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AFDC UPDATE

News of the Alternative Fuels Data Center

NREL Research Brings Improved Technologies to the Road

The National Renewable Energy Laboratory's (NREL) Alternative Fuels Utilization Program, which is widely known for its alternative fuel vehicle (AFV) emissions information, is also doing much to bring better alternative fuel vehicles to the field. Many of the AFVs of tomorrow will include components developed through NREL's research, which is sponsored by the U.S. Department of Energy (DOE). Most of NREL's projects involve ethanol, methanol, natural gas, biodiesel, and propane, but researchers are also working on future fuels such as hydrogen and dimethyl ether. In this issue of *AFDC Update*, we highlight a few of these projects. Up-to-date fact sheets are available on line through the AFDC World Wide Web (WWW) site at: ***http://www.afdc.doe.gov/fuelutil/engoptim.html.***

IN THIS ISSUE

Light-Duty Vehicle Research and Development

Development of a Dedicated Ethanol Ultra-Low-Emission Vehicle (ULEV)

Although Detroit is bringing new flexible-fuel alcohol vehicles (vehicles that run on blends of gasoline and as much as 85% ethanol or methanol) to the market, many believe the lowest emissions and best performance may be obtained in dedicated alcohol vehicles. In a 3-year project that began in September 1993, researchers at Southwest Research Institute (SwRI) are optimizing a dedicated ethanol engine design to achieve ULEV standards.

"Instead of starting with a gasoline engine and compromising it to run on ethanol, why not design one for ethanol and take advantage of the fuel's characteristics?" said Lee Dodge, program manager at SwRI. Ethanol has a higher octane than gasoline does and can be run using a higher compression ratio, which increases fuel efficiency and driving range.

Three improvements in engine design have already been built into a Ford flexible-fuel Taurus. A compression ratio increase from 9.3:1 to 11:1 takes advantage of ethanol's high octane; air-assist injectors developed at SwRI (in place of the standard pintle injectors) improve fuel atomization and reduce fuel transport delays; and an engine controller developed at SwRI better controls the fuel-to-air ratio and spark timing.

Three types of advanced emissions controls are being investigated: an electrically heated catalyst plus a reformulated main catalyst; a hydrocarbon trap upstream of an electrically heated catalyst plus main catalyst; and a combined hydrocarbon trap and light-off catalyst followed by a main catalyst.

Very clean starts have been demonstrated with very few or no misfires, even at lower temperatures. Because alcohol does not vaporize when temperatures approach freezing, alcohol vehicles

How to Reach Us

- The AFDC World Wide Web address is **http://www.afdc.doe.gov**
- The *AFDC Update* newsletter is available on line 2 or 3 weeks before the newsletter is mailed at **http://www.afdc.doe.gov/news**
- Using a modem, dial **(800) 588-2336** with a vt100 emulator and type www. This takes you to the nongraphical LYNX browser. You don't need a user ID or a password.
- To speak to a human being, call the National Alternative Fuels Hotline at ***(800) 423-1DOE.***

inherently have problems starting in cold climates. NREL is looking at several approaches to solving this problem.

- The University of Tennessee designed and is building a rich combustor device, which burns methanol fuel into a gas stream rich in carbon monoxide and hydrogen. This allows the engine to start in temperatures as low as -30° C. This design will be applicable to ethanol vehicles as well.
- The Colorado School of Mines (CSM) is developing an on-board catalytic converter for converting ethanol into diethyl ether to assist in cold-starting. In this effort, CSM has constructed a bench-scale catalytic reactor and an on-line analytical system, and it has tested several catalyst materials.
- Researchers at Arthur D. Little, Inc., are developing a compact partial oxidation reactor as a fuel system component to improve cold-start ability. A 3.1-liter test engine based on the Chevrolet Lumina is being installed in an environmental chamber to simulate cold starts at temperatures as low as -20° to -40° C.

Development of a Dedicated Propane ULEV

Automobile parts supplier IMPCO Technologies has developed a dedicated propane ULEV that has already brought innovation to the marketplace, according to IMPCO's David Smith. As part of its research, IMPCO developed a close-coupled catalyst that can reduce emissions in both light- and heavy-duty vehicles, according to Smith.

