

EVS26

26th International Electric Vehicle Symposium

GRANDES MENTES PENSAM ELETRICAMENTE

LAS MENTES BRILLANTES TIENEN IDEAS ELÉCTRICAS

GREAT MINDS THINK ELECTRIC

LES GRANDS ESPRITS S'ILLUMINENT

AGAR BUDDHIMAN HO BIJLI YAAD KARO

GROTE GEESTEN ZIJN VERLICHT KLUGE KÖPFE DENKEN ELETRISCH

ELECTRIC DRIVE COST REDUCTION BY DESIGN SIMPLIFICATION

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ORGANIZED BY THE WORLD ELECTRIC VEHICLE ASSOCIATION, WEVA

HOSTED BY ELECTRIC DRIVE TRANSPORTATION ASSOCIATION, EDTA

IN COLLABORATION WITH



AVERE

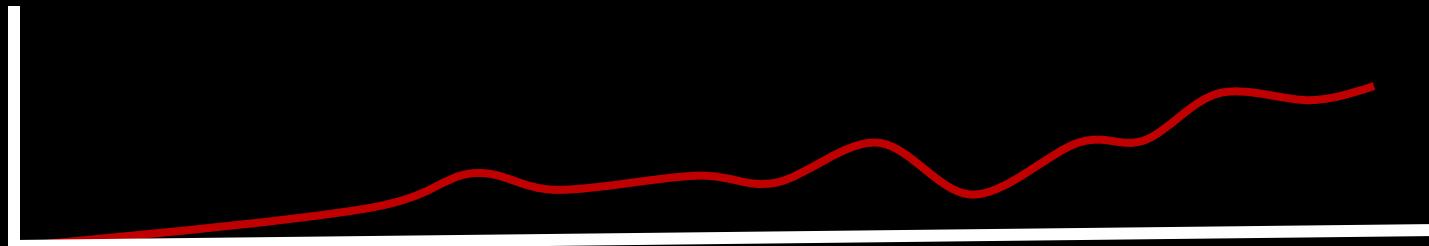
EVAP
Electric Vehicle Association of Asia Pacific

Hybrids and EV's in the 2012 Marketplace

- Technical Feasibility Demonstrated
- Performance Competitive
- Customer Interest Growing

BUT

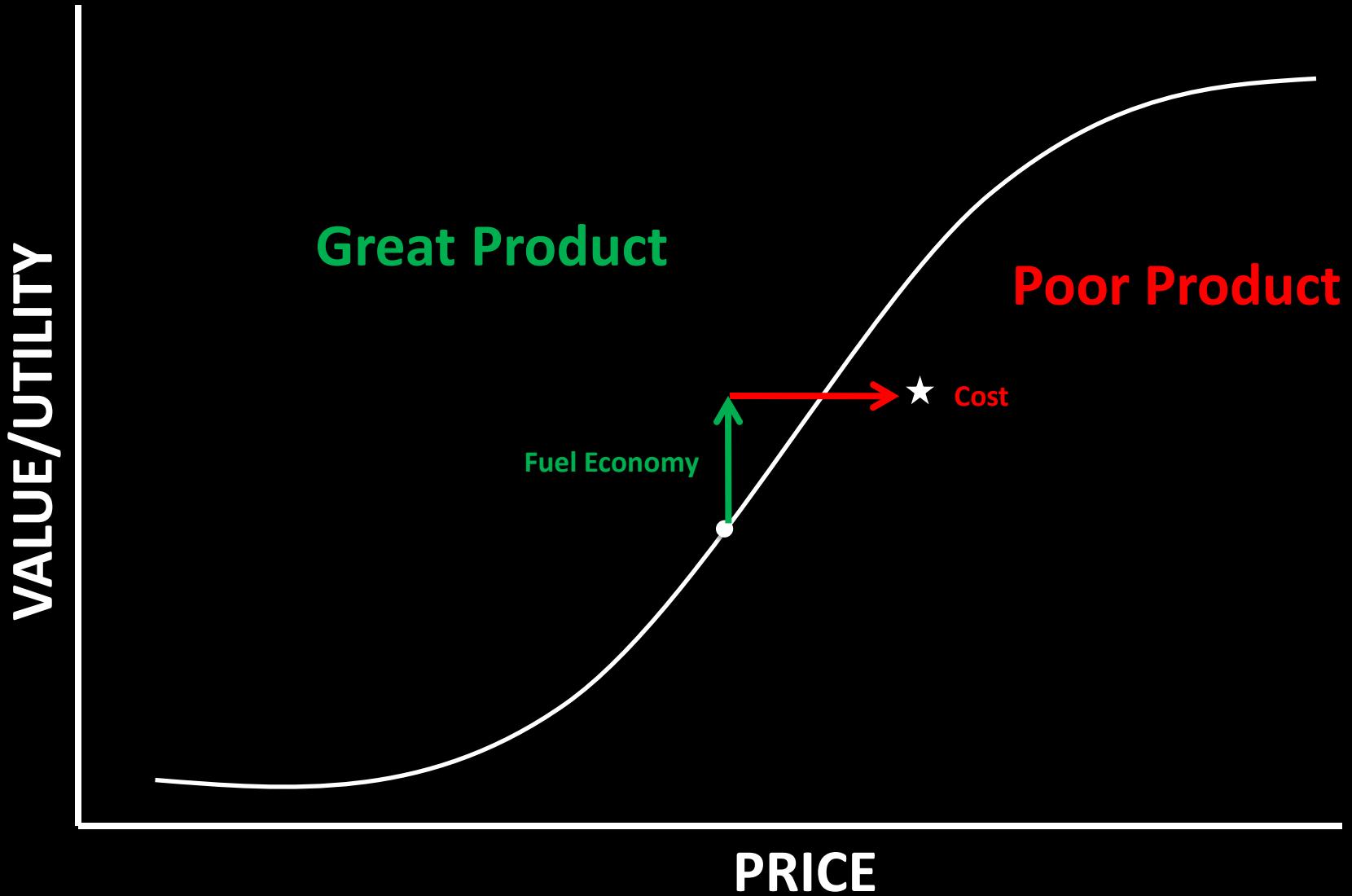
- Market Take Rate Continues to be Hampered by Persistent High Costs
- Aggressive Cost Reduction at all Levels Essential for Commercial Viability and Mass Market Acceptance



