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California's Zero-Emission Vehicle Mandate

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

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To reduce transportation emissions and energy consumption, policy makers typically employ one of two approaches—changing technology or changing behavior. These strategies include demand management tools, such as ridesharing and vehicle control technologies that involve cleaner fuels and fuel economy. Despite the benefits of a combined policy approach, these strategies are normally employed separately. Nevertheless, they have been linked occasionally, for instance in the electric station car programs of the 1990s. Station cars are vehicles used by transit riders at the start or end of a trip. In 1990, the California Air Resources Board (CARB) focused on reducing mobile air pollution by mandating that automakers introduce clean vehicles through its Zero-Emission Vehicle (ZEV) Mandate. In 1998, significant flexibility was introduced through partial ZEV credits for very-low-emission vehicles. In 2000, CARB left the ZEV mandate intact, 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 linkages—CARB proposed additional ZEV credits for vehicles in such programs. Thus, the mandate would formally link demand management and clean vehicles. Explored are carsharing and station car developments, lessons learned, the ZEV mandate, and the proposed 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 other unpaid social costs are also large, especially when travel is by single occupants in light-duty vehicles.

Vehicle travel is expected to double over the next 20 years in California and increase more than 50% across the United States, resulting in more congestion, wasted time, and worsened air quality (*1*). Meanwhile, total highway capacity in the United States is barely increasing, with only about 2% added (in lane miles) over the past 30 years. The next few decades thus 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 transit service; most people do not have easy access to transit stations at the home or destination end of a trip. Carsharing and station cars 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 other locations (*3*).

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 ridesharing, 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 (*4*). There are several exceptions nevertheless. For instance, ridesharing rules in Los Angeles provide credit for use of alternative fuels; tax credits are often provided for clean-fuel vehicles 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 widely understood, though, that large synergies result from a combined approach (*5, 6*).

A potentially attractive synergy can be examined: the integration of clean vehicles with carsharing and station cars. 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 station car programs launched in the 1990s (*7–9*). The linkage between the ZEV mandate and carsharing and station cars is the topic discussed.

CARSHARING AND STATION CARS

The principle of shared-use vehicles is simple: individuals gain the benefits of private car use without the costs and responsibilities of ownership. Instead of owning one or more cars, a household or business accesses a fleet of shared-use vehicles on an as-needed basis. 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 (*3*).

Station cars are often shared, although not always. They facilitate transit access either on the home or destination end of a trip.

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Carsharing can be thought of as organized short-term car rental—often located near transit stations—accessible in convenient locations throughout neighborhoods, office parks, and college campuses. Carsharing organizations (CSOs) are most often found in dense metropolitan areas, distributed throughout a dense network of neighborhood lots. Barth and Shaheen, in a paper in this Record, observe that the concepts of carsharing and station cars are "merging" increasingly so that they include both elements: transit linkages and distributed lots.

Carsharing and station cars are most effective and attractive when seen 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 household vehicle, air transport, rail or bus, or a rental car; and for short distances, one might walk, bicycle, or use a taxi. But for intermediate travel, even routine activities, one might drive a shared-use vehicle. Shared cars provide other customer attractions: they can also serve as mobility insurance in emergencies, and as a means of satisfying occasional vehicle needs and desires such as carrying goods, pleasure driving in a sports car, or taking the family on a trip (*3, 10*). The focus here is primarily on European (carsharing history and lessons learned) and U.S. activities. Nevertheless, carsharing and station cars have gained increasing popularity in Canada and Asia, particularly the use of advanced technologies and electric vehicles in Japan.

Carsharing History and Lessons Learned from Europe

The earliest and broadest carsharing experiences have been in Europe. Carsharing emerged largely from individuals who sought the benefits of cars but were ideologically opposed to widespread car use. One of the earliest experiences with carsharing can be traced to a cooperative, known as Sefage, which originated in Zurich, Switzerland, in 1948 (*11*). Elsewhere, a series of "public car" experiments were attempted, but failed, including an initiative known as Procotip, begun in Montpellier, France, in 1971, and another called Witkar, deployed in Amsterdam in 1973 (*12, 13*).