Less than 1 year after this development, a gaseous propane vehicle is being prepared for emissions testing, calibration, and then a 10,000-mile short-term durability test. IMPCO has completed a production design and expects pilot production of its fuel system next year.

"We're not in the professional research business; we're in the product business. We've had a very good yield from this project," Smith said. Several automakers are benefitting from the research, and IMPCO is exploring the potential of export markets as well.

Neat Methanol Demonstration Program

Mechanical engineering students at Texas Technical University received hands-on AFV experience testing a 1988 Chevrolet Corsica on 100% methanol. The vehicle had been converted to run on 85% methanol blends to compete in the 1989 Methanol Challenge, but NREL wanted to test the effects of neat fuel on engine performance, wear, and emissions during the long term. For this reason, the vehicle was converted to run on 100% methanol in 1992.

The Corsica was still performing well after being driven almost 25,000 miles on 100% methanol, according to Jesse Jones, a professor at the university. "It's an excellent fuel," he said. "The vehicle had excellent performance, much better than the stock Corsica." Emissions were lower than those of the gasoline vehicle, he added. They were low initially and increased only slightly at the end, according to Jones.

However, the project showed that some issues will have to be resolved before a neat methanol vehicle can be viable in the marketplace, according to Jones. "We replaced the fuel pump four or five times," he said. There was also some cylinder damage, probably resulting from the stress of excessive cranking at cooler temperatures without the lubricity gasoline provides in 85% methanol blends.

By the time the program was completed in the spring of 1995, the students had had a good introduction to alternative fuels. "They all ended up learning something. It was a great program," Jones said.

Heavy-Duty Vehicle Research and Development

ULEV Ultra-Safe School Bus

A fully electronically controlled natural gas bus engine developed by Southwest Research Institute in a project managed by NREL has already received rave reviews from fleet managers about its performance (see the January 1996 *AFDC Update*).

The John Deere natural gas engine is being offered in a bus chassis built by Blue Bird Corporation. So far the engine has demonstrated low emission levels while providing good engine performance and fuel efficiency. Researchers at Southwest are also developing other control system features to detect knocks and misfires and to monitor catalyst efficiency.

The "ultra-safe" school bus includes improved lighting, a larger center aisle for better access to emergency exits, extra windshield glass to improve visibility, and child restraints. A rear-view camera and special motion sensors can detect pedestrians near the perimeter of the bus.

Navistar Natural Gas Aftermarket Certification

While new vehicles are gradually being introduced, Tecogen, an energy research and development company, has developed a natural gas aftermarket conversion system for the Navistar 466 engine that can be installed in the field without an expensive engine rebuild.

Fleet managers often rebuild heavy-duty engines to extend their life, and regulations require that conversions meet a vehicle's previous emissions standards. Tecogen engineer T. Chen said

Photo courtesy of Southwest Research Institute/PIX 03658

SwRI engineers modified this natural gas engine in one phase of a multi-task program to build an ultra-safe school bus powered by natural gas.

early tests show that the new system can surpass those levels. Through a contract with California's South Coast Air Quality Management District, the system will be demonstrated in two trucks starting in early 1996. Three more trucks will be converted and tested through a contract with the California Energy Commission.

Heavy-Duty Propane Engine (DDC S50)

Several surveys have shown that transit fleet operators would be interested in using propane if a certified engine were available. They may not have long to wait; industry and government (DOE and NREL) have joined forces to develop the first heavy-duty propane engine certified by an engine manufacturer.

The project, managed by the Adept Group, began in 1994 and is nearing the end of the development phase. Project managers expect the engine to meet ultra-low-emissions standards. Other goals include competitive energy efficiency, a 275-horsepower rating at 2,100 revolutions per minute.

By the end of 1996, the engine will be demonstrated in four transit operations that will test its performance at high altitude, in cold and warm weather, and on short- and long-range routes. Typically, a heavy-duty engine is developed and later reconditioned to fit a manufactured vehicle. In this case, two bus manufacturers—Nova Bus and the Flxible Corporation—have already stepped forward to sell the engine. "This will really expedite the process of getting it to the market," said Alina Kulikowski-Tan, a project manager with the Adept Group. Nova buses will test the engine in Halifax, Nova Scotia, and Flxible buses will test the engine in Corpus Christi, Texas. Existing buses in Denver, Colorado, and Orange County, California, will be reconditioned for the propane engine.

