Silicon Carbide
High Voltage, High Frequency Conversion

Medium-Voltage Wide-Bandgap Power Electronics for Advanced Distribution Grids

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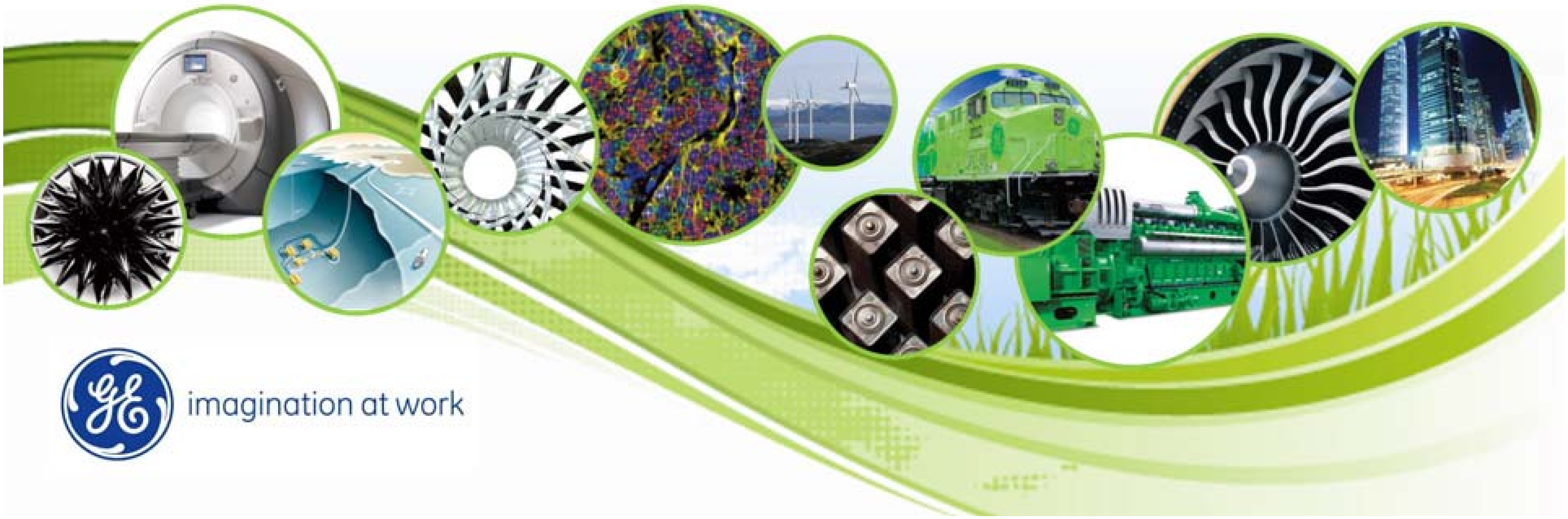
Ravi Raju, GE Global Research



SiC Power Devices

Faster, more efficient, can handle higher temperatures than Si devices

..... advantages widen at higher voltages

Inflection point for applications

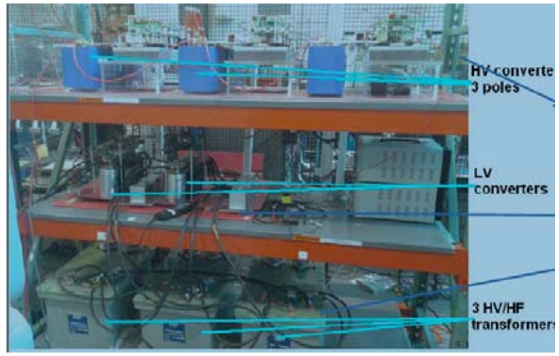
... devices are becoming widely available and affordable

- approaching ~4x cost of Si devices

SiC MV Converters

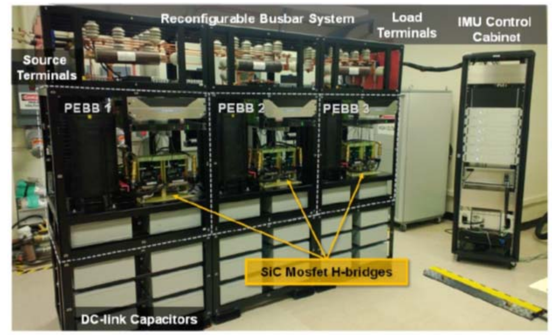
GE SSPS, 1 MW

SSPS 1: 13.8 kVAC / 265 VAC
SSPS 2:   4160 VAC / 1000 VDC



NCSU

13.8kV AC SST



VT - CPES

4160 VAC IMU

SiC MV converters have been demonstrated in prototype lab environments
- efficiency and power density benefits clear vs silicon-based converters

Design challenges
- EMI: high speed switching with large dv/dt and di/dt
- insulation: high frequency stresses

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SiC: Potential MV grid applications

<u>Conventional Distribution Grid applications</u>:

Solid-state transformer (SST)

+ Compact
+ Regulation and control capability
- Efficiency (98% vs conventional 99+ %)
- Difficult to match cost, reliability of conventional transformers
- BIL and fault current capability?

