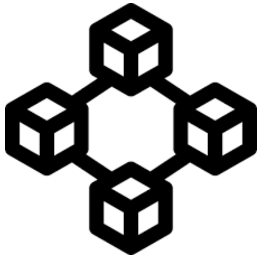
From more and more Data Centers to now **AI Data Centers** that **consume 20 times more energy than current ones**.



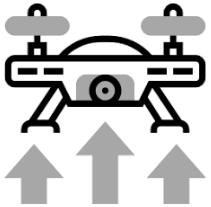
To Electric Vehicles and **EV Charging infrastructure** that **requires MegaWatts per site** (note: 1 MegaWattHour serves around 750 to 1,000 homes).



To **Digital Manufacturing Led By Robots**, which require more electricity non-stop.

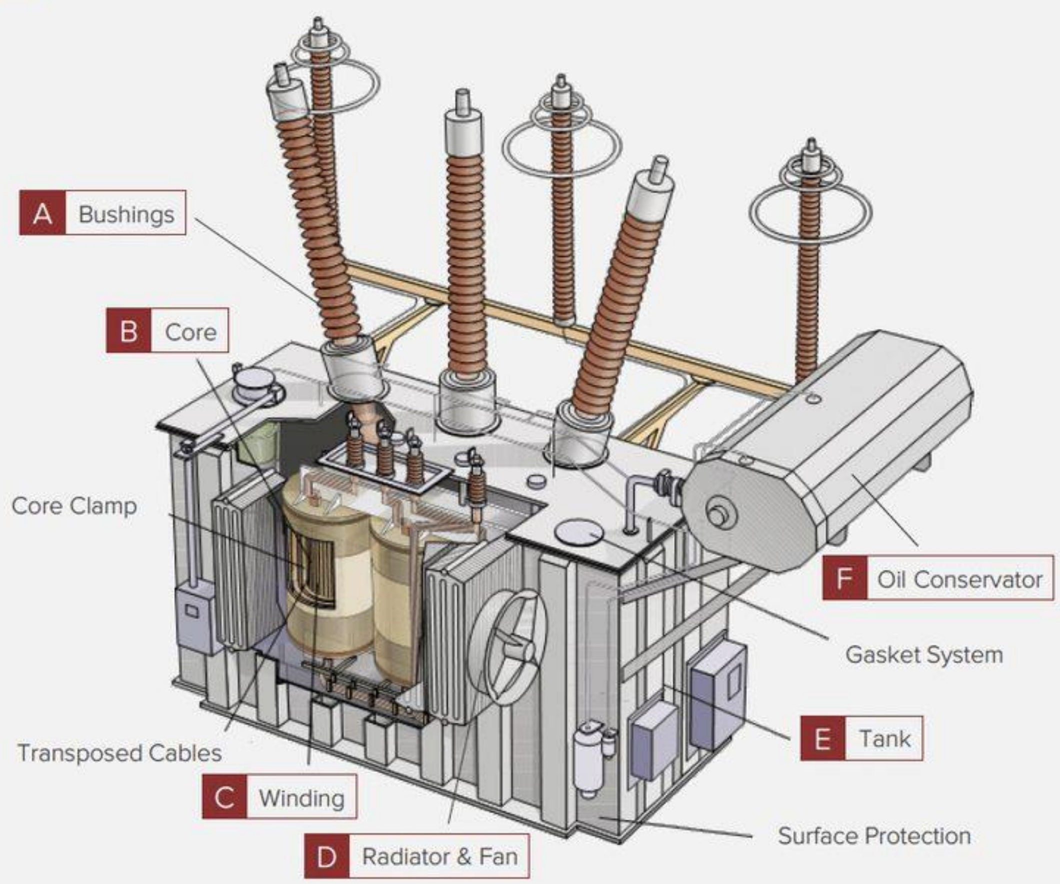


To **Cryptocurrency** and **blockchain farming** from multiple technologies to **enable the digitalization of everything** via **Tokens, NFTs and Currencies will need more electricity**.



