

CERV 2023: Technology Solutions for Future In-Road WPT

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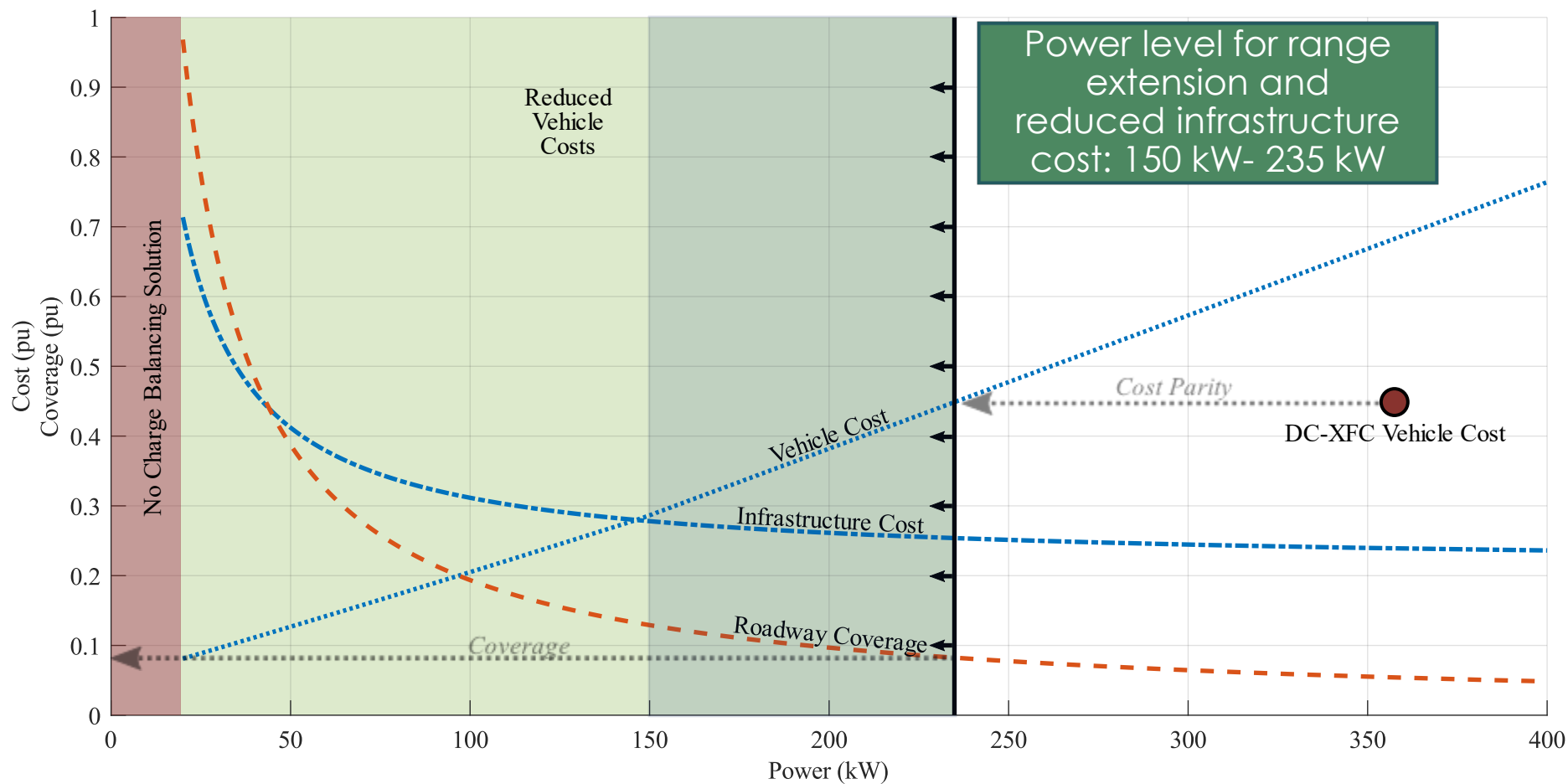
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High Level Cost for LD EV

LD Vehicle Assumptions	
Average Speed	65MPH
Minimum Battery Capacity	37kWh
DC-XFC Battery Capacity	112kWh, 4C Δ SOC=80%