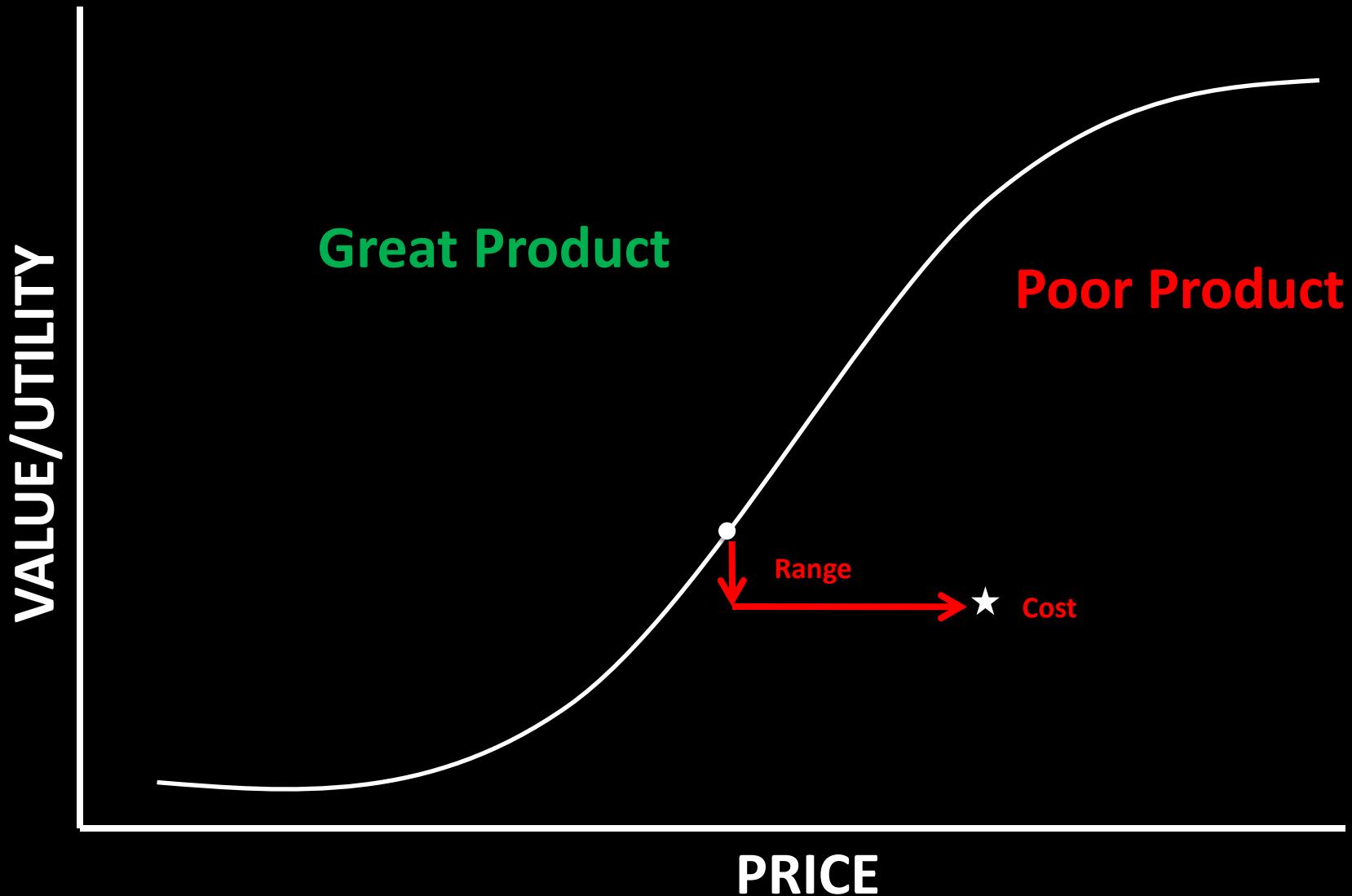
Customer Value Proposition



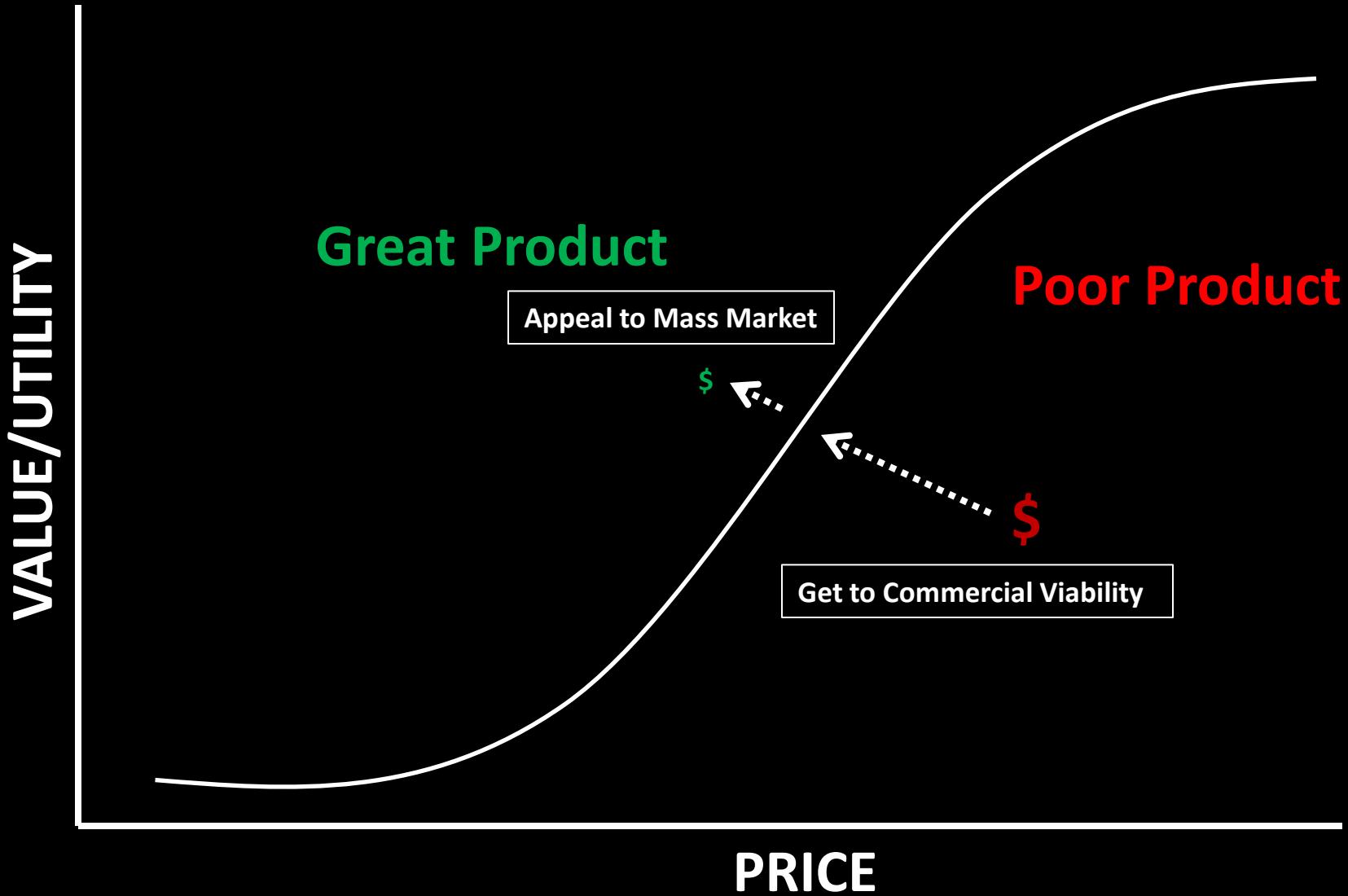
Hybrid Value Proposition



Electric Vehicle Value Proposition



Hybrid and EV \$\$\$ Challenge



Example: High Cost of Electric Drive Systems

- Electric Drive Systems are Typically Considered Mature Today
 - Inverter
 - Electric Motor
 - Reduction Gear
- Mature in Size and Mass
- Mature in Performance
- But not Yet Mature in Cost



