Title
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California’s Zero-Emission Vehicle Mandate

Linking Clean-Fuel Cars, Carsharing, and Station Car Strategies

Susan A. Shaheen, John Wright, and Daniel Sperling

To reduce transportation emissions and energy consumption, policy makers typically employ one or more approaches—changing technology or changing behavior. These strategies include demand-management tools, such as ride-sharing and vehicle-control technologies that involve cleaner fuels and fuel economy. Despite the benefit of a coordinated policy approach, these strategies are normally employed separately. Nevertheless, they have been linked occasionally, for instance in the electric vehicle programs of the 1990s. Station cars are vehicles used by transit riders at the start or end of a trip. In 1996, the California Air Resources Board (CARB) focused on reducing on-road air pollution by mandating that automakers introduce clean vehicles through its Zero-Emission Vehicles (ZEV) Mandate. In 1998, significant flexibility was introduced in the mandatory ZEV credits for very low-emission vehicles. In 2000, CARB left the ZEV mandate alone, but began considering new approaches, including station cars and carsharing. Carsharing is the short-term use of a shared-use vehicle fleet. In January 2001, recognizing the potential for station cars and carsharing to further improve air quality by reducing vehicle miles traveled—particularly with transit riders—CARB proposed additional ZEV credits for vehicles in such programs. Thus, the mandate would formally link demand management and clean vehicles. Employed are carsharing and station car development, reuse of parked, the ZEV mandate, and the government credit structure. Finally, policy and research recommendations are discussed for enhancing the success and effect of this combined approach.

An expanding economy and population means expanding travel demand. The benefits of increased travel are large. But the environmental and often unpaid social costs are also large, especially when travel is by single occupants in light-duty vehicles. Vehicle travel is expected to double or triple by 2020 in California and increase more than 50% across the United States, resulting in more congestion, wasted time, and more polluted air quality (1). Meanwhile, total highway capacity in the United States is already policed, with only about 2% added (in lane miles) over the past 30 years. The next 20 years will present a significant challenge—how to accommodate growing travel demand while limiting vehicle emissions and energy consumption.

One response is enhanced transit. At present, only 4 to 5% of the nation’s 118 million commuters use transit (2). One reason for low transit usage is the sparseness of a rail service, most people do not have easy access to transit stations at the house or destination end of a trip. Carsharing and stations can offer an innovative solution to transit access; they provide customers with short-term use of a vehicle to drive to and from a transit station and offer locations. Innovative policy approaches are needed to address energy, air quality, and congestion concerns. The universe of strategies may be grouped into those that change behavior and those that change technology. Travel demand-management (TDM) strategies, such as ride-sharing, parking restrictions, and road pricing, are examples of behavioral strategies. TDM strategies reduce and eliminate auto trips and improve the efficiency of the transportation system. Technology-targeted strategies aim to enhance the attributes of a specific technology. These strategies include requirements to use cleaner fuels, promulgation of more stringent emission standards, and government-funded technology research and development.

Typically, these two policy approaches (TDM and technology-targeted strategies) are employed separately. These are several exceptions, however. For instance, utilizing incentives in Los Angeles, carpooling credit for use of alternative fuel cars, and combining rules to promote cleaner fuel cars to encourage individuals to purchase and use them; and zero-emission vehicles (ZEV) are allowed to use high occupancy vehicle lanes in many regions. It is vastly understood, though, that target synergies result from a combined approach (3, 4).

A potentially attractive synergy can be examined for integration of clean vehicles with carsharing and incentivization stations. The policy mechanism is California’s Zero-Emission Vehicle (ZEV) Mandate. The motivation and historical precedent for the integrated ZEV initiative was a series of electric vehicle car programs launched in the 1990s (5–9). The linkage between the ZEV mandate and carsharing and station cars is the topic discussed.

CARS/HARING AND STATION CARS

The principle of shared-use vehicles is simple: individuals gain the benefits of private car use without the cash and responsibilities of ownership. Instead of owning one or more cars, a household or business accrues a fleet of shared-use vehicles and an associated pool of individuals gain access to vehicles by joining an organization that maintains a fleet of cars and light trucks in a network of locations. Generally, participants pay a fee each time they use a vehicle (4).

Station cars are often shared, although not always. They facilitate transit access either on the house or destination end of a trip.
Carpooling can be thought of as organized short-term car rental — often located near transit stations — accessible in commuting locations throughout neighborhoods, office parks, and college campuses. Carpooling organizations (CSOs) are most often found in dense metropolitan areas, distributed throughout a dense network of neighborhood lots. Built and Shaken, in a paper in this Report, observe that the concept of carpooling and shuttle cars are "merging... increasingly so that they include both elements: transit linkage and dispersed ride.