"It's a pretty exciting moment for the propane industry," Kulikowski-Tan said. The project brings together sponsors from the U.S. and Canadian propane industries, the U.S. and Canadian governments, bus and engine manufacturers, California's South Coast Air Quality Management District, and the Texas Railroad Commission.

Dimethyl Ether for Heavy-Duty Engines

NREL is also exploring fuels that show long-term promise, such as dimethyl ether (DME). For economic and engine compatibility reasons, "DME is the first alternative fuel that makes sense for diesel engines," said Jim McCandless of AVL Powertrain Engineering, Inc.

AVL Powertrain is working with NREL to develop a DME fuel-injection system that will be commercially feasible for four-stroke diesel engines. The first application will be on Navistar's DTA 530 heavy-duty truck and bus engine.

DME has great potential to reduce emissions from heavy-duty vehicles. "Because of its unique chemistry, it is virtually impossible to produce smoke emissions. Therefore, particulate emissions are almost totally eliminated," McCandless said. "Since we do not have to worry about smoke emissions, special fuel-injection characteristics can be used which can lower nitric oxide emissions by 75% or more."

Other characteristics make DME a practical fuel substitute. Because it is high in cetane, it can be used in diesel engines with simple engine modifications. It can be produced from natural gas, making it cost competitive.

AVL Powertrain's goal is to produce an engine that emits levels less than 1.5 grams per brake horsepower per hour (g/bhp-hr) of NO_x and 0.05 g/bhp-hr particulates at diesel efficiency. Field tests could start as early as 1997, in a small fleet of centrally fueled heavy-duty trucks and buses. In-kind support for the project comes from Navistar, Amoco Corporation, and Rexroth Mobile Hydraulics.

Smog: Will AFVs Come to the Rescue?

More than one-third of all Americans live in cities that violate federal public health standards for air quality. Air pollution, commonly known as smog or low-level ozone, can cause respiratory illnesses, headaches, and other ill health effects. Transportation emissions are believed to cause about 80% of this pollution. Alternative fuel vehicles (AFVs) may be part of the solution.

The Atmospheric Reactions Program (ARP) at the U.S. Department of Energy (DOE) is investigating the potential of alternative transportation fuels to improve urban air quality. The program's mission is to "evaluate alternative fuels' effects on air quality with respect to conventional petroleum-based fuels," said DOE program manager Dr. Michael Gurevich.

The atmospheric photochemistry of conventional and alternative fuels is being studied to predict the "reactivity" or ozone-forming potential. The National Renewable Energy Laboratory (NREL), which designed and manages the five-tier ARP for DOE, cost-shares much of its research with other organizations working in the same area, including the Coordinating Research Council (CRC), the U.S. Environmental Protection Agency (EPA), and the California Air Resources Board (CARB).

Under this program, DOE is funding 20 research projects. These activities are aimed at understanding the following:

