



# **Development and Demonstration of Grid Integration System for PEVs, ESS, and RE**

## **Cooperative Research and Development Final Report**

**CRADA Number: CRD-13-515**

NREL Technical Contact: Tony Markel

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## Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article XI, A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

**Parties to the Agreement:** Ideal Power Converters, Inc.

**CRADA Number:** CRD-13-515

**CRADA Title:** Development and Demonstration of Grid Integration System for PEVs, ESS, and RE

### **Joint Work Statement Funding Table Showing DOE Commitment:**

<b>Estimated Costs</b>	<b>NREL Shared Resources</b>
Year 1	\$25,000.00
TOTALS	\$25,000.00

### **Abstract of CRADA Work:**

NREL and Ideal Power Converters (IPC) will jointly develop and demonstrate a hybrid power converter system integrating bi-directional electric vehicle charging, photovoltaic generation, and stationary battery storage using IPC's 3-Port Hybrid Converter. The organizations will also jointly investigate synergies in tightly integrating these separate power conversion systems.

### **Summary of Research Results:**

The Electric Vehicle Grid Integration team at the National Renewable Energy Laboratory (NREL) has collaborated with IPC to demonstrate vehicle to grid (V2G) operations with an IPC bi-directional inverter. An Azure Dynamics TransitConnect electric vehicle was modified to have bidirectional charging capability, and to accommodate both SAE J1772 combo and CHAdeMO standard power interface connections. IPC provided a TERN embedded system board and an inverter that has three ports (one AC port and two DC ports) for testing purposes. The efficiency of the 3-port inverter was tested with various power levels during vehicle charging and discharging modes. To support testing, NREL interfaced an embedded control board with CAN messages from TransitConnect EV and analog signal inputs for CHAdeMO hardware handshake sequences.

NREL performed tests for efficiency of the 3-port inverter with various power levels during charging and discharging and implemented codes for the embedded board that interface with CAN messages from TransitConnect and analog signal inputs for CHAdeMO hardware handshake sequences. The efforts demonstrate that general solar inverters, like the IPC inverters, can be interfaced with electric vehicles to enable bi-directional power transfer. The IPC inverter

enables smart charging management with integration with renewable by enabling one DC port to serve a solar photovoltaics connection and the other connected to the battery of a vehicle. Research did identify remaining challenges to be addressed for full V2G bi-directional features and enabling vehicles to participate in grid frequency regulation markets in an integrated way with building energy management.

**Subject Inventions Listing:**

None

**Report Date:**

4/18/2016

**Responsible Technical Contact at Alliance/NREL:**

Tony Markel

**Name and email address of POC at company:**

John Merritt, [John.Merritt@idealpower.com](mailto:John.Merritt@idealpower.com)

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