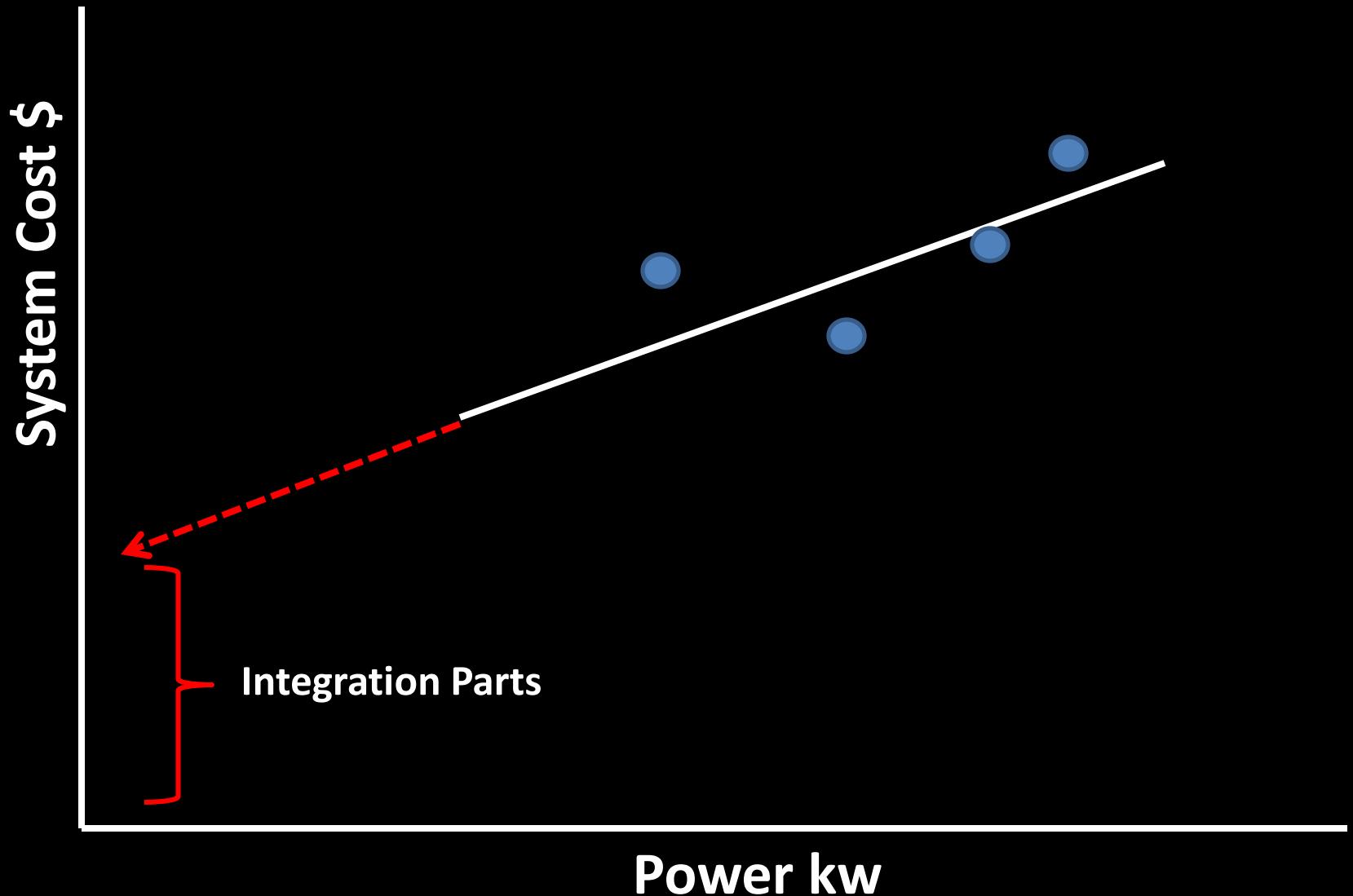
1995 EV1 Inverter



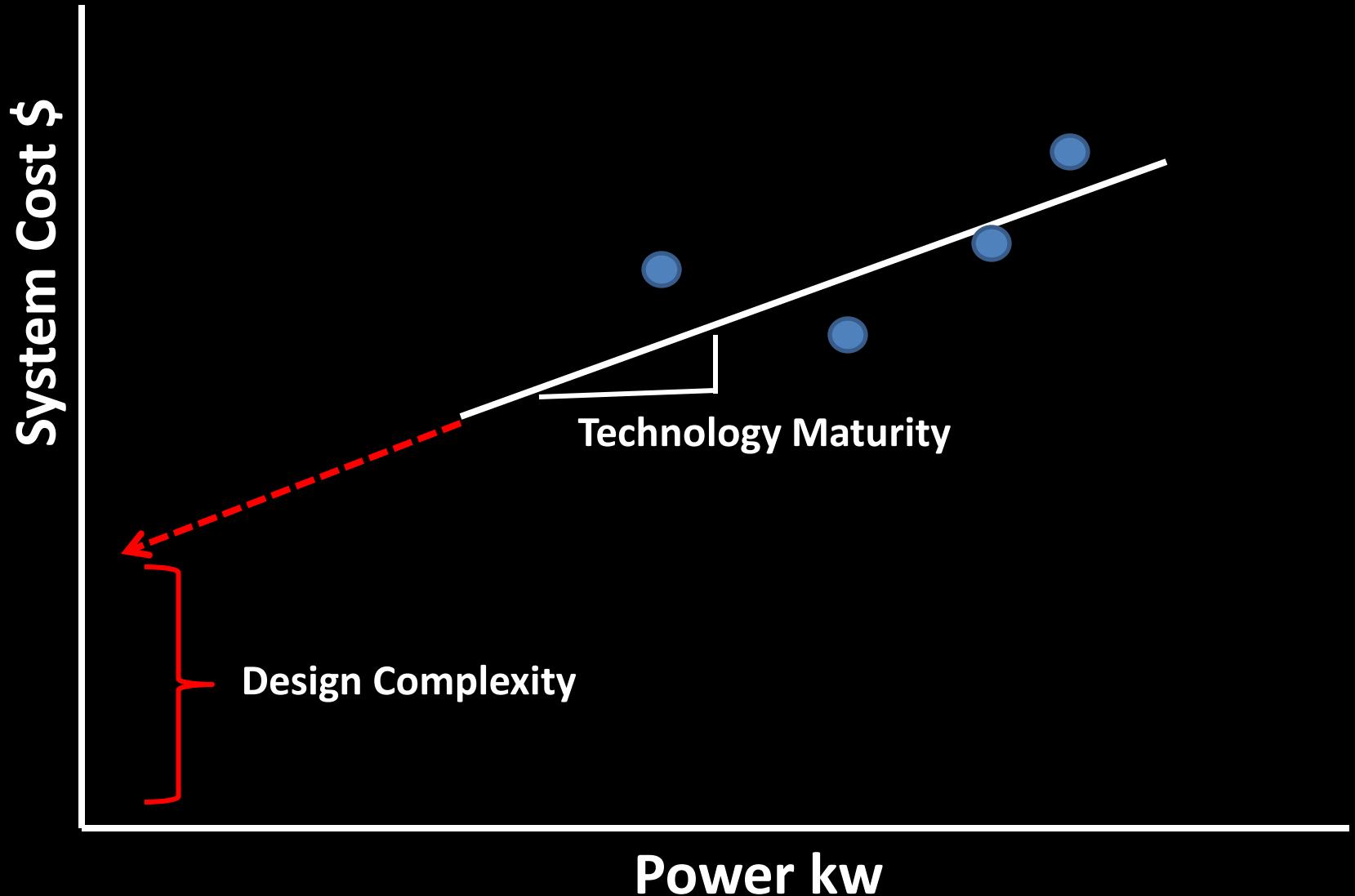
2012 Magna E Car Inverter



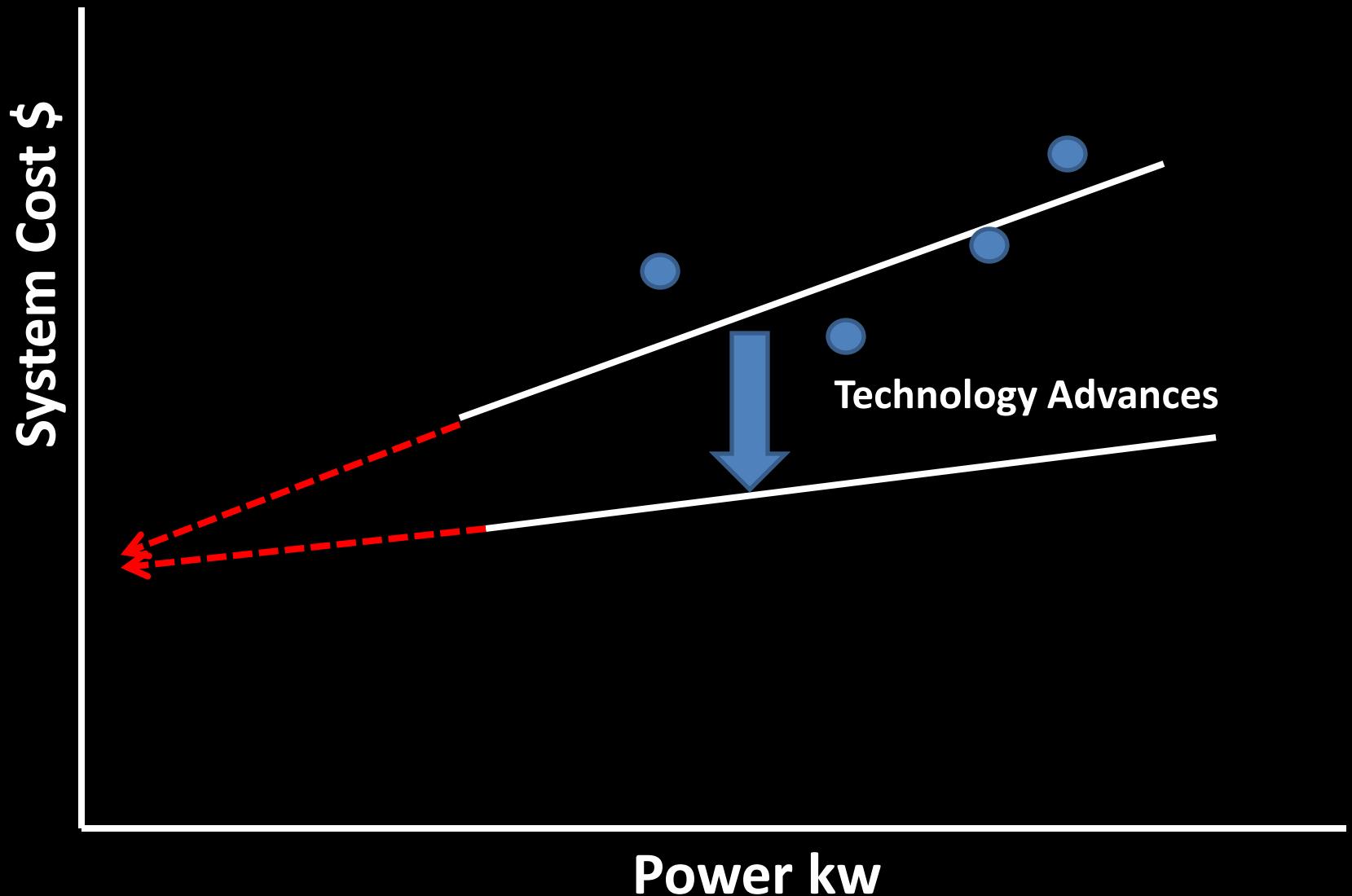
Cost of Integration Parts



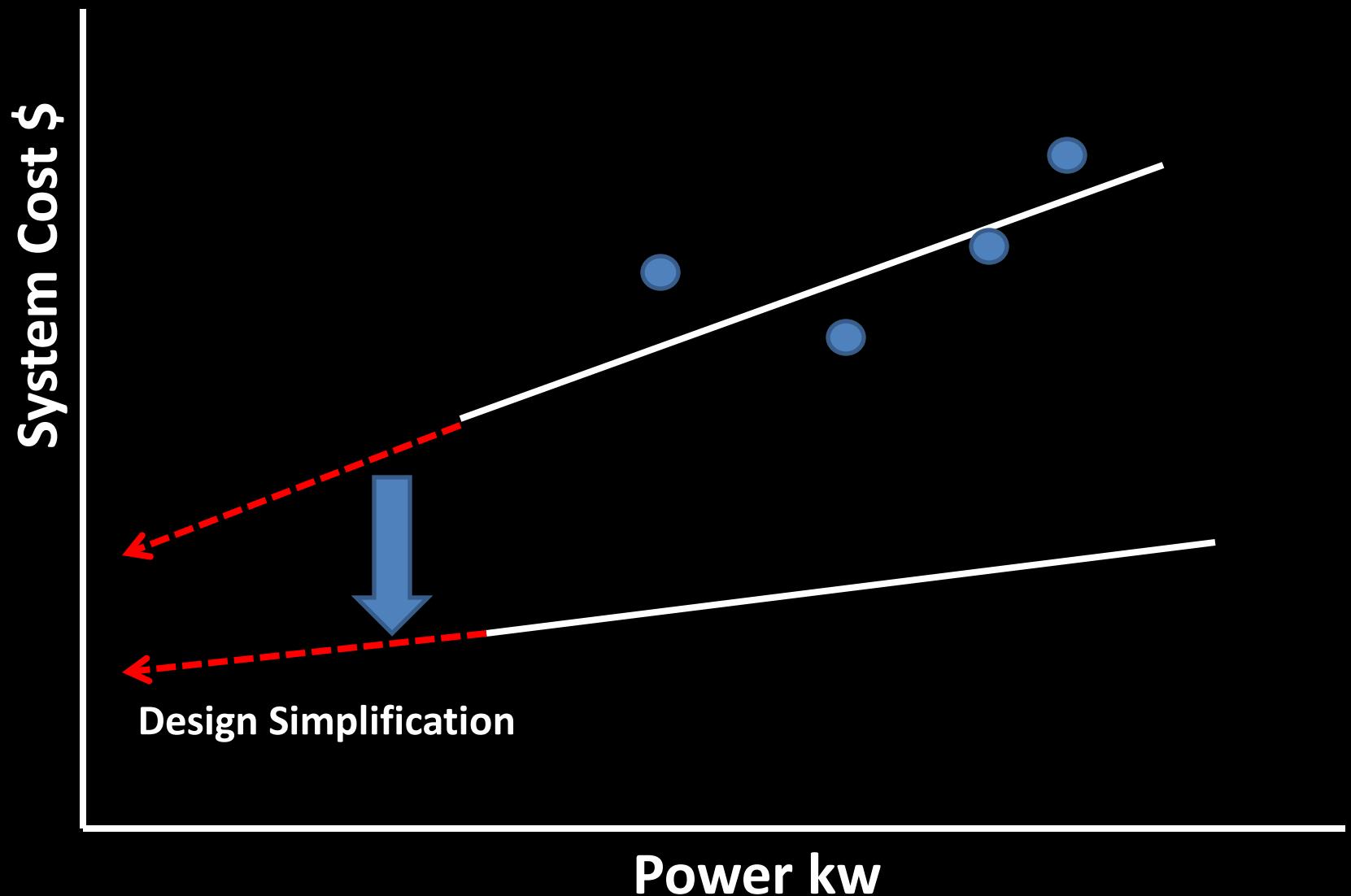
Cost Drivers



Cost Reduction Requires Technology Advances



Cost Reduction Requires And Design Simplification

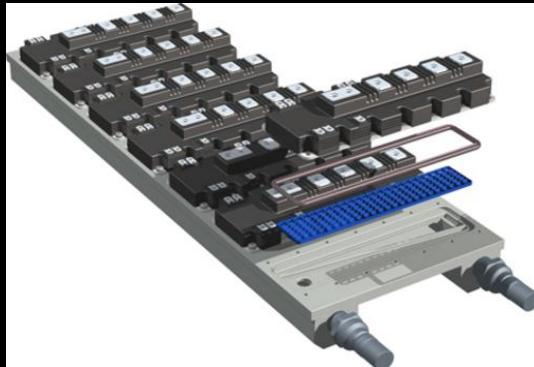


Inverter Simplification/Integration Advances

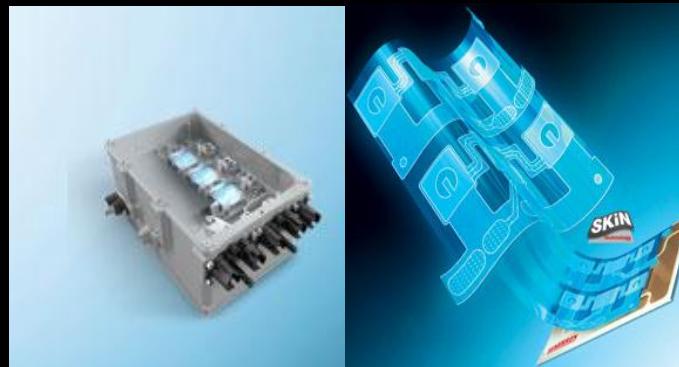
After Two Decades IGBT Silicon DIE Size Reduction and Space Efficiency Achieved Improvements of 75% and Junction Temperatures up to 150C