Minimum Coverage DWPT Solution	
Power	235kW
Battery Capacity	59kWh*
C-Rate	4.0
Roadway Coverage	8.2%
Electrified Miles	5,500 Miles

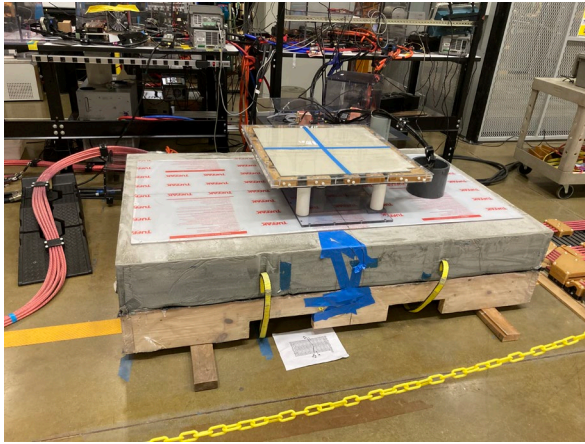


Total paved miles – 4.2 Million

- 1.6 % of total paved miles or 67,200 miles – primary roadways
- 8.2 % of primary roadways or 5,500 miles – electrified roadway

*Battery charge rate limited to 4C

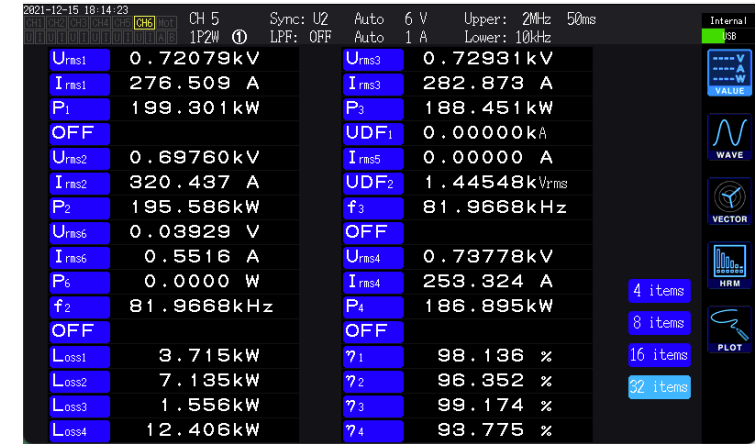
ORNL High Power and Dynamic Wireless Charging of Electric Vehicles



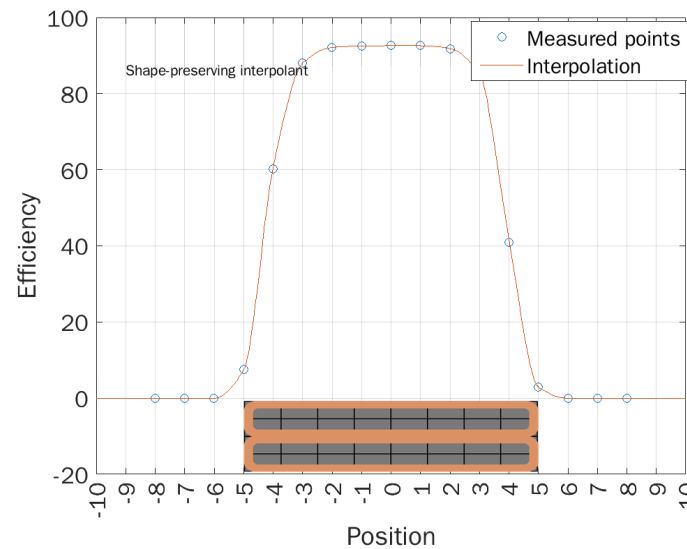
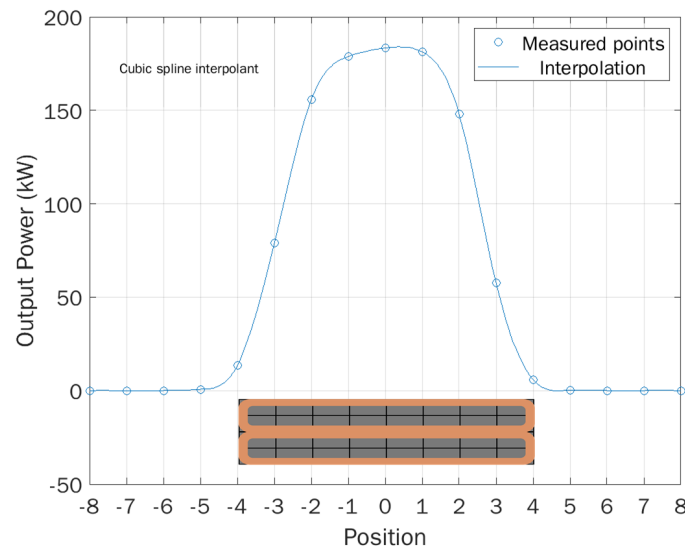
200 kW DWPT system with transmitter set in precast Master flow Epoxy Grout