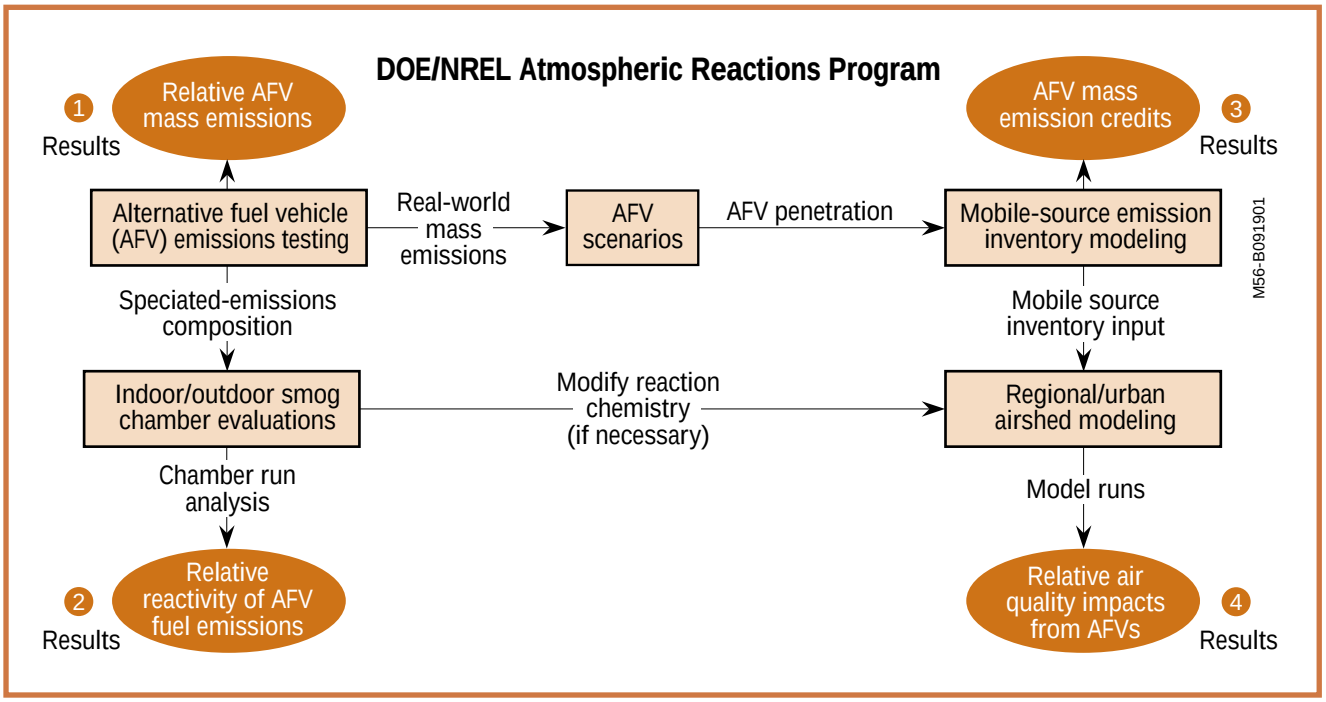
- Speciation of emitted compounds
- Reactivity of compounds and of vehicle emissions
- Mass emissions that vehicles produce in real-world driving conditions
- Contribution of AFV emissions toward the total inventory
- Air quality as determined by computer models.

Speciated-Emissions Collection

As reported in the January 1996 issue of the *AFDC Update*, NREL measures emission performance on more than 600 alternative fuel and conventional vehicles. The EPA regulates only mass emissions (total hydrocarbon emissions, carbon monoxide, particulates, and oxides of nitrogen [NO_x]). NREL tests 15% of its test vehicles for speciated hydrocarbon emissions, also known as volatile organic compounds (VOCs).

This testing process identifies the mass and type of individual hydrocarbon compounds found in the vehicle's combustion products. Individual compounds respond differently in the atmosphere and vary significantly in their reactivity.

Many hydrocarbons produced by AFVs differ from those produced by conventional gasoline vehicles. Thus, identifying speciated emissions is the first step toward understanding alternative fuels' role in air quality; this research has been a fundamental part of the ARP. For example,



methane is the primary component found in natural gas, a viable alternative fuel. Although methane is a hydrocarbon, it has almost no ozone-forming potential.

NREL's speciated-emissions research includes examining the oxidation or combustion efficiency of alternative fuels.

Emissions Reactivity

Two main components leading to ozone formation are VOC and NO_x. Many variables affect the interactions of these compounds and, therefore, VOC reactivity can vary from city to city.

Essentially, when the ratio of VOC to NO_x is greater than 20, reducing NO_x emissions does more to improve air quality. However, when this ratio is 10 or less, reducing VOC emissions is more effective at reducing ozone. This factor is important for those trying to develop urban air pollution strategies.

NREL and EPA are cost-sharing smog chamber studies to measure vehicle emissions reactivity in controlled environments. Using smog chambers, scientists can measure chemical behaviors as they manipulate VOC and NO_x levels as well as sunlight and temperature conditions. "These studies are used in comparison with results from our air quality models," explained NREL Project Engineer Michelle Bergin.

Mass Emissions Collection

In addition to promoting a better understanding of AFV emissions reactions, the ARP, in cooperation with CRC, has completed tunnel studies that collected real-world emissions-performance data. These studies document on-the-road vehicle emissions to compare them with test results obtained in controlled environments. Other studies address the effects of driving behavior on emissions from vehicles using alternative fuels.

