Powering the Future: Harnessing 2kV SiC for a Decentralized Grid

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Senior Product Marketing Manager
Semikron Danfoss

Bodo's Wide Bandgap Event 2024

Making WBG Designs Happen

SiC

Semikron Danfoss - highlights

Highlights

1,100
mEUR Sales in 2023

~4,000
Employees worldwide

10
Factories in 8 countries

600
R&D employees

The largest chip-independent manufacturer of power modules worldwide.

28
Sites on 5 continents

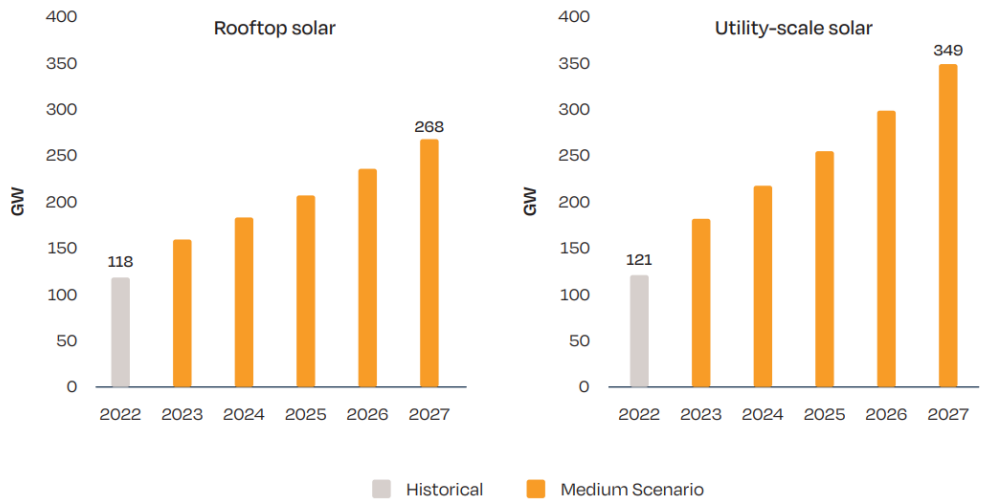
3
Divisions

1
Chip Fab

The Energy Landscape

- Growth of renewables: increased incentives and reduction in carbon emissions
- Importance of ESS: grid stability, integration of solar & ESS
- Growth of EV charging: rise in EV adoption, need for charging infrastructure
- Interconnected grid based on $1500V_{DC}$

FIGURE 21 SOLAR PV ROOFTOP AND UTILITY-SCALE SEGMENTS SCENARIOS 2023-2027



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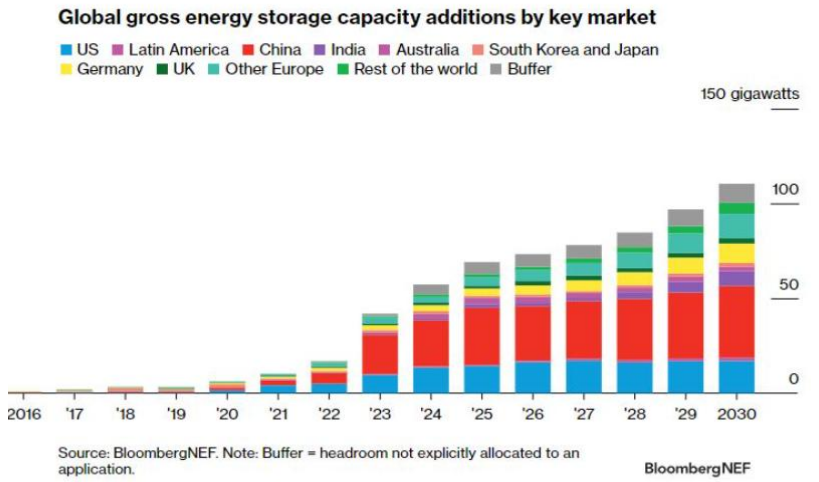
650GW / 1,877GWh

