# Separating Fact from Fiction:

## AN ANALYSIS OF REAL-WORLD ELECTRIC VEHICLE CAPABILITIES

An Alternative Fuel Fact Brief – Presented by:

Autogas FOR America

# Abstract

A new wave of plug-in battery electric vehicles (EVs or PEVs) and plug-in hybrid electric vehicles (PHEVs) have recently come to market in the United States. Politicians, environmental groups and even celebrities have bought into what the EV manufacturers advertise: EVs are viable, cost-effective, and zero-emissions vehicles.

Past studies of electric vehicle technology have struggled to provide a reliable estimate of the emissions caused by an EV over its lifetime (from the manufacturing phase to the disposal of the vehicle components).These studies assert an overall reduction in greenhouse gas (GHG) emissions, but more recent and comprehensive lifecycle emissions reports tell a different story, calling into question the well-publicized zero-emissions claim. These comprehensive studies highlight the energy-intensive EV manufacturing process and a U.S. electric grid system that draws nearly 50-percent of its power from coal.

There are a number of practical problems associated with EVs in addition to their questionable environmental record. Reduced driving range, limited carrying capacity and the high cost of commercial-grade charging infrastructure make current EV technology impractical, particularly for American fleets. Energy experts have also raised a red flag regarding the additional electricity capacity required for mass adoption of EVs. A large increase in electricity demand could overburden an already struggling U.S. electric grid system. Other alternative fuel vehicle technologies have verified environmental benefits and are currently used by fleets across the country.

The challenges associated with wide-scale EV deployment should lead alternative fuel advocates to reconsider the notion that EVs are the only solution for one of our country's most pressing energy challenges – transportation.

# Table of Contents

# Introduction

Rising fuel prices, climate change and other factors have accelerated alternative fuel vehicle technology development in the U.S. in recent years. Plug-in electric vehicles (PEVs) emerged as a favorite in the media and among policymakers and environmental advocacy groups (Sierra Club, 2011a). EV proponents contend that current EV technology can alleviate some of our country's energy challenges by reducing emissions and foreign oil imports.

Automakers including Nissan and General Motors (GM) saw an opportunity in manufacturing EVs to brand their companies as environmentally friendly and to capitalize on emerging trends among consumers and policymakers. In late 2011, only two all-electric models, the Nissan Leaf and the newly introduced Mitsubishi iMiev, and one plug-in hybrid, the Chevrolet Volt, were available to American consumers. The President has even called for "one million electric vehicles" on the road by 2015 (Madrigal, 2011). This is an ambitious goal in light of the fact that Nissan has only supplied 5,000 of its all-electric vehicles to U.S. customers as of August 2011 (Berman, 2011).

Automakers promoted these "eco-friendly" products in campaigns that masked the true environmental impact of electric vehicles.

A coal-sourced electric supply is not the only source of skepticism in examining an EV's net environmental impact. Another key contributor is the manufacturing, lifespan and disposal of the batteries that power EVs like the Nissan Leaf. Fast charging, which can charge an EV battery in 30 minutes or less, is known to accelerate battery aging. Currently, no published plans have been made available to the public for the disposal or recycling of used EV batteries on a large-scale basis.

