Developing and Evaluating Advanced Vehicle Technologies

Challenge

Development and testing of advanced vehicle technologies and components requires a sophisticated systems approach that is capable of integrating elements from different sources. The ability to benchmark individual components and integrated systems is critical to assessing current and developing advanced and hybrid electric vehicle (HEV) technologies. The systems, facilities, and personnel necessary to perform these tasks are expensive. Where can manufacturers turn for dependable evaluation support and cutting-edge technology development?

Argonne's Answer

Argonne National Laboratory conducts emissions and energy-efficiency research and development on HEVs, sport-utility vehicles, and advanced technology vehicles. Argonne's Advanced Powertrain Research Facility (APRF) and other facilities (Figure 1) are available to support model development, component modeling and vehicle simulation, hardware-in-the-loop testing, and technology development and validation. Capabilities and equipment include the following:

- Light- and heavy-duty engine dynamometers
- 2WD and 4WD chassis dynamometers
- Battery/fuel cell emulator (150 kW)
- Precision-controlled environment
- Super-ultra-low-emissions vehicle (SULEV) emissions measurement capability
- Low-emissions raw emissions measurement bench
- Ultra-fast (<5 ms) hydrocarbon and nitrogen oxides measurement
- Fast (10 Hz) direct fuel measurement
- Fast (10 Hz) particulate measurement; unique laser-induced incandescence measurement
- Mini-dilution particulate matter measurement
- Scanning mobility particle sizer

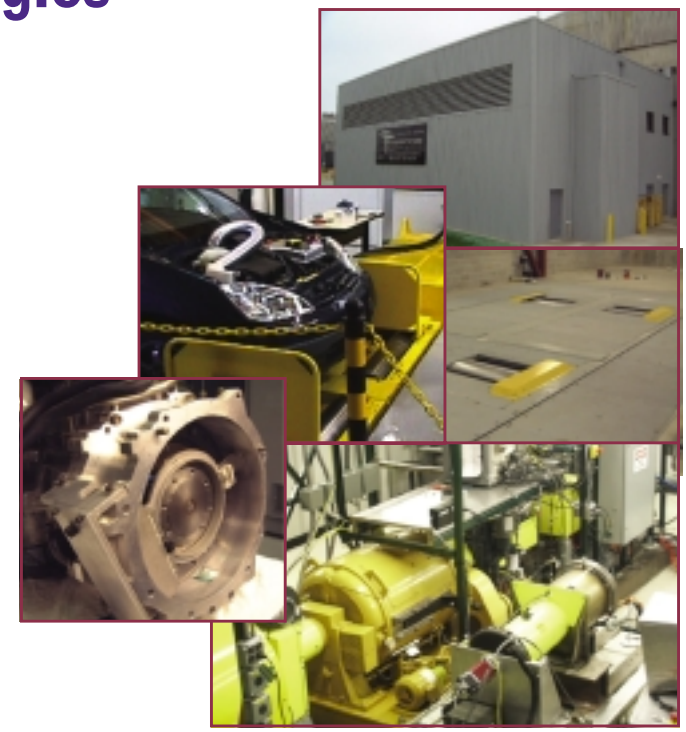

Figure 1. Component, subsystem, and vehicle testing and development are supported at Argonne's state-of-the-art facilities.

Component Modeling and Vehicle Simulation: Advanced batteries, fuel cells, engines, control systems, and vehicles have been modeled, developed, and tested at Argonne for several decades. Argonne's unique combination of analytical, development, and testing experience is reflected in the latest version of Argonne's simulation software, PSAT® 5.0, which offers:

- Software to predict performance, fuel economy, and emissions for conventional and hybrid vehicles
- Forward modeling approach that realistically represents how systems respond (i.e., how driver input influences vehicle response)
- Flexible, open architecture to easily integrate component models
- More than 180 predefined configurations
- Standard domestic and international driving cycles
- Interactive post-processing tools (including data import, animation, and validation)
- Validated driving cycle results and transient component behavior for fuel economy and emissions

Hardware-in-the-Loop Testing and Rapid Control Prototyping: Argonne employs the latest hardware-in-the-loop (HIL) techniques (Figure 2) to cost-effectively evaluate new technologies and control strategies in an emulated vehicle environment. Argonne is the lead laboratory for HIL and technology validation for the U.S. Department of Energy (DOE). HIL provides the ability to:

- Integrate components or propulsion systems in Argonne's test facilities and subject them to realistic loads, using simulated conventional, electric, and hybrid vehicles in almost any configuration
- Rapidly design, prototype, and optimize control strategies by using Argonne's vehicle simulation and control software (PSAT-PRO©)
- Use precision models, cutting-edge measurement devices, and specially designed post-processing tools to ensure accurate and valid results

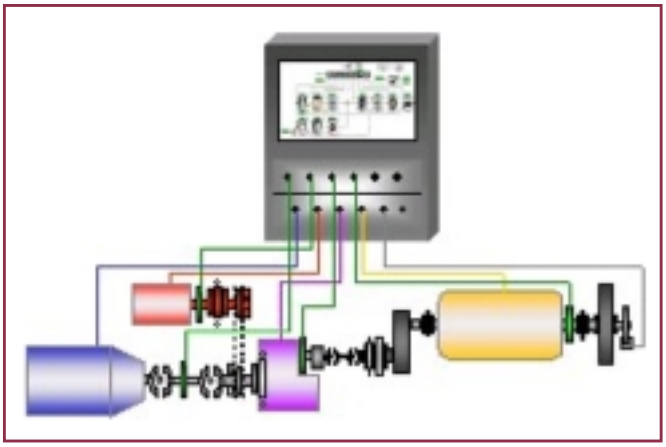

Figure 2. Hardware-in-the-loop integrates real hardware in an emulated vehicle environment.

HEV Test Capabilities: Argonne's modular testing environment allows for easy interchanging of powertrain components without the need for complete system teardowns. The facility is based on a 190-hp motoring dynamometer, which is controlled by an Argonne-designed computer system that simulates the behavior of a vehicle under any driving cycle. The dynamometer maps the energy flows through the individual components and through the powertrain system as a whole. It can also add power to the system to simulate conditions like regenerative braking. Simultaneous emissions testing is built into the test bed configuration. DOE will use data from APRF to verify HEV simulation programs and to test prototype systems developed by DOE research partners.

Four-Wheel-Drive Chassis Dynamometer Testing: Argonne's state-of-the-art 4WD chassis dynamometer offers controlled testing capabilities for highly accurate measurement of exhaust emissions and fuel economy performance. This facility can benchmark the most advanced powertrains for 4WD cars and trucks, including SULEVs, hydrogen- and natural-gas-fueled vehicles, diesel engine vehicles, and those using alcohol fuels. It also incorporates a dilution tunnel for measuring diesel particulate matter.

Impact

Argonne's superior testing, modeling, technology development, and evaluation capabilities are helping vehicle manufacturers increase the energy efficiency of their products. Because a large percentage of our nation's foreign oil consumption is used for transportation purposes, improvements in energy efficiency will help decrease our dependence on imported oil.

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