EV Everywhere Grand Challenge

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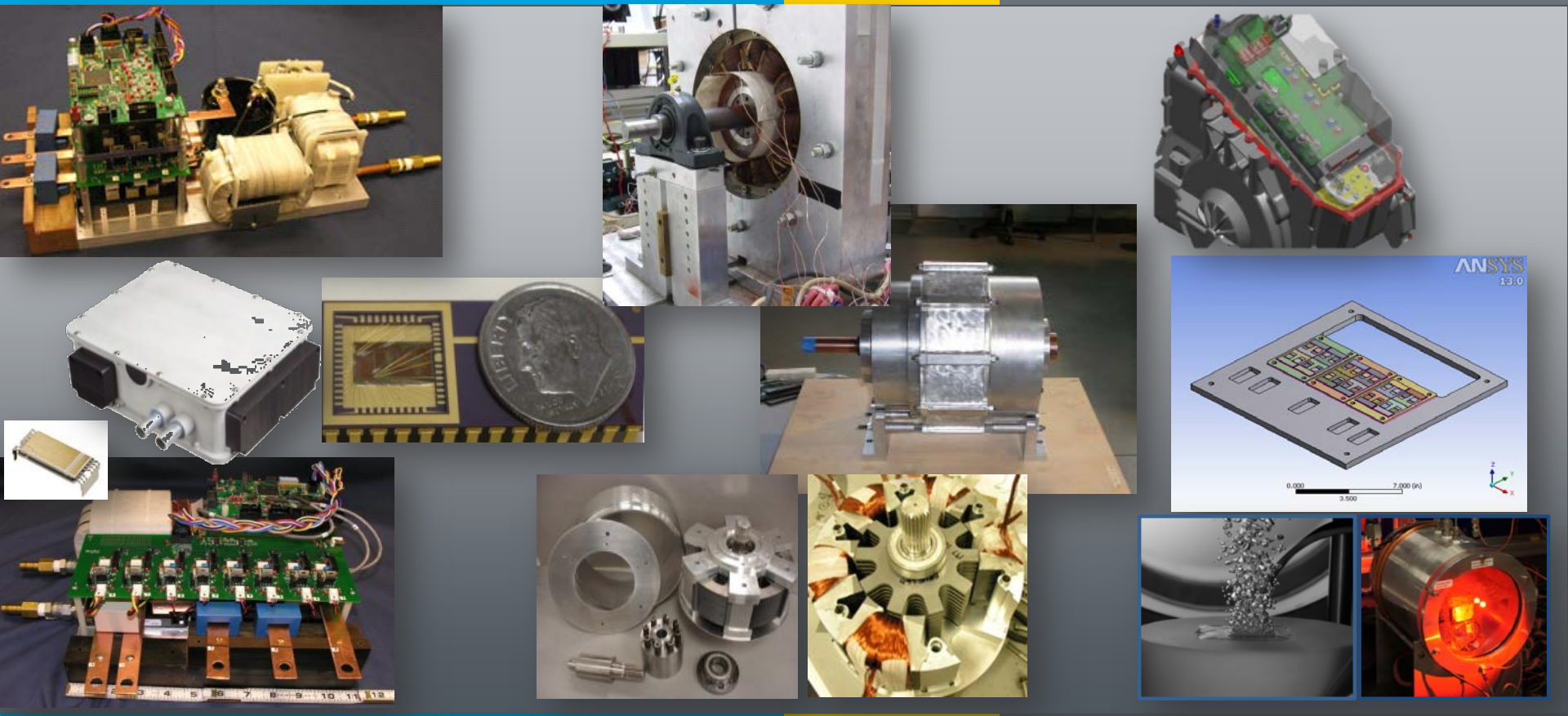

POWER ELECTRONICS AND THERMAL MANAGEMENT BREAKOUT SESSION

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Burak Ozpineci
Oak Ridge National Laboratory
Facilitator

