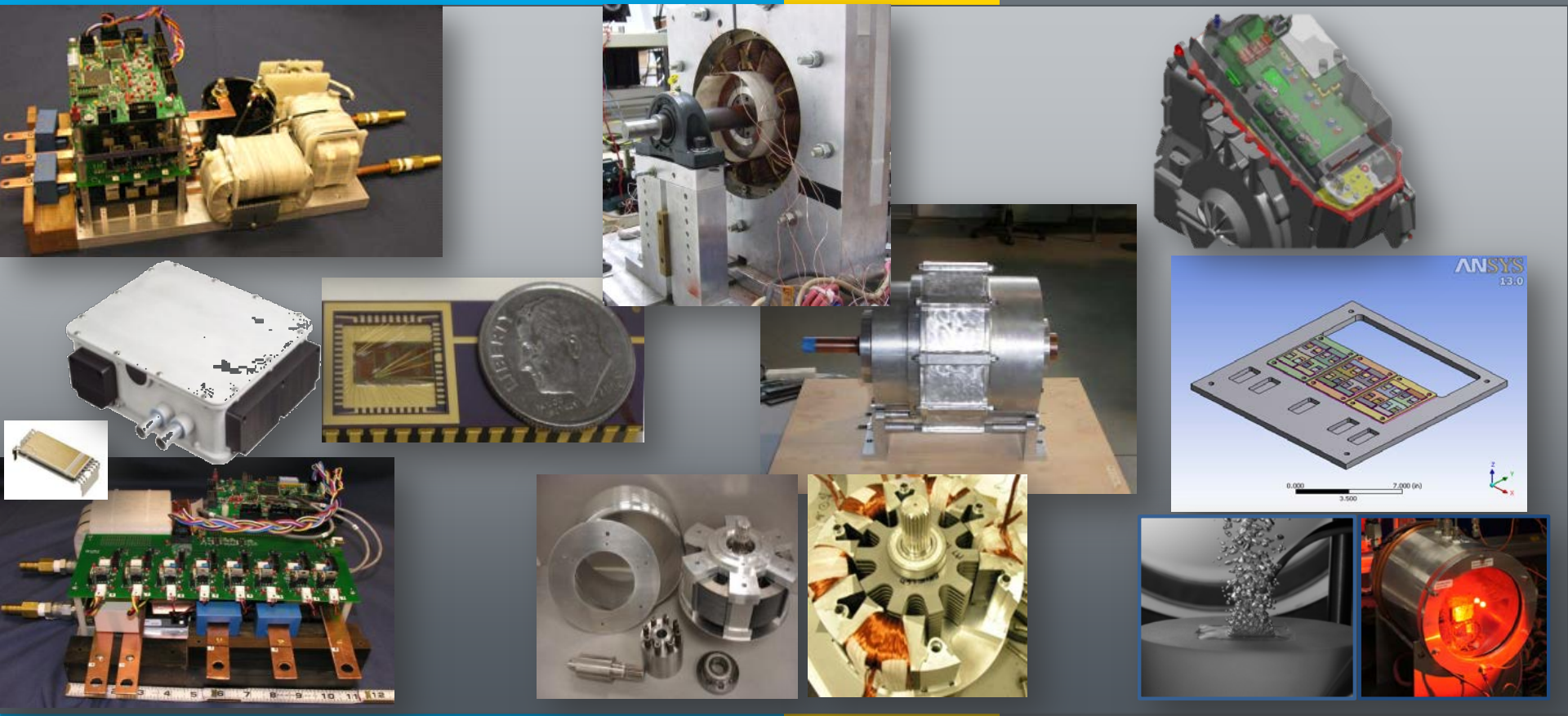
EV Everywhere Grand Challenge

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



Traction Drive Systems Breakout

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- DOE goals for Electric Traction Drive System (TDS) innovations must be disruptive innovation focused to meet the CY2022 price target ($20,000 →$25,000) for a mid-sized 5 passenger sedan having 5 year simple payback.