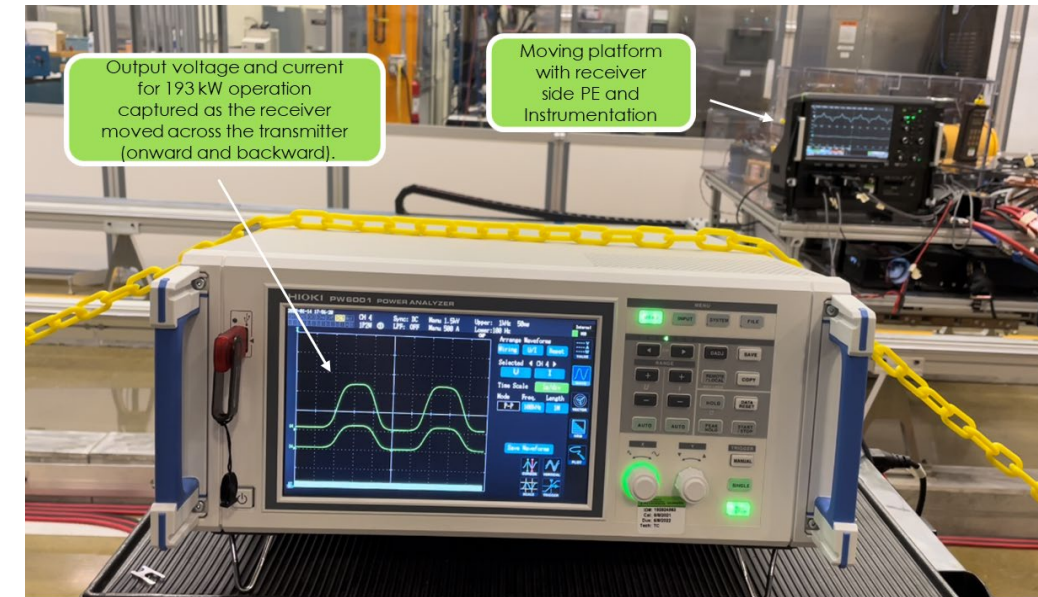
200 kW DWPT system with the receiver coil mounted on Hyundai Kona



Power analyzer reading for 186 kW output without vehicle coil mounted.



Profile of measured output power and efficiency of 200 kW dynamic charging system measured along the length of the transmitter at discrete points