Global cumulative energy storage capacity by the end of 2030

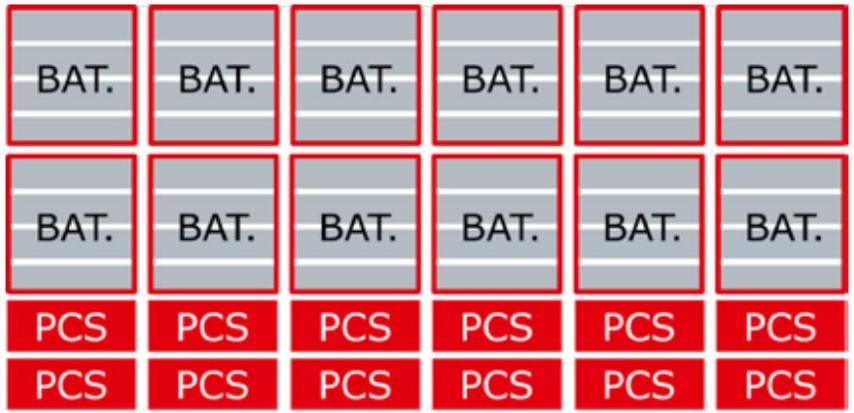


Source: BloombergNEF. Note: Buffer = headroom not explicitly allocated to an application.

BloombergNEF

Modular or Central PCS in ESS System

Low/medium-power system



High-power system

Modular PCS (~210kW)

- Increasing trend for Battery ESS
- Improves serviceability, only subset of batteries offline in case of failure
- Better scalability, able to adjust by 210kW rather than changing entire PCS
- Matches 12 rack system for 2.5MW PCS

Central Inverter (~2.5MW)

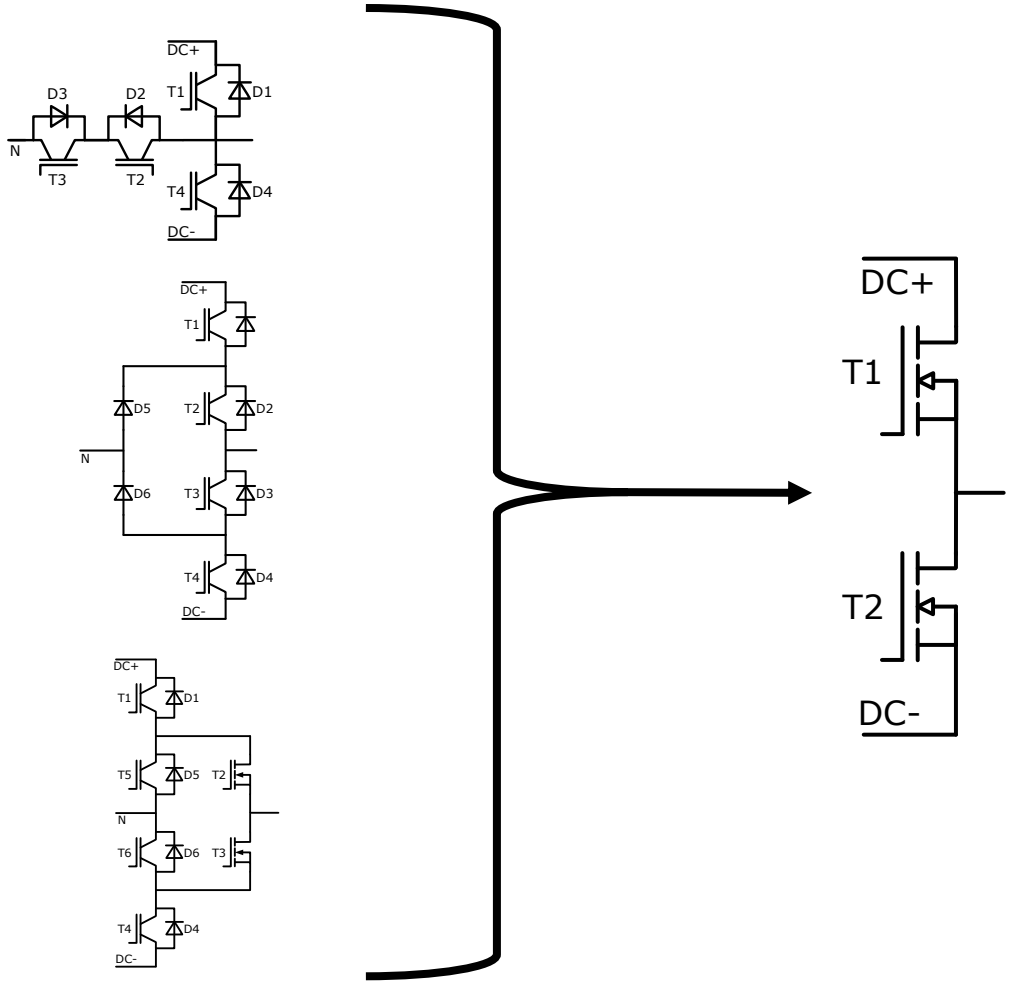
- Originally solution with similar hardware design as solar, achieving economy of scale
- Serviceability a challenge, major downtime with single failure
- Limited scalability, creating large power mismatch with batteries

