



Alternative Fuel Information Series

Alternative Fuel

Public Transit

NICHE MARKETS



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U.S. DEPARTMENT of ENERGY, OFFICE of ENERGY EFFICIENCY and RENEWABLE ENERGY

Alternative Fuels in Public Transit: A Match Made on the Road

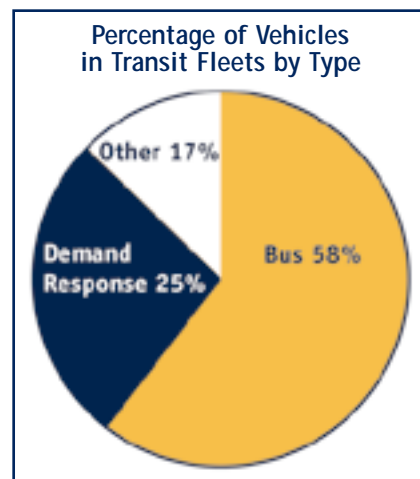
As alternative fuels compete with conventional fuels for a place in public awareness and acceptance, one of their most visible applications is in public transportation. Vehicles, particularly buses and shuttles, that carry people in large numbers, stand to gain much from using alternative fuels. Such high-demand fuel users can help sustain a fueling infrastructure that supports private autos and other smaller vehicles.

Public transit operations are well suited to alternative fuel use. Transit vehicles often travel on contained routes with centralized fueling, they are serviced by a team of technicians who can be trained consistently, and they are part of fleets that travel many miles, so economies of scale can be favorable. Transit agencies also typically operate in urban areas that may have air quality concerns. Alternative fuel transit vehicles offer substantial improvements in emissions, including visible soot, and often operate more quietly.

Use of alternative fuels by transit agencies can also help address local and national concerns about energy security. Agencies that diversify their fuels can better withstand fluctuations in fuel supply and price. Because different alternative fuels are typically available in different regions, their use helps build local and regional economies, and reduces our nation's dependence on imported petroleum.

Transit agencies across the nation operate approximately 75,000 buses. As shown in the table, transit buses consume more fuel per vehicle annually than some other niche market vehicles on average, although the fuel use of individual buses varies widely. (Source: *Charting the Course for AFV Market Development and Sustainable Clean Cities Coalitions*, Clean Cities, March 2001; see www.cities.doe.gov/pdfs/ccstrategic.pdf.)

Buses are the most visible transit vehicles and account for 58% of the transit vehicle miles traveled, but transit agencies operate a variety of other vehicles that can also use alternative fuels. Many agencies operate vans or shuttles in "demand response" service. In addition, most agencies have fleets of support vehicles, such as pickup trucks, vans, specialized maintenance vehicles, and, often, large numbers of police or security patrol cars. Using alternative fuels in these vehicles extends the benefits beyond the bus fleet. All major transit motor coach suppliers, as well as manufacturers of trucks, vans, and cars, now offer alternative fuel options.



The benefits of adopting alternative fuels are evident in a growing body of success stories, ranging from individual retrofits at small transit districts to wholesale fleet replacements by major metropolitan authorities. Successes are most prevalent among buses, but they are common in many other transit vehicles, including shuttle vans and service vehicles.

Vehicle Type	Number of Vehicles	Total Annual Fuel Use (million gal)	Average Annual Fuel Use/Vehicle (gal)
Buses <35 ft.	11,000	43	3,910
Buses 35-40 ft.	13,600	119	8,750
Buses >40 ft.	50,000	500	10,000
Total Buses	74,600	662	8,870
Airport shuttles	16,950	106	6,250
Freight/delivery trucks	5,180,000	5,820	1,120



Smog and airborne particulate matter are a major motivator behind the move to alternative fuels.

A Challenging Environment

Alternative fuels can help solve some of the challenges faced by today's transit agencies. Environmental and health issues provide powerful arguments to support alternative fuels. Buses powered by natural gas, for example, emit significantly less toxic fumes than those powered by diesel. Diesel exhaust contains more than 40 toxic chemicals, some of which are carcinogenic. Public health officials suspect diesel exhaust is a possible contributor to the alarming rise in asthma and other respiratory ailments in urban areas.

For many transit agencies who have moved to alternative fuels, air quality regulations provide one of the strongest incentives. The U.S. Environmental Protection Agency (EPA) has designated many urban areas as nonattainment for certain criteria pollutants. Some transit agencies have adopted alternative fuels to help meet the compliance standards.