Enhanced Efficiency Reduced Cost Traction Drive System

EETT Roadmap: “Therefore, research is needed to develop technologies that are less expensive and, at the same time, smaller, lighter, more efficient, and equally reliable as conventional automotive technologies. “

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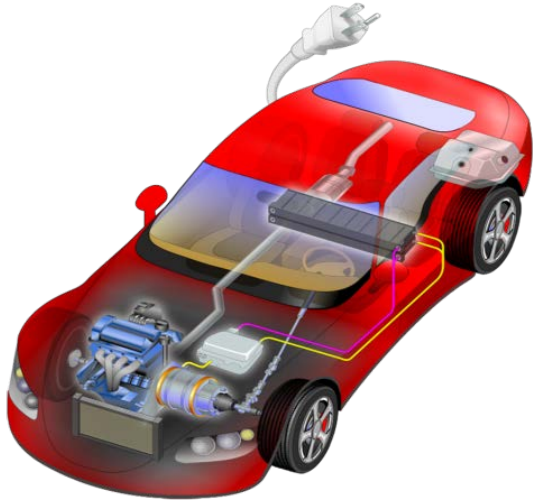
- Electric Traction Drive System (TDS) Big and Bold Innovation

– 5 key EERE Core Questions (source: David Danielson, assistant secretary, EERE)

1. Is this a high impact problem? (if deployed, will it matter)
2. Will EERE funding make a large difference relative to what private sector is already doing?
3. Focus on the broad problem you are trying to solve and be open to new ideas, new approaches, and new performers? (disruptive innovation)
4. Will EERE funding result in enduring economic benefit to the U.S.?
5. Is this something best left to the private sector to address on its own?



Identify TDS innovation impact areas

Breakthrough opportunities

Push the envelope

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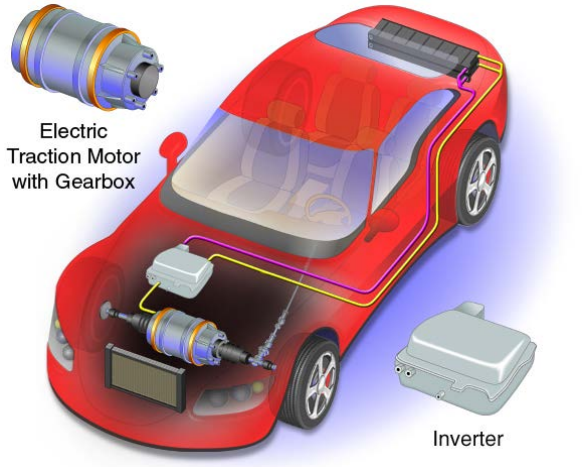
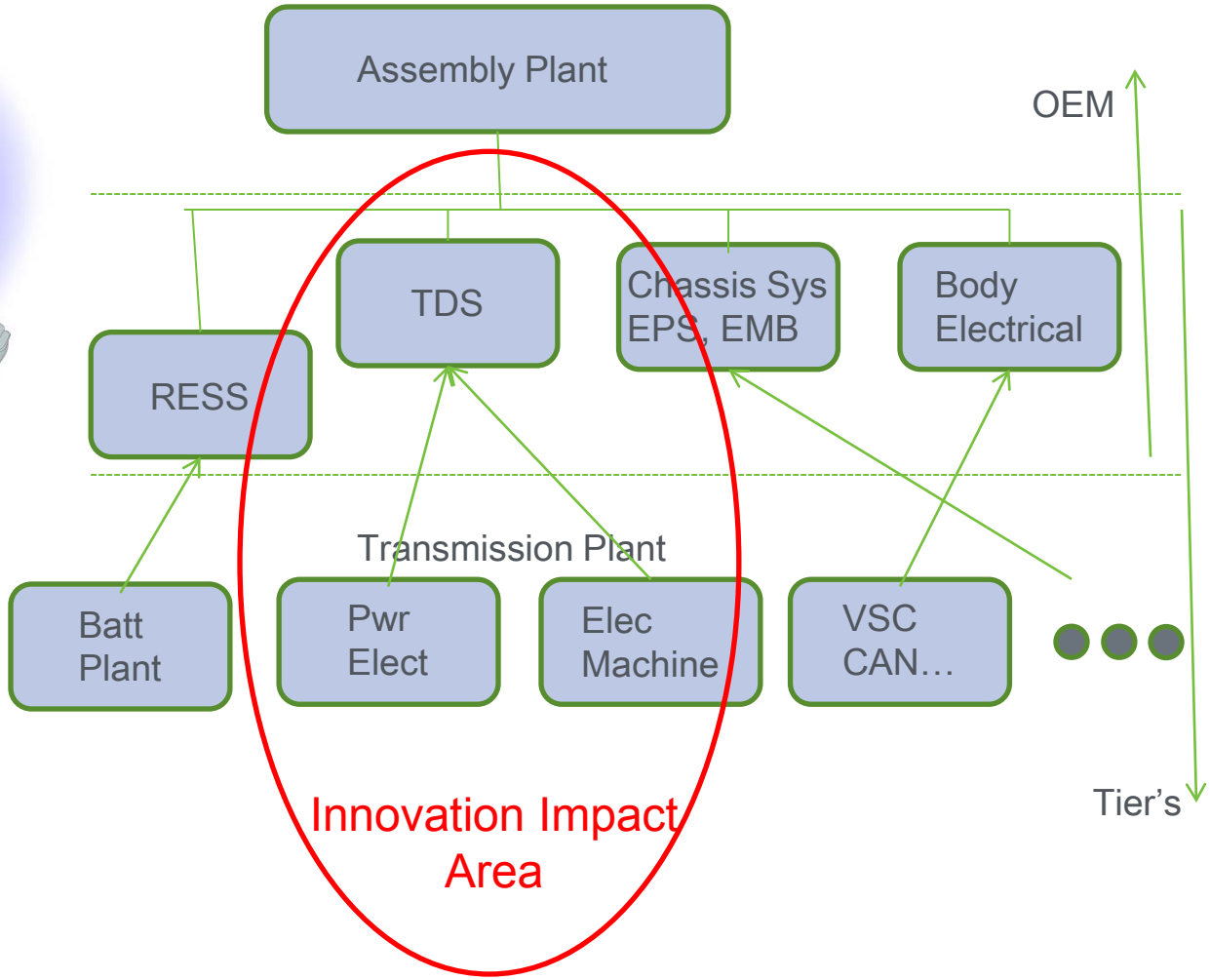
- Electric Traction Drive System (TDS) disruptive innovation big picture view