Innovation Has Now Reached the Module Level

Danfoss



Semikron



Infineon



Direct Path Cooling

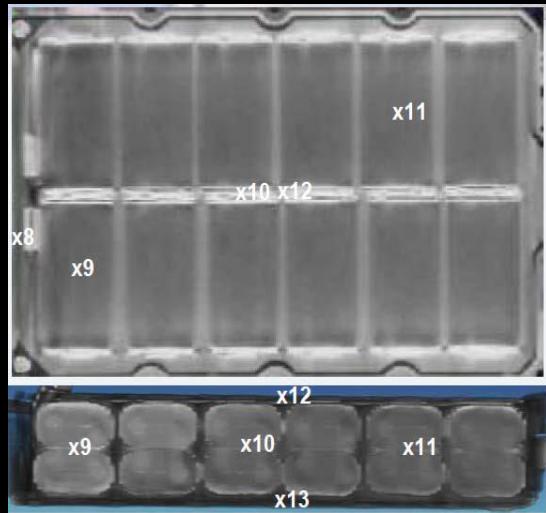
Wire Bond Free High Power Density Interconnect

Integrated Current Sensors /Drivers

To Get Further Down the Inverter Cost Curve, More Design Simplification and Reduction of Integration Parts is Needed

SBE Technology Integrates DC BUS Capacitors

Many Individual Parallel Components



SBE Single “Power Ring” Capacitor



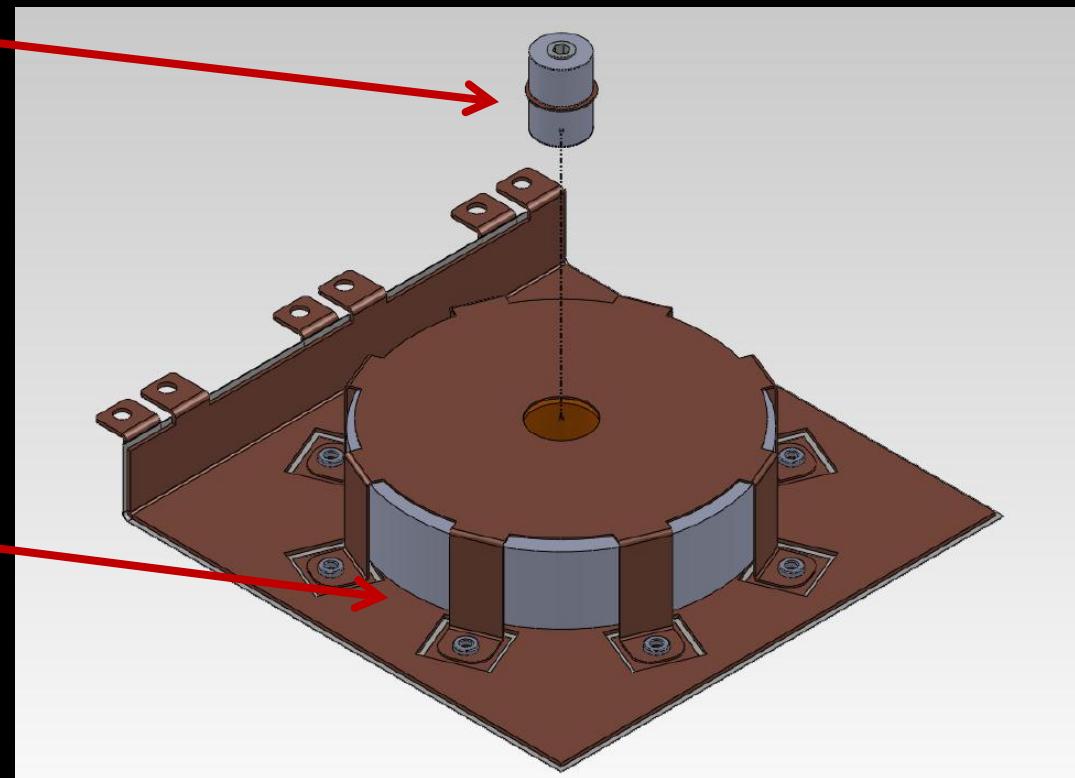
Leading Edge Performance
1,000 uF, 600 Volt
125 micro-Ohms at 20 kHz
5 nH
105 C
Test Proven Durability
Low Cost Materials

Enabling Further Inverter Simplification ,Integration & Cost Reduction

Even More Integration Possible

**Integrated EMI High
Frequency Filter “Cartridge”
Saves Space and Reduces
Assembly Time**

**Direct Connection of Metal
Sprayed Capacitor Contact
Surface to Laminated Bus Bar
Eliminates a Terminal Plate**



Up-Integration

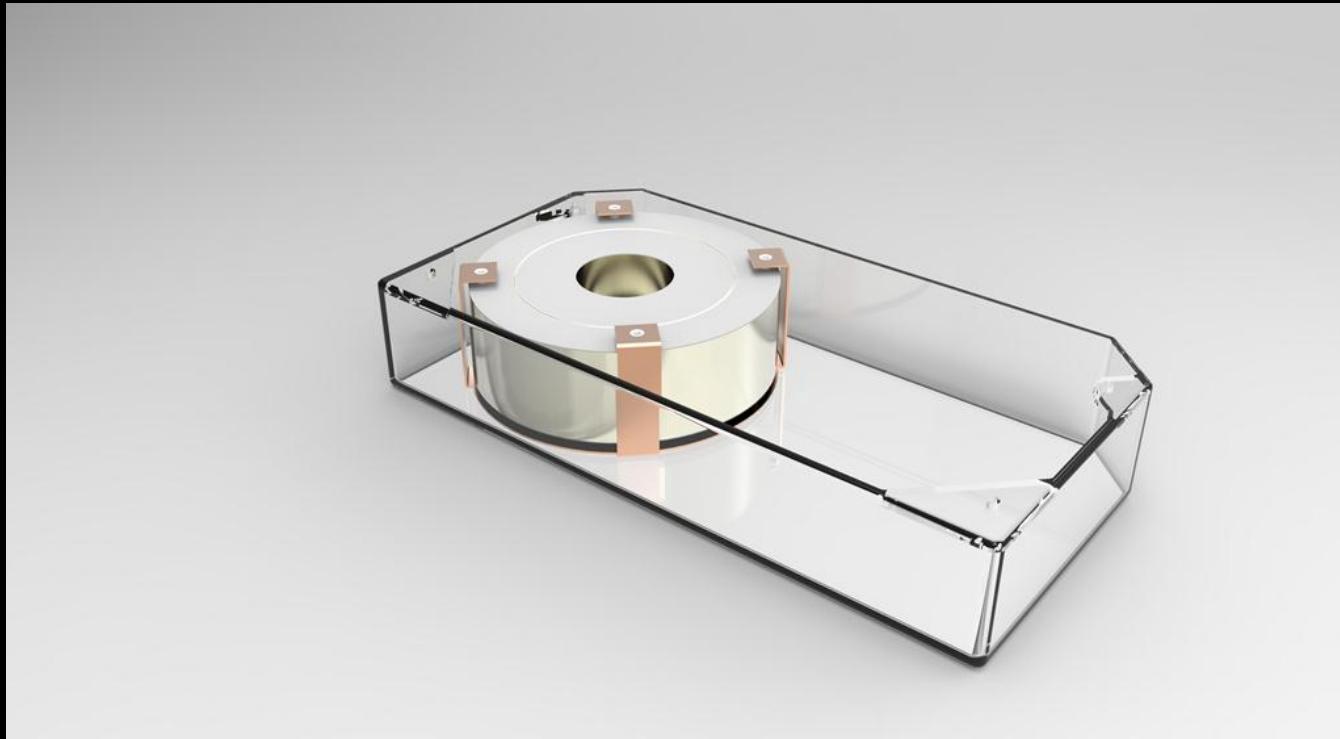
A Design Concept



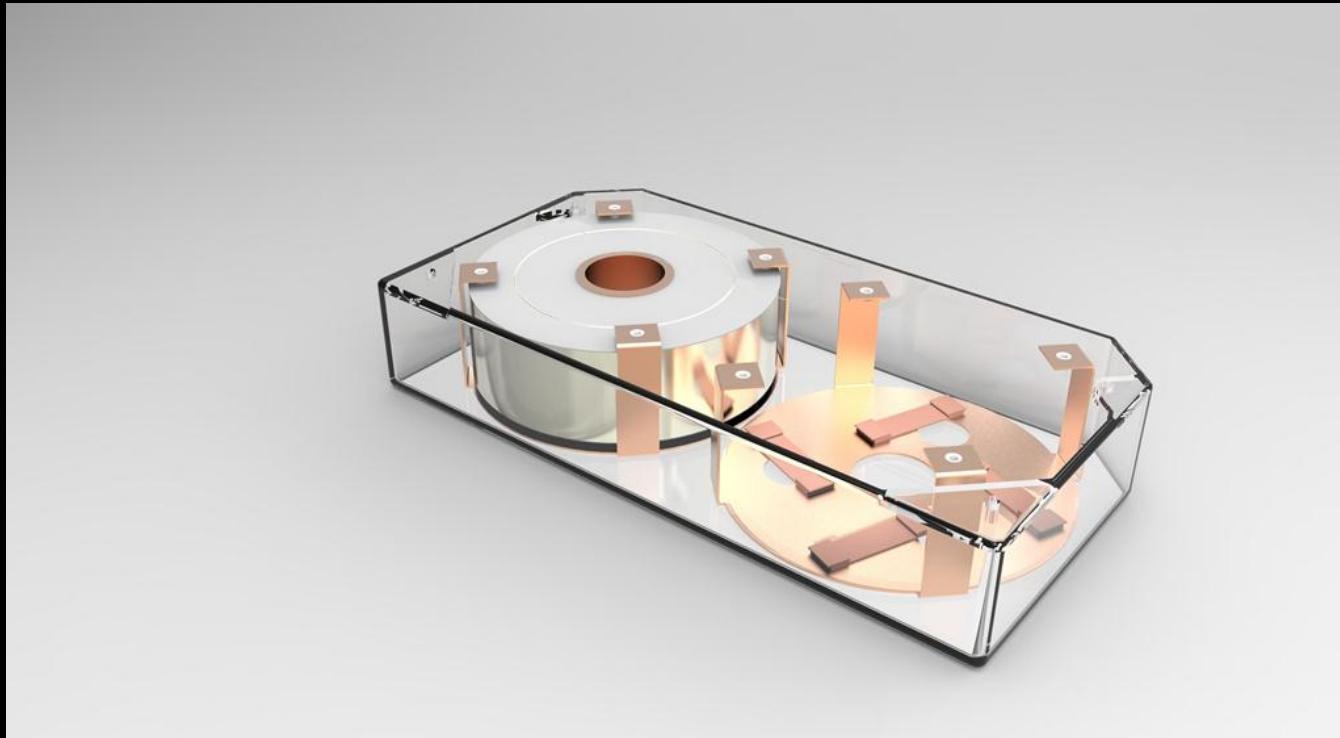
Next Level of Integration Facilitated by SBE Power Ring DC Bus Capacitor