State regulations are often also driving factors. For example, in 2001 the California Air Resources Board (CARB) initiated enforcement of its new Transit Bus Fleet Rule, which sets requirements for reduced emissions and requires agencies to declare a "path"—either diesel or alternative fuel—toward meeting state standards for nitrogen oxide (NO_x) and particulate matter emissions.

Several agencies in California are procuring fuel cell buses to meet requirements for 2003 set by CARB. In this early stage, however, fuel cell technology is most appropriate for development and demonstration projects. Agencies choosing the alternative fuels path benefit from easing of the requirements for demonstrating a certain number of zero emission vehicles—either fuel cell or electric-powered—by 2003.

Decision makers can face public pressure as well, as they hear complaints from people tired of seeing and

breathing black smoke. According to a 1999 report from the General Accounting Office on alternative fuels in transit buses, EPA "receives more complaints from the public about emissions from transit buses than all other environmental issues combined."

Community and political pressure to reduce health hazards and clean the air can be substantial. For example, strong community interest was a factor in New York City Transit's decision to embark on a clean fuel program that is one of the most aggressive in the country. Its plans include converting three depots to compressed natural gas (CNG) and purchasing 300 CNG and 350 hybrid electric buses.

Financial issues often concern transit agencies that consider adding newer technology buses to their fleets. Alternative fuel buses can cost 20%-40% more than diesel buses to purchase. But offsetting savings can be achieved in fuel and service costs and, in some cases, through grants, credits, and rebates from a variety of sources. Some agencies report longer engine life, due to a reduction in carbon deposits and other ills associated with older diesel buses. Replacing an entire fleet in a short time can be cost prohibitive, however, so many transit agencies have adopted a multi-tiered, phased approach to improving their fleets, which may include a mix of vehicles using alternative fuels and some using newer diesel technology with advanced emission control devices.

Funding for public transit projects can come from a variety of public sources. One is the U.S. Department of Transportation's Congestion Mitigation and Air Quality (CMAQ) improvement program, which funds traffic reduction and air quality improvement strategies by state and local governments. In Cincinnati, a \$50,000 CMAQ grant was secured to purchase biodiesel fuel for the city's 154 biodiesel-fueled buses. In Rhode Island, CMAQ helped cover the cost of a comprehensive alternative fuels development program, including new buses and public outreach activities. Another source is the U.S. Department of Energy's (DOE's) State Energy Program, which provides grants specifically for the development of alternative fuels applications.

Fuels and Infrastructure

Fuel delivery is one of the great challenges facing alternative fuel fleet operators. Fueling numerous vehicles daily, often with fuels not commercially available to local motorists, requires a carefully planned fuel infrastructure. A fleet that makes a successful transition to alternative fuels typically works with its local utility or fuel provider as a key partner in the project.

A transit agency that uses alternative fuels can be a catalyst in the community for creating a market for nonpetroleum fuels. By opening and supporting new fueling stations, they can stimulate both supply and demand. To further extend the benefits of alternative fuels and help justify the investment, agencies can install fueling stations that are accessible to the public or other local government users. This approach has proven successful in other alternative fuel niches such as airports, particularly for CNG fueling.

CMAQ funding is not restricted to vehicle acquisitions; it can also be used for infrastructure development, parking facility construction, and other related activities. In building its own state-of-the-art natural gas fueling center, Sun Metro of El Paso, Texas, incurred some \$1.4 million in construction costs. CMAQ funding covered 100% of those costs. The facility stores LNG and converts it to CNG, and provides fueling for both types of buses.

Compressed Natural Gas is presently the most common alternative fuel for buses. In the 8-year period beginning in 1993, its use in public transit buses increased more than tenfold, growing to an estimated 5.7% of the bus population in 2000, according to the American Public Transportation Association (APTA) 2001 Fact Book. In recent years, more than 20% of all new public transit buses ordered and built have been CNG fueled. Many transit agencies have vowed to stop buying diesel buses, opting exclusively for CNG power in the future. The SunLine Transit Agency fleet in Thousand Palms, California, is 100% alternative fuel, including 54 CNG buses. Other fleets planning to go to 100% natural gas include Centre Area Transportation Authority in State College, Pennsylvania, Pierce Transit in Tacoma,



Sun Metro Transit

Sun Metro Transit runs 28 administrative support vehicles and 45 and demand-response vans on CNG.