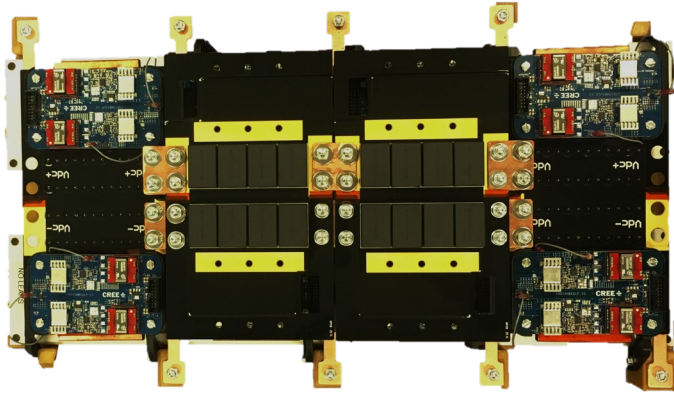


Dynamic inductive charging setup in the laboratory

Some Key Challenges and Important Questions

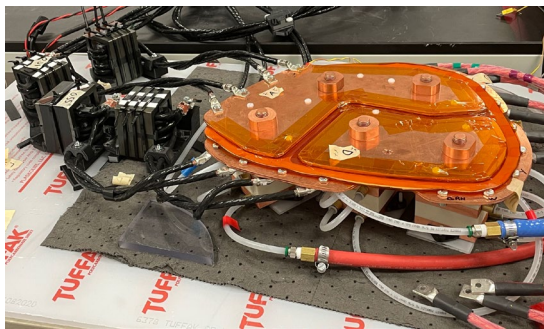
Grid interface

Power Electronics



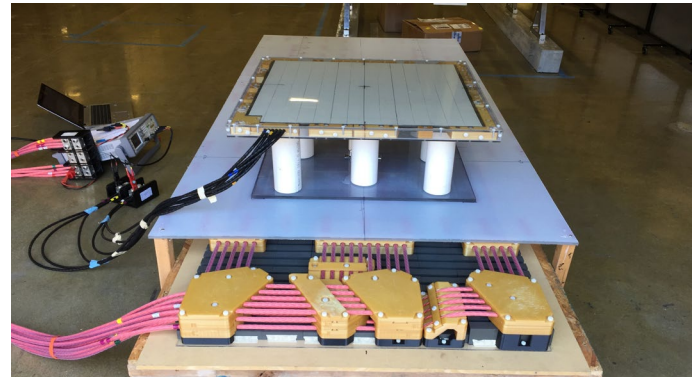
Challenges

- Control and protection at highway speeds
- Lack of fast and robust primary side control techniques
- High-frequency, High-current, high-voltage components



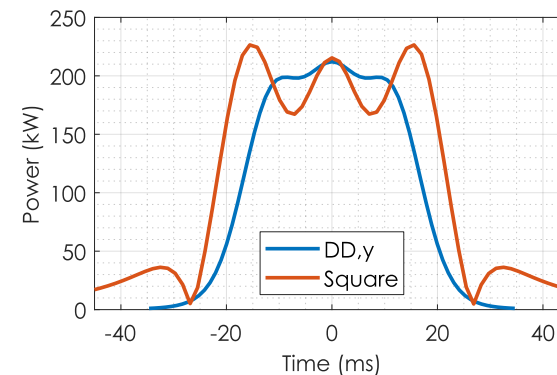
Liquid cooled resonant capacitor

Transmitter and receiver



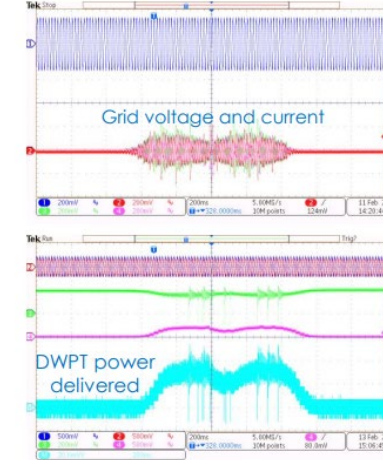
Challenges

- How do we integrate with the roadway?? (Installation, maintenance, serviceability, Asphalt, life-cycle, recycling)
- Interoperability
- Power density and specific weight