To the coming of **Drones and Vertical Takeoff** and **Landing Vehicles (VTOLs)**.

*Denotes components that are not typically included in dry-type transformers



A Bushings serve as an insulation device and allow safe connection of transmission wires into the tank enclosure.

B The core houses the windings and provides the path for magnetic flux.

C Windings receive electricity from the AC source and deliver it to the load.

D The radiator and fan provide air flow and cooling to regulate internal equipment temperature levels.

E The tank protects internal components from dirt, moisture, and mechanical damage.

F The oil conservator provides storage for insulation liquids, which can increase in volume at high temperatures.

Limitations With the Existing Systems

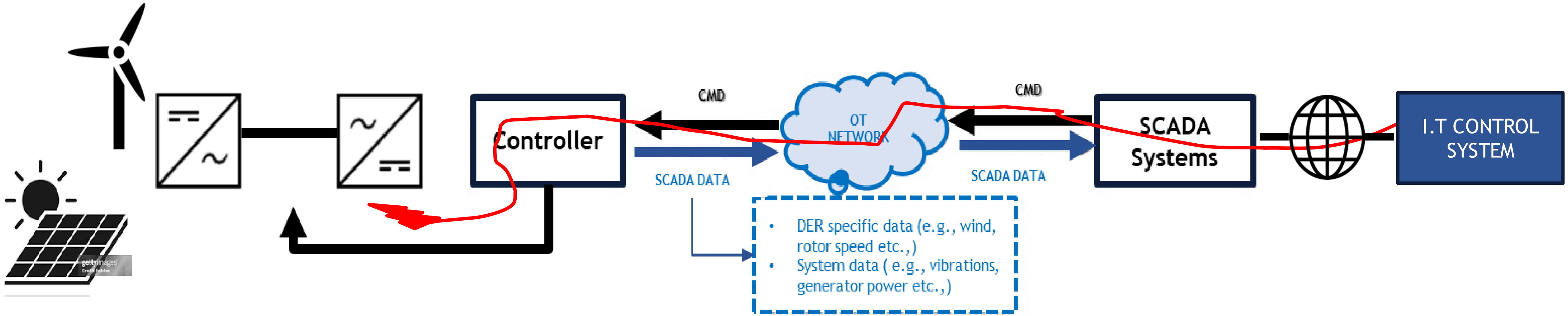
Today's AC to DC conversion and voltage step up and step down is bulkier, electromechanical, resource intensive, and passive.

- Missing on Intelligence, Communications, Resilience, Adaptability to meet the energy demand of the future in a sustainable manner.

Transformer material	Cost, %
magnetic steel	32.5 ± 5.5
windings (copper or aluminium)	22 ± 6
insulation	14.1 ± 5.5
carbon steel	16.4 ± 8.5
fabricated parts	15 ± 9
total	100

Source: Cost of materials that are used for the manufacturing of distribution... | Download Table

Limitations With the Existing Systems - Can Be Hacked



Hackers can rely on the OT network spoofing, jamming, manipulation of the data and system settings to conduct cyber attack through the escalation of privileges of the IT network

- **DoS attack:** Control systems communication lines are overloaded causing complete loss of control or significant addition of the delay. Overloading of Cmd and SCADA Data transfer network caused due to tampering of Controller and SCADA systems by malware.
- **FDIA attack:** malicious manipulation of the sensor data or reference set points resulting in the instability to the wind turbines. For example, manipulation of the DER specific data points.
- **ZDA attack:** exploitation of the system model. If the zero dynamics of PID controller are unstable then there exists the input signal that derives the unbounded behavior of the internal variable