Washington, and the Metropolitan Transit Development District of San Diego, California. More than a dozen medium and large municipalities nationwide have eliminated or significantly reduced their use of diesel buses in favor of natural gas.

Liquefied natural gas (LNG) is less common than CNG, but is also prevalent as a transit fuel. LNG is believed to fuel roughly 1.5% of buses nationwide. (The estimate comes from APTA surveys that cover about two-thirds of all buses nationwide.) LNG is essentially natural gas that has been condensed to a liquid by cooling to about -250°F . The extra cost of the fuel storage equipment can often be offset by the extended driving range of LNG vehicles. Heavy-duty truck fleet operators often opt for LNG for the same reason.

LNG has been a winner at Sun Metro, which operates about 270 vehicles, including 35 LNG buses and 45 CNG buses. Sun Metro has also purchased 28 support vehicles—vans, minivans, sedans, and light trucks—each fueled either by CNG or LNG. It has also converted several off-road vehicles, such as forklifts and sweepers, to CNG power. Such conversions cost about \$3,000 per vehicle.

Historically, one perceived drawback of alternative fuels, including natural gas, has been a shorter driving range than diesel fuel. But modern CNG buses can go roughly 300 miles per fueling—a distance more than adequate for most daily transit applications. LNG increases driving range to about 400 miles per fueling. (A typical diesel bus has a potential driving range of 400 miles per fueling.)

Liquefied petroleum gas (LPG), commonly called propane, is a product of petroleum refining. It also derives from the processing of natural gas. LPG is the



Leslie Eudy, NREL/PIX 03024

A city's image is enhanced by clean transportation such as the LNG buses serving Tempe, Arizona.

most widely used alternative fuel in the United States for light-duty applications, but its use for transit has been limited to medium and small buses. According to APTA, fewer than 40 propane-powered buses were active in 2001, with orders for 42 more. Propane is widely used by public and private fleets in south central Texas. One user is VIA Metropolitan Transit, serving San Antonio, Texas, and surrounding Bexar County, which operates 38 30-foot transit buses and 187 on-demand shuttles powered by propane.

Using **biodiesel**—diesel fuel generated from biological sources, such as soybeans—is one way for transit agencies to support energy security and clean air goals without replacing their vehicle fleets. Using biodiesel in a conventional diesel engine can reduce unburned hydrocarbons, carbon monoxide, and particulate matter, although NO_x emissions tend to show a slight increase. Acid rain-causing sulfur oxides and sulfates (emissions from conventional diesel) can also be reduced significantly. Biodiesel is most often used in blends of 2% (mainly for lubricity) or 20% (B20) with conventional diesel fuel. It can also be used in its pure form (B100), but this requires engine modifications to avoid maintenance and performance problems. B20 can be used with minimum modifications to established fueling infrastructure.



Chattanooga's battery-electric buses serve more than 600,000 passengers annually.

Battery-electric power can also play a role for transit agencies. With zero tailpipe emissions, electric vehicles are arguably the cleanest alternative fuel vehicle (AFV) choice for local air quality, depending on the source of the electricity. Electric buses are also very quiet. The biggest drawbacks to battery buses are their limited range and high capital costs. Charging infrastructure must also be added to a site that uses these buses. In the right situation, however, battery buses can be the perfect solution. In Chattanooga, Tennessee, officials wanted an

ultra-clean transit system to “make a statement” about clean air, when its small downtown area was revitalized in the early 1990s. The city opted for all-electric buses powered by batteries. Its fleet now includes at least 20 electric buses, serving more than 600,000 passengers annually. Chattanooga has since added a battery charging station in the downtown area. Electric buses are used in many other municipal agencies, often in test and demonstration programs. According to survey results published in APTA's Fact Book (year 2000 edition, covering two-thirds of all buses nationwide), a total of 32 battery-powered buses were operating in U.S. transit agencies.

Hydrogen is an alternative fuel that can be derived from either renewable sources or petroleum feedstocks. Currently its part in the nation's energy mix is miniscule, but its potential is enormous, as corporations and governments are investing heavily to develop fuel cells powered by hydrogen. Several transit agencies are already testing buses that use hydrogen. Fuel cell-powered buses have been tested by agencies serving Southern California, Chicago, and Washington, D.C.