**Approximately half of an electric vehicle's lifetime emissions are accumulated during the manufacturing phase**

## Electricity sources and the lifecycle emissions of plug-in electric vehicles

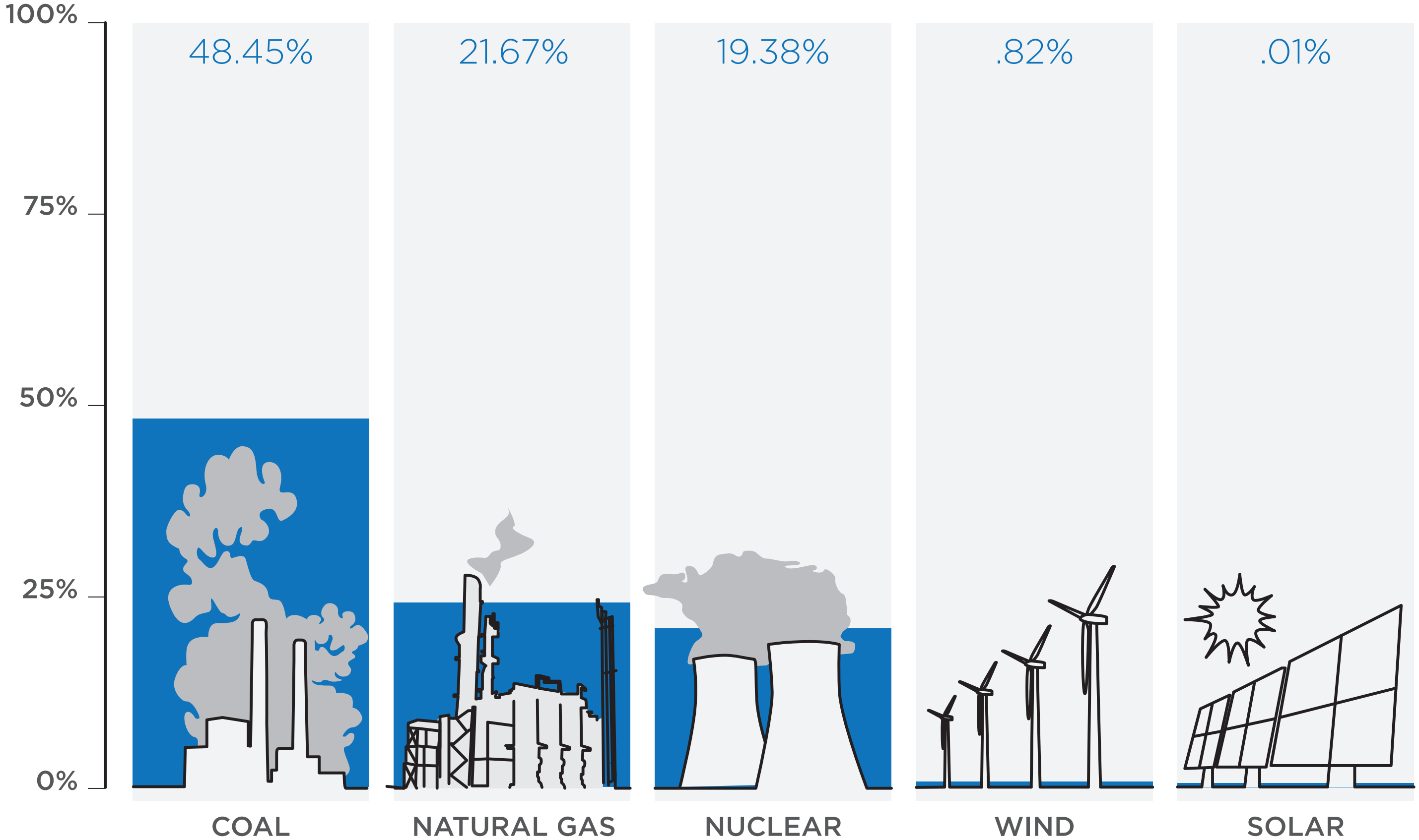
Dozens of studies in the last decade attempted to assess the lifecycle emissions of EVs and PHEVs. However, until EVs came to market, researchers struggled to accurately depict the lifecycle emissions of real-world EVs. Lifecycle emissions of PHEVs can vary dramatically based on a number of factors, which include driving habits and the proportion of electric-drive use to gasoline-drive use. For this reason, estimating emissions for all-electric EVs may yield more precise conclusions. The manufacturing and disposal of toxic EV batteries and sources of electrical generation are also important variables in evaluating EV emissions.