Mobile-Source Emissions Modeling

The various aspects of the ARP build on each other to complete the picture of how AFVs contribute to overall mobile-source emissions. This program benefits from other scientists' work in designing sophisticated models.

Scientists can estimate the contribution of vehicle emission in any given city using mobile emissions factor models, such as EPA's MOBILE and CARB's EMFAC. These models account for vehicle age and model, duty, miles traveled, driving patterns, and emissions performance. Using data generated under this program, scientists will be able to predict the effect that AFVs have on mobile-source emissions scenarios.

Air Quality Models

Once a mobile-source emissions scenario has been generated for a given city, it can then be incorporated into comprehensive urban air quality models. The urban air quality models are used for both regulatory and research purposes. Unlike the mobile emissions factor models, these models can account for nontransportation emissions contributed by sources such as utilities or industrial power. Further, these models can account for climatic conditions

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Advanced Natural Gas Vehicle Under Development

In a project being directly sponsored by the U.S. Department of Energy (DOE) through the Applied Physics Laboratory at Johns Hopkins University, an advanced natural gas vehicle has spent more than a year in field tests (see April 1995 *AFDC Update*). Researchers are fine-tuning the engine and redesigning the fuel storage system to increase safety and storage space.

In cosponsoring the project, DOE hopes to show that a natural gas vehicle can perform identically to a gasoline vehicle while surpassing California's ultra-low-emission vehicle (ULEV) standards. Goals include a driving range of at least 350 miles and crashworthiness. "We know we can build a ULEV, but this is an overall design that hasn't been done before," said Richard Wares, a DOE program manager.

The Applied Physics Laboratory is testing the safety of a new fuel storage system designed with cylinder manufacturer Lincoln Composites. "It's a completely different way of carrying the fuel," said John Wozniak, a researcher with the laboratory. "It increases the amount of fuel we can carry and attaches like a gasoline tank," he said. When initial testing is complete, the system will be applied to a second-generation vehicle.

When the program began, auto manufacturers were not planning any similar research. Because the first phase has been a success, there are now plans for a cooperative program with an original-equipment manufacturer.

Hotline Keeps Callers Current on Industry Issues

The National Alternative Fuels Hotline has assisted more than 21,000 callers since it first opened its telephone lines in May 1992. As more people find out about alternative fuel vehicles, the number of callers continues to increase.

The hotline's main objective is to distribute information on alternative transportation fuels—to students, policy makers, interested consumers, fuel providers, auto manufacturers, entrepreneurs, and many others. However, it also helps fleet managers comply with alternative fuel requirements of the 1992 Energy Policy Act (EPAct).

Hotline customers learn about the service in a variety of ways, from reading about it in a newsletter to word of mouth from peers. Since the Alternative Fuels Data Center hit the World Wide Web (WWW), increasing numbers are finding out about the hotline by cruising the "Net." Many find the hotline a useful resource; the majority of inquiries were from repeat callers. Hotline staffers are also helping to guide callers through the AFDC Web Site at ***http://www.afdc.doe.gov***.

Most callers this year had general questions that pertained to all alternative fuels (55%), but when they got specific, it was usually about compressed natural gas (15%), propane (12%), ethanol (8%), or electric (5%). The hotline also provided callers with specific information on the AFDC, conversions, EPAct, the Clean Air Act Amendments of 1990, refueling sites, funding, tax incentives, and automobile availability.

Questions range from the general to the technical. To handle the wide variety, the hotline staff must stay abreast of new policy and technical developments. Operators read many industry and government publications and frequently attend conferences and special events. Many hotline callers themselves also help keep the operators up-to-date on local AFV activities.

The Internet has brought another way to get help from the hotline—e-mail. Callers from overseas especially find it helpful to ask a question without worrying about the time difference. The hotline's e-mail address is: ***hotline@afdc.nrel.gov***. In the future the hotline hopes to be able to send documents in addition to answers over the Internet; until then, e-mail customers requesting publications can get faster service by including a postal address.

