



## **Hybrid 320 Ton Off Highway Haul Truck: Quarterly Technical Status Report 11, DOE/AL68080-TSR11**

This eleventh quarterly status report for the Hybrid Off Highway Vehicle (OHV) project, DOE Award DE-FC04-02AL68080 presents the project status at the end of June 2005, and covers activities in the eleventh project quarter, April 2005 – June 2005.

### **Project Management**

Customer and production demands continue to challenge the project staffing requirements. GE has been working with a temporary staffing firm to alleviate this resource shortage and hired a contractor to provide assistance with development and testing at GE Rail in Erie, PA. The contractor provided several weeks of service starting at the end of April, but has since been unable to provide services as he had several family emergencies to tend to. The contractor is expected back in early September and is planned to assist in the integration effort at the Proving Grounds, as he is very well qualified for this effort. An additional contractor is currently being sought as a replacement for the development and testing work at GE Rail and for potential follow-on work at the Proving Grounds.

A design review was held in May to coordinate all parties with regard to the integration of equipment on the vehicle. Several items were identified requiring further investigation and actions have been taken. The team plans to begin modifying the vehicle next quarter and to complete integration of hybrid components by year-end.

The system validation date, last reported to occur in early 2006, is expected to occur in the first half of calendar year 2006. Both GE and Komatsu are committed to a successful system validation of hybrid technology and are working to achieve this goal.

### **Technical Status**

#### ***Full-scale testing***

Full-scale testing has been on hold due to the unavailability of the contractor resource responsible for leading this effort, as described in the Project Management section, above. GE Global Research is making plans to send staff from Global Research in Niskayuna, NY to help fill in this gap. An additional contractor is also being sought.

#### ***Truck Integration***

A final design review was held in May at the battery enclosure fabricator, CBM Fabrications. Present were Komatsu, GE Rail, GE Global Research and CBM. Several items required further investigation and work has proceeded in this area.

The battery enclosure and cooling enclosures have been designed and are nearly ready for fabrication. Few finishing details are required before fabrication of the enclosure begins. The hybrid control group enclosure is close to completion and components will be populated and wired next quarter. Komatsu is working to align the truck support modifications with the battery enclosures and hybrid control group.

The physical size and weight of the smoothing reactors (inductors) was finalized and verified to fit within the truck integration spaces available. With this finalized, the reactors were ordered and Komatsu is working to design the support modifications required to integrate the reactors into the truck.

#### ***Life testing***

MES-DEA, manufacturer of the ZEBRA battery, has been actively testing ZEBRA cells, as they will be applied in the system validation. Two operating points are being investigated: a nameplate operating point,



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DOE/AL68080-TSR11

and a high charge power operating point. The test measures charge resistance and discharge resistance at critical portions of the profile. Resistance rise will be the dominant factor in determining useful life of the battery system. Excessive resistance will limit the power rating of the system and generate excessive heat causing decreased hybrid benefits and thermal failures of cells.

The normal operating point utilizes the ZEBRA battery at 32kW per Z12 for 384kW total hybrid system power. The test applies the power we expect to see from the Proving Ground route as calculated by GE's mission analysis model. The test has successfully reached 710 nameplate cycles (9750 OHV cycles, or about 6 months time) with minimal resistance rise.

The high charge power test, at 50kW per Z12, is continuing, though the stability of the cell resistance is degrading. It is becoming clear the data sheet specifications are likely the maximum operating point for continuous duty. The test, however, has achieved over 3,000 cycles with acceptable resistance rise and high power testing is still planned during proving ground system validation.

Because vibration is always present in OHV applications, a shaker table test was performed at GE Rail to investigate the battery's performance. The MES-DEA ZEBRA batteries utilize materials that are solids at room temperature and must be heated above their melting point to become active cells. A cold test was first carried out to understand the mechanical impact of vibration. After the test, the battery was disassembled and minor wear marks were noticed, but no failure of structure was evident.

A hot test was performed to simulate long-term performance of the battery at temperature. During the test, the Z5 battery experienced an internal electrical short causing high currents to flow. Based on analysis of the fault and the inclusion of vibration isolators into the mounting structure of the battery enclosures, the OHV team is confident that the battery will survive system validation testing. However, improvement of the battery technology will be required for commercialization and long life. The GE hybrid locomotive team is currently pursuing improvement strategies based on the results of this test.