Improving Energy Efficiency in Mobility: High-Power Charging for Medium/Heavy Duty Electric Vehicle Fleets

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Who is Rhombus Energy Solutions?

- We are industry leaders in advanced power conversion
- Our expertise is bidirectional high-power inverters for V2G EV charging, energy storage and microgrids
- We provide solutions for:
  - Transportation Electrification (Medium/Heavy Duty Fleet EV Charing)
  - Energy Storage Systems For Power Load Leveling
  - Microgrids, with Integrated Energy Management Capabilities
- We are headquartered in San Diego with high-power testing/mfg in Dearborn and an India design center
- Rhombus has deployed over 820 systems worldwide

Rhombus: The Expert in V2G Charging for EV Fleets
Vehicle Electrification is Real—Especially for Medium/Heavy Duty Fleets

- Fleet sales: Growing % of US vehicle sales (17% to 19%, 2013-2019)
- M/HD trucks: 2% of US vehicle sales, but 24% of US fleet sales
  - School buses: 40K sold in US (2019)
  - 118K medium-duty trucks sold in US (2019, not including buses)
- US electrification trends:
  - School buses: 3% now, 68% by 2040
  - Transit buses: 18% now, 68% by 2040
  - Med-duty trucks: 7% by 2030
- V2G is critical to these fleets
What is Vehicle to Grid (V2G)?

• V2G utilizes the energy stored in the batteries of electric vehicles (EVs) to augment the electrical grid during peak load hours
  • EVs return at the end of the shift and connect to a bi-directional charger
  • The charging system communicates with the grid and puts power back into the grid (at a premium)
  • The EVs then recharge in the night during super-off-peak load hours at a lower per-watt-hour price
• This significantly reduces EV fleet energy cost
Why is V2G Compelling for EV Fleets?

- An EV auto with 85kWh battery can store nearly 3 days of the power consumed by an average US home
- An 155kWh EV school bus can store over 5 days of the power consumed by an average US home
- A long-distance EV transit bus can store up to nearly 23 days of the power consumed by a US home

*Putting energy back onto the grid can significantly reduce fleet energy costs*
Why Is V2G Challenging?

- V2G implementations are complex. They involve:
  - The **EV Owner**
  - The **EV Manufacturer**
  - The **EVSE** (charging system) manufacturer
  - The **Aggregation** software vendor
  - The **Grid Operator** and **Utilities**
    - Utility DSO (Distribution System Operator)
    - Utility TSO (Transmission System Operator)
  - Industry “groups” creating competing standards
- The lack of comprehensive standards means that every current V2G implementation is a “one-off”
Rhombus: State-of-the-Art V2G Chargers

• Rhombus “smart” bidirectional charger are the gateway to the utility grid
  • Chargers controls power flow and direction, communicate to aggregator, grid and EV user

• Our V2G chargers support multiple communication paths
  • Measuring, Monitoring, and Metering for demand energy characterization
  • Advanced electric vehicle communication link (ISO15118)
  • Aggregator platform and back-end service provider connections

• Rhombus V2G chargers meet current certifications/standards
  • e.g.: UL 1741-SA, IEEE1547, UL 2202, UL 2231, UL 9741…

• Rhombus V2G chargers are built to support M/HD EV Fleets
  • Industrial rated design to reliably operate at full power continuously day and night
  • Easily maintained and serviced if problems occur
  • Remote diagnostics/prognostics to reduce downtime and prevent issues before they happen