*True environmental impact of EVs*

Early adopters of EVs consider environmental benefits one of the top factors motivating their interest in electric vehicle technology (Zyprme Research & Consulting and Airbiquity, 2010, p.15). Nissan and European automakers have created extensive worldwide advertising campaigns asking viewers, "What if everything ran on gasoline?" The message is that by switching to EVs, air pollution and other emissions can be eliminated (Kranz, 2011). These advertising campaigns conveniently avoid the fact that pollution is simply shifted from the vehicle's tailpipe to the power plants. In fact, some experts have speculated that carbon dioxide and toxic pollutant emissions could stay the same or even increase as a result of increased electric power generation. This is particularly true for coal-rich regions of the United States, like the Northeast or Midwest.

The quantity of downstream emissions, or emissions resulting from the fuel powering an EV, is determined by the energy source(s) used to generate the electricity. According to the Environmental Protection Agency (2011), as of 2007, over 48 percent of our country's electricity is sourced from coal, with an additional 21 percent supplied by natural gas. The following chart illustrates selected U.S. electricity generation sources by proportion.

# What powers an electric vehicle?




Source: Environmental Protection Agency (2011)

Non-nuclear renewable energies, including wind, solar, hydropower, biomass and geothermal, accounted for less than 10 percent of total American electricity generation in 2007. The Sierra Club's "Stopping the Coal Rush" project estimates there are approximately 95 proposed coal power plants in America classified as either "active," "upcoming," "progressing," or status "uncertain" (Sierra Club, 2011b) Coal-based electricity generation is unlikely to decrease dramatically in the immediate future.

*Lifecycle emissions assessments of EVs*

UK-based energy industry specialists Ricardo, Inc. published one of the most comprehensive EV lifecycle emissions studies to date. Emissions sources taken into account included vehicle production, in-use (fuel) emissions, fuel delivery and end-of-life vehicle disposal. The authors used data from the European electric grid system and assumed downstream emissions at 500g/$CO_2$ equivalents per kWh (Patterson, Alexander, & Gurr, 2011, p.48). Taking these factors and assumptions into consideration, the model showed that an all-electric vehicle could lower lifetime $CO_2$ equivalent emissions by up to 25 percent, compared to an average gasoline-powered vehicle (p.50). The study also established that approximately half of an EV's lifetime emissions are accumulated during the manufacturing phase, including the production of the battery.

## The minerals and metals used to manufacture EV batteries are toxic and environmentally damaging if not recycled or disposed of properly

At first glance, a 25 percent reduction in greenhouse gas emissions seems noteworthy, until other variables are considered. First, the U.S. electric grid is more reliant on coal than European electric grids. Second, for each kilowatt hour of electricity used by Americans, the EPA estimates $CO_2$ equivalent emissions of 610g. In regions of the U.S. more heavily powered by coal, this figure is significantly higher.

Additionally, the Ricardo study did not consider the possibility of battery replacement when calculating EV emissions reductions. The company and the organization that commissioned the study acknowledged shortly after the study's publication that using more than one battery in the vehicle's lifetime would negate any environmental benefit (Jackson, 2011).

Due to high incremental vehicle costs, the lack of large-scale fast charging infrastructure, and a maximum emissions reduction of 25 percent, EVs may not provide environmentally conscious consumers the desired return on investment. In fact, EVs could increase total output of harmful pollutants like sulphur dioxide and particulate matter. Other technologies, like propane autogas and natural gas vehicles, yield quantifiable emissions reductions at a fraction of the cost. When compared to gasoline engines, autogas technology can dramatically reduce pollutants that cause smog and ozone by over 20 percent (Alliance AutoGas, 2009). Autogas vehicles also produce nearly 20 percent less greenhouse gas emissions than gasoline vehicles, but remain much more economical than most EVs (Sloan, Johnson, Saha, & Duleep, 2011). In addition, the average autogas vehicle achieves nearly 90 percent of the mpg of gasoline vehicles (p. 15).