In the late 1980s and early 1990s, many carsharing 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 grassroots, neighborhood-based programs into viable business ventures. They miscalculated the number of vehicles needed, placed too great an emphasis on advanced technology, or were ineffective in their marketing. Many failed organizations merged or were acquired by larger organizations.

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

Carsharing activity and interest continues to increase. Italy's Ministry of the Environment recently invested 5 million (U.S.) dollars for a national carsharing program. Operations were planned in four initial cities for Fall 2001, leading to a total of 15 deployments. Further, in June 2001, Germany's railway announced that they would launch "dbRent"—a carsharing and bike service throughout the nation. In Europe, there are over 200 CSOs operating nearly 4,000 vehicles.

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

In the United States, two formal carsharing demonstration research projects were conducted in the 1980s. The first was Mobility Enterprise, 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 fleet of "special purpose" vehicles (i.e., large sedans, trucks, and recreational vehicles).

In this field test, the dedicated minivehicles leased by participants were used for 75% of the households' vehicle miles traveled (VMT). In contrast, the carsharing fleet was only used 35% of the time that it was available to households throughout the experiment.

A second major U.S. carsharing project was the Short-Term Auto Rental (STAR) 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 Department 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 light-duty trucks), with 10 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 often difficult to obtain vehicle payments from "unofficial" tenants. Another failing was the pricing structure of STAR: it encouraged long-term (more than 24-h), as well as short-term (less than 24-h) rentals. Long rentals sometimes resulted in long-distance towing charges when the old, often poor-quality cars broke down several hundred miles from San Francisco. STAR's management tried to cut costs 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 dissatisfied 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 station car rentals at Bay Area Rapid Transit (BART) district stations. For this BART project, Cervero et al. (*15, 16*) conducted an early market assessment of station cars using a stated-preference survey. Nearly 50 electric vehicles were used, including forty Personal Independent Vehicle Company City Bees from Norway, two Toyota recreational active vehicles with four-wheel drive (RAV-4s), and five Kewets from Denmark (*17*).

In addition, several station car programs were launched in the mid-1990s by rail transit operators seeking to relieve parking shortages at stations (and desiring to avoid the high cost of building more parking infrastructure), electric utilities (eyeing a potential market for battery-powered electric vehicles), and air quality regulators (seeking to reduce vehicle usage and pollution). Many of these programs struggled with the high cost and low reliability of first-generation electric cars. Although shared use is the goal of many station 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 was these experiences of "zero-emission" battery electric vehicles, ostensibly used to reduce travel, encourage transit, and reduce pollution that inspired California regulators to integrate the carsharing and station car concepts into the ZEV mandate credit structure.

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

In the United States today, there are 7 active CSOs (Table 1), 4 station car programs (Table 2), 3 carsharing research pilots [CarLink, Intellishare, and ZEV Network Enabled Transport (ZEV-NET)], and over 10 programs currently planned for 2002 and 2003. Most CSOs follow the predominant European operational model: private individuals access cars from nearby neighborhood lots, returning them to the same lot. Several of these programs use advanced technology (i.e., smartcards, Internet-based reservations, and vehicle tracking) to facilitate reservations, operations, and key management. Four are run as commercial businesses, six are nonprofits, one is a cooperative, and three are research pilots.

The Dancing Rabbit Vehicle Cooperative, located in Rutledge, Missouri, has been in operation since 1998 as a cooperative. CarSharing Portland (now Flexcar Portland) was the first full-scale carsharing program in the United States, opening its doors in 1998. Flexcar started in Seattle in 1999, acquired CarSharing Portland in April 2001, and expanded to Washington, D.C., in November 2001.

