GE Electrical Machines-Integration of SiC Power Devices into High-Power Motor Drives

NIST/DOE Workshop on HMW Direct-Drive Motors and Front-End Power Electronics

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GE Global research
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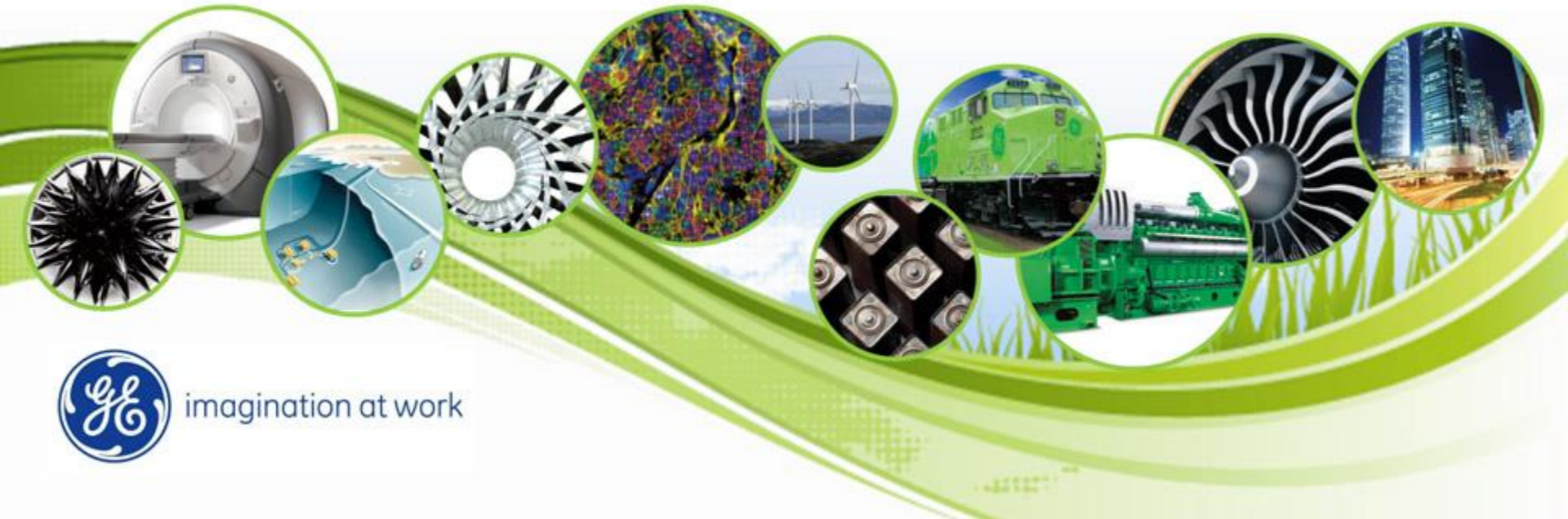
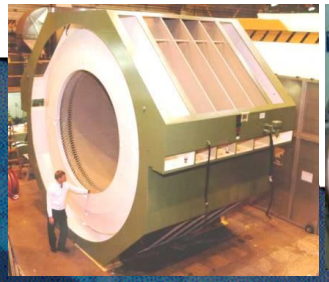


imagination at work

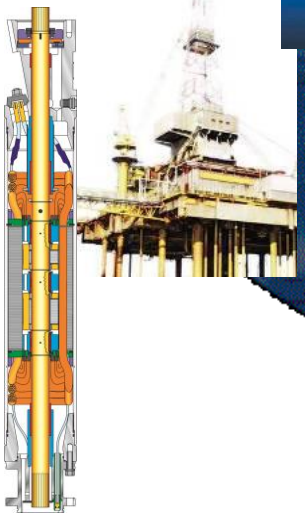
GE Electrical Machines Portfolio

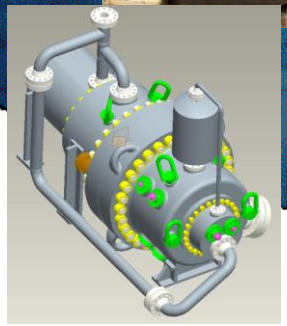
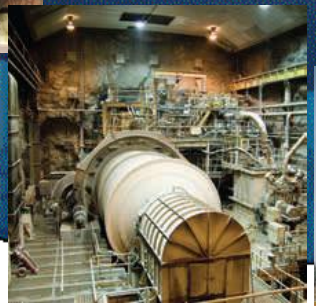