Key DOE Technical Targets

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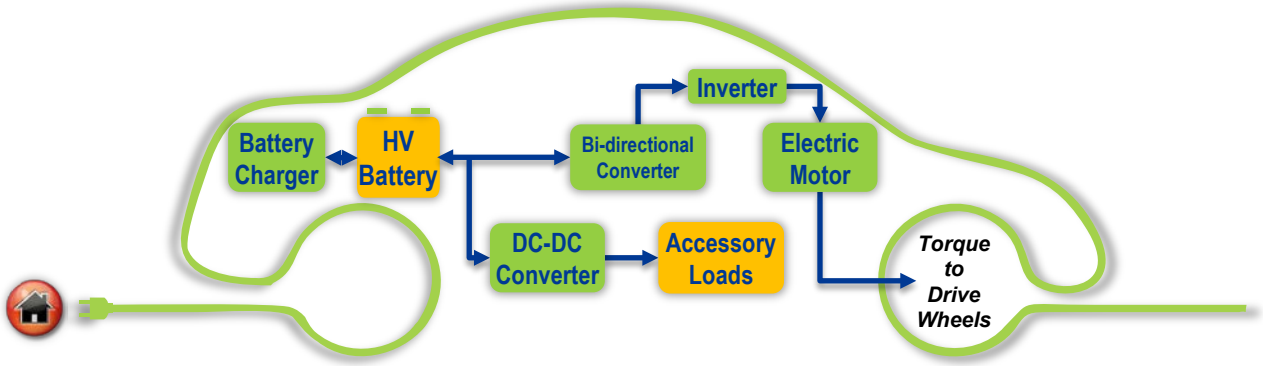


Traction Drive Requirements: 55 kW peak power for 18 sec; 30 kW continuous power; 15-year life

Traction Drive System

Impacts →	Reduce Cost	Reduce Weight	Reduce Volume	Reduce Energy Storage Requirements
Year	Cost ($/kW)	Specific Power (kW/kg)	Power Density (kW/l)	Efficiency
2010*	19	1.08	2.60	>90%
2012	17	1.12	2.86	>91%
2015	12	1.17	3.53	>93%
2020	8	1.44	4.00	>94%

Power Electronics

($/kW)	(kW/kg)	(kW/l)
7.9	10.8	8.7
7	11.2	10
5	12	12
3.3	14.1	13.4

Electric Motors

($/kW)	(kW/kg)	(kW/l)
11.1	1.2	3.7
10	1.24	4
7	1.3	5
4.7	1.6	5.7

* 2010 traction drive cost target achieved with development of the GM integrated traction drive project

Traction Drive Performance and Cost Status

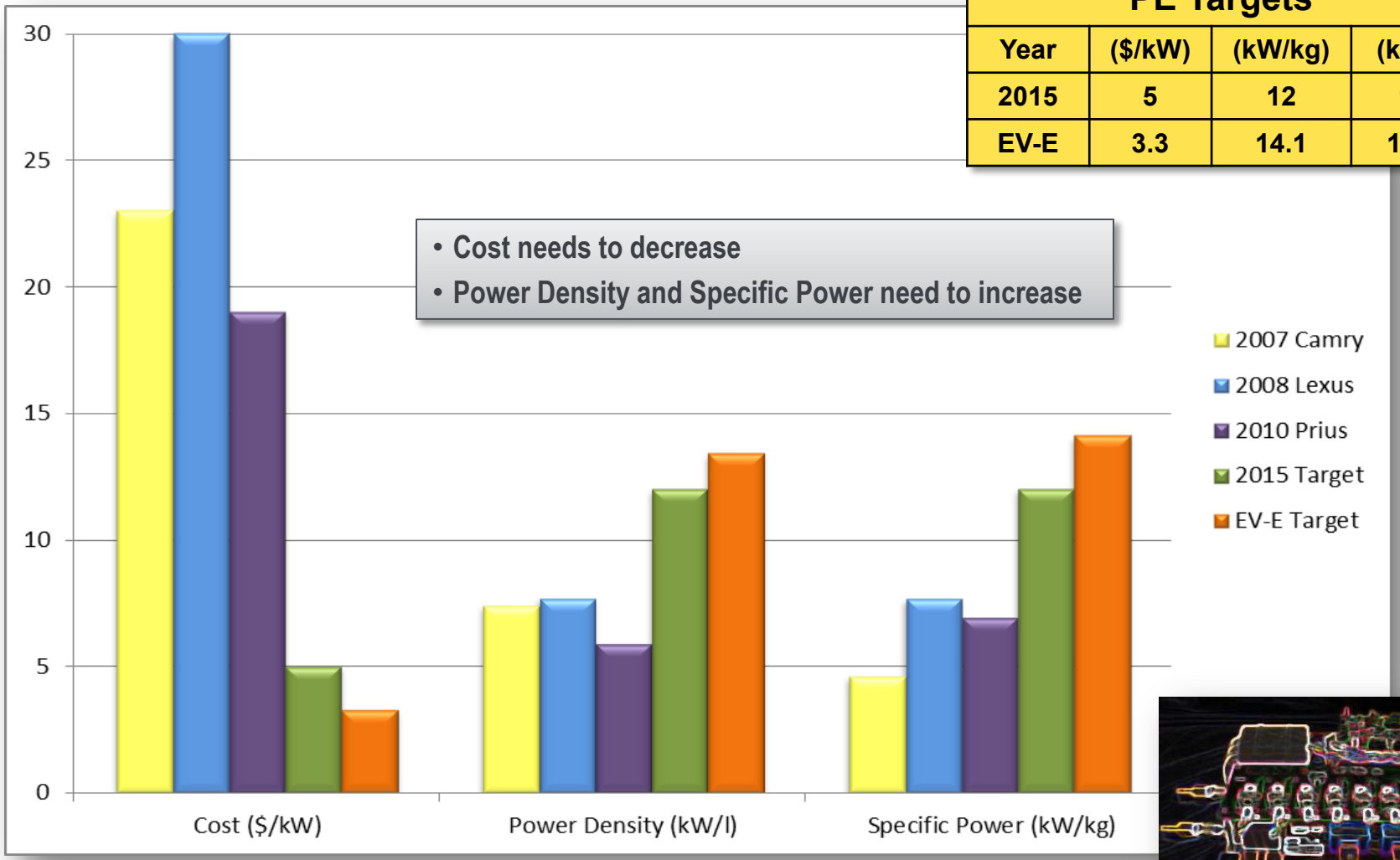
Traction drive cost reduction and performance improvements are necessary to achieve the *EV Everywhere* Grand Challenge