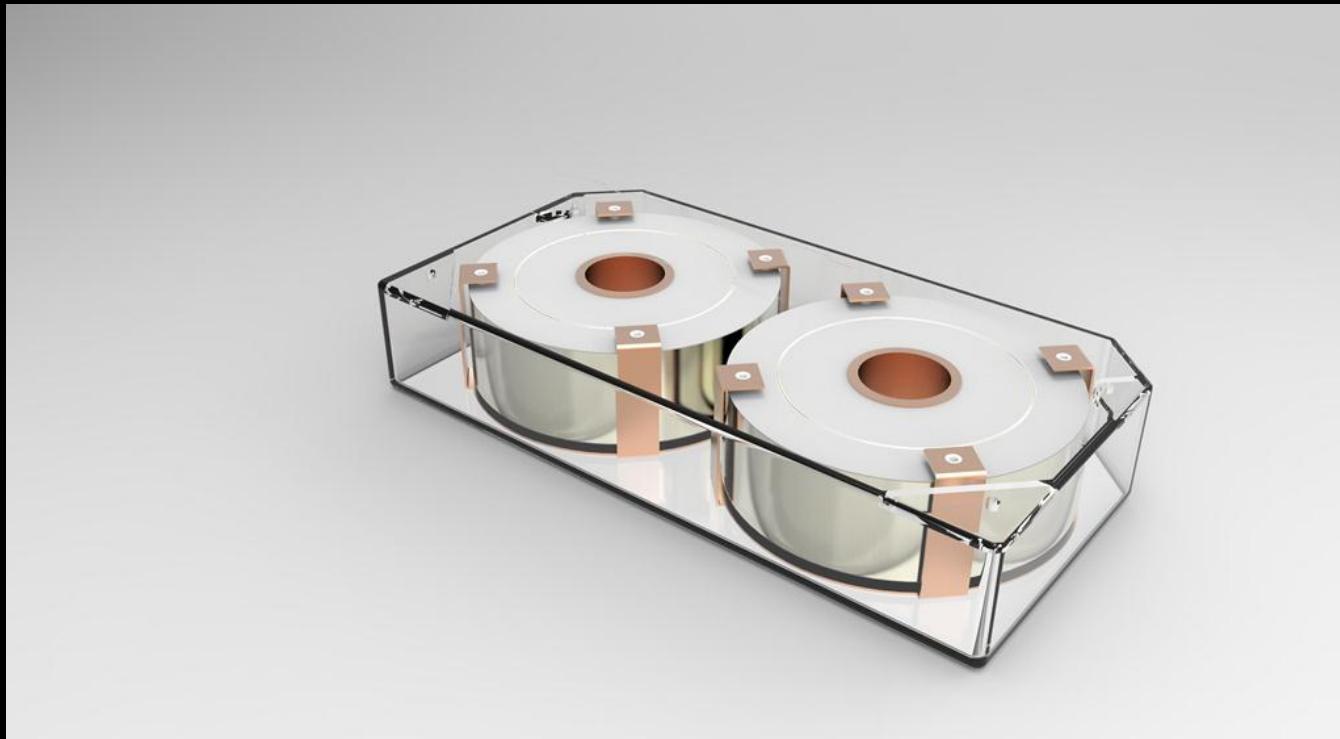
Next Level of Integration Facilitated by SBE Power Ring DC Bus Capacitor



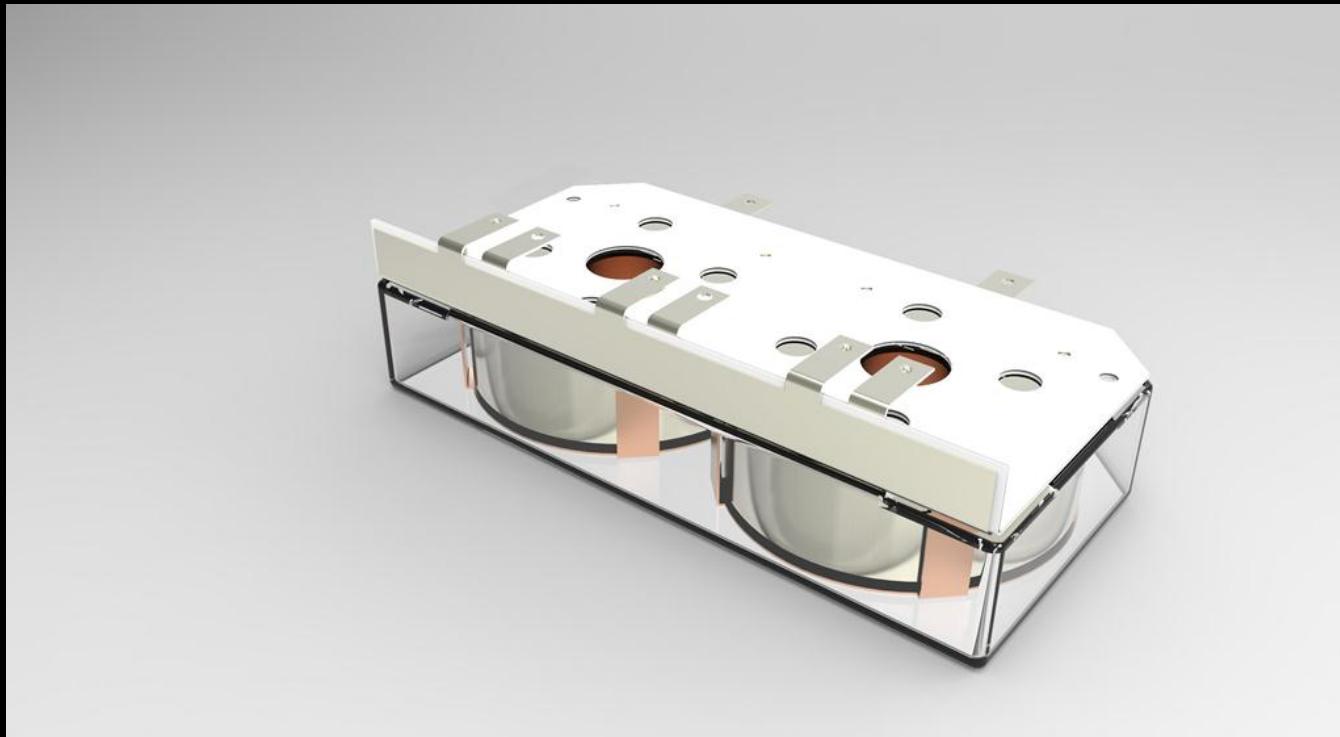
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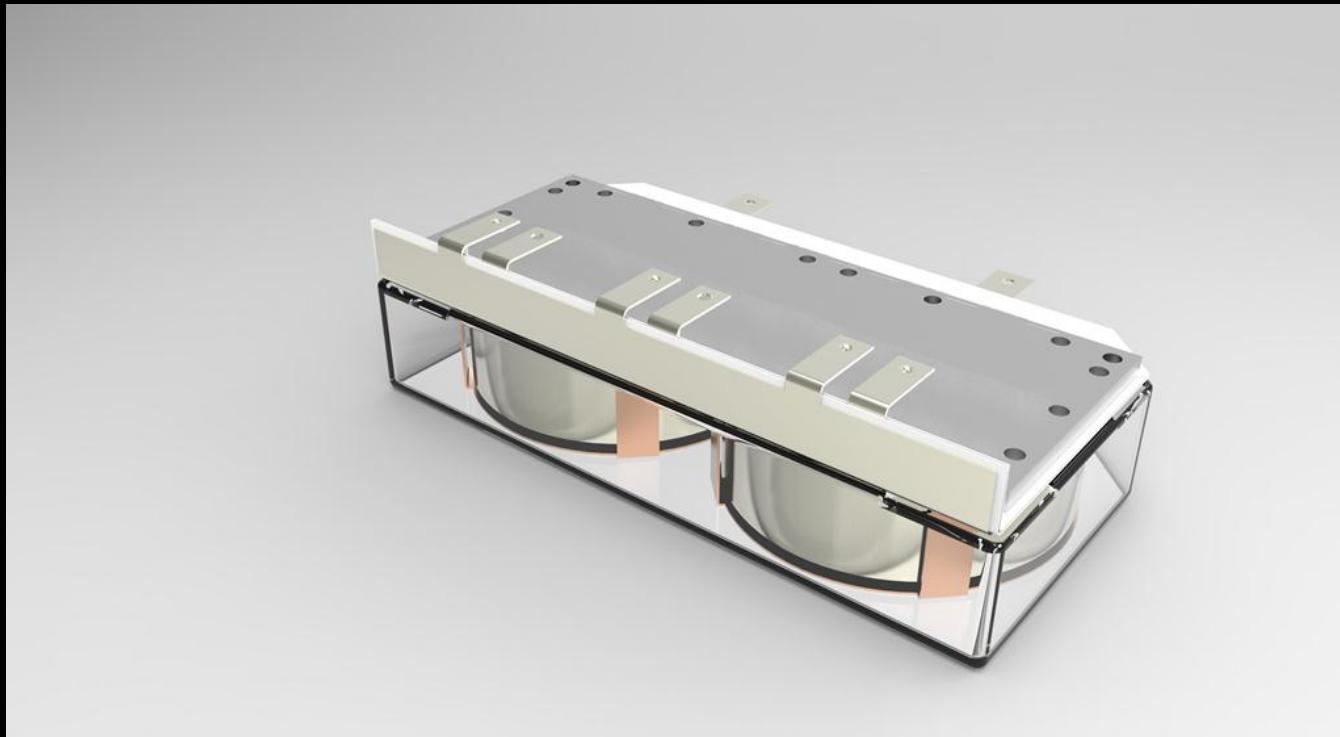
Next Level of Integration Facilitated by SBE