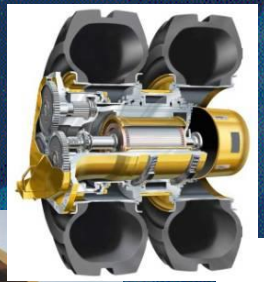








GE Businesses

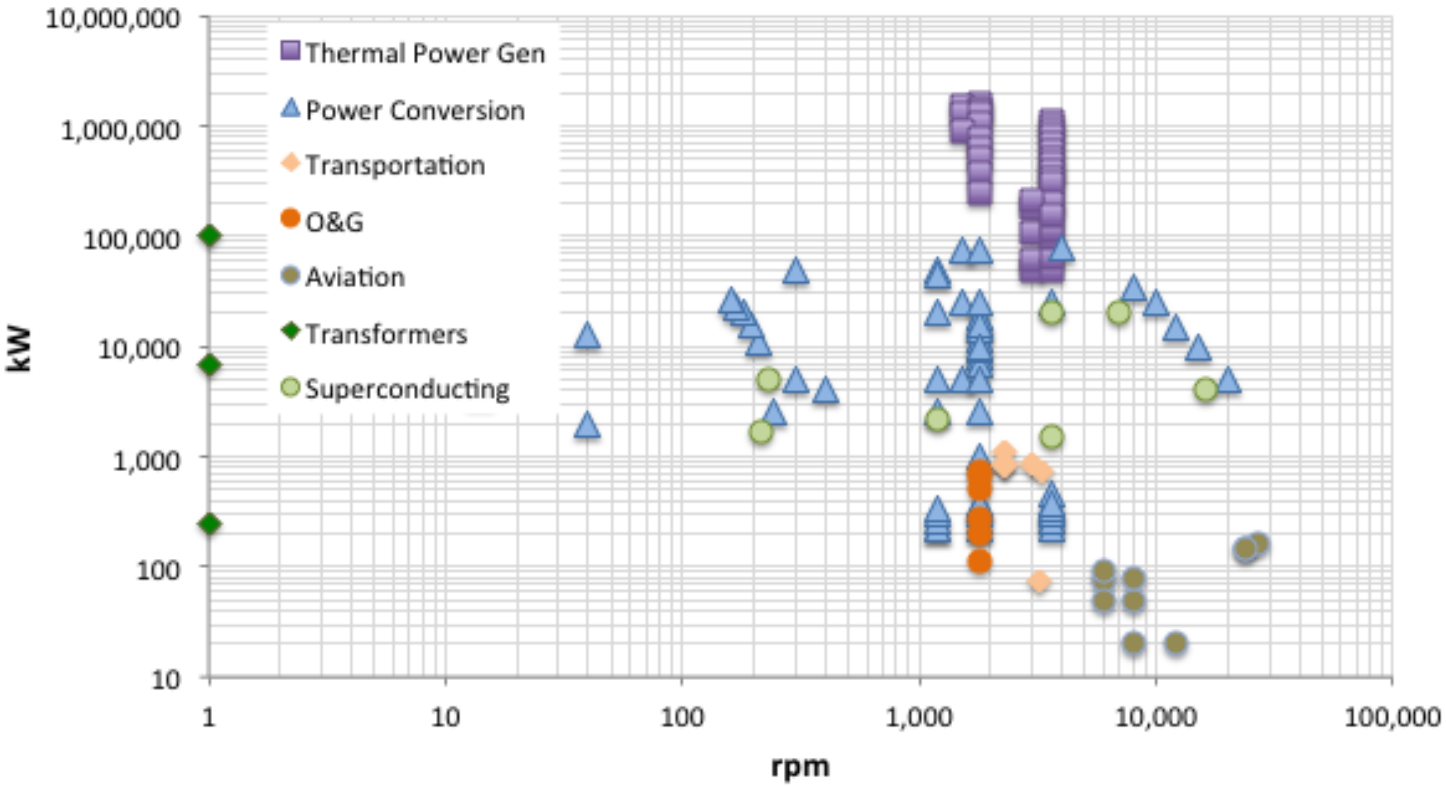
Joint Technology Development

Global Research

Technology incubation & prototyping

GE Electrical Machines Portfolio

develop » design » manufacture » monitor » service



Broad capability across infrastructure domain

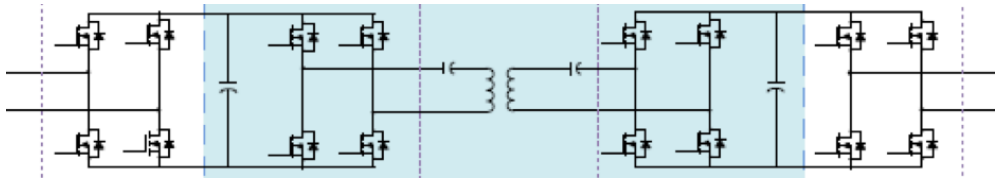
Enabling New Solutions with SiC

High-Speed Oil & Gas Machines : Integrated Compressor Line (ICL)

- Direct-drive high-speed Induction motor / Permanent Magnet motor
- MV drives typically limited to fundamental frequency in the range of 100 Hz; typical switching frequency of 1 kHz
- High-speed direct drives in compression systems require up to 1kHz fundamental