Classified as Business

Design Simplicity with 2kV SiC for 1500V_{DC} Applications

3-Level design

- 12 to 18 total driver channels
- Three-layer bus plate for DC-link
- Module positioning may be complex to minimize low stray inductance
- Multiple gate voltages if integrating silicon and SiC
- Optimization may be required for PF: -1 to eliminate de-rating



2-Level design

- Meets 1500V applications with ≥2000V chip rating
- Six total driver channels
- Single gate voltage
- 2-layer bus plate for DC-link
- Simple module layout on heatsink

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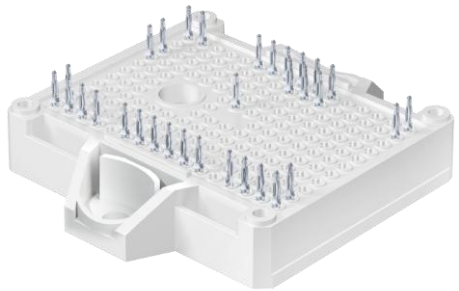
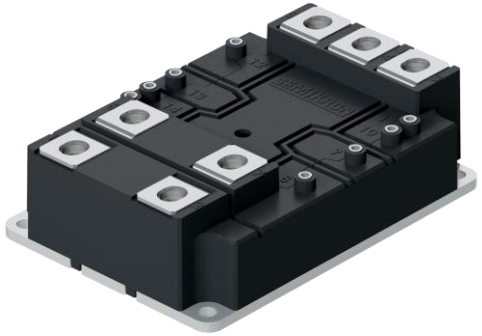
Expanding the Power Module Portfolio

Low/medium-power system



High-power system



SEMITOP E2 with 2kV SiC

- Half-bridge variants with 4.3mΩ (200A) & 6.5mΩ (150A) $R_{ds,on}$
- Optimized pin layout for paralleling
- Increased isolation voltage

SEMITRANS 20 with 2kV SiC

- Half-bridge with 1mΩ $R_{ds,on}$ (1700A)
- Sintered for increased lifetime
- Symmetrical chip layout for optimal performance
- Improved substrates

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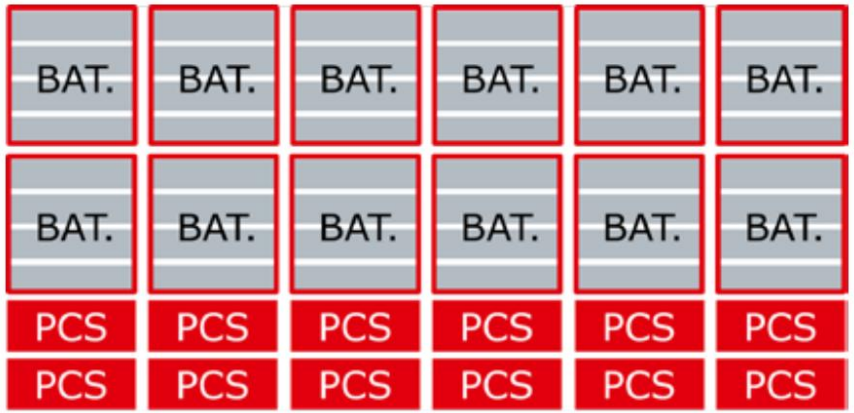
Modular or Central PCS in ESS System