Addressing the limitations leveraging AI,ML,Block chain & Metaverse

	AI & ML	Blockchain	Metaverse
Denial-of-Service (DoS) Attack	• **Traffic Filtering & AI-Based Load Balancing:** AI-driven network filtering can detect and block malicious traffic in real time, ensuring continued operation • **Predictive DoS Detection:** ML models can analyze traffic patterns to predict and mitigate DoS attacks before they cause system overloads.	• **Decentralized SCADA Systems**: Using blockchain for distributed SCADA networks can reduce single points of failure and mitigate DoS attacks..	• **Virtual Resilience Testing:** Operators can simulate DoS attack scenarios in a metaverse-based digital twin environment to develop countermeasures..
False Data Injection Attack (FDIA)	• **Real-Time Data Validation**: AI models can cross-check sensor data with expected values to detect malicious alterations. • ML algorithms can compare multiple sensor readings to identify inconsistencies.	• **Immutable Sensor Data Records:** Logging sensor readings on a blockchain ensures that data integrity is maintained	• **Simulation of FDIA Scenarios:** Digital twins can simulate FDIA attacks to refine AI models for real-time threat detection.
Zero-Dynamics Attack (ZDA	• AI-driven adaptive controllers can detect and neutralize unstable zero dynamics conditions before exploitation. • ML-based predictive analytics can continuously monitor PID controller behavior and flag anomalies.	• **Secure Configuration Management:** Storing PID controller configurations on a blockchain ensures they remain tamper-proof.	• **PID Controller Digital Twin Analysis**: Engineers can use metaverse-based simulations to analyze controller vulnerabilities and enhance robustness.

Power Unified Grid Architecture (PUGA)

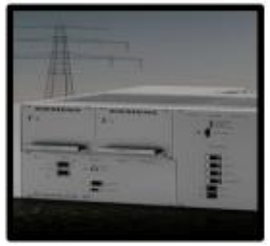
The Power Unified Grid Architecture (PUGA) is a **comprehensive software framework** and **platform designed** to revolutionize the **next generation of power grid systems** and delivering on the demand of Electrification of Everything.

- **Smart Grids** featuring **adaptive**, and **self-healing** features.
- **Integration** of **real-time control** and **communication technologies.**
- **Resilient** bi-directional **power** and **data flow** for network optimization.

PUGA System Use Cases

DC-DC Architecture

High-Efficiency Conversion, Compact Design, Thermal Management:



Modular and Portable DC Substation

Rapid Deployment, Scalability, Reliability, Energy Efficiency

Power Grid Architecture for V2G and V2X

Bidirectional Power Flow, , Grid Stability, Efficiency, Scalability

Generative AI for Energy

Predictive Analytics, Efficiency Scalability, Real-Time Monitoring

Smart Solid-State Transformer

Efficiency, Reliability, Scalability, Integration

Smart Solid-State Transformer with Energy Storage

Bidirectional Power Flow, Energy Efficiency, Reliability, Integration

Smart Reclosure SoC

Fault Detection and Isolation, Reliability, Scalability, Real-Time Monitoring

SCADA Smart Converter/ Inverter SoC

Power Conversion Efficiency, Reliability, Integration, Scalability

PUGA System Requirements for Grid of Future

- **Unified Architecture** which is modular, scalable, flexible, and adaptable

  ->Standardized solid state power electronics building block that can be used within all substation applications. Functionality support features bidirectional power flow control from one or more sources regardless of voltage or frequency

- Avoidance of **single point of failure** (centralized control method)

  ->Need for distributed control method.

- **Coordination** of multiple generators for achieving **global control objectives** (voltage and frequency control in timely manner.

  ->Low latency grid forming technologies ideally less reliance on communication technologies for added resilience (example droop control).

- **System resilience**

  ->Consensus based algorithms and communication technology that can provide a high level of cybersecurity and data privacy.