- Requires multi-level topologies and filtering with Si devices
- Simpler 2L or 3L topologies using high switching frequency of SiC devices can enable this application

SiC Power Electronics Building Block

AC » DC » HF AC » DC » AC



SiC as enabler for high-frequency

SiC as enabler for high-frequency

Integrated HF Transformer
as enabler for 10x size reduction
Via 10 – 100 kHz

system benefits
Compactness
Efficiency
Controllability

Power-electronics transformer for AC/AC or DC/DC applications

SiC Power Electronics Building Block
GE Examples

3 MW 4160 V AC / 1000 V DC

1/10 weight

50 kW 1/5 kV DC @ 100 kV DC offset

Significant size & weight reduction
for off-shore HVDC terminal

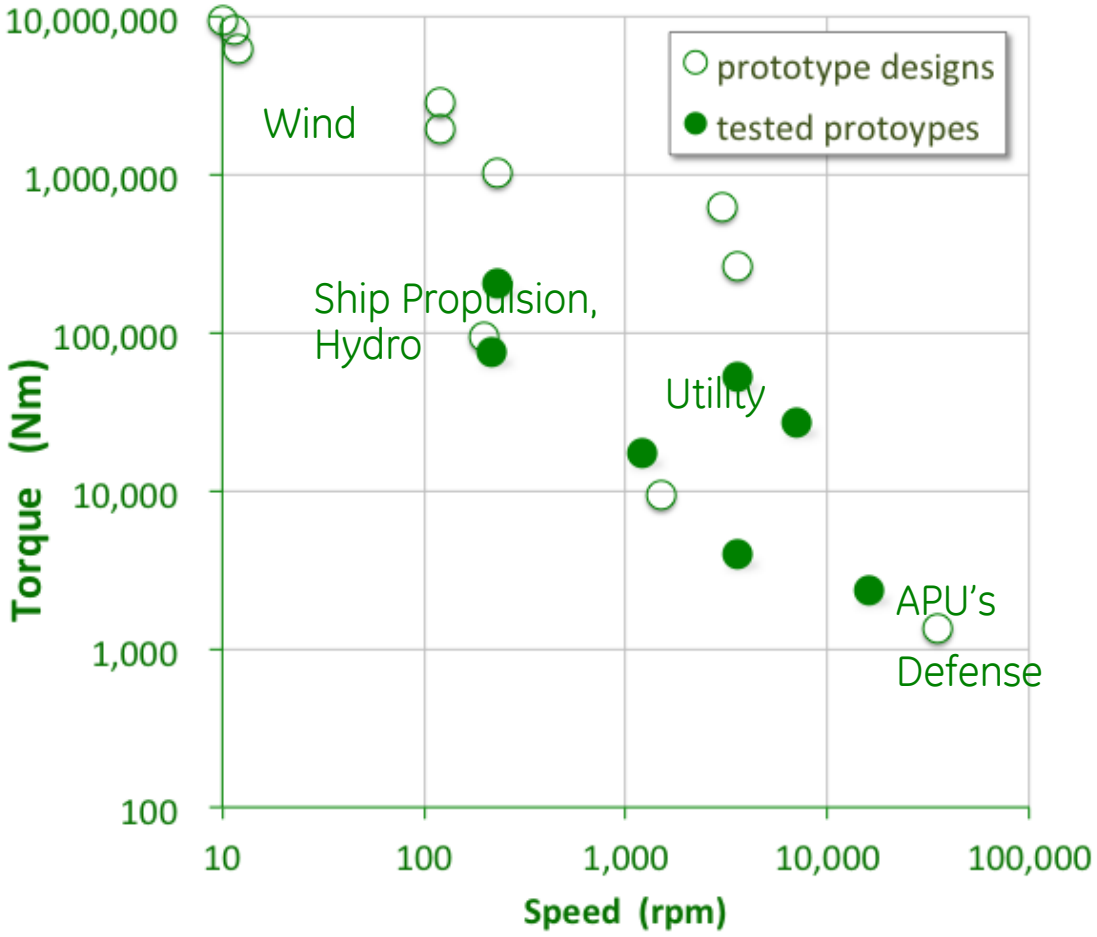
Substantial benefits at the SYSTEMS level