Low/medium-power system



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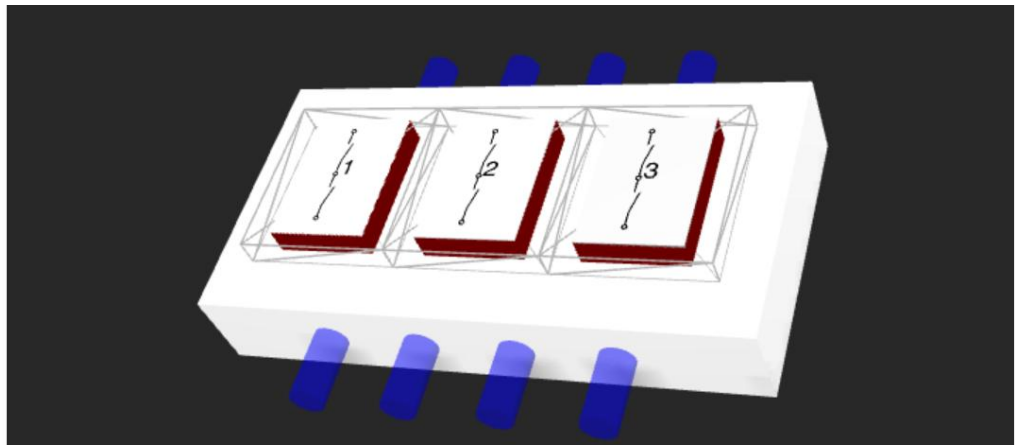
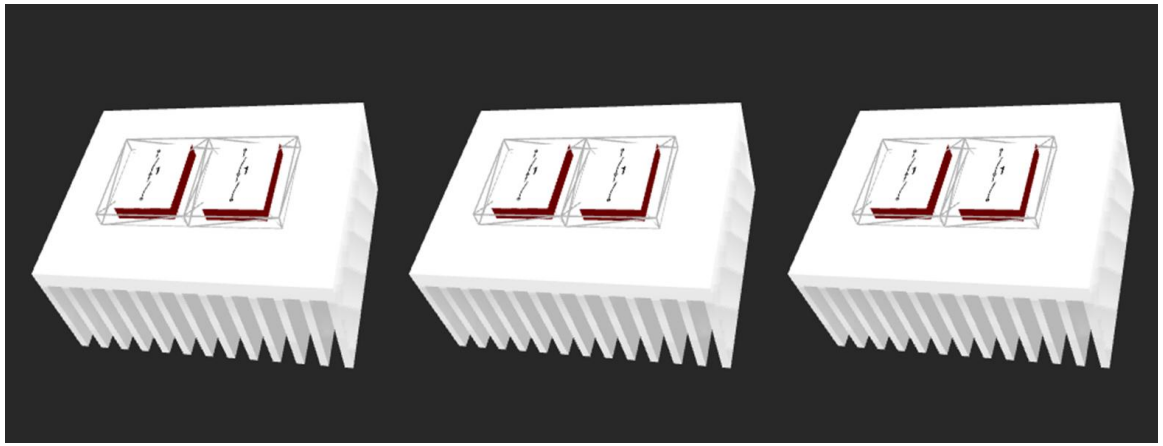
Low/Medium-Power Module: SEMITOP E2 with 2kV SiC





215kW PCS with liquid cooling

- 1x 200A power module per phase
- $1500V_{DC}$, $690V_{AC}$, 50Hz, fsw:12kHz, PF:±1
- 40°C coolant
- Power module efficiency: 99.1%
- $T_{j,max}$: 133°C

215kW PCS with air cooling

- 2x 150A power modules per phase
- $1500V_{DC}$, $690V_{AC}$, 50Hz, fsw:12kHz, PF:±1
- 40°C inlet airflow
- Power module efficiency: 99.1%
- $T_{j,max}$: 130°C

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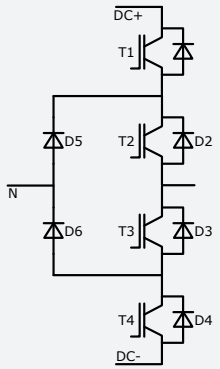
High-Power Modules for 1500V$_{DC}$ Applications

Power module cost

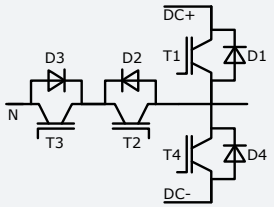
- 1500V battery with 1200V IGBTs

NPC



2023

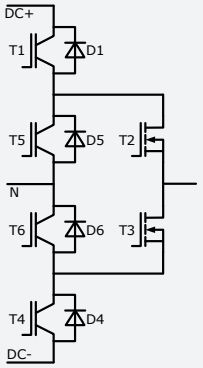
TNPC



- 1500V battery with 2.3kV IGBTs

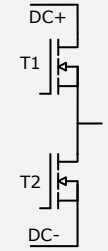
- Enables PF = -1..+1 without de-rating
- 1500V battery with 1200V IGBTs and MOSFETs

ANPC



2024

2kV SiC



- **1500V battery with 2kV SiC MOSFETs**
- Increased power density, efficiency
- Enables PF = -1..+1