Carpooling and shuttle cars are most effective and attractive when used as transportation modes that fill the gap between transit and private cars and can link to other transportation modes and services. For long distances, one might use a shuttle vehicle, air transport, rail or bus, or a rental car, and for short distances, one might walk, bicycle, or use a taxi. For mid-range travel, even routine activities, one might drive a shared-use vehicle. Shared-use cars provide other customer attractions: they can also serve as mobility insurance in emergencies, and as a quasi or satisfying occasional vehicle needs for tasks such as carrying goods, pleasure driving in a sports car, or taking the family on a trip (1, 10). The focus here is primarily on European carpooling history and lessons learned and U.S. activities. Nevertheless, carpooling and entire cars have gained increasing popularity in Canada and Asia, particularly the use of advanced technology and electric vehicles in Japan.

Carpooling History and Lessons Learned from Europe

The earliest and broadest carpooling experiences have been in Europe. Carpooling emerged largely from individuals who sought the benefits of cars and were ideologically opposed to widespread use. Out of the earliest experiences with carpooling can be traced to a cooperative, known as the Friends of Modern, which originated in Zurich, Switzerland, in 1956 (17). Elsewhere, a series of "public car" experiments were attempted, but failed, including an experimental initiative known as Purokoff, begun in Montréal, France, in 1971, and another called Wilkus, deployed in Amsterdam in 1973 (22, 23).

In the late 1960s and early 1970s, many carpooling efforts were initiated in Europe and initially supported by government grants. Most involved the shared use of a few vehicles by a group of individuals. Most found it difficult to make the transition from grass-root, neighborhood-based programs into viable business ventures. They calculated initially the number of vehicles needed, placed too great an emphasis on advanced technology, or were ineffective in their marketing. Many failed organizations emerged or were acquired by larger organizations.

Those that survived were more professional, and they integrated advanced electronic and electronic technologies. But even today, carpooling accounts for only a small amount of travel in all but a handful of locations. The largest organization, Mobility CarSharing, has 2,000 cars and 50,000 customer, in 900 locations throughout Switzerland. In Germany, about 75 organizations serve approximately 40,000 customers with about 1,500 vehicles.

Carpooling activity and interest continue to increase. U.S. Department of Transportation (DOT) research on the potential market for car sharing programs has indicated that over 30 million people are currently involved in carpooling programs, with 25 million people sharing vehicles in over 300 cities. In addition, over 200 CSOs are operating 1,000 vehicles.

Early History of U.S. Carsharing and Shuttle Car Programs

In the United States, two formal carsharing demonstration research projects were undertaken in the 1980s. The first was Mobility Enter- prise, operated as a Purdue University research program from 1983 to 1986 in West Lafayette, Indiana (12, 13). Each household leased a very small "mini" car for short local trips and was given access to a shared pool of "special" passenger vehicles (1, 4, large sedans, trucks, and recreational vehicles).

In this field, the dedicated minivans were leased to participants who were not allowed to use them for less than 25% of the household vehicle miles traveled (VMT). In contrast, the carsharing fleet was used only 35% of the time that it was available to households throughout the experiment. A second U.S. carsharing program was the Shuttle Car Pilot Test (STARK) demonstration in San Francisco (12). The STAR company operated as a private enterprise from December 1983 to March 1985, providing individuals in an apartment complex use of a short-term vehicle (for a few minutes up to several days). Feasibility study funds were made available from the Urban Mass Transportation Administration and the California Employment of Transportation.

Users paid on a per-minute and per-mile basis until a maximum daily rate was reached. The members shared a fleet of 51 vehicles (44 cars, 5 wagons, and 2 large-duty trucks), with additional vehicles available as backups during periods of peak demand. Membership peaked at approximately 350 participants (14).

This project failed halfway through the planned 3-year program. The primary problem was that many tenants were students who shared apartments and were not actually listed on the lease. Thus, it was difficult to obtain vehicle payments from "unaffordable" ten- ants. Another failing was the pricing structure of STAR's encour- aged long-term (more than 25%), as well as short-term (less than 25%) rental. Long-term contracts resulted in long-distance tow- ing charges when the old, often poor-quality cars broke down several hundred miles from San Francisco. STAR's management tried to car- rent by purchasing used economy-class vehicles, but this resulted in high repair costs. Also, STAR apparently offered too many models in each vehicle class, leaving members disappointed when a particular car was unavailable (Martin Russell, unpublished data).