*Electric Vehicle Batteries*

The minerals and metals used to manufacture EV batteries are toxic and environmentally damaging if not recycled or disposed of properly. There are a limited number of recycling and disposal facilities in the United States, many of which have received millions of dollars in grants to "boost capacity for lithium-ion batteries" (Taylor, 2009). However, efforts to increase the recycling or reselling of lithium and other minerals in these batteries face a significant financial obstacle.  Currently, these recycled products garner relatively low market prices. As a result, the revenue from reselling the battery materials would not currently offset the cost of extracting them, discouraging businesses from providing this service.

**EV batteries may face dramatically shorter lifetimes if fast charging is the primary recharge method**

# Fast charging EV batteries and reduced battery life

Purchasing additional hardware to charge an electric vehicle at a residence is a necessary expense for many EV consumers. Residential chargers are commonly referred to as Level 2 “trickle” chargers, which charge vehicles over a seven-to-eight hour period. While this option may suit some consumers’ needs, eight hours of vehicle downtime for charging would prove impractical for many commercial fleets.

*Fast charge technology*

EV technology developers have designed “fast charge” Level 3 battery chargers and the DC Quick Charger for public use and for commercial EV fleets. There are several options on the market, but the reported retail price for a single Level 3 or DC Quick charger is nearly $50,000. Level 3 chargers can charge an EV with the battery specifications of the Nissan Leaf up to 80 percent capacity in approximately 30 minutes (Vandervelde, 2009, and AeroEnvironment, 2011).

While this technology makes EVs seem more viable, growing evidence suggests that EV batteries may face dramatically shorter lifetimes if fast charging is the primary recharge method. According to Nissan’s Mark Perry, director of product planning, “If fast charging is the primary way that a Leaf owner recharges, then the gradual capacity loss is about 10 percent more than 220-volt charging. In other words, it will bring the capacity…closer to 70 percent after 10 years” (Hybrid Cars, 2010). Nissan has also stated that a battery has reached its end of life (EOL) after a capacity loss of 20 percent, which the company says occurs after 10 years of trickle charging.

Some batteries may reach their EOL even more quickly. Published estimates for battery degradation assume similar driving habits and annual mileage for both trickle- and fast-charge users. However, due to the high number of miles commercial light-duty fleet vehicles typically accrue, these assumptions may not be accurate. Many vehicle fleets would require the use of fast charging stations and more frequent recharging. Since battery life for lithium-ion EV batteries includes a finite number of charge cycles, more frequent charging will result in a shorter battery life (O’Keefe, Brooker, Johnson, Mendelsohn, Neubauer, & Pesaran, 2010).

*Replacement battery costs*

The approximate production cost for a Leaf battery pack is $18,000, according to Nissan (Ramsey, 2010). If a battery replacement is required after the warranty period, a Leaf owner would incur the cost of replacing the battery pack. A hefty battery price tag has left EVs like the Leaf with low expected resale values (Ryan, 2010). Batteries remain one of the most expensive elements of the electric car, with an industry research firm estimating an $8,000 to $18,000 premium for the technology over their gasoline-powered counterparts (Gartner, 2010). While Nissan has revealed battery production costs, the company has not announced the exact consumer cost for a replacement battery, ambiguously stating on its website that “at this point, [Nissan] can’t estimate a cost. [Nissan will] be able to share more when more info is available.” Unfortunately for EV manufacturers, nearly 65 percent of consumers say that vehicle price will be the number one factor determining if they purchase an EV (Zyprme Research & Consulting and Airbiquity, 2010, p. 17).

**Strains on the electric grid will be exacerbated if fast charging becomes the primary method of recharging EVs**

# Do we have the electric grid capacity to support EVs?

Energy experts express concern about the potential impact of millions of EVs and PHEVs recharging through the U.S. electric grid. Estimates vary regarding the impact additional demand would have on the electric grid; but many assessments question the readiness of the U.S. grid to supply power to millions of EVs.