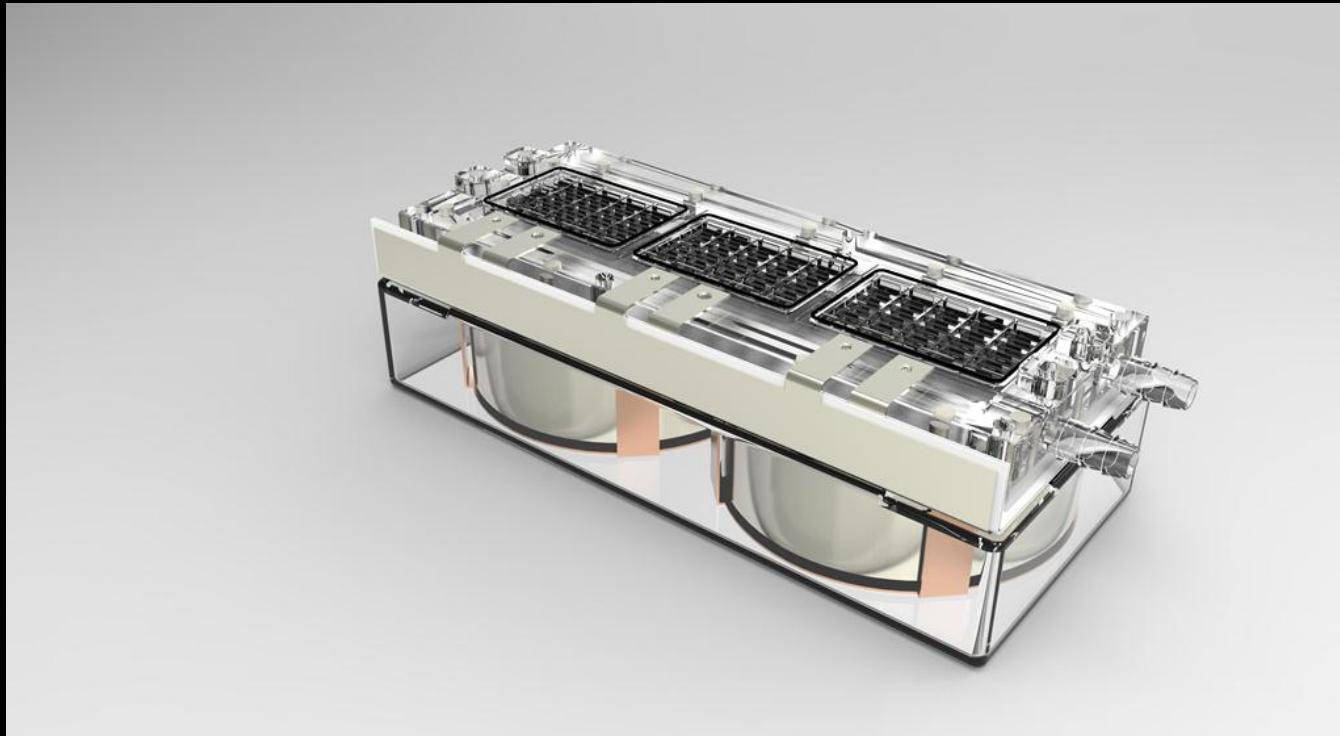
Next Level of Integration



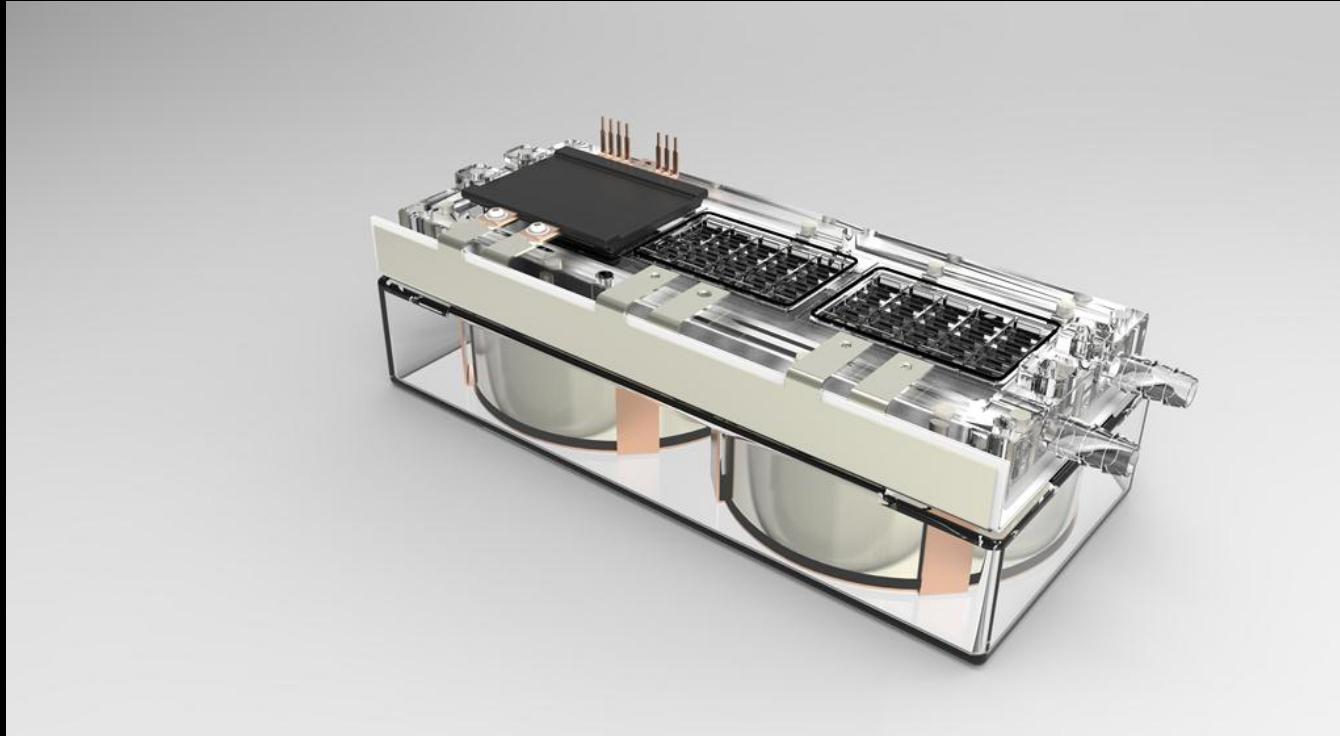
Next Level of Integration



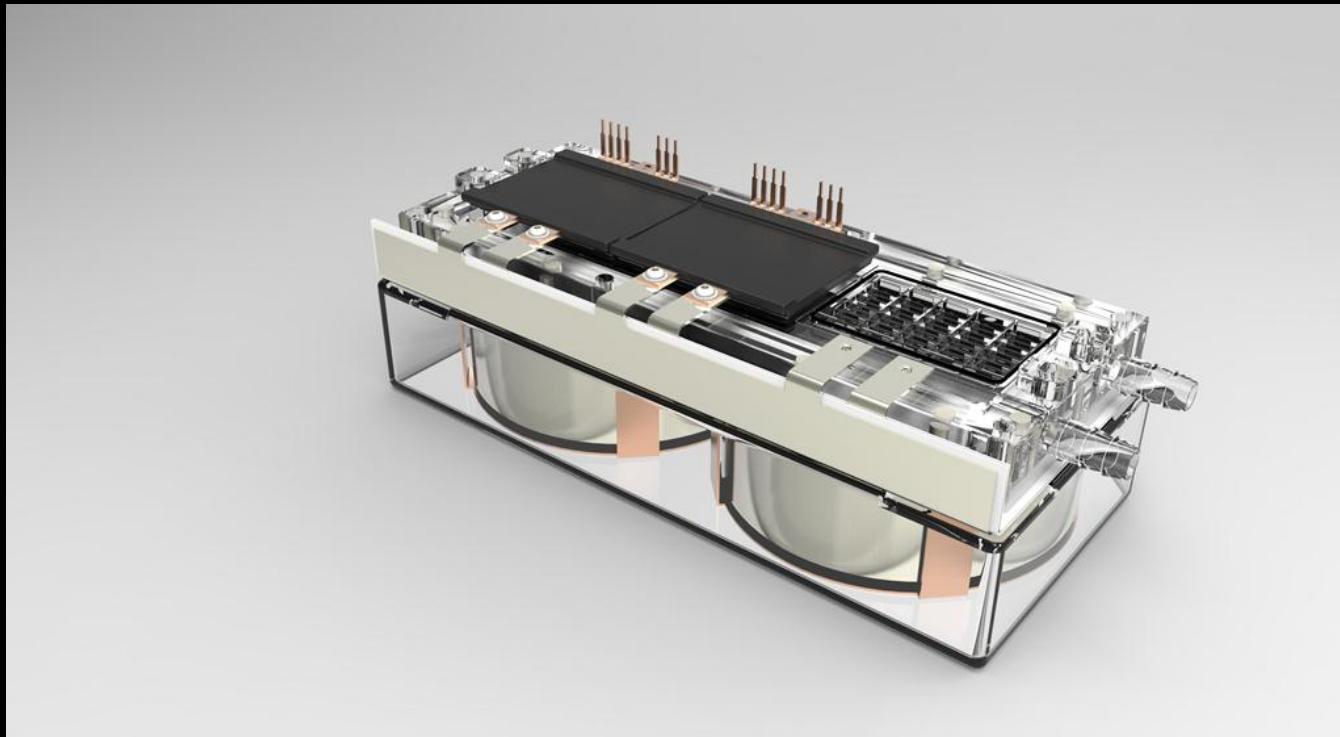
Next Level of Integration Facilitated by Danfoss Heat Exchanger