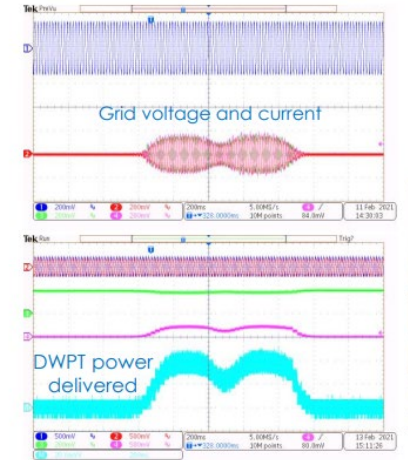


Power transfer profile of DD and Square coil

Conventional Grid-interface Control Scheme



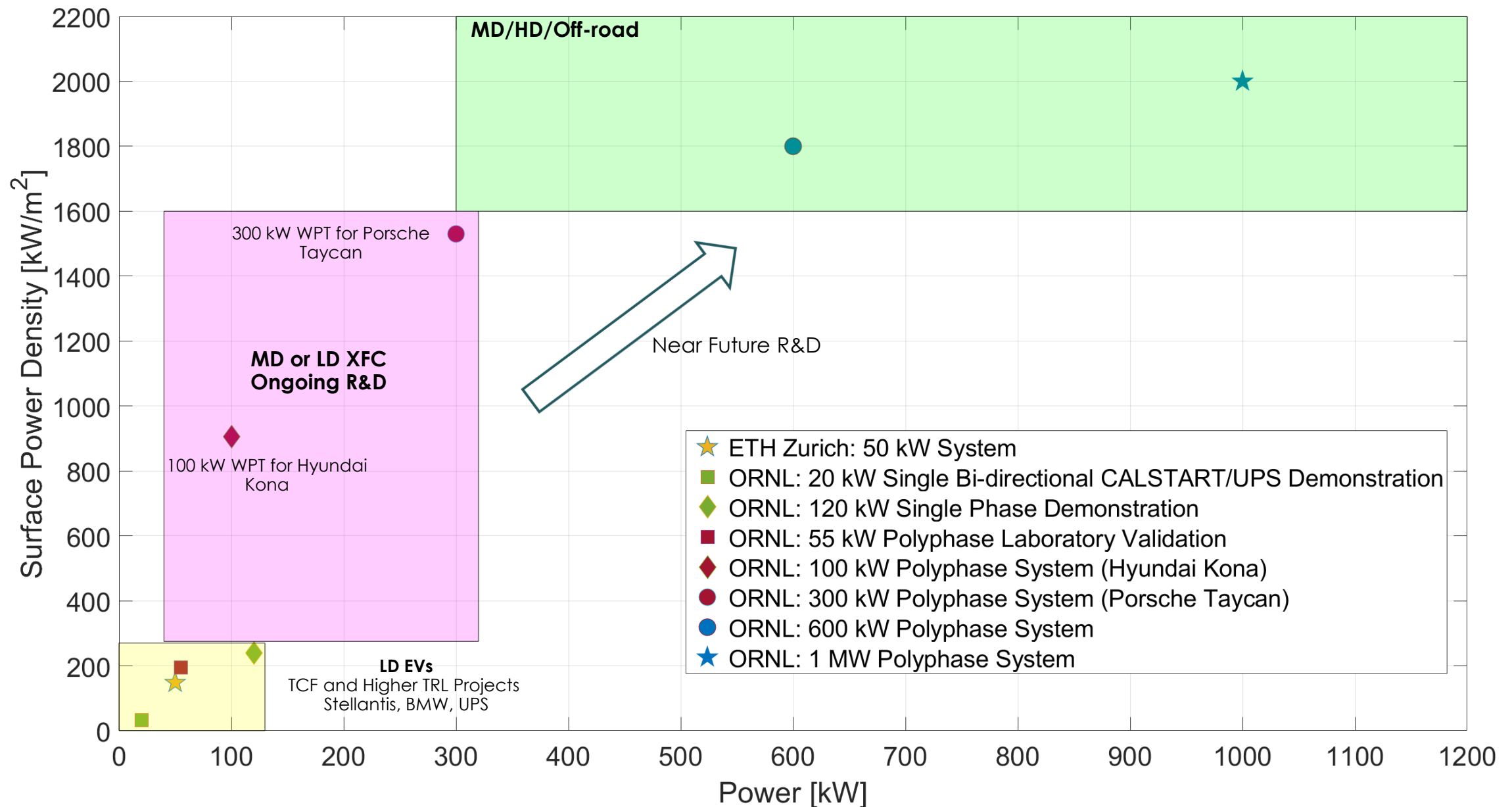
Proposed Grid-interface Control Scheme



Challenges

- Grid capacity
 - Augmentation with energy storage
 - Upgrades
- Can MV connected DWPT system mitigate grid impact and reduce cost?
- Can DWPT distribute the load on the grid?
- Can DWPT enable creature comforts during inclement weather and traffic congestion?
- Bi-directional for kinetic energy recovery and transfer to grid?