accomplished through

tight integration of advanced HF transformers

with SiC bridges

GE SC Machine Experience



Topologies

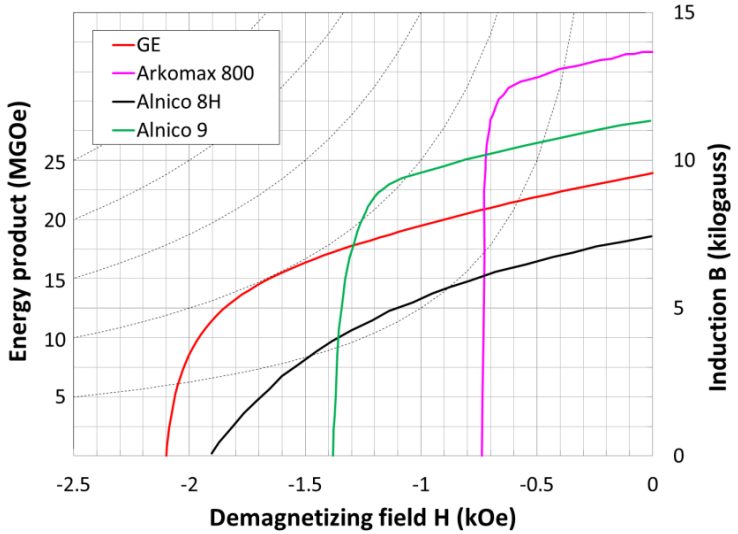
- Conductors: LTS, HTS, MgB_2
- Machine Type: Wound field synchronous, Homopolar Inductor Alternator
- Magnetics: Iron core, Airgap winding, Air core
- Mechanical Configuration: rotating field winding stationary field winding

SC machines if cost-effective can benefit from SiC-based drives similar to conventional machines