In 2000, another major commercial organization, Zipcar, launched in Boston and has recently expanded into the Washington, D.C., area and New York City. Carsharing Traverse in Michigan launched in 2000. City CarShare, a San Francisco nonprofit organization, began

TABLE 1 U.S. Carsharing Programs

Program Name, Location & Web Site	Launch & Business Model	Program Size	Description
Dancing Rabbit Vehicle Cooperative (Rutledge, MO) www.dancingrabbit.org/drvc	1998 Cooperative	15 Members 3 Vehicles 1 Location	Program is operated in the Dancing Rabbit Ecovillage cooperative. Vehicles are fueled with biodiesel.
Flexcar (Seattle, Washington; Washington, D.C. Metropolitan Area; and Portland, Oregon) (Note: Flexcar Portland was formerly CarSharing Portland) www.flexcar.org	1999, Seattle 1998, Portland 2001, D.C. Commercial	4400 Members 108 Vehicles 85 Locations	A neighborhood carsharing model with a strong transit linkage. Flexcar acquired Portland (first full-scale commercial CSO in the U.S.) in 2001. Flexcar launched operations along D.C. Metro line in November. Gas-electric hybrid vehicles are incorporated into all fleets.
Carsharing Traverse (Traverse City, MI) www.carsharingtraverse.com	2000 Commercial	30 Members 3 Vehicles 3 Locations	Program is located in a community of 15,000 residents. Approximately 18 of 30 members are active users.
Zipcar (Boston, Massachusetts; Washington, D.C. Metropolitan Area; and New York City) www.zipcar.com	2000, Boston 2001, D.C. 2002, NYC Commercial	2150 Members 96 Vehicles 88 Locations	Zipcar operates a neighborhood carsharing model with corporate, individual, and household membership packages. They are planning to add gas-electric hybrid vehicles to their fleet. They expanded to the Washington D.C. metropolitan region in 2001, and then into the New York metropolitan area in 2001.
Boulder CarShare (Boulder, CO) www.carshare.org	2001 Non-profit	30 Members 4 Vehicles 1 Location	This CSO operates a neighborhood carsharing program, with one electric vehicle.
City CarShare (San Francisco, Berkeley, and Oakland, CA) www.citycarshare.org	2001, San Francisco 2002, East Bay Non-profit	1400 Members 40 Vehicles 17 Locations	City CarShare is a neighborhood carsharing program with household and business memberships. Vehicles are often placed proximate to public transit stations. They began expansion into Oakland in the fall of 2001 and are continuing to expand into Berkeley.
Roaring Fork Valley Vehicles (Aspen, CO) www.roaringforkvehicles.com	2001 Non-profit	30 Members 1 Vehicle 1 Location	This CSO operates a neighborhood carsharing program with one gas-electric hybrid vehicle. They are located in a small community with many seasonal workers.
I-Go Car (Chicago, IL) www.i-go-cars.com	2002 Non-profit	4 Members 2 Vehicles	This program operates a neighborhood carsharing model, with vehicles proximate to public transit. They plan to start with two vehicles and began accepting applications in March 2002.
Clean Mobility Center (Long Beach, CA) www.calstart.org	2002 Commercial	Recruiting after April 2002 5 Vehicles	This Center will launch with five electric Th!nk vehicles, a variety of electric bicycles, scooters, and conventional bikes. Vehicles will be available for shared use at Metrolink stations.

TABLE 2 U.S. Station Car Programs

Project Name, Location & Web Site	Launch & Business Model	Program Size	Description
Clean Commute Program (New York, NY) www.nypa.gov/ev	1995 2001, expansion Non-profit	40 Members 40 Vehicles 7 Locations	This program initially began operations in 1995 with six electric vehicles, driven from a train station to an IBM facility. In fall 2001, new efforts were launched to expand to a total of 100 Ford Th!nk electric vehicles along a commuter rail line.
Power Commute (Morristown, NJ) www.transoptions.org	1997 Non-profit	20 Members 10 Vehicles 1 Location	Power Commute deploys electric vehicles to aid users in traveling among one train station and several work sites: Lucent, Bauer, and Verizon Wireless.
Anaheim Transportation Network RAV4 Program (Anaheim, CA) www.atnetwork.org	2000 Non-profit	18 Members 8 Vehicles 2 Locations	Workers carpool in electric vehicles from two Metrolink stations to their work sites.
Hertz-BART Program (Fremont, CA)	2000 Commercial	6 Members (Regular) 6-36 Vehicles (depending on demand) 1 Location	Hertz runs this program based out of the Fremont BART station, which includes two Ford Th!nk electric vehicles. Vehicles are also used as traditional rental vehicles. Hertz plans to expand program to a second BART station (Colma) in 2002.