*How will EVs impact electricity demand and the electric grid?*

Potential problems that could stem from a significant increase in electricity demand go beyond basic supply and demand analysis. A report published by the Air & Waste Management Association identified multiple variables that must be measured to determine the impact of additional demand on the electric grid, including location, time of charging, demand quantity and the amount of marginal power generation needed (i.e., above the base load requirements) (Yang and McCarthy, 2009). At the national level, the study reports that "if each of the 240 million registered vehicles in the United States charged 5-10 kWh per day, this would require an additional 12-23% electricity generation" (p.17). However, 5 to 10 kWh is a conservative figure compared to data released by Nissan. According to Nissan (2011), trickle charging a Leaf to full capacity requires 25 kWh of electricity and provides a range of approximately 73 miles.

The Air & Waste Management study states that during off-peak hours of electricity demand, "many power plants are underutilized," so additional demand for electricity may be minimal (p.19). However, if demand were concentrated by location and time of charging (e.g., residents of a particular neighborhood recharge EVs in the early evening after work), "it could…require utilities to upgrade the distribution infrastructure." While electric vehicles will likely demand more energy from the grid gradually during 2011 and 2012, there could be issues associated with increased demand on the electric grid in the short-term. Strains on the electric grid will be exacerbated if fast charging becomes the primary method of recharging EVs, because this method requires significantly more power than trickle charging.

# Conclusion

A technological leader like the United States should continue to look for ways to improve energy conservation, lower fuel costs and spur economic growth. Despite advancements in automotive technology, a dramatic shift to technologies like solar power and electric or hydrogen vehicles cannot occur within a few years. Autogas vehicle technology is one viable option for high-mileage fleets, offering emissions reductions, lower operating and fuel costs, and decreased vehicle maintenance downtime.

Electric vehicles, especially all-electric vehicles, are praised today as environmentally friendly and affordable. However, mounting evidence casts into doubt the real environmental benefits of EVs. The high production cost of EV batteries makes EV's financially unattainable for many drivers wanting comparable performance to gasoline-powered vehicles. Fleets interested in alternative fuel vehicles have options, but limited-range EVs are likely unfeasible.

Expensive advertising campaigns and electric-vehicle propaganda have misled many consumers about the practicality and environmental impact of electric vehicles. Electric vehicle technology may progress in the future, but it is currently incapable of solving our country's significant energy problems.

# References

AeroEnvironment. (2011). *Electric Vehicle Fleet Charging Solutions*. Retrieved November 21, 2011, from EV Solutions: http://evsolutions.avinc.com/products/fleets/#charging_fleets_a

Berman, B. (2011, August 11). *Nissan Passes 5,000 Electric Car Sales, But What About Tennessee?* Retrieved August 2011, 2011, from PluginCars.com: www.plugincars.com/nissan-passes-5000-electric-car-sales-what-about-tennessee-107559.html

Environmental Protection Agency. (2011, May). *eGRID2010 Summary 1.1: Year 2007 Summary Tables*. Retrieved October 15, 2011, from EPA.gov: http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_1_year07_SummaryTables.pdf

Gartner, J. (2010, January 21). *The EV Conundrum: Uncertain Resale Value Complicates Li-ion Battery Market Pike Research.* Retrieved November 1, 2011, from Pike Research: http://www.pikeresearch.com/blog/the-ev-conundrum-uncertain-resale-value-complicates-li-ion-battery-market

Hybrid Cars . (2010, May 27). *13 Key Questions and Answers about Nissan Leaf Battery Pack and Ordering.* Retrieved November 1, 2011, from Hybrid Cars: http://www.hybridcars.com/news/13-key-questions-and-answers-about-nissan-leaf-battery-pack-and-ordering-28007.html

Jackson, N. (2011, June 13). *LowCVP / Ricardo response to Press Coverage on Life Cycle CO2 Report.* Retrieved November 1, 2011, from Low Carbon Vehicle Partnership: lowcvp-isleint4.isledev.co.uk/assets/news/Response%20to%20Press%20Coverage%20on%20Life%20Cycle%20CO2%20Report.pdf