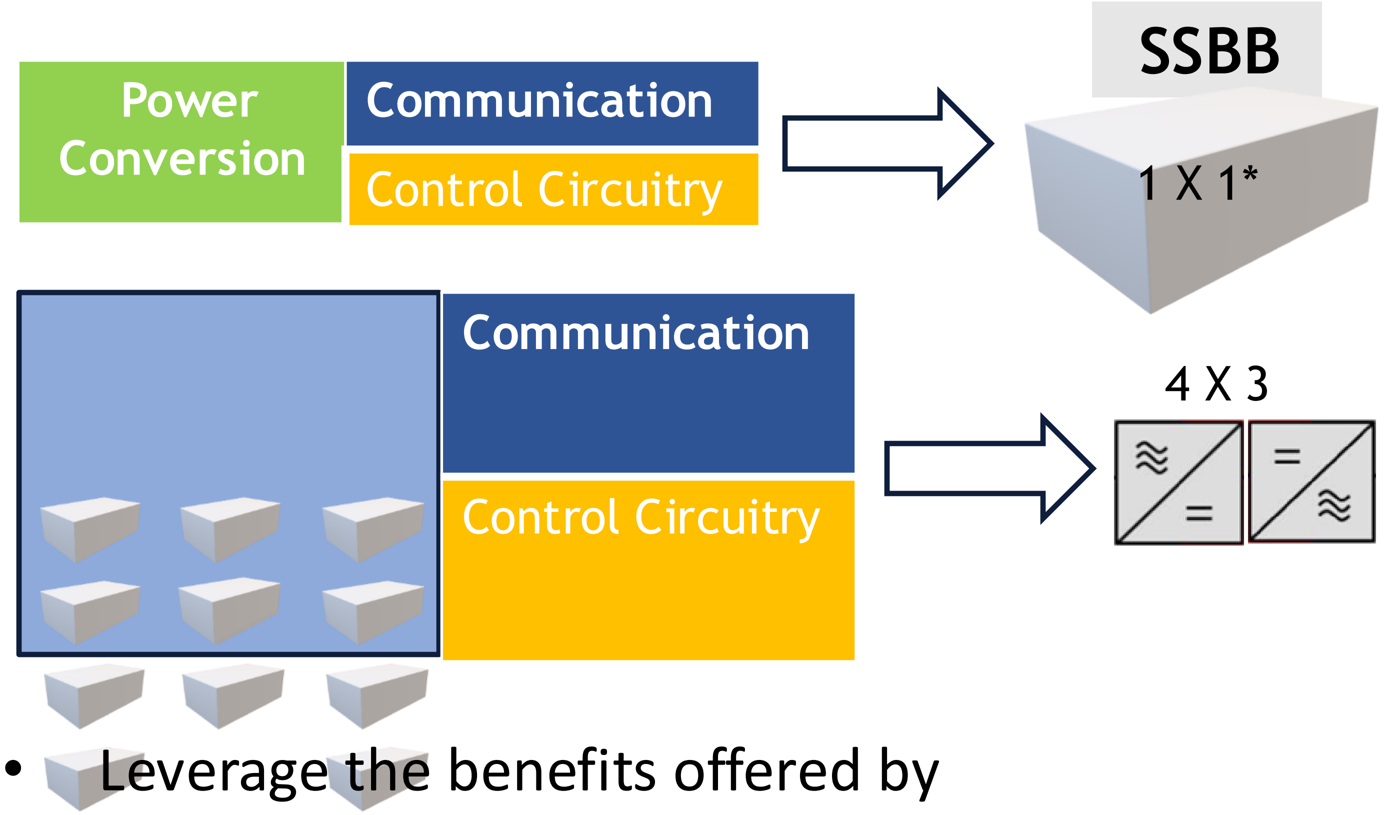
Solid State Building Blocks For Next Generation Systems

- Configurable Power Conversion Design with inbuilt control and communication features.

- With monitoring and analytics empowered gate drivers.

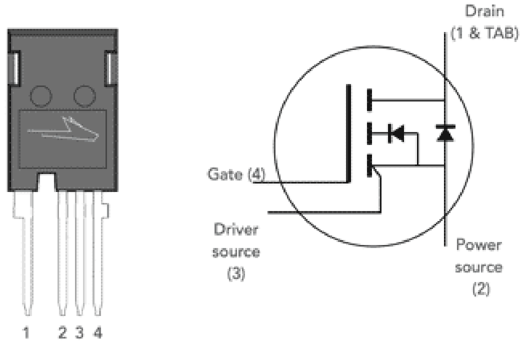
- Bi-directional power flow capability with necessary resilience and low latency features.

- Voltage and Frequency scalable design for active and reactive power sharing.