GE has the broadest experience in Superconducting machines

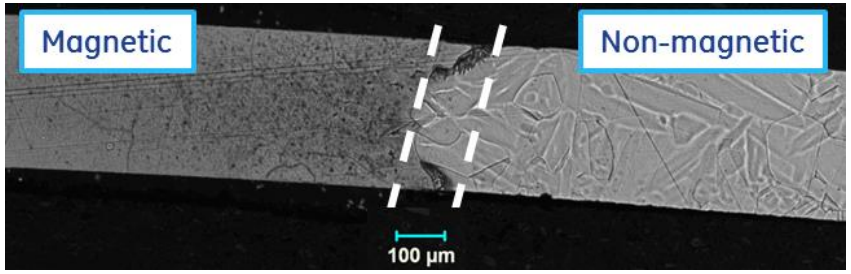
Advanced Materials is a Key Enabler

Advanced lower-cost high-performance permanent magnets



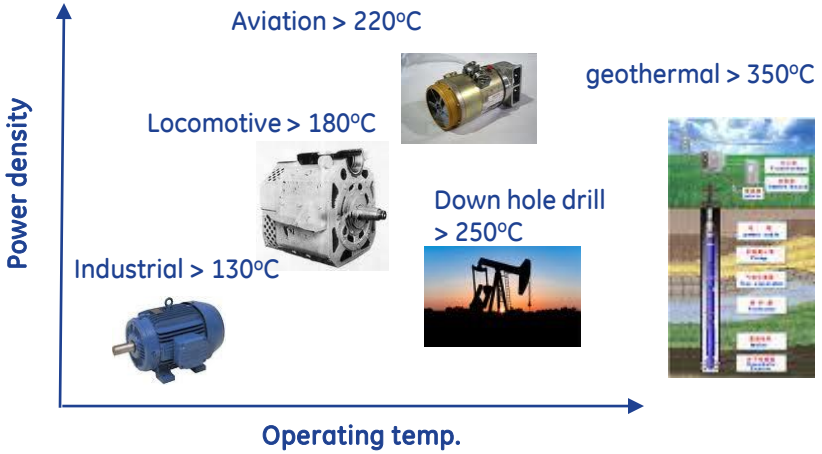
Advanced soft magnetic material:

Dual-phase motor laminates with locally patterned low μ regions for flux path control

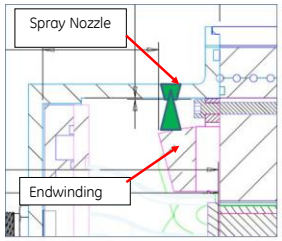


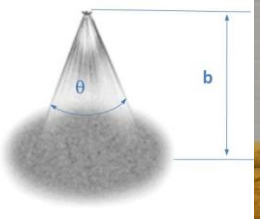
Advanced Insulation Systems:

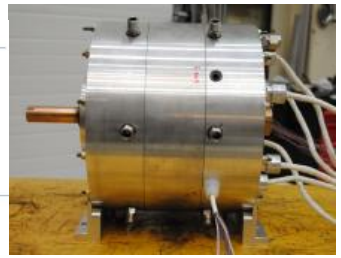
- High thermal stability/temp.
- High voltage, thin film insulation
- High dV/dt pulse resistant
- High thermal conductivity
- Chemical resistant



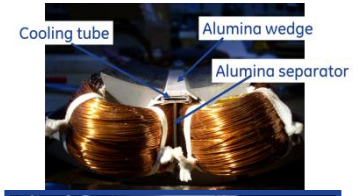
Different Thermal Management Solutions



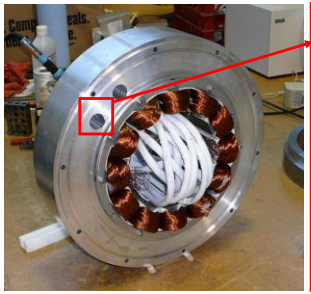


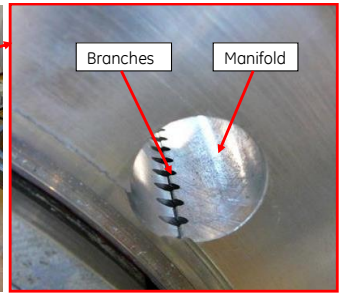


Micro-channel cooling jacket & EW spray



Micro-channel cooling jacket & slot cooling tubes





Micro-channel cooling jacket

Performance

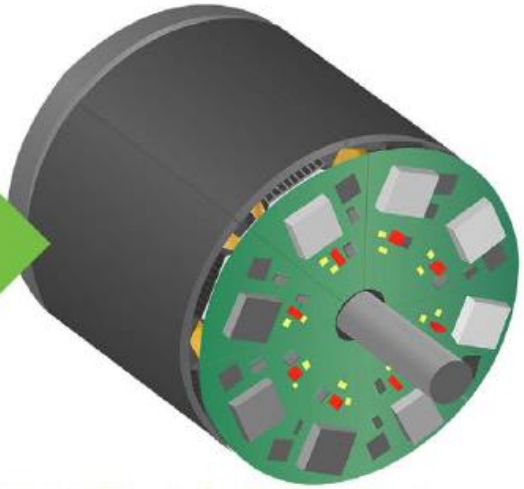
Cooling System Complexity

Synergy with other applications and leveraging other federal funding will accelerate risk mitigation and adoption of technology