TDS Musts:

Understand mission

Focus on interfaces

Execute powertrain matching at lowest cost and highest efficiency

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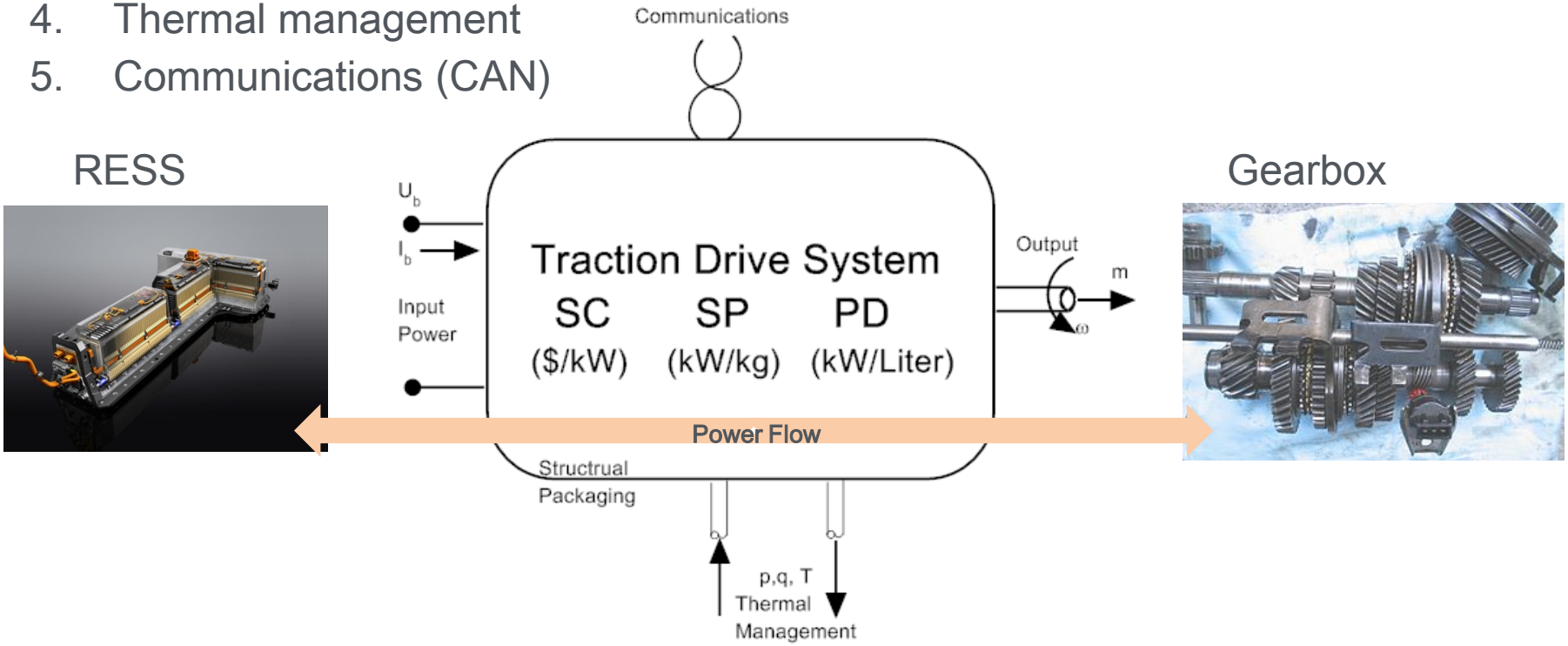
The 5 Interfaces of an Electric Traction Drive System (TDS):