A more recent U.S. research project was a 2-year (1996 to 1998) study of van-car rentals at Bay Area Rapid Transit (BART) district stations. Pay BART project, Ceversco et al. (15, 16) conducted an early market assessment of car rental using a staged preference sur- vey. Nearly 50 electric vehicles were used, including Four-Person Independent Vehicle Company City Bots from Norway, two Toyoaks electrically active vehicles with four-wheel drive (EAV-4), and five Kewest from Denmark (17).

In addition, several electric car programs were launched in the mid-1990s by rail transit operators in large cities serving parking shortages at stations (and denying to the high cost of building more parking infrastructures), electric utilities (receiving a potential market for battery-powered electric vehicles), and air quality regulators (seek- ing to reduce vehicle usage and pollution). Many of these programs struggled with the high cost and low reliability of first-generation electric cars. Although those plans in the past of many such car programs, as of early 2002 only a few had aggressively incorporated shared-use practices (i.e., the programs typically have low user-to- vehicle ratios). Nonetheless, it has been experiment of "electro- ential" battery electric vehicles, assemblability used to reduce travel, encourage transit, and reduce pollution that inspired California
revisions to integrate the carsharing and station car concepts into the ZEV mandate and structure.

Current Status of U.S. Carsharing and Station Car Programs

In the United States today, there are 7 active CSOs (Table 1), 4 car- 
tion car programs (Table 2), 3 carsharing research pilots (Curlink, 
Infill, and ZEV Network) and ZEV Network Enabled Transport (ZEV NET), and 
over 10 programs currently planned for 2002 and 2003. More CSOs 
follow the predominant European operational model: private individu-
als access cars from nearby neighborhood lots, renting them to the 
same kit. Several of these programs use advanced technology
(i.e., multicard, Internet-based reservations, and vehicle tracking) 
to facilitate reservations, operations, and key management. Four are 
now in commercial business, six are integrated, one is a cooperative, 
and there are now 4 pilot sites.

Table 1: U.S. Carsharing Programs

<table>
<thead>
<tr>
<th>Program Name, Location &amp; Website</th>
<th>Launch &amp; Business Model</th>
<th>Program Size</th>
<th>Description</th>
</tr>
</thead>
</table>
| EcoCar Denver, Colorado (www.ecocar.org) | Cooperative | 15 Members, 1 Vehicle | Program is operated in the Denver
| Dancing Rabbit Vehicle Cooperative (Washington, D.C.) (www.dancingrabbit.org) | Cooperative | 1 Location | Carsharing program. Vehicles are fueled with biodiesel. |
| Portland, Oregon (www.pdxcar.org) | Commercial | 2000 | Program is located in community of 5,000 people. Approximately 10 of 30 members are active users. |
| Zipcar (Amherst, Massachusetts; Washington, D.C.; Minneapolis, MN; and No. York City) (www.zipcar.com) | 2000 | 12500 Members, 50 Vehicles, 48 Locations | Zipcar operates a neighborhood car-sharing model with corporate, community, and household membership packages. They are obtaining new gas-


to-electric hybrids vehicles for their fleet. They expanded to the Washington D.C. metropolitan region in 2001, then into the New York metropolitan area in 2001. |
| Boulder Carshare (Bozeman, CO) (www.carshare.org) | Non-profit | 30 Members, 4 Vehicles | This CSO operates a neighborhood carsharing program with one electric vehicle. |
| City Carshare (San Francisco, Berkeley, and Oakland, CA) (www.citycarshare.org) | Non-profit | 600 Members, 17 Locations | CarShare is a neighborhood carsharing program with household and business memberships. Vehicles are short-term permits or public transit

| Rainier Park Valley Vehicles (www.rainierparkvalley.com) | Non-profit | 20 Members, 1 Location | This CSO operates a neighborhood carsharing program with one electric hybrid vehicle. They use locations on small properties with electric vehicles. |
| The Car (Chicago, IL) (www.car-chicago.org) | Non-profit | 2 Members, 2 Vehicles | This program operates a neighborhood carsharing model, with permits to parks in public transit. They plan to start with 20 vehicles and begin accepting applications in March 2002. |
| Clean Mobility Carshare (Long Beach, CA) (www.carshare.org) | Commercial | Operating after April 2002 | The CarShare will launch with five electric vehicles. A variety of electric, battery, acoustic, and conventional types. Vehicles will be available for shared use in a few months. |
TABLE 2  U.S. Station Car Programs

