

TRANSPORTATION AND SAFETY IN JAPAN

SHARING ELECTRIC VEHICLES IN KYOTO: KYOTO PUBLIC CAR SYSTEM*

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INTRODUCTION

The Kyoto Public Car (KPC) System project, an electric-vehicle (EV) sharing demonstration project, is an endeavor to achieve several objectives. The first is to examine the feasibility of the system comprising smart EVs produced by two manufacturers, an advanced fleet management system, and a rental transaction administration system. The second is to test whether the service can be extended to general driver populations including tourists visiting Kyoto. The third is to determine whether the proposed "public" car system is a workable concept in Japan. The fourth objective is to evaluate the economic viability of the proposed car sharing system as a commercial undertaking. Under the sponsorship of the New Energy and Industrial Technology Development Organization (NEDO), the KPC System commenced its operation in December 2000. The System was initially configured with 5 stations, a total of 29 rechargers, 19 two-seater EVs (Toyota e-coms and Nissan Hyperminis), and an additional 4 EVs set aside as backups. Approximately 250 individuals had applied by the time of opening, of whom about 180 qualified as members.

1. KYOTO PUBLIC CAR SYSTEM

One of the important features of the KPC System is that the same

operating system has been successfully implemented on both e-coms and Hyperminis. The same IC membership card can be used to operate both models, and they can be recharged with the same recharger. Also important are the efforts that have been made to minimize the operating cost of the System. For example, vehicles are not manually dispatched to, or reallocated among, the EV stations to reduce labor cost. Requests for reservations are handled completely automatically through the Internet. Features of the KPC System are summarized in Table 1 below.

To use an EV, a member must first make a reservation, by indicating the date, time, and stations for

checkout and return, and other information through the Internet. A request for a reservation is accepted when there is an appropriately charged EV at the origin station and a recharger available at the destination station. The checkout process starts at the depot terminal at the origin station, which has a touch-screen monitor and an IC card reader/writer, and is connected to the operation center by a dedicated line. Once the user is identified and checked against the reservation record, the EV to use is indicated on the monitor. The IC membership card is then used as a car key to unlock the door and operate the specified vehicle.



Photo 1 Kyoto Public Car System Fleet

Table 1 Features of the Kyoto Public Car System

Reservation	Via Internet from PC or cellular phones (the terminal at each EV station is connected to the Internet).
Use of vehicle	The member identifies himself at the depot terminal using the IC membership card. The door can be unlocked and the electric system started by the IC card. The same card operates on both e-com and Hypermini.
Recharging	Quick recharge to both e-com and Hypermini with the same inductive recharger.
Information service	Provides traffic and other information through MONET (e-com) and Compass Link (Hypermini). Tourist information available at the terminal at each EV station.
Location management	Fleet management by GPS. Warns the driver when the vehicle goes out of the designated service area.

* This paper contains materials presented at EVS-17, Montreal, October 2000 (Kitamura et al., 2000)¹, and EVS-18, Berlin, October 2001 (Kitamura et al., 2001)².



Photo 2 Hypermini in the Gion Area

2. OPERATION RECORD

The operation of the KPC System has been aided by simulation studies. A simulation model system was developed to represent the operation of the KPC System, and was combined with genetic algorithms (GA) in the effort to search for the optimum system configuration. A major finding is that there must be about twice as many EV parking spaces with rechargers as EVs. For further results, see Nakayama et al.³

Operation data are summarized in Table 2 in terms of mean utiliza-

tion rates (the frequency of checkouts per EV) and load factors (fraction of time an EV is in use), along with the number of EVs, number of stations and number of rechargers. There was a total of 3,087 checkouts between December 18, 2000, and March 20, 2001. Of these, 2,148 (69.6%) were for "round trips," i.e., an EV was returned to the same station from which it had been checked out.

Once checked out, an EV was used on average for 1 hour and 44 minutes. The mean duration of one-

way trips (an EV was checked out from a station, then returned to another station) was 68 minutes, which is substantially shorter than the mean of 120 minutes for round trips. About 37% of uses were within 1 hour, while 39% exceeded 2 hours, and 15% exceeded 3 hours. The distribution of trip distances also shows the tendency of frequent short trips. Vehicle checkouts concentrated around 9:30 AM and 1:00 PM, resulting in highest utilization of EVs between 11:00 AM and 2:00 PM. Use for commuting was rather infrequent and mid-day use was prevalent.

The use of EVs increased gradually, from an average of 29 checkouts per day in December to 33 in January, 38 in February, and 40 in March. This is presumably because the membership size increased, the members became more familiar with the System, and a new station was added and more EVs were introduced into the System. EVs were checked out on average 38 times on a weekday, and 31

Table 2 Mean utilization rate and load factor: December 2000 March 2001[†]

	12/23 ~ 1/11	1/12 ~ 1/28	1/29 ~ 3/07	3/08 ~ 3/15	3/16 ~ 3/20
Members	177	270 ^a		355 ^b	
No. of EVs ^c		19	23	28	31
No. of Stations		5		6	
No. of Rechargers		29	35	40	43
Mean Utilization		2.12	2.11		2.13
Weekdays		2.22	2.21		1.88
Weekend		1.86	1.88		2.54
Mean Load Factor		32.4%	26.1%		28.5%
Weekdays		31.3%	26.3%		26.0%
Weekend		35.4%	25.6%		32.4%

a: 1/12 ~ 1/25

b: 1/26 ~ 3/20

c: Includes one EV per station (except for the Miyako Messe station) which is set aside as a backup vehicle.