2025

Efficiency

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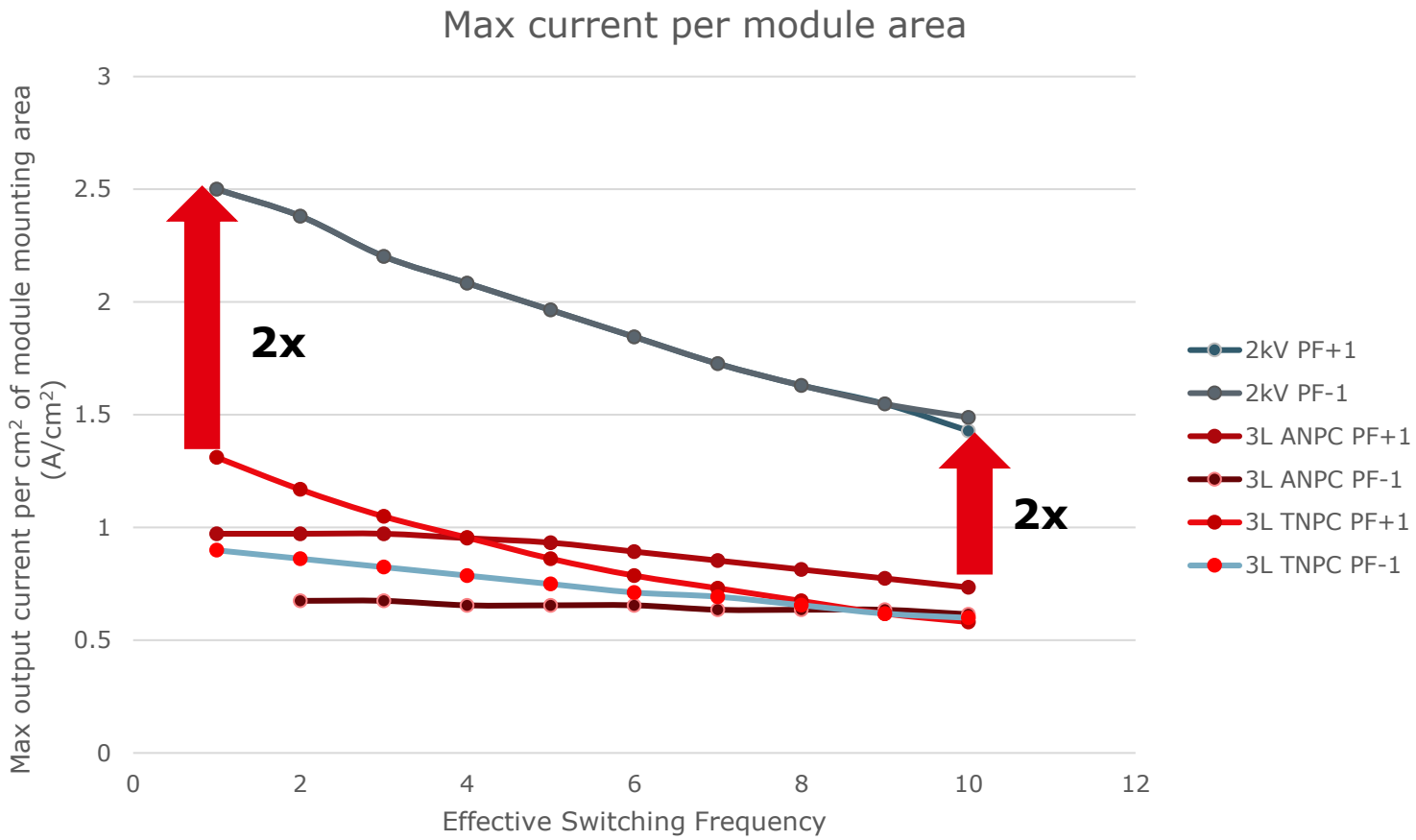
Power Density Comparison: Maximum current per power module area

- The **2kV SiC** solution provides **over 2 times current for a given area**
- Leading to smaller, more power dense PCS
- Reduced losses for 2kV SiC compared to silicon support increase in power density