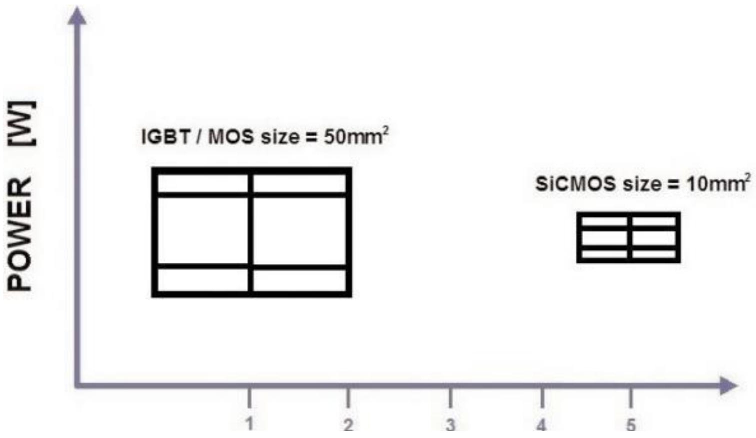
- Leverage the benefits offered by W.B.G Device technology.

Wide Band Semiconductors Technology

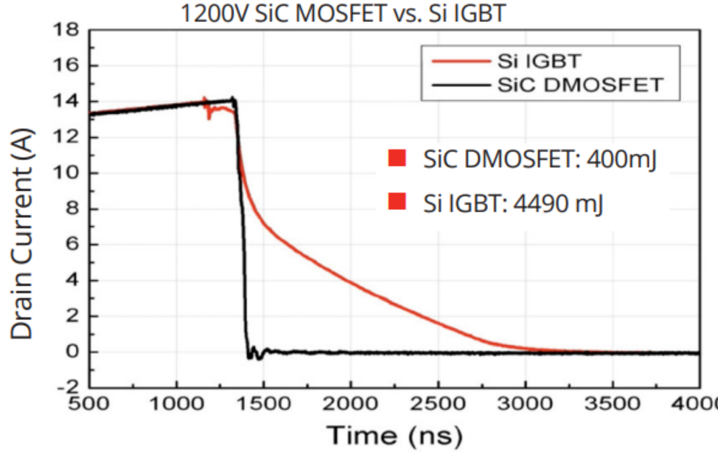


Properties @ 300K	Si	SiC (4H)
Band Gap Energy [eV]	1.1	3.2
Electronic Mobility [$cm^2/V \cdot s$]	1400	900
Breakdown electric field [KV / cm]	300	2400
Thermal conductivity [W / cm·K]	1.5	4

