

# History of Hybrids

<http://www.hybridcars.com/history/history-of-hybrid-vehicles.html>

## THE EMERGENCE OF HYBRID VEHICLES

Hybrid electric vehicles have had a long history, but only recently have a conjunction of forces resulted in this technology emerging as a mass-market product. This conjunction reflects the melding of consumer attitudes, multi-billion dollar investments in new technology, public policy, environmental activism, and government regulations.

### Regulatory Initiatives

Topography, climate, population and the large number of vehicles have resulted in California, and Los Angeles in particular, having the worst air quality in the United States. The principal cause of this poor air quality has been vehicle emissions.

The California Air Resources Board, the state regulatory agency responsible for air quality issues, is permitted under the United States Clean Air Act to regulate vehicle emission standards for vehicles sold in that state. In 1990 CARB responded to the challenge of meeting its air quality targets by implementing a new set of regulated emission standards for vehicles. These new standards, the most stringent in the world, were called LEV &ndash; Low Emission Vehicle standards.

### LEV and ZEV &ndash; Technology Forcing Standards

The CARB regulation required that all new vehicles sold in that state beginning model year 1998 meet the new stringent LEV family of tailpipe emission standards. These standards included Transitional LEV, LEV, Ultra LEV, Super Ultra LEV and ZEV (zero emission).

The most controversial aspect of the regulation was the requirement that a percentage of new vehicles sold in the state be ZEV&rsquo;s. The regulation required that in 1998 2% of all new vehicles sold in the state by major manufacturers be zero emission and by 2003 10% of new car sales would have to meet this requirement.

### Actions By Other Governments

In 1994 the British Columbia Government proposed to follow California&rsquo;s lead and implement similar regulations on a similar timetable except for the ZEV requirement. States in the northeast US such as New York and Massachusetts, which under the US Clean Air Act are allowed to adopt the California regulations, did so. Given the integrated nature of the auto industry in North America the result was a strong regulatory momentum in both the US and Canada to dramatically reduce emissions from vehicles.

### Technical Options For Vehicles and Fuels

The powerful regulatory movement resulted in a technical challenge for vehicle manufacturers to achieve the LEV standards for conventional vehicles using internal combustion engines operating on gasoline. In order to achieve the LEV standards substantial investments were made in new engine control technologies, new engine designs, enhanced fuel management systems and catalytic converters. At the same time California led the way in requiring that gasoline be reformulated to facilitate vehicles meeting the LEV standards. Canada has a similar fuel requirement that will take effect in the year 2006.

One strategy some manufacturers have adopted in efforts to meet the LEV standards was optimizing engines to operate on cleaner burning alternative fuels like natural gas, propane, ethanol and methanol. Due to cost and fueling infrastructure constraints, only a few models have been introduced to the market with limited success. Due to consumer acceptance issues most manufacturers have focused on developing vehicles that operate on gasoline and meet the LEV standards.

Today, all vehicles sold in North America, at a minimum, meet the LEV standard.

### ZEV Mandate &ndash; The Big Issue

For manufacturers the ZEV regulatory requirement was a major challenge. To offer a product that had no tailpipe meant that such vehicles would need to use a variety of new technologies, many of which yet had to be technically or commercially proven, meet cost criteria and be acceptable to consumers. The elimination of the tailpipe also eliminated the combustion engine as the source of motive power. This meant that vehicles had to use an electric drive that would be powered by either a battery based or fuel cell based system. As fuel cells were still under development the major short-term product development focus for manufacturers was battery-based vehicles.

### Battery Vehicles Enter Test Markets

By the mid-1990&rsquo;s vehicles such as Ford Ecostar , Toyota RAV4 EV and General Motor's EV-1 were on the road as test vehicle platforms. Other manufacturers also released their versions of battery-based vehicles.

Perhaps the most popular model of the battery-based electric vehicles was the Ford Ranger Pickup truck, which saw 2,000 of these vehicles placed in specialized fleets prior to the termination of the program.

As manufacturers invested billions of dollars in developing battery based vehicles the auto industry was not convinced that a market existed for vehicles which had a range of only 150 Km between charges and for which batteries cost in the order of up to \$15,000 extra per vehicle. These factors plus recharge times of five hours per vehicle resulted in extensive discussions, studies, hearings and legal actions by auto makers to modify California's original ZEV requirement, which has been partially successful.

#### The Path To Hybrids

A key outcome of the multi-billion dollar investments in battery-based technologies was that a hybrid type vehicle, using a combination of a gasoline driven internal combustion engine, and a scaled down battery, would almost achieve CARB's ZEV requirement. Such a vehicle would also be substantially less expensive than a pure battery vehicle while offering all the standard operational features consumers expect from a conventional gasoline fueled vehicle.

In 1997 Toyota introduced into the Japanese market the first generation hybrid Prius. In 2000 a Prius model was introduced into North America, as was the Honda Insight, a two-passenger vehicle. Consumer acceptance of the Prius has been very positive with even Hollywood celebrities driving and touting the vehicle. Honda successfully migrated its hybrid technology to the Civic model and many other manufacturers have announced they will be introducing hybrid vehicles across their product lines.

#### Fifteen Years of Accomplishments

There were two very significant accomplishments from California's LEV program that forced technology development. One, all gasoline fueled vehicles have become much cleaner with even a few gasoline only models meeting the PZEV (partial zero emission) standards, a feat thought impossible a few years ago. A PZEV is a vehicle that meets the Super Ultra Low Emission Vehicle (SULEV) tailpipe standard, has near-zero evaporative emissions and its emission control equipment has a 15-year/150,000 mile (240,000 km) warranty.

The second major accomplishment was that manufacturers have invested in developing and bringing to the market price-competitive new technologies that are being well received by consumers, such as hybrids. In the case of some hybrids, during certain portions of their drive cycle, they are de facto zero emission vehicles.

#### The Future

Scale matters in the auto industry and as hybrid technology rolls out across more vehicle models costs will decline as a function of volume over time. Hybrid technology is rapidly expanding across many car and SUV product lines and also into different vehicle types such as buses, medium and heavy duty trucks and specialized applications.

New hybrid technologies such as plug-in hybrids promise to offer a vehicle that can potentially, in some commuter applications, deliver up to a 1,000 MPG. To the extent that such vehicle platforms also use renewable fuels or hydrogen the net impact will be a quantum leap in the reduction of fossil fuel use, smog and CO2 emissions.

For an update on the regulatory actions by CARB related to fostering the roll out of electric vehicles in California see this story.