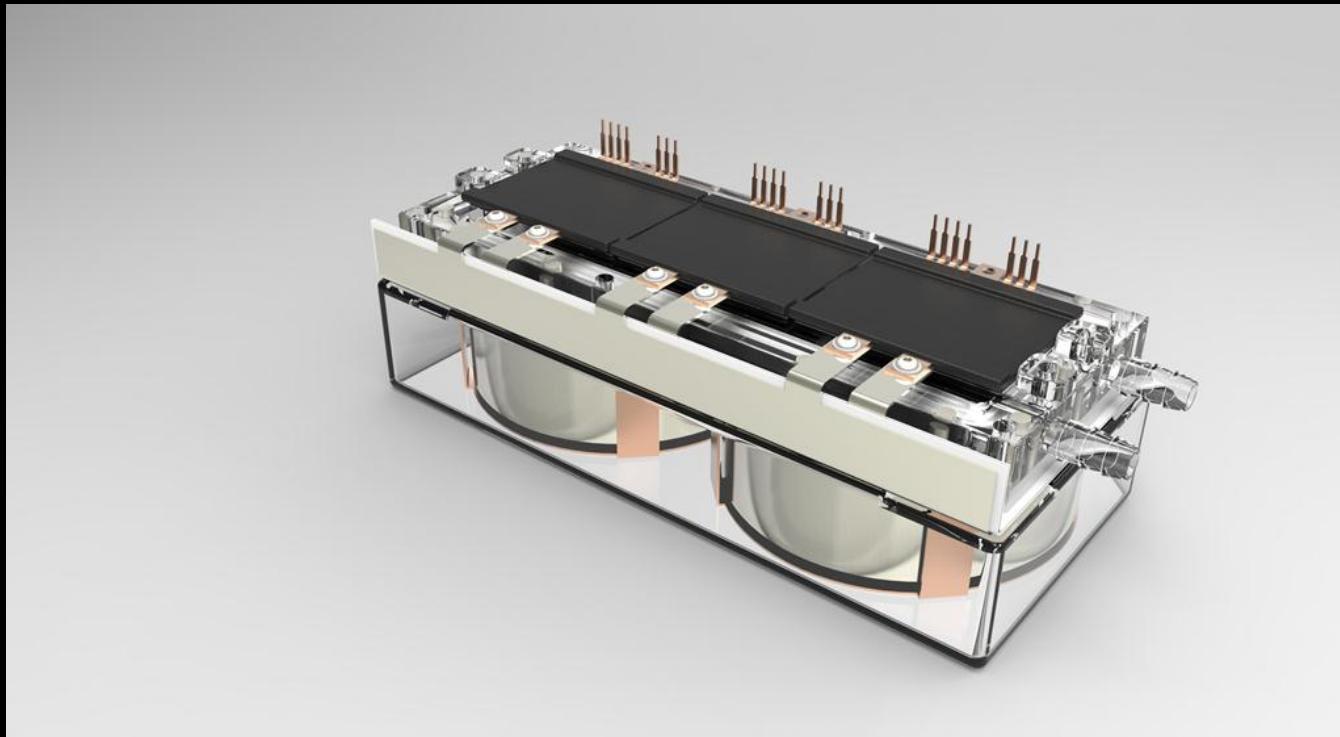
Next Level of Integration Facilitated by Danfoss IGBT Package