Source: www.semiconductor-today.com

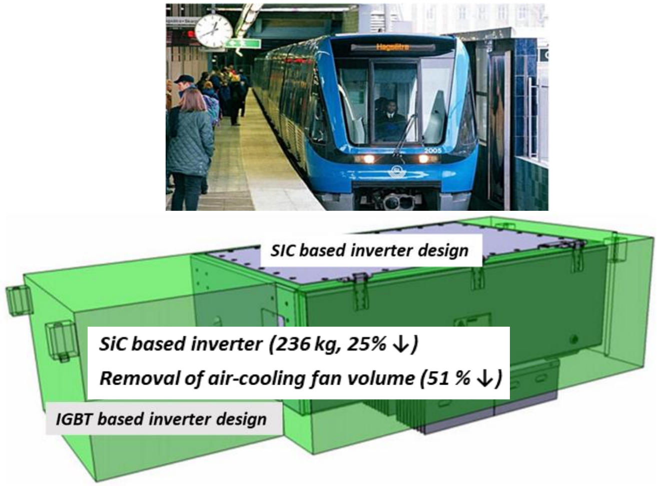


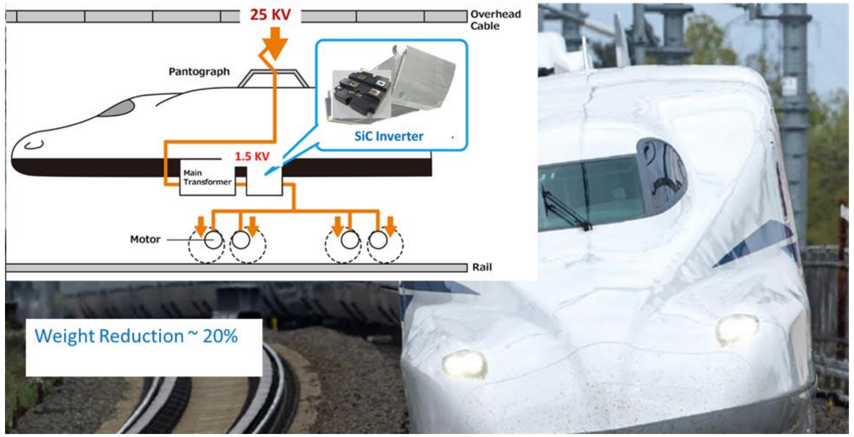
Conduction Loss

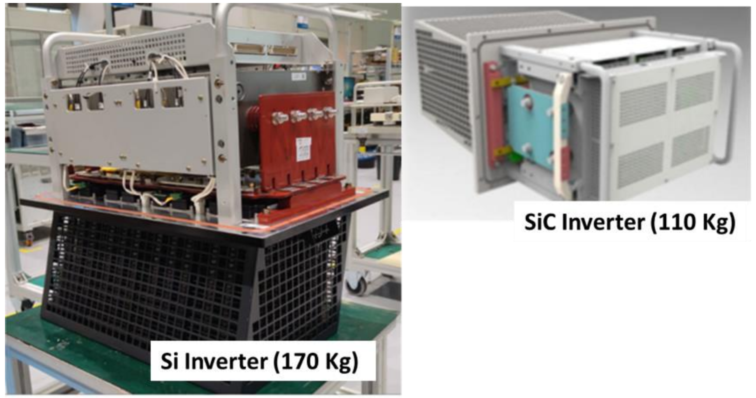


- **Circuit level**
  - Simplified topologies thanks to reduction in number and size of active and passive components
  - Improvement in conversion efficiency.
- **System level**
  - Reduction in wire counts and cooling requirements.
  - Resilience to harmonics (elimination of filtering requirement).

Leaner and More Efficient Power Conversion







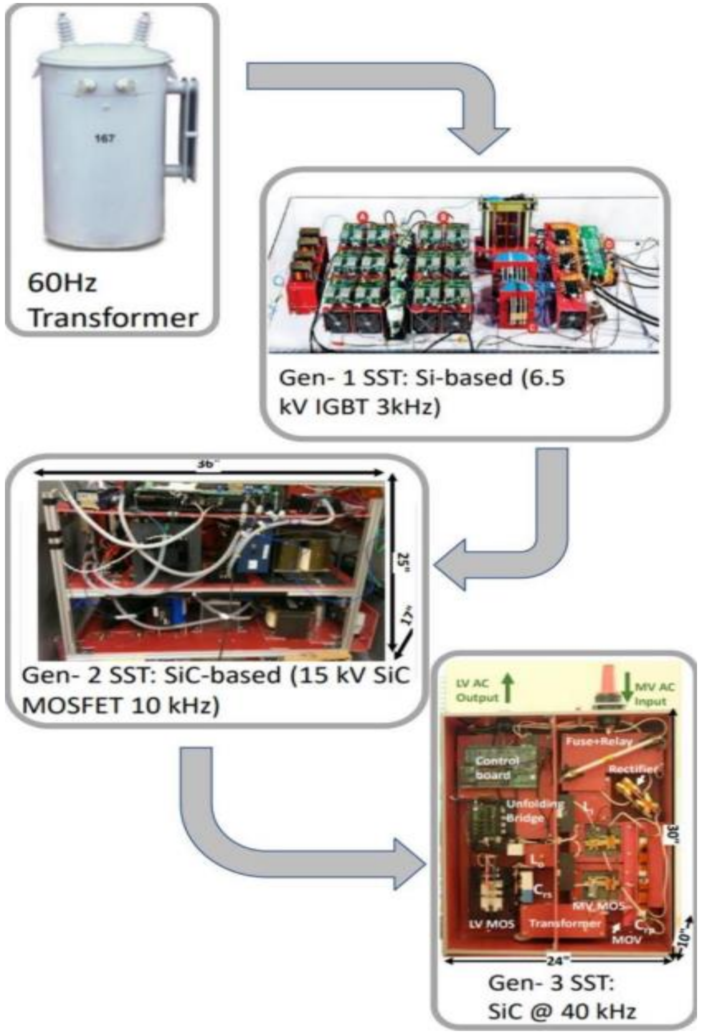
Source: Stockholm Metro C20 SiC Trials (2018), Hitachi SiC module	*Source: Japan Shinkansen SiC Trials,N700S (2020). Fuji Electric SiC module*	*Source: CRRC Zhuzhou Research Institute China Trials (2020). SiC module provider no information*

