

OFFICE OF TRANSPORTATION TECHNOLOGIES

ADVISOR . . . Why Does DOE Require a Simulation Tool?

Hybrid Electric Vehicle (HEV) development requires decision-makers to quickly narrow the technology focus to the best vehicle configurations and components. Systems analysis, based on effective computer modeling tools, enables the study of trade-off between candidate subsystems during the technology selection process. The computer models facilitate the preparation of specifications for each candidate subsystem and support the establishment of engineering targets for building and testing prototype automobiles.

NREL Developed ADVISOR to Meet a Research and Development Need

One of the most widely used computer simulation tools for HEVs is the ADvanced Vehicle SimulatOR (ADVISOR) developed in 1994 by the National Renewable Energy Laboratory (NREL). ADVISOR can predict vehicle performance, energy consumption, emissions output, control strategy function, and average component efficiencies over urban and highway driving cycles. It can simulate conventional, electric, and hybrid vehicles and quickly perform parametric and sensitivity studies. As ADVISOR evolves to meet the changing needs of the vehicle design teams, ongoing testing and validation continues to ensure that it maintains its usefulness as a simulation tool. ADVISOR has gained credibility through benchmarking against the Ford, GM, and Chrysler proprietary models, as well as the

Partnership for a New Generation of Vehicles (PNGV) Systems Analysis Toolkit. ADVISOR has also been validated using data from a number of student-built "Future Car Challenge" HEVs from engineering colleges and universities around the country.

ADVISOR uses simple physics and measured component performance to model existing or conceptual vehicles. The user defines a vehicle using overall vehicle data, and prescribes a speed versus time trace, along with road grade, that the vehicle must follow. ADVISOR then puts the vehicle through its paces, making sure it meets the cycle to the best of its ability and then can calculate predicted torque, speed, and power passed from one component to another.



Success Stories: ADVISOR Provides Assistance with HEV Design Decisions

Over 750 users worldwide have downloaded ADVISOR from the Internet, and its usage continues to grow each day. ADVISOR's non-proprietary nature and free distribution has made it the vehicle simulator of choice for many organizations, with applications illustrated by the following:

- General Motors sized HEV components by combining data collection with ADVISOR simulation. The team collected velocity and grade data on a stretch of mountainous highway and then used the information in simulations to help determine the minimum size for its HEV heat engine and batteries.
- Using the ADVISOR program as a foundation, Chrysler engineers developed a customized simulation model that integrates complex HEV hardware configurations and design validation.

How Does it Work?

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- Was the vehicle able to follow the trace?
- How much fuel and/or electric energy were required in the attempt?
- What was the peak power delivered by the drivetrain components?
- What was the distribution of torque and speeds that the piston engine delivered?
- What was the average efficiency of the transmission?
- At what road grade can the vehicle maintain 55 mph indefinitely?
- What's the smallest engine that can be put into this vehicle to accelerate from 0 to 60 mph in 12 seconds?

- ADVISOR was utilized by an SAE Task Force, formed to develop a "recommended practice" for testing the exhaust emissions and fuel economy of HEVs. Physical testing on dynamometers was not practical; virtual testing, using ADVISOR, saved time and money. The Task Force used the ADVISOR simulation software to validate previous performance assumptions and recommended changes to the standard procedure.
- ADVISOR is being used to facilitate PNGV selection of technologies that will be used in the year 2004 concept car. For example, ADVISOR was used to rank a list of candidate PNGV drivetrain technologies and evaluate how well they help achieve the fuel economy goal of 80 mpg.

- What's the final drive ratio that minimizes fuel use while keeping the 40 to 60 mph time below 3 seconds?

ADVISOR is flexible enough to operate on most computer platforms in the commercially available MATLAB/SIMULINK graphical/object-oriented program. A new version of the model, ADVISOR 2.1, was recently released and can be downloaded from the Website: <http://www.ctts.nrel.gov/analysis>.

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