[†] Due to snow, operation was terminated at 2:30 PM on January 7, and at 1:00 PM on January 20.



Photo 3 E-coms in the Kodaiji Area



Photo 5 Miyako Messe Depot



Photo 4 E-coms at JR Kyoto Station



Photo 6 Kyoto Astem Depot

times on a weekend day and holiday during the study period. Cancellation rates were high and ranged between 20% and 30%. Of all the requests for reservations entered, 50.7% were actually accepted. About 40% of rejected cases were due to input errors by members, and 60% were due to unavailability of EVs or spaces to return EVs. These remain problems to be resolved. There were reports of 3 minor accidents, and 1 case of a flat tire. No serious accidents or serious mechanical problems were reported during the study period.

3. USER RESPONSE

Reviewing the communication logs maintained by the system operators indicates the most frequent questions raised by members were concerned with the exact location of the stations (40 calls during the study period), followed by those concerning forgotten user ID numbers and passwords (36 calls). Other frequent questions were concerned with: battery status, how to get into or out of a station, and how to use their own mobile phones to make reservations. There were 16 reported incidents where members could not start the motor with the IC card,

and 15 cases where the card did not work properly at the depot terminal. There were 5 cases where no EVs were available despite valid reservations, and 4 cases where EVs could not be properly returned because there was no space available. Considering that the System had just started its operation with the common operating system installed on both e-com and Hypermini, and that there were 3,087 checkouts altogether during the study period, the number of incidents is surprisingly small.

The operation data indicate a small number of frequent users ac-

counted for a majority of the EV use. Of the 355 members, 91 (25.6%) used an EV at a rate of at least once a week (the total frequency of use was divided by the number of days as a member), and another 105 members (29.6%) did so at a rate of at least once a month. On the other hand, 62 members (17.5%) checked out an EV less than once a month, 16 members (4.5%) never used an EV because either their requests for reservations were not accepted or they cancelled their reservations. Finally, 79 members (22.3%) never placed a reservation request at all. Quite notable are 6 members who checked out an EV at a rate of 4 to 6 times a week, and 4 members who did so at least 7 times a week. While approximately one quarter of the members never used an EV, there were a few quite intensive users of the System. These heavy users tended to have shorter use durations, and used EVs for commuting and chauffeuring others more often than the rest of the members. Business owners had the highest average use rate of 0.27 checkouts per day. Homemakers followed this with a rate of 0.21, and employed workers had a rate of 0.14.

Member surveys conducted as part of the evaluation study have indicated that 37.2% of those who made reservations did so most frequently via the Internet from work, 25.7% via the Internet from home, 16.2% via mobile phones, and 8.7% at the depot terminal. Over 75% of them thought it was easy to make a reservation. Likewise, 77.1% indicated that recharging was easy once they got used to it. Opinions about

the adequacy of two-seater EVs as car-sharing vehicles split, with 45.2% responding positively and 42.7% negatively. Overall, 81.8% of respondents had a positive experience with the KPC System, and about two-thirds were satisfied. Finally about one-third of the respondents thought the use of their gasoline vehicles had been reduced.

4. SYSTEM EXTENSION

In September of 2001, membership was extended to non-residents of the City of Kyoto, including tourists and business visitors to the city. Rules and regulations of the KPC System were placed on the project homepage for review by prospective members. Also in September 2001, charging for EV use commenced at the rate of 20 yen per minute, or 15 yen per minute with the payment of a 1,000-yen fee per month. These rates are roughly speaking between bus and taxi fares. Users were billed monthly and payments were made through a credit card account. This phase of the demonstration project ended on December 24, 2001, and operation data are now being analyzed.

The KPC System is envisaged to grow into a self-supporting enterprise after the third year of the demonstration project. Toward that end, roles to be played by the national government, local governments, and private sector entities are currently being identified. Expected revenues are likely to be limited because an initial examination of the data indicates utilization rates decreased significantly when charging started. Charges for EV use, on the

other hand, cannot be set much higher than those during the experiment because the EVs compete with private vehicles as well as rental cars, buses, taxis, and other public transportation modes. To make the System financially viable, efforts are being made to minimize expenses.

The KPC System demonstration project has proven the car-sharing system that deploys state-of-the-art IT technologies is fully operational with general drivers. The project has also proven the automated reservation system and the rental transaction system work well without any serious problem with drivers who have diverse backgrounds. Continuous improvements are being made to make the system more efficient and easier to use, while remaining problems will be resolved as we continue with the demonstration project. It is hoped that the current System will develop into an economically viable enterprise in the near future.

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