Guidance for Creating Successful AFV Programs at Transit Agencies

For transit agencies considering alternative fuels, economic and technical issues are often situation specific. Proximity to a natural gas main line, for example, may make CNG or LNG much more affordable than electricity. Biodiesel prices vary regionally as well. Other variables include the level of skill and training among technicians, the degree of commitment by management, and environmental and air quality concerns.

Experience gained in hundreds of real world trials has produced valuable lessons for transit authorities. Data and case studies are available from many private and government sources, including the DOE Alternative Fuels Data Center, operated by the National Renewable Energy Laboratory (NREL). See “Information and Resources” on back page. Results from these studies show that several steps must be taken to ensure a successful program. And some advice is nearly universal:

Investigate options and learn about the new technology. There are multiple fuel and technology options to choose from and more are being developed. Costs for vehicles, fueling infrastructure, and maintenance facilities vary depending on location and technology. A thorough investigation will lead to the best choice for a particular transit agency. Transit agencies with the most successful

programs stress the need to know as much as possible about the fuel and vehicle options, and how to be prepared for any challenges that may arise. Other transit agencies that have successful alternative fuel programs are some of the best sources of information, and warrant a few field trips. Working groups such as the APTA Alternative Fuel Committee or the Natural Gas Transit Users Group can be invaluable to an agency just starting out with alternative fuel buses. See “Information and Resources.”

Assemble the necessary partners. Working with the right partners can make or break a program. A transit agency must work with the bus manufacturer, fuel provider, local fire department, and industry training organizations to help integrate a new technology into its fleet.

Dallas Area Rapid Transit/PX 09176



Training of service technicians is key to wide acceptance of alternative fuel transit buses.

Training, training, training. One of the main causes of failure in adopting a new technology into a fleet is lack of proper training. Employees need to be familiar with the differences in operating and maintaining AFVs and fueling stations. Technician training is available from a growing body of trade and technical schools listed at www.ott.doe.gov/education/training.html. Many larger agencies now offer their own training. The National Institute for Automotive Service Excellence, familiar to many by the “ASE” patch worn by auto technicians who have been trained and certified under this program, now offers certifications specifically in AFV service. The National Alternative Fuels Training Consortium also offers training through a network of facilities in 14 states. Information is available on its Web site at www.naftp.nrcc.wvu.edu/.

Be committed to the project. Past success stories have repeatedly confirmed the importance of the right attitude among all participants. Agencies that have succeeded

with alternative fuels emphasize the need for consensus building at all levels of involvement. But resistance to change can come from many fronts. Members of the agency’s own governing board may be resistant to alternative fuels. Technicians may be reluctant to work with a new technology because they are unfamiliar with service procedures. Aversion to alternatives may surround issues pertaining to the fueling infrastructure, such as how to pay for it and which fuel to choose. Getting everyone from technicians to chief executive officers onboard, often requires educational outreach efforts. Proponents can point to success stories at the Clean Cities Web site at www.cities.doe.gov/success/transit.shtml to help build their case.

Capitalize on public relations benefits. For a city considering its image among citizens and visitors, transit buses represent the “front line.” Transit agencies can benefit from a public relations campaign to promote the benefits of alternative fuel buses. Many agencies use prominent vehicle signage or different color schemes to advertise and educate. The natural gas buses operated by Pierce Transit in Tacoma, Washington, are painted with blue sky, clouds, and the logo “Clean Machine.” The paint scheme for the CNG buses at the Montgomery County Transit System in Rockville, Maryland, is different from that of its diesel buses, and the logo reads “Ride the Clean Alternative.”

Transit vehicles operating on alternative fuels can become ambassadors of clean air, blazing a trail in their successful use of new fuels as each one replaces dozens of cars on the road. Transit agencies across the nation have proven that with the right approach, alternative fuels can help meet a range of challenges faced by their communities. By tapping into a variety of helpful information and resources, transit agencies just beginning to explore the potential of alternative fuels can help ensure their own success and reap the benefits for their community.



ENRG, Inc.

Demand-response vehicles such as SunLine’s CNG vans make up 25% of all transit vehicles in the United States.

Transit Agency Case Studies: Building Upon Experience

LNG: Dallas Area Rapid Transit

Dallas Area Rapid Transit (DART) operates 860 buses in the Dallas metropolitan area. With more than 130 local and express routes, DART serves an average 182,500 passengers each week. EPA has classified the Dallas/Fort Worth area as a serious nonattainment area for ozone. Because of air quality problems and EPA's more stringent diesel emissions regulations, DART has been proactive in working to meet the community's needs with the cleanest transportation available. Forty-one percent of DART's current fleet operates on natural gas.