1. Input power (from RESS)
2. Output power (to driveline, generally single speed gearbox)
3. Structural & packaging (transaxle)
4. Thermal management
5. Communications (CAN)



Higher operating voltage
Dc link @ 800V→1200V

Breakthrough Opportunities

Higher output speed
Gearbox input >14krpm

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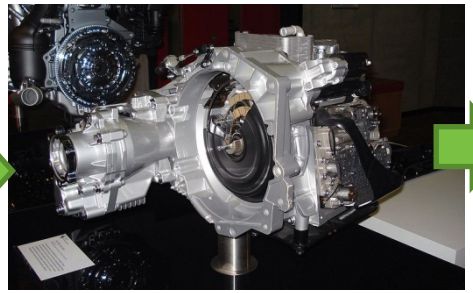
- Conventional vs. Electric TDS
- ICE Comparator: Ecoboost GTDi 1.6L, 134kW, 244Nm, 114kg, SP=1.18kW/kg
- Transmission: 6 spd, DCT, ~80kg for total powertrain mass: 194 kg

Fuel



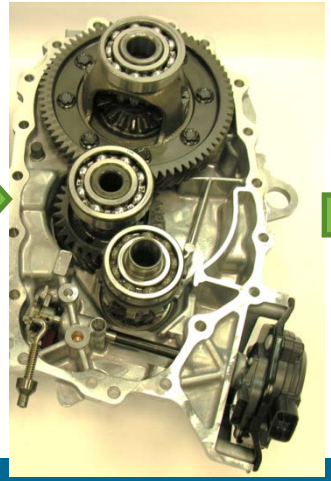
Wheels

1.6L Ecoboost, 6spd DCT

ICE	Engine	Trans	Metric
Power, Mass	134 kW 114 kg	6 spd 244 Nm ~80 kg	engine SP=1.18 (kW/kg)
EDS	Elec Machine	Power Elect	Metric
Power, Mass	80 kW 58 kg	1 spd 280 Nm, 16.2 kg	E-Mtr SP=1.38 (kW/kg)

- Electric TDS exemplar
- Nissan Leaf 2011, IPM 80kW, 280Nm, 10,390rpm, 58kg, SP=1.38kW/kg

Battery



Wheels

Leaf 80kW IPM, 110 kVA PCU

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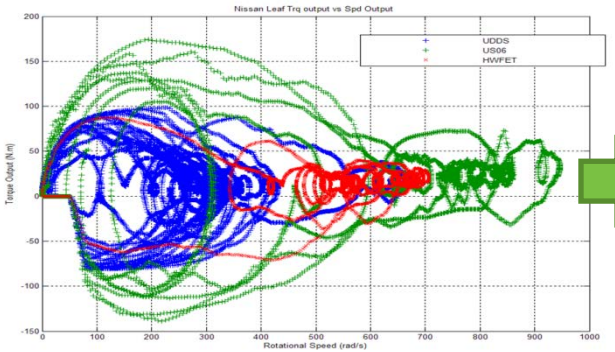
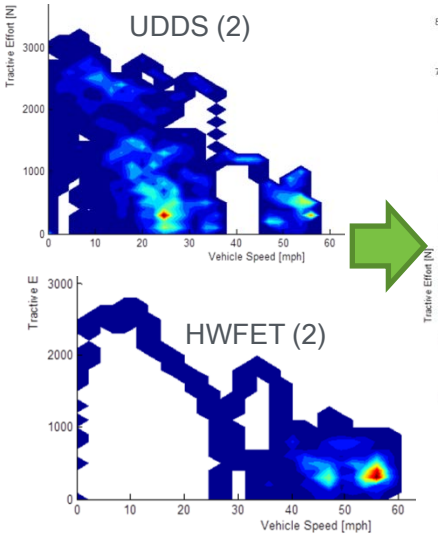
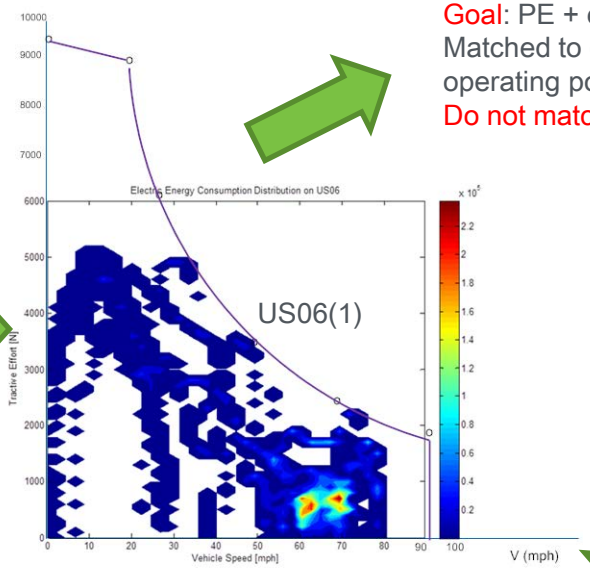
- System level analysis to identify TDS cost and efficiency opportunity
- Model real world driving: UDDS(2)+US06(1) + HWFET(2)
- Translate BEV tire load to TDS
- Breakthrough opportunities revealed