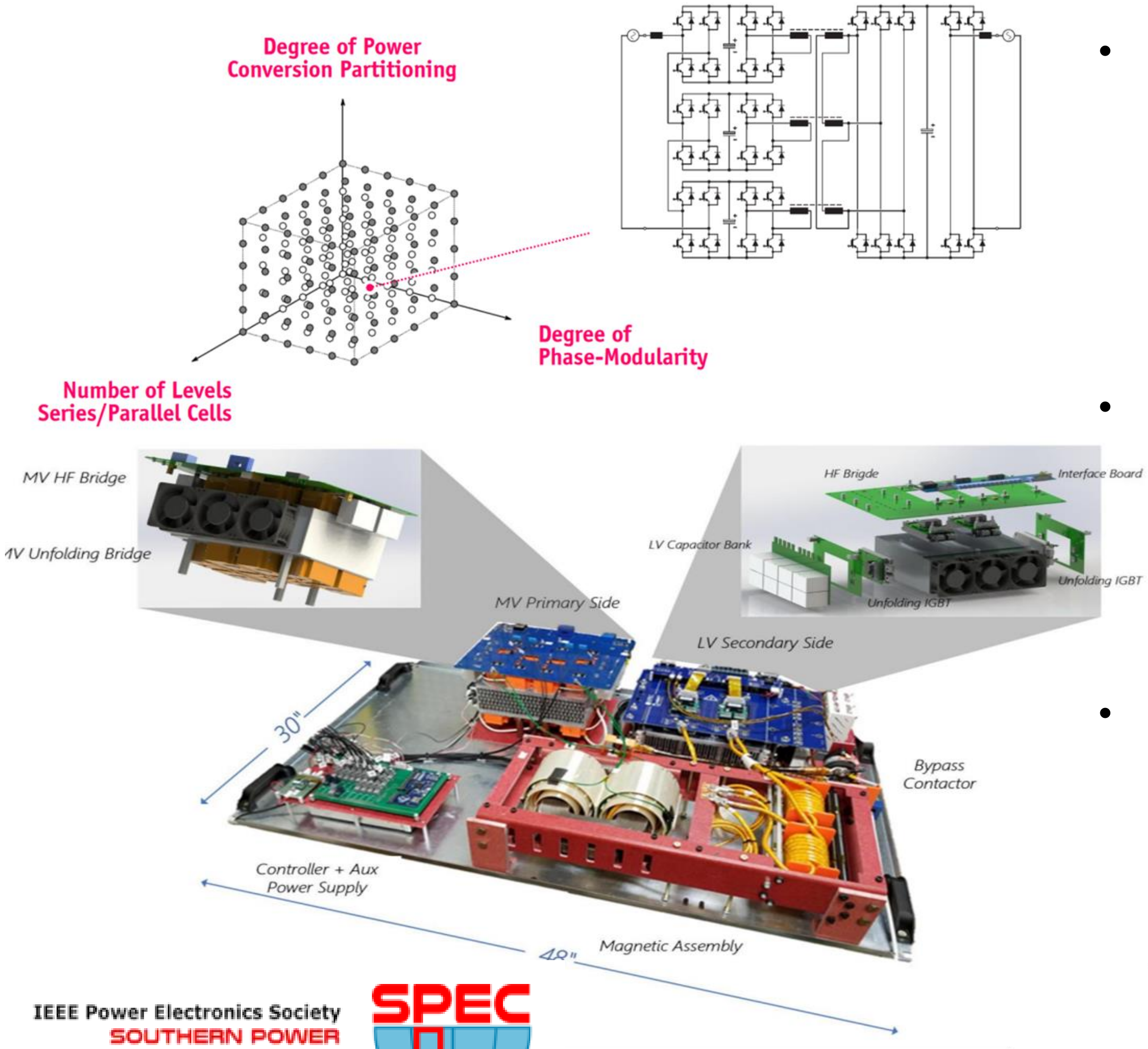
- **Weight and volume reduction:** Reduction in power losses with SiC leads to elimination of fan cooling systems or smaller sized air fins (Shinkansen N700S).