<table>
<thead>
<tr>
<th>Project Name, Location &amp; Web Site</th>
<th>Launch &amp; Business Model</th>
<th>Program Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Commute Program (New York, NY)</td>
<td>1995</td>
<td>40 Members</td>
<td>This program initially began operations in 1995 with six electric vehicles, driven from a train station or LEED building. In fall 2001, new efforts were launched to expand to a total of 100 First @ Work electric vehicles along a commuter rail line.</td>
</tr>
<tr>
<td><a href="http://www.nyc.gov/cce">www.nyc.gov/cce</a></td>
<td></td>
<td>40 Vehicles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2001, expansion</td>
<td>7 Locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-profit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Commute (Montclair, NJ)</td>
<td>1997</td>
<td>20 Members</td>
<td>Power Commute deploys electric vehicles to aid in travel among two major urban and several other small cities: Lucas, Sumner, and Verona. Wisconsin.</td>
</tr>
<tr>
<td><a href="http://www.powercommute.org">www.powercommute.org</a></td>
<td></td>
<td>10 Vehicles</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-profit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaheim Transportation Network RAV Program (Anaheim, CA)</td>
<td>2000</td>
<td>14 Members</td>
<td>Wayne's carpool in Anaheim vehicles with two Motorlink members to their work sites.</td>
</tr>
<tr>
<td><a href="http://www.ravnetwork.org">www.ravnetwork.org</a></td>
<td></td>
<td>8 Vehicles</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-profit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hertz/BART Program (Fremont, CA)</td>
<td>2001</td>
<td>6 Members</td>
<td>Hertz runs the program based out of the Fremont BART station, which includes two Ford Think electric vehicles. These vehicles are also used for traditional rental vehicles. Hertz plans to expand program to a second BART station (Contra Costa) in 2002.</td>
</tr>
<tr>
<td><a href="http://www.hertz.com">www.hertz.com</a></td>
<td></td>
<td>55 Members</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>6-36 Vehicles</td>
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<td></td>
<td></td>
<td>depending on demand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial</td>
<td>1 Location</td>
<td></td>
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</tbody>
</table>

227 locations. Strong interest in carsharing is continuing in other U.S. cities. In 2002 and 2003, additional efforts are planned in San Diego, Los Angeles, Sacramento, and San Francisco (California), Denver, Colorado; Newark, Delaware; Adena, Georgia; Silver Spring, Maryland; Minneapolis, Minnesota; Philadelphia, Pennsylvania; and Madison, Wisconsin.

Lessons Learnt

Until the past decade, almost all efforts at organizing COSs resulted in failure, for a variety of reasons, a new era began in the late 1990s in Europe. A number of COSs are now firmly entrenched and on steep growth trajectories. These organizations appear to provide social benefits. Car sharing and car ownership diminished greatly when individuals were able to access car-sharing services, which is far greater that with virtually any other shared transportation strategy known. Particularly appealing is that carsharing represents an enhancement to mobility and accessibility for many people, especially those who are less affluent.

Some lessons in how and where to launch car-sharing programs are becoming apparent. On the basis of a review of the literature, car-sharing programs can be modeled most likely to be economically successful when the providers offer a network and variety of vehicles, serve a diverse mix of users, create joint-marketing partnerships, design a flexible yet single rate system, and provide for an easy emergency access to taxis and long-term car rental. They are more likely to thrive when environmental consciousness is high, driving disincentives such as high parking costs and one-way generation are pervasive, car ownership costs are high, and alternative modes of transportation are easily accessible. As new and important lessons, though not well documented, is the need for partnerships and mobility providers to offer enhanced products and services. Moreau's orientation of car-sharing programs thrive by acquiring those that fail or lack strong leadership. But to
retain customer loyalty, they may improve services and reduce costs. Two linked strategies are being followed.

1. Coordinate and link with other mobility (e.g., smart parking, public transportation, and mobility (e.g., employers and residential developers) services); and
2. Invest in advanced compensation, automation, and piloting technologies in conjunction with significant membership growth.

Both advanced technologies are expensive and piloting with other services is necessary. If the customer base is large, it may be possible to start new programs or to incorporate existing services. These mobility companies may then have to adjust their business models to account for the financial implications and to assess the feasibility of the business model.

It is important to understand the different ways in which these services can complement each other. For example, combining a car-sharing program with a bike-sharing program can provide a more efficient solution for short-distance travel. Additionally, integrating car-sharing programs with ride-sharing services can offer a more flexible and convenient option for travelers.

In conclusion, car-sharing programs have the potential to become a significant part of the transportation landscape. To ensure their success, it is crucial to understand the different aspects and to carefully plan their implementation. By doing so, car-sharing programs can contribute to a more sustainable and accessible transportation system.