		Current Status	PHEV 40	BEV 100	BEV 300
System Cost	$/kW	20	5	14	4
Motor Specific Power	kW/kg	1.3	1.9	1.5	2
PE Specific Power	kW/kg	10.5	16	12	16.7
System Peak Efficiency	%	90	97	91	98

Are these electric drive component performance and cost targets achievable?

Power Electronics for Traction Drive Applications

PE Targets			
Year	($/kW)	(kW/kg)	(kW/l)
2015	5	12	12
EV-E	3.3	14.1	13.4



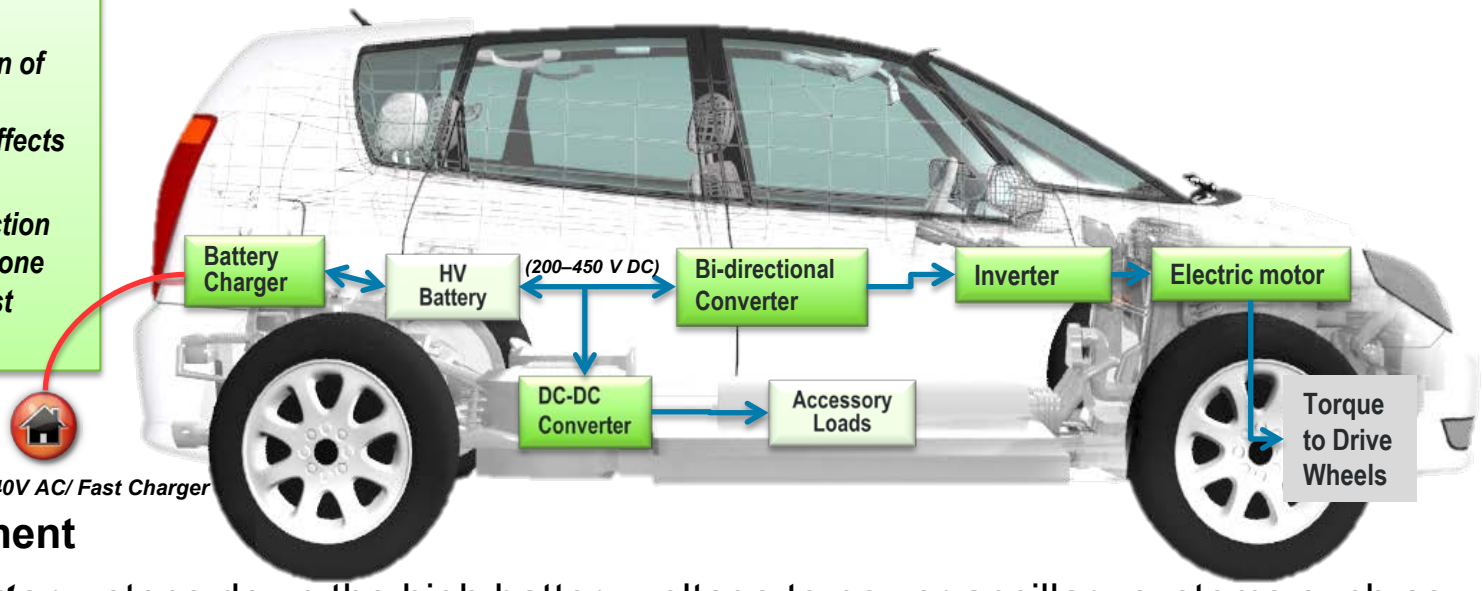
PEEM Applications for Vehicle Traction Drive Span a Number of Functions