in 2001 and grew to 24 vehicles in its first 6 months. In the fall of 2001, City CarShare contracted to expand its operations into the East Bay communities of Oakland and Berkeley; several locations will be near BART stations. Other programs that launched in 2001 include Boulder CarShare and Roaring Fork Valley Vehicles in Aspen.

As of Spring 2002, two more CSOs have recently launched. I-Go in Chicago, Illinois, began recruiting members in March. The Clean Mobility Center, in Long Beach, California, publicly announced its launch in April 2002. They will provide electric vehicles, bikes, and scooters for shared-use along the Metrolink rail line.

The Clean Commute Program began as a demonstration in 1995. In June 2001, they reported seven members and five vehicles. In Fall 2001, this program announced plans to expand to 100 Ford Th!nk vehicles along the commuter rail line in the New York City suburbs. Power Commute launched its station car operations in 1997. This program is operated by a transportation management association and maintains a stable membership of 20 users. In 2000, the Anaheim Transportation Network and Hertz-BART programs started. Both focus on providing transit linkages to commuters and employment sites.

Three "smart" carsharing research pilots are currently in operation in California. CarLink II was launched in Northern California in July 2001; it builds on the 1999 CarLink I field test and is a transit-based commuter program with 20 Honda Civics (*18–20*). Southern California's Intellishare program, which incorporates 25 Honda EV Plus electric vehicles, smartcards, and onboard computer technologies, operates under the direction of University of California, Riverside researchers. The third, ZEV-NET is a public–private partnership between Toyota and University of California, Irvine (UCI), consisting of 15 e-coms and smart technologies, shared among six employers located in the UCI office park. ZEV-NET plans to link with transit 10 e-coms, 30 RAV-4 electric vehicles, and 10 Prius vehicles in 2002.

As of March 2002, U.S. carsharing and station car programs collectively claimed 8,689 members and operated 419 vehicles from 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 (Presidio), California; Denver, Colorado; Newark, Delaware; Atlanta, Georgia; Silver Spring, Maryland; Minneapolis, Minnesota; Philadelphia, Pennsylvania; and Madison, Wisconsin.

Lessons Learned

Until the past decade, almost all efforts at organizing CSOs resulted in failure. For a variety of reasons, a new era began in the late 1980s in Europe. A number of CSOs are now firmly established and on steep growth trajectories. These organizations appear to provide large social benefits. Car travel and car ownership diminish greatly when individuals gain access to carsharing services, which is far greater than with virtually any other demand management strategy known. Particularly appealing is that carsharing represents an enhancement in mobility and accessibility for many people, especially those who are less affluent.

Some lessons in how and where to launch carsharing programs are becoming apparent. On the basis of a review of the literature, carsharing programs can be concluded most likely to be economically successful when they provide a dense network and variety of vehicles, serve a diverse mix of users, create joint-marketing partnerships, design a flexible yet simple rate system, and provide for easy emergency access to taxis and long-term car rentals. They are more likely to thrive when environmental consciousness is high, driving disincentives such as high parking costs and traffic congestion are pervasive, car ownership costs are high, and alternative modes of transportation are easily accessible.