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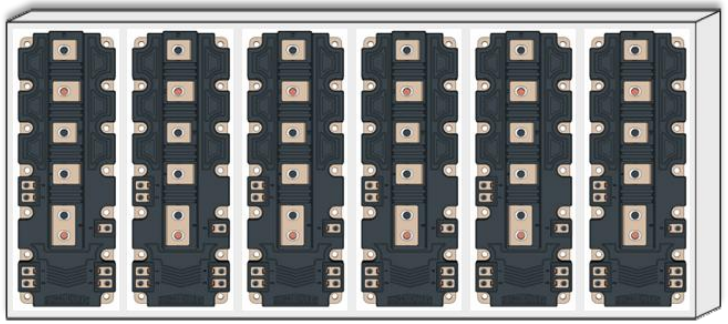
High-Power: Power Density Comparison
$1500V_{DC}$, $690V_{AC}$, 5kHz $f_{SW,effective}$, Liquid Cooling

1.2MW

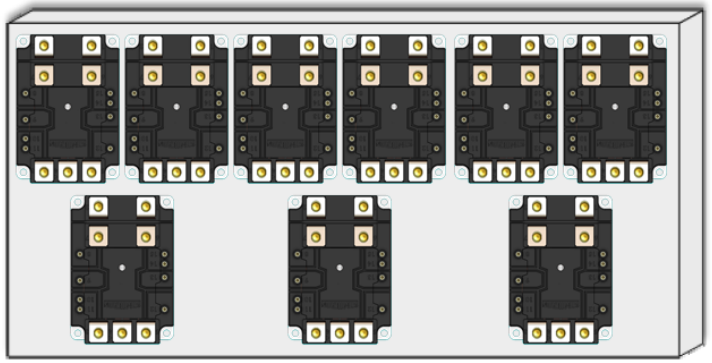


ST10 TNPC (2.3kV/1.2kV IGBT)

- ST10: 8.9 x 25cm
- Losses: ~13900W
- Total module area: **~1300cm²**

900W/cm²

1MW

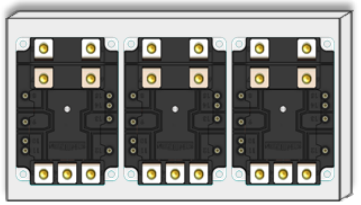


ST20 ANPC (1.2kV IGBT)

- ST20: 10 x 14cm
- Losses: ~9800W
- Total module area: **~1300cm²**

800W/cm²

1MW



ST20 2-level (2kV SiC)

- ST20: 10 x 14cm
- Losses: ~7600W
- Total module area: **~400cm²**

2400W/cm²

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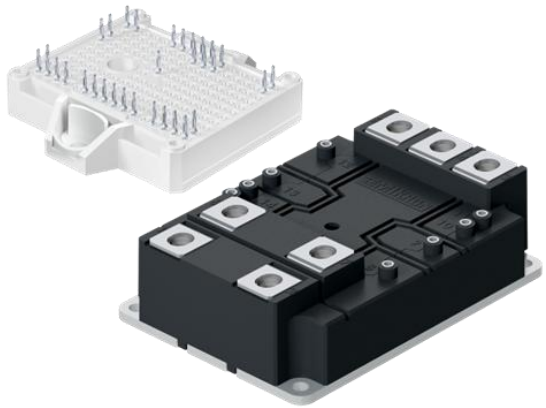
Summary of Key Points

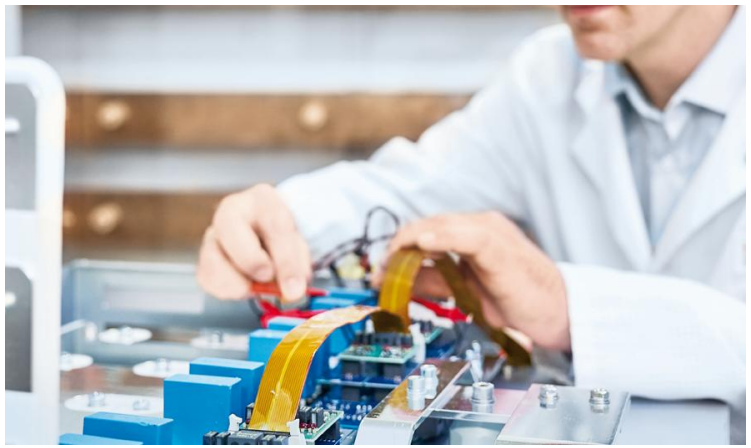
Energy storage is important

- Critical for grid reliability and facilitating renewable energy integration
- SD’s innovations meet growing demand for efficient energy management



2kV SiC module advantages

- Design simplicity
- Increased efficiency
- Meets 1500V applications



Semikron Danfoss supports advancing innovation

- A leader in 2kV SiC
- Growing SiC portfolio
- Multiple chip suppliers
- Leading packaging technologies

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Contact us

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