Goal: PE + e-mtr efficiency Matched to driveline operating points
Do not match at present

Match the hardware to the mission

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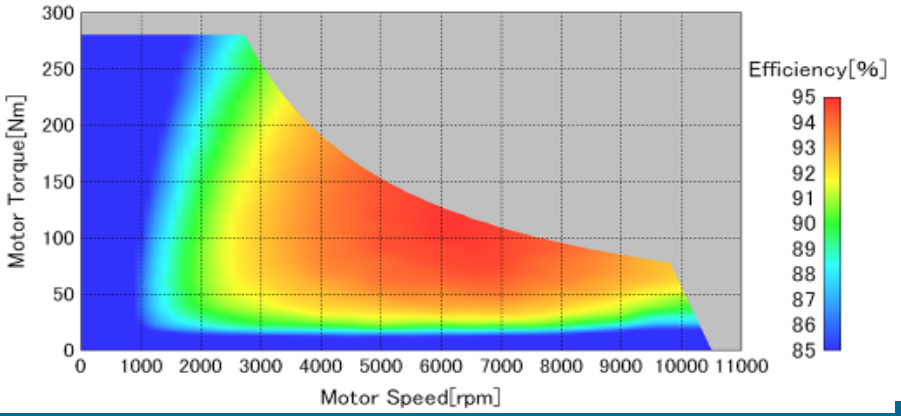
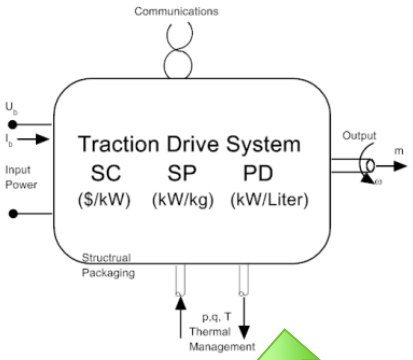


Enhanced Efficiency Reduced Cost

Wrap up:

Architectural Elements of a Electric Traction Drive System (TDS)



Traction Drive System Controls for High Efficiency

Power Electronics Subsystem Higher Voltage for Low Cost

Electric Machine Subsystem Higher Speed for Low Cost

* Vehicle System Level Modeling and Simulation
* Control of Functionally Integrated Subsystems
* RT Efficiency Optimization

* PSD for 800V<Ud<1200V for enhanced efficiency
* Gate Drivers & Sensors
* Integration Opportunities for Inverter/Converter/OBC

* EM's for >14,000 rpm
* Materials for Reduced Core and Winding Loss
* Designs that Meet System Level Efficiency Matching

Breakout plan and Questions

1. EV everywhere scope & technical targets
   - Current state of the art
   - Are performance and cost targets achievable?
   - Major pathways to achieving cost and efficiency targets?
   - Major Barriers?
2. Indentify needs/game-changing ideas
   - Highest impact critical technology breakthroughs needed?
   - “out of the box”, risky approaches?
   - Each participant should propose a single research idea or concept!
3. Action plans and preparation of slides for plenary session and report
   - System level considerations: TDS, PE & Motor interface to battery and other groups
   - What advances in other groups enable success in TDS area?