An even more important lesson, though not well documented, is the need for partnerships and mobility providers to offer enhanced products and services. More business-oriented carsharing programs thrive by acquiring those that fail or lack strong leadership. But to retain customer loyalty, they must improve services and reduce costs. Two linked strategies are being followed:

1. Coordinate and link with other mobility (e.g., smart parking management) and nonmobility (e.g., employers and residential developers) services; and
2. Incorporate advanced communication, reservation, and billing technologies in conjunction with significant membership growth.

But advanced technologies are expensive and linking with other services is successful only if the customer base is large, so most carsharing programs have either remained quite small or followed a notable growth trajectory.

Taking a longer view, carsharing companies may be the prototype of an entirely new business activity: innovative mobility service companies. As vehicle ownership proliferates and vehicles become more modular and specialized, entrepreneurial companies may see an opportunity to assume the full care and servicing of a household's or an individual's mobility needs in neighborhoods, work sites, transit stations, and shopping centers, on the basis of mobility management. These innovative mobility companies might handle insurance, registration, maintenance, and parking management and could substitute vehicles as a household's situation changes. One can imagine a future in which pioneering carsharing programs combine their operational expertise with the entrepreneurial capabilities of advanced technology suppliers to create mobility services that enhance our social, economical, and environmental well-being. Although experience and evidence are not extensive, there is reason to believe that "smart" carsharing concepts and technologies provide the foundation to create new transportation solutions. It is impossible to know the ultimate market for carsharing and its derivatives and spin-offs, although some new directions are emerging (e.g., linkages to employers, residential and commercial managers, developers, and parking management facilities). It is difficult to estimate demand for new technologies and new attributes when customers have no experience with those products and attributes and when those attributes remain somewhat uncertain. Further, determining the demand for carsharing is especially difficult because it implies some reorganization of a household's travel patterns and lifestyle. People use and view their cars in many different ways that are poorly understood. They value them not only for utilitarian travel, but also for storage, quiet time away from family and work, and office space. How important are these uses and activities and for whom? How much inconvenience are people willing to accept in return for less cost? And how much value will be associated with such services?

It is also impossible to know what effects carsharing systems and their innovative mobility offshoots will have. Early evidence from Europe suggests up to a 50% reduction in vehicle travel—the result of travelers now having easier access (and egress) to transit stations and a greater share of fixed costs shifted to variable costs (*11, 21*). One would expect the net effect of these new types of ownership patterns and innovative mobility services to be less vehicle travel, for the reasons cited above. Indeed, this belief is what motivates many of the pioneers and sponsors of carsharing and station car programs. But the future evolution of these services and usage patterns is still highly uncertain and indeed will be influenced by many factors, including the ZEV mandate.

To summarize, this section provided an overview of carsharing and station car activities in Europe and the United States and lessons learned. Next is discussion on the California Air Resources Board's (CARB) proposed linkage of clean-fuel vehicles, through its ZEV mandate to transportation systems, which include carsharing and station car services.

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 in future years. Pure ZEVs are defined as vehicles that produce no tailpipe emissions. At present, battery electric vehicles are the only commercially available vehicles that meet this specification.

Originally, the ZEV mandate required that automakers produce at least 2% ZEVs by 1998, 5% by 2000, and 10% by 2003 (the percentage was applied to cars only, not light trucks, and applied to the seven largest suppliers to California in 1998 and 2001 and then expanded to include all but the very smallest suppliers in 2003). The credits were, and still are, tradable, with a $5,000 fine imposed for each vehicle not made available for sale.

The ZEV mandate was subject to biennial reviews up to the year 2000. In 1992 and 1994, no changes were made. In 1996, on the basis of assessment of current battery technology, CARB modified the regulations to allow time for technology development. They eliminated the production requirements for 1998 to 2002, but retained the 10% requirement for 2003, in exchange for a Memorandum of Agreement with the seven major automakers, that is, DaimlerChrysler, Ford, General Motors, Honda, Mazda, Nissan, and Toyota. The automakers agreed to do these things:

- Continue to invest in ZEV and battery research and development, and
- Produce up to 3,750 advanced battery-powered ZEVs from 1998 to 2000.