CALIFORNIA'S ZEV MANDATE AND TRANSPORTATION SYSTEMS

In 1990, CARB adopted the low-emission vehicle (LEV) program, a long-term strategy to reduce air pollution from mobile sources through the gradual introduction of LEVs. Included in the LEV program is the ZEV mandate, which sets production requirements for ZEVs from manufacturers.

Originally, the ZEV mandate required that automakers produce a certain percentage of zero-emission vehicles (ZEVs) each year. The percentage increases each year, and in 2024, all new vehicles will be ZEVs. This mandate has been successful in reducing emissions from vehicles and improving air quality in California.

In 2019, the California Air Resources Board (CARB) proposed a new rule to phase out sales of new internal combustion engine vehicles by 2035, a move to accelerate the transition to zero-emission vehicles. The rule would require automakers to sell only zero-emission vehicles in California by 2035, and it would phase in the requirement for zero-emission vehicles starting in 2026.

The proposed rule is intended to reduce greenhouse gas emissions and improve air quality in California. The rule would require automakers to sell only zero-emission vehicles in California by 2035, and it would phase in the requirement for zero-emission vehicles starting in 2026.

In conclusion, the ZEV mandate and the transition to zero-emission vehicles are critical steps in reducing air pollution and improving the environment. By implementing these policies, California is setting an example for other states and countries to follow.
An additional credit multiplier is offered based on the vehicle's energy efficiency.

Beginning in 2007, the ten federal agencies used to calculate each automaker's ZEV requirement will be incentivized to include sport utility vehicles, pickup-trucks, and vans, thereby increasing the actual number of ZEVs expected.

The percentage increase of ZEVs will gradually increase, from 10% in 2010 to 16% in 2018.

Additional credits are provided for vehicles placed in "transit-transportation systems" (27).

This last change was made in recognition of the potential for car-sharing and station car programs to improve air quality by reducing total VMT and cold-start emissions because of shared-use and the linkage of clean-fuel vehicles to transit. The staff proposal, which was approved on January 25, 2001, provides a general description of the transportation system's credit mechanism. Additional proposed changes released on October 31, 2001 expanded and further defined the program. Under the most recent proposed language, each ZEV vehicle placed at an approved car-sharing/transit car program by automakers would receive additional credits as shown in Table 2. Note that automakers are not required to link "smart" car-sharing vehicles to transit in such programs but are eligible for additional credits if they do so. Furthermore, ZEV vehicles placed at transit stations are eligible for additional ZEV credits, without sharing use of advanced technology (27).

**LINKING ZEV VEHICLES TO CAR-SHARING AND STATION CAR PROGRAMS**

The motivation for the "transportation systems" portion of the ZEV requirement is to increase the vehicles in ZEV inventory that can be leveraged to increase the benefits of ZEVs. The assumption is that if ZEVs are placed at car-sharing or transit stations, they will be more accessible to the public. The proposed changes will provide an incentive for automakers to link ZEVs to transit or car-sharing programs. The motivation for this change is to encourage automakers to place ZEVs at transit stations or car-sharing programs, thereby increasing the number of ZEVs available to the public.

**TABLE 3: ZEV Credits for Vehicles Placed in Car-sharing and Station Car Systems (Proposed)**

<table>
<thead>
<tr>
<th>Program Elements</th>
<th>ZEV (i.e., battery electric vehicles)</th>
<th>Advanced Technology-PHEV (i.e., conventional fuel vehicles and hybrids)</th>
<th>PEV (i.e., super-deep low emission vehicles with no evaporative emissions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrated Shared-use Vehicles and Advanced Technology</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Transit Linkage</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total Possible Additional Credits</td>
<td>9</td>
<td>6</td>
<td>5</td>
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</table>
The potential of this combined approach—demand and technol-
gy management—in is significant. In upcoming years, planning, col-
aboration, and creativity will be needed to realize the benefits of this
approach. In working together, government agencies, local decision
makers, and private industry have the potential to create large-scale
car-sharing/station car programs. Lessons learned will aid in this
process, as well as comprehensive monitoring and evaluation. In
the final section, several policy and research recommendations
are outlined for the future.

RECOMMENDATIONS

As present, little is known about the social and environmental effects
of car-sharing and station cars. A statistically significant database on
car-sharing/station car programs does not yet exist. We cannot
accurately assess how the various programs have failed due to
accidents or due to underperformance. Furthermore, we have not yet
assessed whether or not car-sharing programs are effective. The
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