Traction Drive

- ***Battery charger*** – necessary for plug-in hybrids and electric vehicles
- ***Bi directional boost converter*** – steps up the battery voltage when the traction system requires a higher operating voltage than the battery can supply
- ***Electric motor*** – converts electrical to mechanical power for the wheels
- ***Inverter*** – converts direct current (DC) to alternating current (AC) for the electric motor

Emphasis:

- ***Design and integration of electric traction drive critical to OEMs - it affects driving "feel".***
- ***Goal is to integrate traction drive components into one system for greatest cost efficiency.***

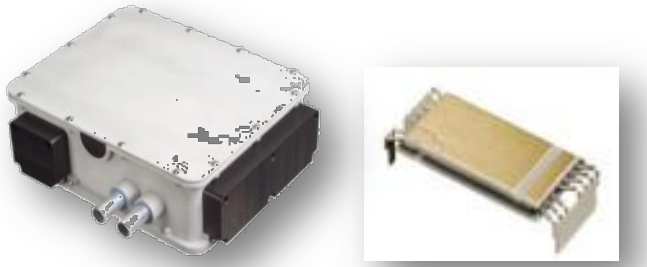


Power Management

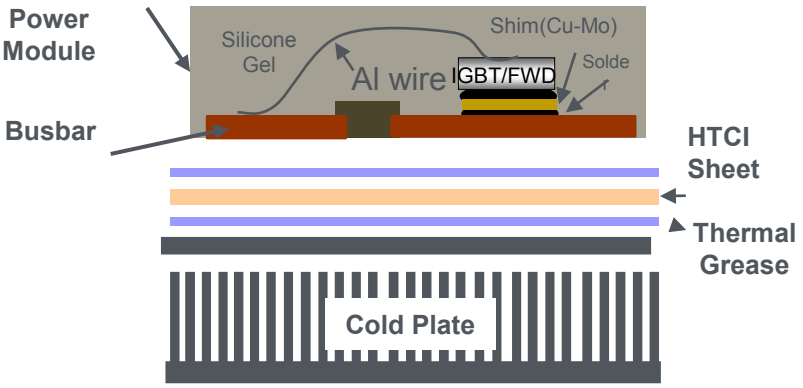
- ***DC-DC converter*** – steps down the high battery voltage to power ancillary systems such as lighting, brake assist, and power steering, and accessories such as air conditioning and infotainment systems.

Power Electronics Challenges & Issues

- **Cost is the biggest challenge**
  - Power module and passive components
  - Emphasis on modular, scalable designs
- **Volume and mass reductions are needed**
  - Driven by passive devices
  - Packaging issues exist-at all levels
- **Packaging and Advanced materials required**
  - Higher temperature capability
  - Increase thermal conductivity
- **Reliability**
  - Wirebonds, die and substrate attach, solders, & connectors
  - Substrates and epoxies
- **Thermal Management**
  - Liquid cooling to air
  - Single sided or double sided
- **Efficiency**
  - Idle or quiescent loads