In 1998, CARB introduced significant flexibility into the program. Under the new regulations, automakers could earn partial ZEV (PZEV) credits as incentives for producing very-low-emission conventional vehicles (e.g., gasoline vehicles with extremely low emissions). Additional incentives were provided to encourage the use of advanced componentry, and the introduction of "pure" ZEVs before the 2003 deadline. Up to 6% of the 10% requirement in 2003 could be met with PZEVs (*22*).

At the 2000 review, CARB chose to leave the ZEV mandate intact, but asked staff to present proposals to address the challenges associated with a successful long-term ZEV implementation program. At a board meeting on January 25, 2001, several staff proposals were approved that granted automakers even more flexibility, whereas more stringent requirements were added in future years. The approved changes include

- In early years, the required number of pure ZEVs are reduced by approximately half, from 4% to 2% of total sales.
- Advanced technology PZEVs (AT-PZEVs) such as compressed natural gas, gas–electric hybrid, or methanol fuel cell vehicles can satisfy up to one-fifth of the 10% requirement (i.e., equivalent to 2% of total vehicle sales).
- ZEV credits will be given to automakers who produce vehicles for demonstration projects to encourage participation in programs such as the California Fuel Cell Partnership.

- An additional credit multiplier is offered based on the vehicle's energy efficiency.
- Beginning in 2007, the sales figures used to calculate each automaker's ZEV requirement will be broadened to include sport utility vehicles, pickup trucks, and vans, thereby increasing the actual number of ZEVs required.
- The percentage requirement of ZEVs will gradually increase, from 10% in 2003 to 18% in 2018.
- Additional credits are provided for vehicles placed in "transportation systems" (*22*).

This last change was made in recognition of the potential for carsharing and station cars (or transportation systems) 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, provided 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 in an approved carsharing/station car program by automakers would receive additional credits as shown in Table 3. Note that automakers are not required to link "smart" carsharing 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 credit, without sharing or use of advanced technology (*23*).

LINKING ZEV VEHICLES TO CARSHARING AND STATION CAR PROGRAMS

The motivation for the "transportation systems" portion of the ZEV regulation was twofold. First, CARB staff recognized that a significant benefit of carsharing is short-term customer access to a variety of vehicle models. Thus, a wide range of ZEV vehicles (e.g., electric, compressed natural gas, and hybrid vehicles) could be introduced into carsharing programs, allowing customers to select the most appropriate clean-fuel vehicle for their trip needs on the basis of driving range, fueling infrastructure availability, number of passengers, and so forth. Accordingly, the transportation systems credit structure awards additional credits for ZEV, AT-PZEV, and PZEV vehicles incorporated into carsharing and station car programs. Both carsharing and station car programs are perceived to offer a potential market for the near-term placement of ZEV vehicles.

The board also believed that such programs (particularly shared-use vehicle programs linked to transit) are well matched to the performance characteristics of battery electric vehicles (e.g., 113 to 120 km on a charge) because of the short length of many station car and commuter carsharing trips. Furthermore, cold-start emissions can be reduced through the use of clean-fuel vehicles (e.g., battery electric and fuel cell vehicles, fueled by hydrogen) for multiple trips throughout the day. Shared-use vehicle programs also could make use of smaller electric vehicles, which might serve as local neighborhood or city vehicles. Since smaller vehicles would need much less energy and smaller batteries, they would be relatively less expensive to operate.

A second motivation was to link the ZEV mandate to transportation strategies that reduce vehicle usage. Carsharing and station car programs can result in more transit-based trips, thus reducing vehicle travel and air pollution. In their proposal, CARB staff specified a direct link to transit (i.e., the car must be placed at or close to a transit station) for ZEV vehicles to be eligible to receive additional "transit linkage" credits. This is an important point, as many carsharing operators claim that users increase transit ridership as a result of carsharing, often without a direct transit linkage (e.g., a lot located at a transit station).