DART has operated LNG buses since early 1998, and currently has 139 LNG buses that operate out of two facilities that have been modified to enable safe maintenance of alternative fuel buses. Each facility also has an LNG station capable of fueling several buses at a time. The LNG buses compare favorably



Kevin Chandler/PIX 07850

At DART's fueling facility, above-ground insulated pipes deliver LNG from two tanks to the fueling island.

with the diesel buses with respect to performance. DART bus drivers report that it is difficult to tell them apart. DART is committed to its clean fuels program, but its experience has had its challenges. When the first buses delivered did not have the range expected, DART worked with the manufacturer to solve the problem, adding a fourth tank to each bus. There were also difficulties in filling all four tanks when the buses were fueled. The manufacturer added a level indicator and pressure indicator for each tank to ensure all the tanks were filled.

In June 2000, NREL published a report on a year-long evaluation of the DART LNG bus program. The report details DART's experience with the buses as well as the costs and maintenance of the program. (It can be viewed and downloaded at www.nrel.gov/docs/fy01osti/28739.pdf.) The agency has more LNG buses on order, and is looking into more advanced technology vehicles for the future. The agency plans to purchase five hybrid electric buses, and is reviewing other technologies, including fuel cells.

Biodiesel: Bi-State Development Agency

The Bi-State Development Agency, a mass transit provider for the St. Louis area, operates more than 600 buses serving an average of 130,000 passengers daily. Bi-State announced in June 2001 that it would begin using B20 in its bus fleet. The agency chose B20 for several reasons. B20 is a cleaner-burning fuel with performance similar to diesel, and it can be used in unmodified diesel engines. Because it is made from renewable sources, its use can also



Dallas Area Rapid Transit/PIX 09147

DART operates 139 LNG-powered buses. Dallas/Fort Worth has been named a serious non-attainment area for ozone.

Lee Harris/PIX 03029



B20-powered buses operated by the Bi-State Development Agency serve St. Louis, Missouri.

benefit the local farming community by increasing the market for soybeans.

For more than 10 years, the Bi-State Development Agency has extensively tested biodiesel for DOE and NREL. Results have been very favorable: the agency has noticed a significant reduction in vehicle emissions with no impact on fuel economy and performance. Use of the fuel posed no operational problems, and conversion was simple because no infrastructure or engine modifications were required.

Besides reducing vehicle emissions and particulate matter, Bi-State also noticed that the high lubricity of B20 increased injector life and decreased the need to perform regular maintenance. Passengers riding the B20 transit buses appreciated this alternative fuel because the acrid smell and black smoke from exhaust, normally associated with diesel buses, were no longer present. When told that the buses were fueled with biodiesel, customers also appreciated the transit agency's use of a renewable fuel that reduces the nation's dependence on imported oil. Because of its success with biodiesel, Bi-State's board of commissioners passed a resolution allowing the agency to pursue a plan that incorporates B20 into its entire fleet long-term. The agency also operates a fleet of 38 CNG buses.

CNG: Metropolitan Atlanta Rapid Transit Authority

EPA has designated Atlanta as a serious nonattainment area for ground-level ozone. In fact, since monitoring began in 1980, the Atlanta metropolitan

area has not yet met the one-hour federal standard for ozone. Growth in the area has led to increased traffic congestion, which contributes to the air quality problem. Atlanta has the highest vehicle miles traveled per capita of all major urban areas in the United States, and the resulting congestion is estimated to cost more than \$1 billion per year in travel delays and wasted fuel. Transit can be a part of the solution by taking multiple vehicles off the road during rush hour.

The Metropolitan Atlanta Rapid Transit Authority (MARTA) serves 13 counties in the Atlanta metro area, traveling more than 274 million annual passenger miles on almost 700 buses. MARTA currently has 222 CNG buses in operation; by late 2001 it will have 324. The agency was subject to public pressure to use clean vehicles, and CNG has provided a successful path forward.

MARTA's infrastructure includes two CNG filling stations; one of which it owns and operates; the other is owned and operated by Atlanta Gas Light Company.

MARTA has been so successful with its CNG buses that it served as a model for the newly formed Georgia Regional Transportation Authority that has just started operating a CNG express bus service in the Northeast Atlanta suburbs. When the express bus program is completely phased in, 180 to 220 CNG buses will be used.