- **Lower maintenance costs and fans noise elimination:** Higher reliability due to fewer moving parts fan removal.

- **Lower acoustic noise and power loss:** Higher switching frequency for same cooling requirements results in decrease of harmonics leading to increase in propulsion system efficiency (reduction in system losses) and acoustic noise from the motors.

Solid State Transformers – Energy Routers !



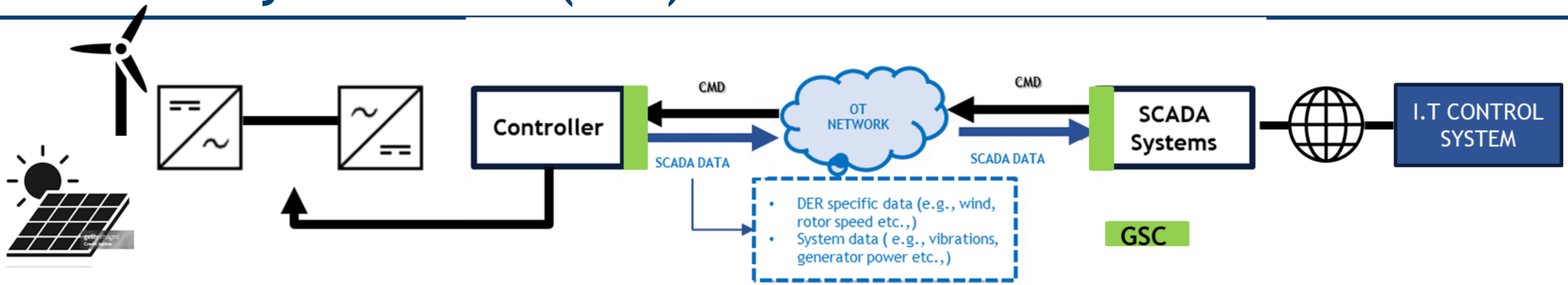


IEEE Power Electronics Society
SOUTHERN POWER
ELECTRONICS CONFERENCE

- SST is a kind of transformer which can control input and output power with controlling the voltage level using a numbers of switched electronic devices.
- SST efficiency could be increased from 90% to more than 95%, the size and weight will absolutely decrease using SST.
- Enormous savings (dematerialization)realized with the replacement of the 8,000-pound transformer with a small board circuit and thus shrink it down to look more like a suite case.

Source: Modular Hybrid Solid State Transformer for Next Generation Flexible and Adaptable Large Power Transformer

Grid Security Controller (GSC)



Grid Operational Technology Security Chip (GSC) agnostic to underlying communication protocols with support for legacy communication systems. Compliance: FIPS 140-2, with target for CC EAL 6+ certification

- ✓ Authentication, authorization and data encryption.
- ✓ Secure communication between DERS and control centers across WANs.
- ✓ Key management (PKI Certificates)
- ✓ Firewall enforcement (white-listing IP addresses)
- ✓ Hardware accelerator for PQC and AES

Q&A