ORNL – Stationary WPT Evolution and Roadmap



Power transfer level and surface power density of state-of-the-art stationary wireless power transfer systems

Acknowledgement

1. US DOE VTO (Lee Slezak)
2. ORNL WPT Team Members and Program Managers
3. NREL and NREL partner on high-power dynamic wireless charging project
4. Partners and participants of DOE VTO EVs@Scale Consortium

Questions

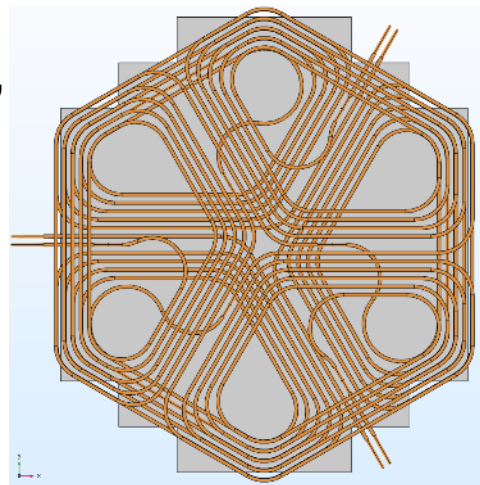


Polyphase WPT System for XFC

- Polyphase WPT Systems

- Single-phase systems “pulse” power across the airgap
- Low space-time average utilization since fields oscillate between peak values and zero

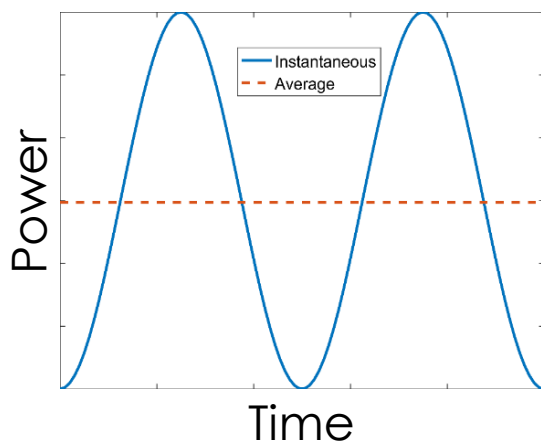
Polyphase coupler wiring



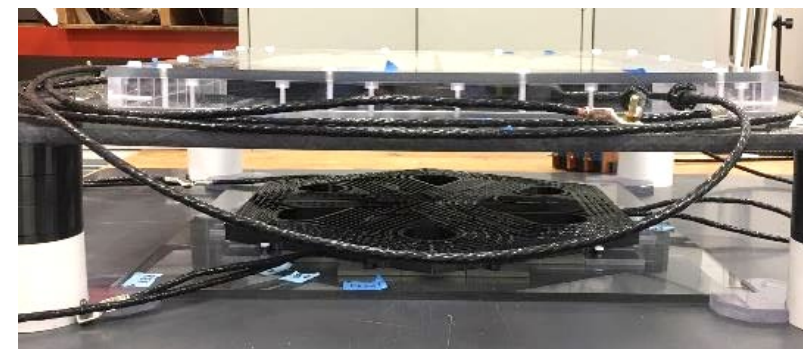
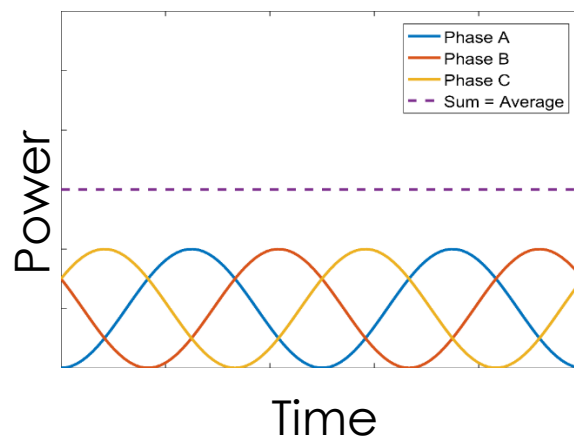
- Polyphase systems using rotating fields for constant power transfer
- Phase shifted excitation and spatially shifted coils
- Much higher power density due to improved space-time field utilization
- Lower current ripple



Instantaneous and average power variations for conventional circular couplers



Instantaneous and average power variations for polyphase coupler



Any proposed future work is subject to change based on funding levels