Partial SST add-on for conventional transformer

Solid-state breakers

Solid-state alternatives not competitive at present vs conventional equipment

- higher cost and unproven reliability
- difficult to meet grid requirements (eg, surge voltage, fault currents)

SiC: Potential MV grid applications

Emerging applications :

Renewables

- Solar: Utility-scale farms with MVDC collection
- Wind: MV turbine-grid interface instead of 690 V

EV charging/ storage

- Fast charging stations with MV feed in space-constrained locations

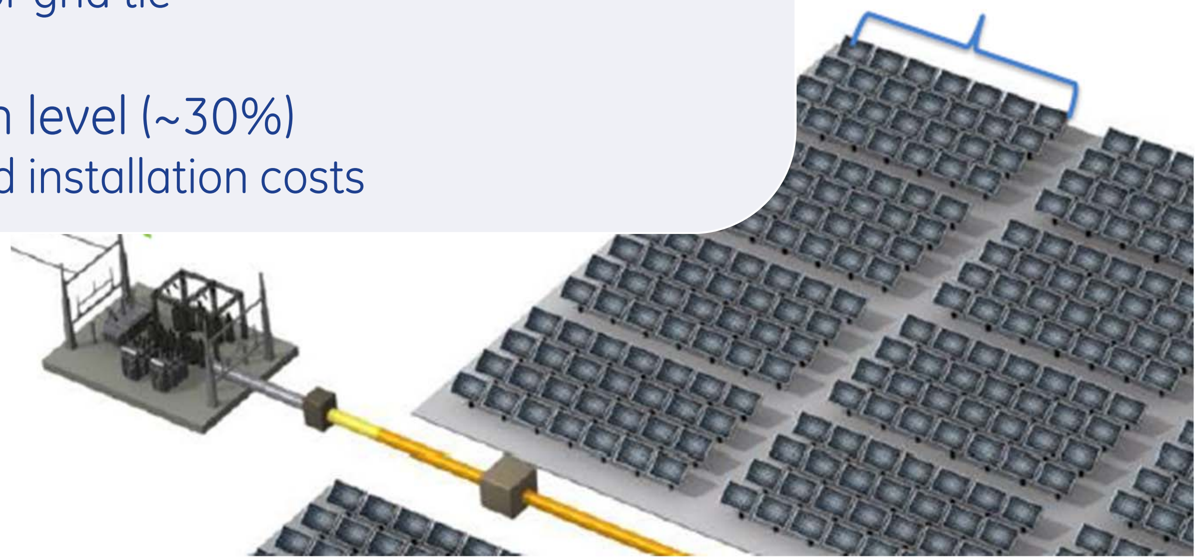
SiC can bring cost savings in these applications in near future.

Early Adoption Opportunities for MV grid applications

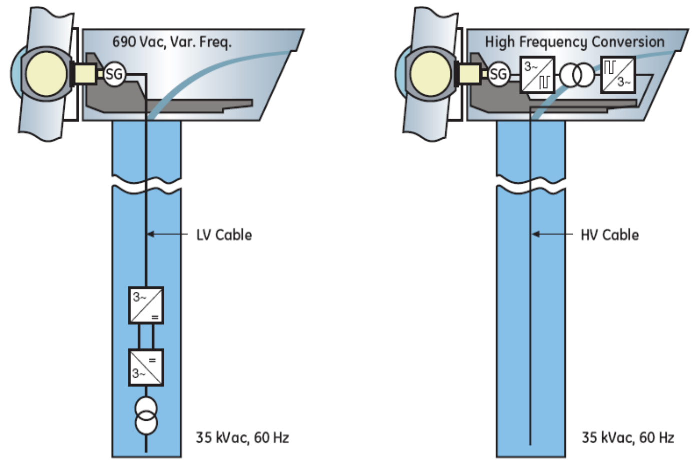
Utility-scale Solar Farms

From AC to DC
- DC-MVDC step-up at strings
- $\pm$ 10 kVDC collection
- Central inverter for grid tie

Cost savings at farm level (~30%)
- reduced cable and installation costs



Early Adoption Opportunities for MV grid applications



<u>Wind Generator-Converter</u>

<u>From LVAC to MVAC</u>

Today's turbines:

- Doubly-fed machines typically with MV stator and LV rotor
- Rotor side converter: 690 V due to IGBT and slip ring advantages at LV.
- Cable costs are significant due to LV cables

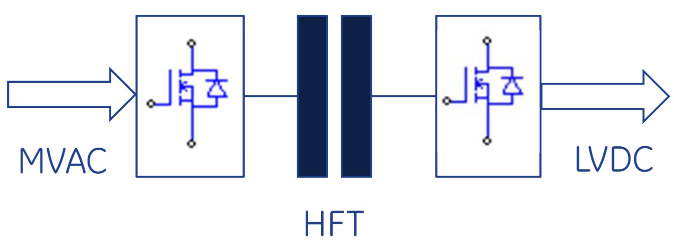
<u>SiC can enable move to MV conversion</u>

- Step-up to MV (eg, 13.8kV) with up-tower conversion
- Can provide ~25 k$ savings in cables and installation for a 3 MW turbine

Early Adoption Opportunities for MV grid applications

Fast EV Chargers in space-constrained locations

- Will require hundreds of kWs in tight spaces
- MV-fed charger with HF isolation can provide compact solution



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Outlook:
Near-term MV grid applications where SiC is attractive

Renewables

- Solar DC Farm
  (10 kV collector system with SiC step-up converters)
- Wind converter with MV connection
  (13.8 kV DFIG turbine?)

Transportation

- Marine/ Naval: MVDC power distribution
- Locomotives: Catenary-fed traction supplies

Fast EV Chargers

MVDC Data centers

...

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Thank you

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