To summarize, carsharing and station cars provide a potential market niche for LEV and a modal alternative that offers the promise of reduced vehicle travel. The current proposal of CARB staff for granting extra credit to automakers is presented in Table 3. As proposed, the use of these transportation system credits would be capped at an amount equivalent to one-half of a manufacturer's pure ZEV obligation, one-fourth of the AT-PZEV category, and one-thirtieth of the PZEV category (*23*).

As indicated, a battery electric vehicle used as a station car, even without vehicle sharing, would receive three vehicle credits. If this transit-linked vehicle is also part of a carsharing program, with advanced technologies used for reservations, billing, and management, then it receives an additional six credits. For example, a 2003 Th!nk city vehicle (European model) is eligible for 1.25 credits (including early introduction credits). If placed in a carsharing program, linked to transit (or transportation system) with advanced technology, it would be eligible for an additional 9 credits, totaling 10.25 credits for one individual vehicle.

If hybrid or natural gas vehicles (categorized as AT-PZEV) are used, then they would receive four additional credits if part of a smart carsharing application and another two if linked to transit (or used as station cars). For instance, a 2003 natural gas Civic is eligible for 2.0 credits (again, reflecting early introduction). Similarly, if placed in a carsharing program linked to transit with advanced technology, this vehicle would be eligible for an additional 6.0 credits, for a total of 8.0. PZEV vehicles (such as very-low-emitting gasoline cars) are also eligible for additional credits, but in smaller amounts. To summarize, the additional credits offered here are the equivalent of up to several vehicles—a significant incentive to vehicle manufacturers.

The addition of transportation system credits in the ZEV mandate could have a substantial effect within and outside California. The

TABLE 3 ZEV Credits for Vehicles Placed in Carsharing and Station Car Systems (Proposed)

Program Elements	ZEV (i.e., battery electric vehicles)	Advanced Technology-PZEV (e.g., compressed natural gas vehicles and hybrids)	PZEV (i.e., super ultra low emission vehicles with no evaporative emissions)
Demonstrated Shared-Use Vehicles and Advanced Technology	6	4	2
Transit Linkage	3	2	1
Total Possible Additional Credits	**9**	**6**	**3**

effects outside California result in part from the technology and concepts being demonstrated and publicized—but also because other states are also adopting the ZEV mandate. Initially, New York, Massachusetts, Vermont, and Maine adopted California's original ZEV mandate; and others may follow in the future (*24*). If other states adopt the mandate, then they must adopt the entire package of embedded rules (although flexibility is available with regard to the timing and phase-in of the various requirements). This requirement is rooted in a federal law that requires all states to adopt either the national emission standards (as promulgated by the U.S. Environmental Protection Agency) or California's. There is no "third" standard allowed at present. Thus, California's ZEV credits for carsharing and station car vehicles will have a significant effect nationally. Widespread growth of shared-use vehicle programs in California will, if successful, provide a highly visible model for the nation, automakers, information technology companies, and third-party service operators interested in expanded market opportunities. And the transportation systems provisions of the ZEV mandate will likely influence how those initiatives evolve, perhaps sharply.

SUMMARY AND RECOMMENDATIONS

Smart carsharing and station cars provide a promising opportunity to reduce vehicle travel, and the ZEV mandate has been perhaps the most effective policy instrument for accelerating the development and commercialization of clean-propulsion technology. The integration of carsharing and station cars with the ZEV mandate could have important implications. This is an illustration of how creative policy making can be used to integrate behavior and technology strategies. It is also an illustration of the need for regulators and policy makers to be flexible and attentive to new knowledge and changing circumstances. The ZEV mandate of 2001 has greatly changed since the mandate of 1990. And with the integration of carsharing and station cars, the technology transformation inspired by the ZEV mandate may now spread more broadly into the design and use of passenger transportation systems.