Electric Vehicles Receive DOE Funding

Although funding for the federal government to acquire alternative fuel vehicles (AFVs) for its fleet was eliminated from the budget, U.S. Department of Energy (DOE) Assistant Secretary for Energy Efficiency and Renewable Energy Christine Ervin has announced that DOE will allocate $2 million to purchase and demonstrate approximately 100 electric vehicles (EVs) in the federal fleet during fiscal year 1996. These funds will support the industry's 1996 EV Market Launch, which includes a plan to bring 5,000 EVs to the road by 1997. DOE, along with the Department of Defense, has made a commitment to assist the Market Launch Program by placing as many as 2,500 EVs in the federal fleet, provided funds are available.

As part of the EV Market Launch, sponsored by DOE, the U.S. Department of Transportation, the Electric Transportation Coalition, and the Electric Vehicle Association of the Americas, community leaders in 10 selected cities will hold workshops to address the framework needed to support high EV populations. This includes issues such as building and health codes, fire and rescue personnel training, and public information.

The first workshop was held in Washington, D.C., in December 1995. During the year, the program will continue in Los Angeles, Sacramento, Atlanta, Phoenix, New York City, Richmond, Boston, Detroit, and Ft. Lauderdale.

Anticipation of a California mandate that would require major domestic automobile manufacturers to make EVs account for 2% of their sales in the state starting in 1998 has spurred many EV developments. The California Air Resources Board is now looking at ways to weaken the rule, but auto manufacturers seem poised to enter the market. General Motors, Chrysler, and Ford have all announced that they will have EV models available before 1998.

Fax — The choice is yours, but we need to know . . .

To improve our service, the Alternative Fuels Data Center and the National Alternative Fuels Hotline recently updated our system with a new database. That's when we realized how many people have called our hotline and now receive our free quarterly newsletter *AFDC Update*.

In an effort to keep printing and mailing costs down, we are asking that readers who want to continue to receive *AFDC Update* "subscribe" by returning this form with their complete address and phone number. As always, there is no cost for the newsletters. If we do not hear from you, we will not send you another issue. We would also like to hear any suggestions on how to make our service and newsletter more helpful.

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Of course, we'd like you to check the second option. Shortening our hard-copy mailing list will save dollars and resources—and you will be able to read the newsletter on line 2 to 3 weeks ahead of when hard copies are mailed. *But we must hear from you by April 30, 1996, or your name will be automatically removed from the mailing list.* Please fill out this form and fax to ***(703) 528-1953.***

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If you prefer, you can mail this form to: ***The National Alternative Fuels Hotline***
P.O. Box 12316
Arlington, VA 22209

or e-mail us at: ***hotline@afdc.nrel.gov***

or call us at: ***(800) 423-1DOE***

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and chemical reactions, which are integrated with the emissions inputs to predict pollutant transport and ozone formation.

Sunlight, wind, cloud coverage, temperature, and other climate factors play a role in ozone formation. The same vehicle emissions data applied to different cities could present very different ozone formation scenarios.

Soon city planners and policy makers will be able to apply the results of DOE/NREL's work to understand how AFVs can best be used to help solve cities' air quality problems.

The evaluation of AFV emissions reactivity is ongoing work. However, preliminary results show "definite benefits for natural gas vehicles and modest benefits for methanol vehicles," said NREL's Acting Program Manager Brent Bailey. Ethanol and liquefied petroleum gas will also be evaluated under this program.

The Atmospheric Reactions Program has generated numerous reports and program briefs. For those who have access to the Internet, copies of the Photochemistry Project Summaries can be viewed or downloaded through the Fuels Utilization Atmospheric Photochemistry Project Summaries at ***http://www.afdc.doe.gov/fuelutil/atmospc.html****.*

Alternative Fuels News

The California Air Resources Board (CARB) is reviewing a proposal to lift its requirement that major auto manufacturers make 2% of their car sales in the state zero-emission vehicles (ZEVs). In the near term, only electric vehicles can be classified as ZEVs. Instead, manufacturers would begin low-volume sales to prepare for a 10% requirement that would start in 2003. CARB expects to make a final decision by the end of March.

Upcoming Events

For a complete listing of upcoming events, call the National Alternative Fuels Hotline at **(800) 423-1DOE**, or check "Conferences and Events" on the AFDC Home Page at ***http://www.afdc.doe.gov***.
To have your event listed on the WWW, fax the information to Greg Haigwood at (703) 528-1953 or e-mail: ***hotline@afdc.nrel.gov***.

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