55 kW Delphi Inverter with Viper Power Module

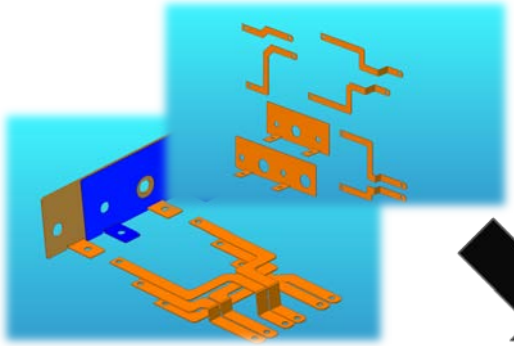


Nissan LEAF Power Module

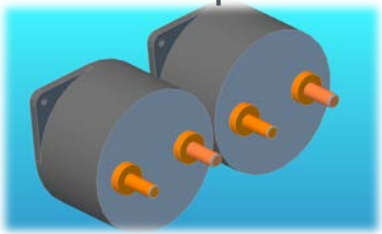
Wide Bandgap Device

Components of an inverter

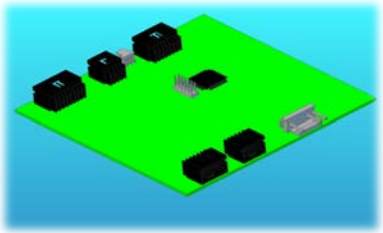
Busbars



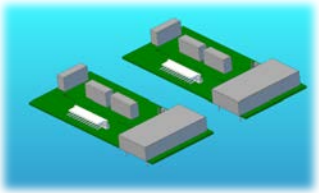
DC link capacitors



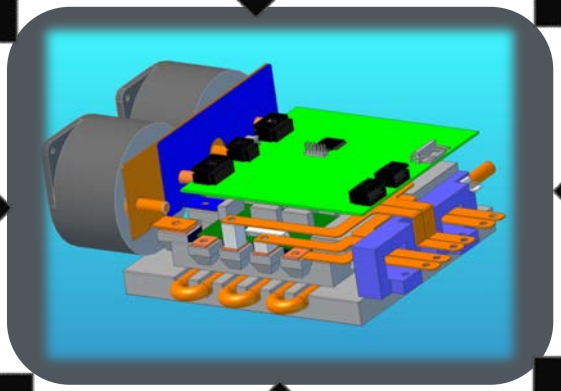
Controller/DSP board



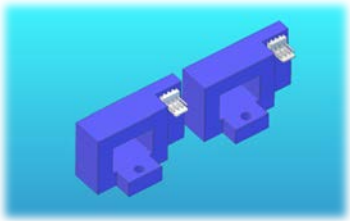
Gate drivers



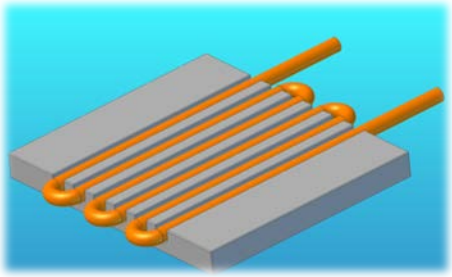
Electrical Architectures
(Current-Source, Voltage Source, etc.)



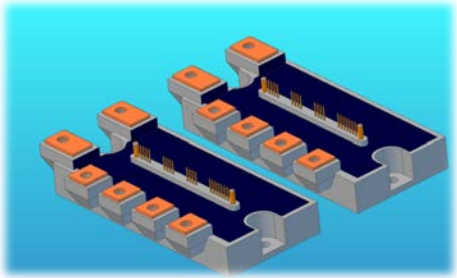
Sensors



Heatsink/Thermal Management



Power modules (Devices and Packaging)



Work Group Focus Questions

BRAKOUT SESSION #1 – *EV EVERYWHERE* SCOPE & TECHNICAL TARGETS

- *Introductions and discussion of current state-of-art of the breakout group's focus area.*
- *Are the initially posed EV Everywhere electric drive component performance and cost targets achievable?*
- *What role can the breakout group's focus are play on achieving these targets? What are the major pathways to cost reduction? What are the major barriers?*

BREAKOUT SESSION #2 – IDENTIFY NEEDS / GAME-CHANGING IDEAS

- *What are the specific highest-impact critical technology breakthroughs that are needed to achieve the EV-Everywhere Challenge?*
- *Are there "out of the box", risky, or other approaches that should be considered?*
- *Each participant is encouraged to informally endorse or propose a single research idea or concept that could be applied to EV Everywhere*