CARB has taken on a broad responsibility. It has been respectful of its role in the past by periodically revising the ZEV mandate to reflect new knowledge and understanding. To play an effective and beneficial role as CARB proceeds into broader transportation issues, it will need to broaden and deepen its expertise and develop new partnerships and means of information gathering. In 2002, CARB plans to finalize this regulation and begin developing strategies to support these efforts in California. At present, CARB is exploring a joint memorandum of understanding with two other state agencies (California Department of Transportation and California Energy Commission) to support the ZEV–carsharing/station car program linkage. Issues that CARB will need to explore further include

- Role of advanced technologies in facilitating use and program operations,
- Model approaches (e.g., carsharing and station cars),
- Economic viability,
- Lessons learned and success factors,
- Need for large-scale and coordinated efforts (e.g., interoperability among systems for users),
- Guidelines for assigning ZEV credit,
- Public–private partnerships, and
- Effect assessment (e.g., societal and environmental system effects).

The potential of this combined approach—demand and technology management—is significant. In upcoming years, planning, collaboration, 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 carsharing/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

At present, little is known about the social and environmental effects of carsharing and station cars. A statistically significant database on carsharing/station car program effects does not yet exist. One cannot accurately generalize about behavior, viability, and actual social benefits. Furthermore, there has not yet been significant "scaling" in any U.S. test. Indeed, several carsharing programs failed in Europe because they lacked economies of scale (i.e., too few vehicles and high overhead rates made profitability difficult to achieve). The hypothesis is that with scale (e.g., 1,000+ vehicles) and supportive policies (e.g., ZEV mandate, reduced or donated "premium" parking spaces, partnerships with employers and developers, and start-up subsidies), carsharing programs can become economically sustainable.

Current and future efforts should focus on increasing vehicle and membership numbers and on introducing the latest labor-saving technologies to reduce overhead and provide user-friendly services. To gain a statistically valid data set on system benefits and costs, Key questions should be answered:

- Can carsharing and station car systems facilitate transit access and encourage use?
- Can they reduce parking needs at transit and work?
- Can they help attract and retain employees?
- Can they support air quality and other environmental goals?
- Can they encourage more careful tripmaking with regard to duration and distance traveled?
- Finally, can they become economically sustainable?

To answer these questions will require travel behavior analysis, market research, and economic analysis, as well as investigation of environmental and social effects, technologies and services needed, technology standardization, and institutional issues (e.g., insurance). Finally, in linking the ZEV mandate to carsharing and station car programs, an assessment of this policy should be conducted, which looks at the role of subsidies and incentives that can help foster these programs, as well as the role of creative partnerships (e.g., transit discounts, parking incentives, and insurance).

Over the next decade carsharing and station car system success may depend on how well such programs can integrate advanced technologies—electronic and wireless systems and clean-fuel vehicles and infrastructure. On the operations side, advanced technologies need to be further developed to make carsharing services economically efficient to manage. Key research components include analyzing institutional issues (e.g., determining the ideal institutions for managing such programs, for instance, nonprofits or commercial); deployment barriers (e.g., insurance costs); and which technologies and services are necessary from an operational perspective.

On the user side, carsharing services aim to provide as much flexibility and mobility as the private auto. Thus, advanced technologies are needed to make an individual's tripmaking more seamless, so users can easily access carsharing and station car vehicles (even spontaneously) or switch modes quickly with little hassle. Information technologies will be critical to facilitating modal connectivity and integrating reservations, smartcards, and fleet management systems to enable convenient vehicle access and billing. Furthermore, user-friendly interfaces could be expanded to provide real-time traveler information to users, so they will know vehicle locations, traffic conditions, time and travel costs, and how to use each system.

To conclude, the long-term potential and viability of carsharing and station car programs could be strengthened through a combination of approaches, including

- Cost-reduction strategies (e.g., scale, advanced technologies, and insurance);
- Policy incentives (e.g., parking management);
- Public–private partnerships;
- Partnerships with employers and developers;
- Increased user revenues; and
- Local program support.

Although these fundamental issues and questions are noteworthy independently, a focused agenda is needed to help coordinate individual efforts and to concentrate research and evaluation in needed areas.

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