In addition to its bus fleet, MARTA has about 50 support vehicles that operate on natural gas. Its CNG buses operate from two facilities that have been modified to maintain gaseous-fueled vehicles.



AGL Resources/DOE

MARTA is the nation's ninth largest transit agency, and the sixth largest in its use of natural gas buses.

Information and Resources:

U.S. DOE Clean Cities Program
800-CCITIES
www.ccities.doe.gov

DOE's Alternative Fuels Data Center
and Hotline
www.afdc.doe.gov
(800) 423-1363

DOE AFV Fleet Buyer's Guide
www.fleet.doe.gov

Dallas Area Rapid Transit's LNG Bus Fleet:
Final Results
www.nrel.gov/docs/fy01osti/28739.pdf

U.S. Department of Transportation Congestion
Mitigation/Air Quality (CMAQ) program
www.fhwa.dot.gov/environment/cmaq/eligblty.htm

Federal Transit Administration
www.fta.dot.gov

California Air Resources Board: Transit Bus Program
www.arb.ca.gov/msprog/bus/bus.htm

American Public Transportation Association
202-898-4000
www.apta.com
APTA Alternative Fuels Committee
www.apta.com/cmmmt/altfuel/altfuel.htm
APTA Electric Bus Subcommittee
www.apta.com/cmmmt/buseq/elecbus.htm

AFV Training providers
www.ott.doe.gov/education/training.html

National Alternative Fuel Training Consortium
www.naftp.nrcce.wvu.edu/

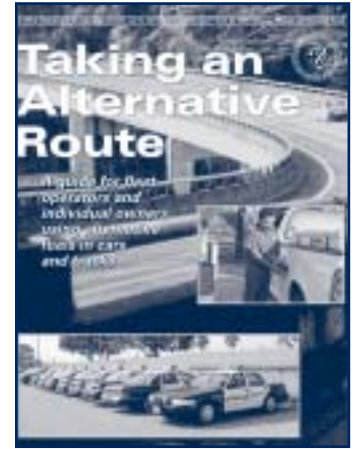
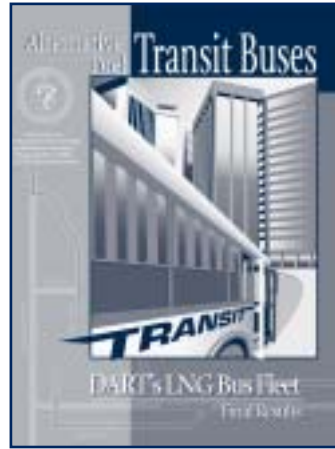
Natural Gas Vehicle Institute
www.ngvi.com/html/about.html

Transit Users Group (sponsored by DOE and
Natural Gas Vehicle Coalition)
Hank Seiff, NGVC 202-824-7364; hseiff@ngvc.org

Links to Bus Manufacturers
www.motorbussociety.org/links/mfrs.html

*Guidebook for Evaluating, Selecting, and Implementing
Fuel Choices for Transit Bus Operations, TCRP Report
38.* Transportation Research Board, National
Academy Press, 1998; can be ordered through
www.nas.edu/trb/index.html

Altoona Bus Testing
www.vss.psu.edu/fta/index.htm



Publications available from DOE's Alternative Fuels Data Center include a report on DART's LNG bus fleet; and *Taking an Alternative Route*, a general guide to alternative fuel use. Visit www.afdc.doe.gov.

About Clean Cities...

The Clean Cities Program is a voluntary, locally based government and industry partnership. The program, now in its ninth year, seeks to expand the use of alternatives to gasoline and diesel fuel to reduce dependence on imported oil, lessen air pollution, and increase public awareness about the benefits of using alternative fuels over gasoline and diesel. At least 80 coalitions and some 5,000 stakeholders have joined to support the Clean Cities Program.

In addition to presenting the Clean Cities Coalition Awards, the Clean Cities Program annually recognizes the outstanding achievements of National Partners. Together with its partners and coalitions, Clean Cities strives to promote alternative fuel use, develop AFV infrastructure, and support alternative fuel and AFV legislation.

For more information, you can:

- Call the Clean Cities Hotline at 1-800-CCITIES
- Visit the Clean Cities Web site at www.ccities.doe.gov or www.ccities.doe.gov/international or
- E-mail the Clean Cities Hotline at ccities@nrel.gov

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