EV Everywhere Electric Drive Targets

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

4X Cost Reduction
35% Size Reduction
40% Weight Reduction
40% Loss Reduction



2012 Electric Drive System
$30/kW, 1.1 kW/kg, 2.6 kW/L
90% system efficiency

- Discrete Components
- Silicon Semiconductors
- Rare Earth Motor Magnets

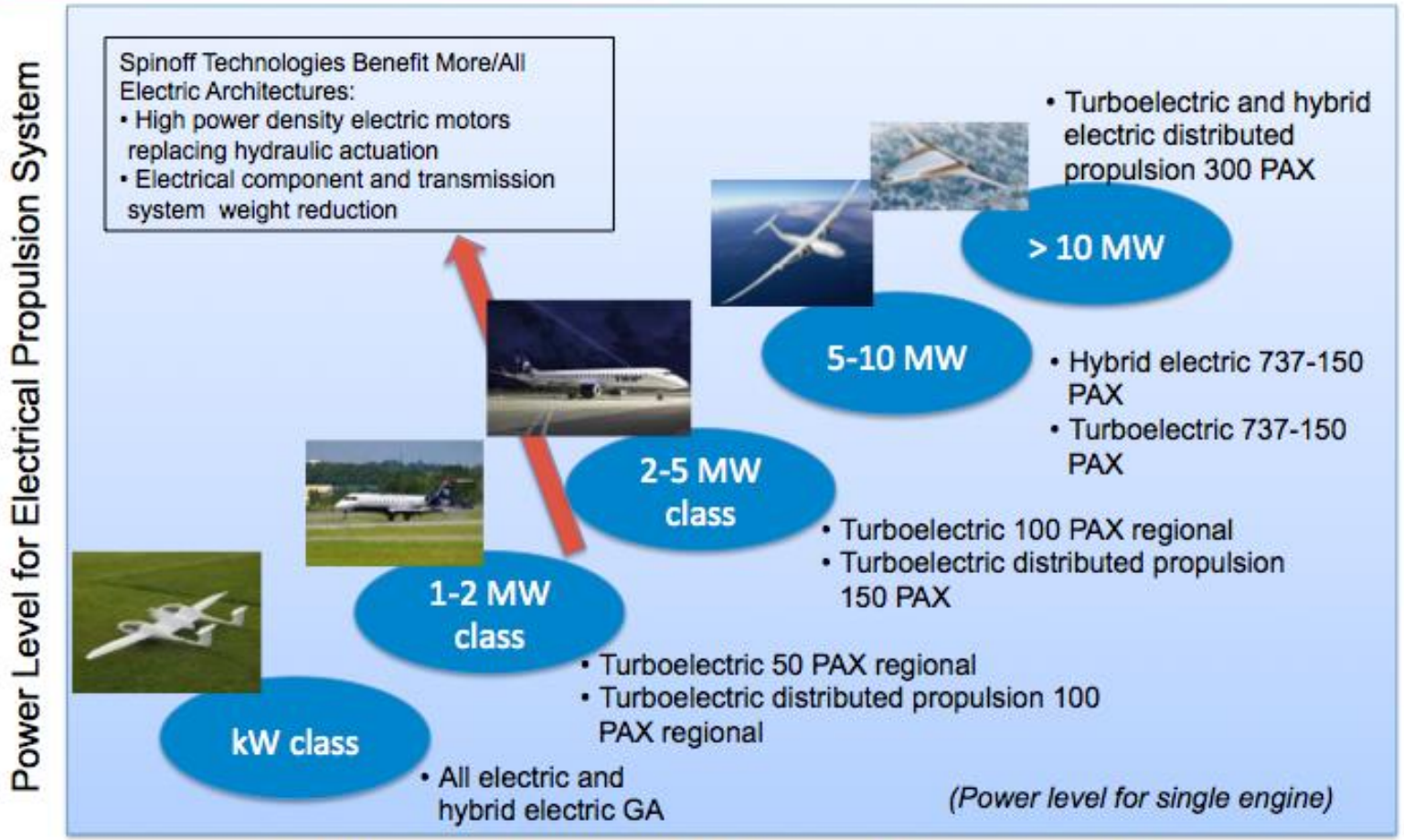
EV Everywhere

2022 Electric Drive System
$8/kW, 1.4 kW/kg, 4.0 kW/L
94% system efficiency

- Fully Integrated Components
- Wide Bandgap Semiconductors
- Non-rare Earth Motors

GE has been partnering with the DoE to achieve these targets

Progression of Adoption of Electric Technologies



Fixed Wing Project
Fundamental Aeronautics Program

Advanced electrical machiness and SiC are key enablers of this roadmap

imagination at work