Kranz, R. (2011, June 1). *Leaf commercial has viewers buzzing, especially at GM.* Retrieved November 1, 2011, from Automotive News: http://www.autonews.com/article/20110601/BLOG06/110609982/1499&sectioncat=product

Madrigal, A. (2011, January 26). *Chart: Obama Calls for 1 Million Electric Vehicles, but Is That Enough?* Retrieved November 1, 2011, from The Atlantic: http://www.theatlantic.com/technology/archive/2011/01/chart-obama-calls-for-1-million-electric-vehicles-but-is-that-enough/70291/

Nissan USA. (2011). *How much will a replacement battery cost?* Retrieved November 1, 2011, from Nissan USA: http://www.nissanusa.com/leaf-electric-car/faq/view/34#/leaf-electric-car/

O'Keefe, M., Brooker, A., Johnson, C., Mendelsohn, M., Neubauer, J., & Pesaran, A. (2010). Battery Ownership Model: A Tool for Evaluating the Economics of Electrified Vehicles and Related Infrastructure. *25th International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium & Exposition.* National Renewable Energy Laboratory, U.S. Department of Energy.

Patterson, J., Alexander, M., & Gurr, A. (2011, August 25). *Preparing for a Life Cycle $CO_2$ Measure.* Retrieved November 1, 2011, from Low Carbon Vehicle Partnership: www.lowcvp.org.uk/assets/reports/RD11_124801_5%20-%20LowCVP%20-%20Life%20Cycle%20CO2%20Measure%20-%20Final%20Report.pdf

# References (cont.)


Ramsey, M. (2010, May 13). *Nissan Says Leaf Electric Will Be Profitable With U.S. Plant.* Retrieved November 1, 2011, from The Wall Street Journal: http://online.wsj.com/article/NA_WSJ_PUB:SB10001424052748704635204575242382820806878.html

Ryan, C. (2010, July 6). *Battery Replacement Brings EV Resale Down.* Retrieved November 1, 2011, from AutoTrader.com: http://www.autotrader.com/research/article/68584/battery-replacement-brings-ev-resale-down.jsp

Sierra Club. (2011). *Electric Vehicles - Sierra Club.* Retrieved November 1, 2011, from Sierra Club: www.sierraclub.org/electric-vehicles/

Sierra Club. (2011). *Stopping the Coal Rush.* Retrieved November 1, 2011, from Sierra Club: http://www.sierraclub.org/environmentallaw/coal/plantlist.aspx

Sloan, M., Johnson, E., Saha, B., & Duleep, K. (2011, November). *Economic Impacts of the Propane Green Autogas Solutions Act of 2011.* Retrieved November 10, 2011, from National Propane Gas Association: http://www.npga.org/files/public/Propane_GAS_Act_Propane_Vehicle_Tax_Credit_Impact_Study_Nov_2011.pdf

Taylor, P. (2009, September 14). *When an Electric Car Dies, What Will Happen to the Battery?* Retrieved November 16, 2011, from Scientific American: http://www.scientificamerican.com/article.cfm?id=lithium-ion-batteries-hybrid-electric-vehicle-recycling

Vandervelde, J. (2009, August 2). *Green Car Reports.* Retrieved November 1, 2011, from 2011 Nissan LEAF: Batteries: www.greencarreports.com/news/1033848_2011-nissan-leaf-batteries

Yang, C., & McCarthy, R. (2009). Electricity Grid: Impacts of Plug-in Electric Vehicle Charging. *Environmental Management*, pp. 16-20.

Zyprme Research & Consulting; Airbiquity. (2010, December). *The Electric Vehicle Study.* Retrieved November 2, 2011, from Zyprme: zpryme.com/SmartGridInsights/The_Electric_Vehicle_Study_Zpryme_Smart_Grid_Insights_Airbiquity_Sponsor_December_2010.pdf