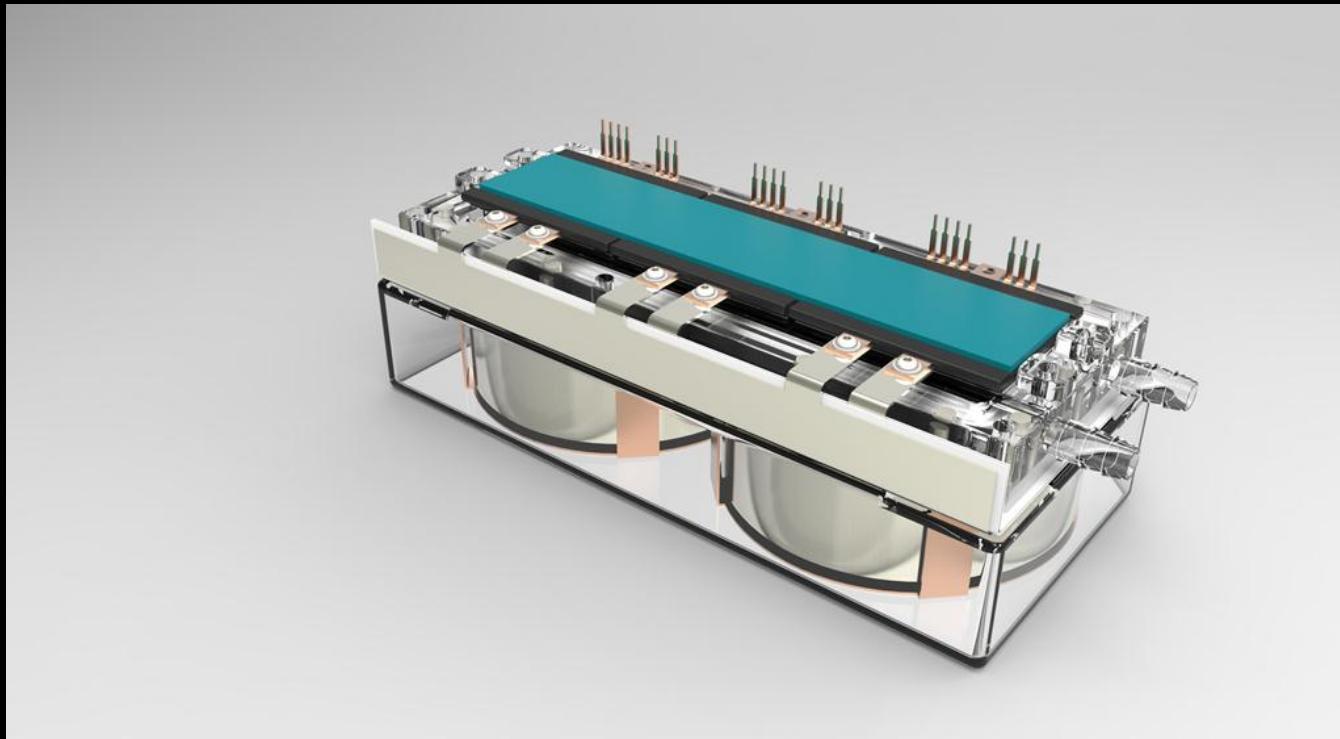
Next Level of Integration



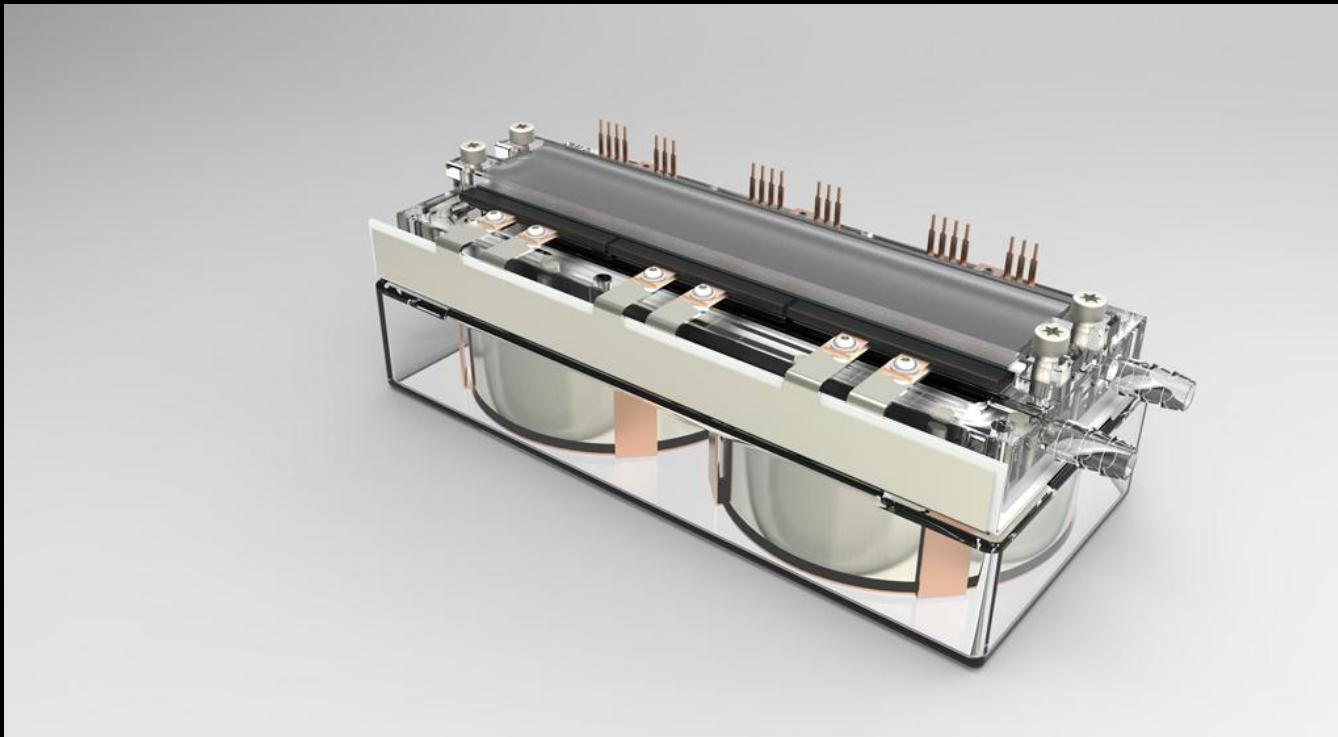
Next Level of Integration



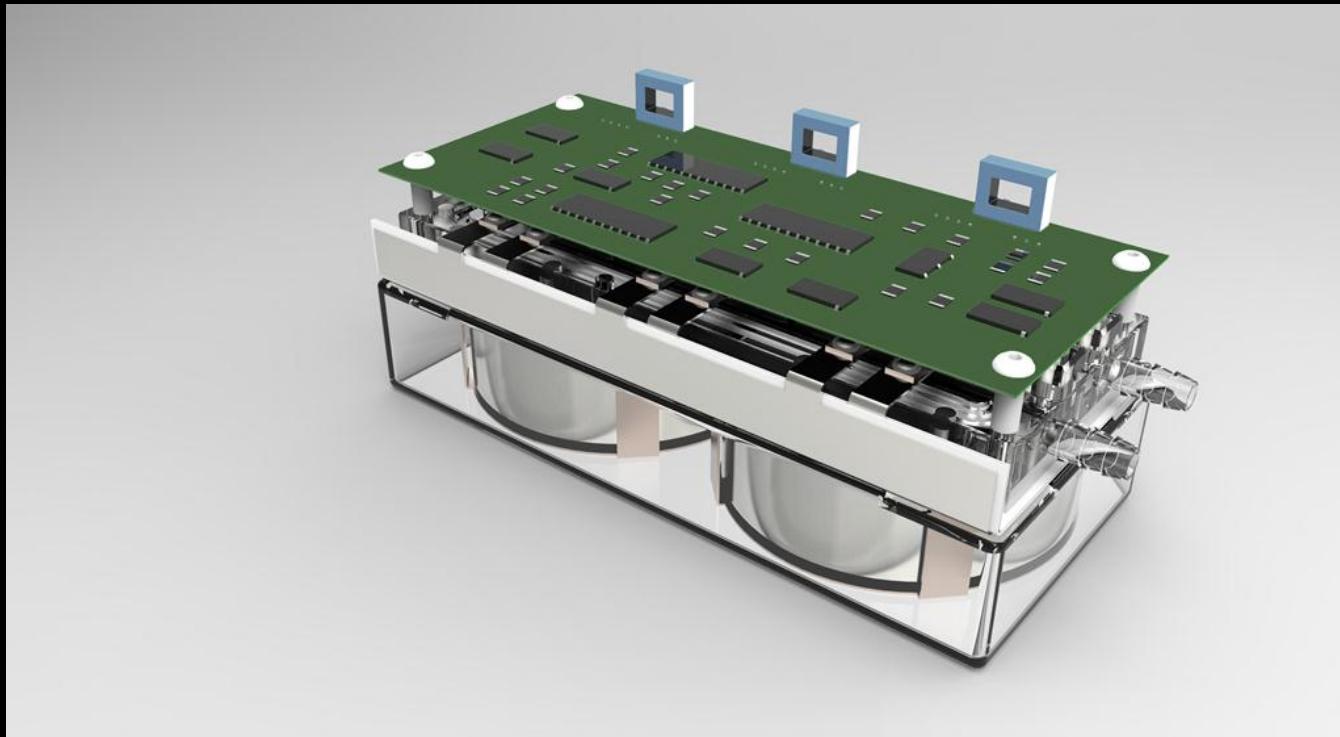
Next Level of Integration



Next Level of Integration

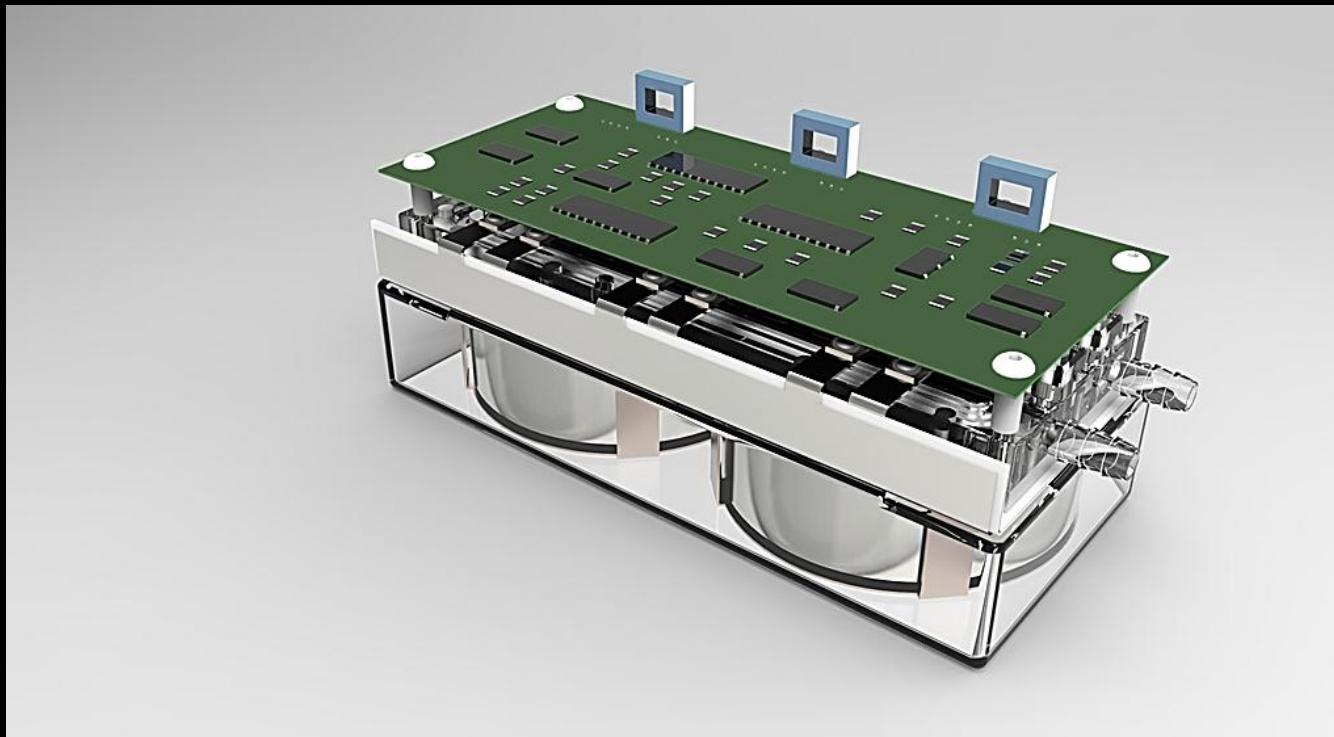


Final Level of Integration



Final Level of Integration

3D Design Strategy



Snubbers Eliminated

40% Mass & Volume Reduction

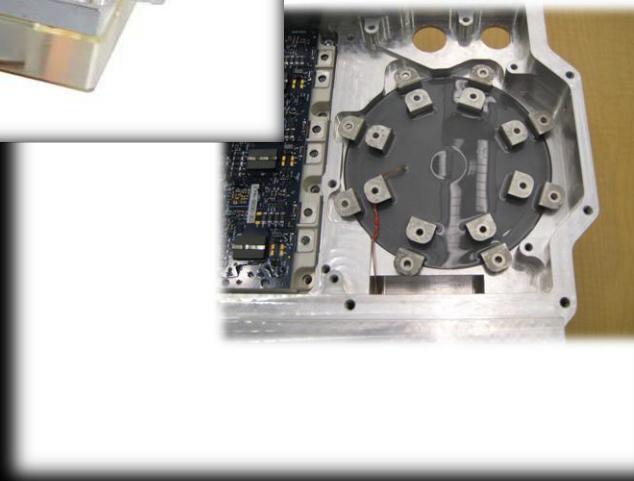
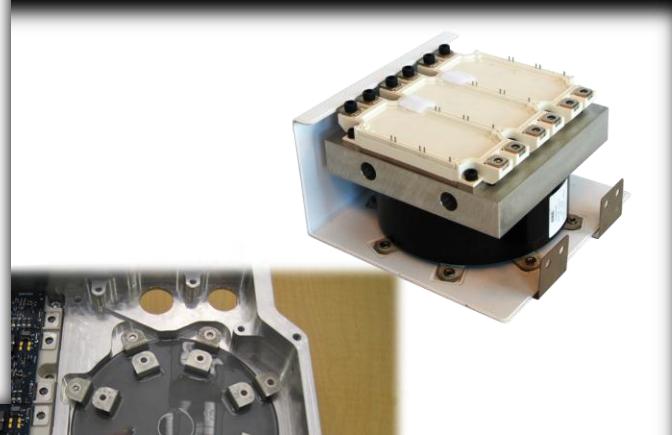
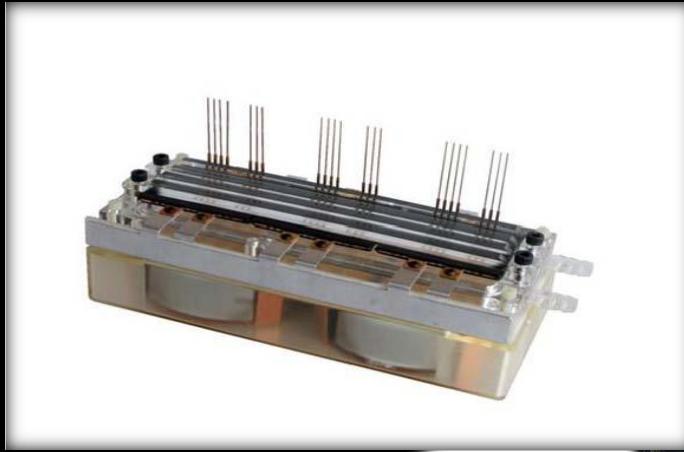
25% Cost Reduction

Power 80 kw

Mass 1.2 kg

Volume 2.0 l

Power Ring Enables Flexible 3D Packaging



Inverter Up-integration Enables Propulsion System Additional Cost Reductions

- **Inverters - Up to 25% Cost Reduction**
 - Compact 3D Designs
 - Snubbers & Integration Parts Eliminated/Reduced
 - Power Densities up to 65 kw/kg and 40 kw/l
 - Thermal Paths Reduced/Optimized



- **Electric Drives – Additional Large System Level Cost Reduction Potential via Operation up to 105C Coolant**
 - Electric Vehicles (Now)
 - Reduced size and cost of heat exchanger
 - Higher quality of heat for occupant compartment
 - Fuel Cell Vehicles (Now)
 - Eliminate dedicated thermal system and cost
 - Share cooling loop with fuel cell stack
 - Hybrid Vehicles (Next)
 - Could Eliminate dedicated thermal system and cost
 - Share engine cooling loop or direct mount in transmission



The Path to Mass Market Acceptance of Vehicle Electrification

FOR THE LAST 15 YEARS WE HAVE BEEN
FOCUSED ON MAKING EV TECHNOLOGY WORK

The Path to Mass Market Acceptance of Vehicle Electrification

FOR THE LAST 15 YEARS WE HAVE BEEN
FOCUSED ON MAKING EV TECHNOLOGY WORK

FOR THE NEXT 15 YEARS WE MUST FOCUS
ON MAKING IT COST COMPETITIVE