APPENDIX A
NOMENCLATURE

Abbreviations

CP	Charging Pile
CS	Charging Station
DR	Demand Response
EV	Electric Vehicle
V2G	Vehicle-to-Grid
VPP	Virtual Power Plant

Parameters

α_1	Coefficient corresponding to the lower limit of the DR power requirement for the CS
α_2	Coefficient corresponding to the upper limit of the DR power requirement for the CS
τ	Size of the planning time horizon
C^{o}	Subsidy from the grid for unit response electricity
C^{p}	Penalty from the grid for unit deviation electricity
C_j^{chmax}	Expected maximum price of unit electricity for EV_j to charge
C_j^{chmin}	Expected minimum price of unit electricity for EV_j to charge
C_j^{dcmax}	Expected maximum subsidy of unit electricity for EV_j to discharge
C_j^{dcmin}	Expected minimum subsidy of unit electricity for EV_j to discharge
C_k^{pur}	Unit purchase price of electricity for CS_k from the grid
C_k^{resmax}	Maximum recruitment subsidy of CS_k for unit response electricity
C_k^{resmin}	Minimum recruitment subsidy of CS_k for unit response electricity
C_k^{sell}	Unit sell price of electricity for CS_k to EVs
C_k^{s}	Unit sales profit of electricity for CS_k to EVs
C_k^{wait}	Subsidy of CS_k for unit waiting time of EVs
C_k^{resbase}	Basic recruitment subsidy of CS_k for unit response electricity
K_j	Price preference type of EV_j, 1, 0, and -1 represent the driver as sensitive, neutral, and insensitive, respectively
L	Size of the planning lead time
N_k	Total number of CPs at CS_k
$P_{k,i}^{\mathrm{max}}$	Maximum charging or discharging power of CP_i at CS_k
$P_{k,t}^{\mathrm{base}}$	Base power of CS_k at time t
Q_j^{max}	Maximum battery capacity of EV_j
Q_j^{safe}	Minimum battery power level of EV_j at which the driver won't have energy anxiety
Q_k^{resthre}	Required amount of response electricity of CS_k for recruited EVs
S_k	Type of DR task received by CS_k, 1 indicates valley filling task, and -1 indicates peak shaving task
T	Time limit of a certain DR task

Sets and Indices

i	Index of CP
j	Index of EV
k	Index of CS
l	Index of planning time horizon
t	Index of time

Variables

$\mathrm{Pr}_{j,k,t}^{\mathrm{ch}}$	Probability of EV_j charging to participate in the DR task of CS_k
$\mathrm{Pr}_{j,k,t}^{\mathrm{dc}}$	Probability of EV_j discharging to participate in the DR task of CS_k
$C_{k,j,l}^{\mathrm{res}}$	Unit response electricity subsidy for recruited EV_j at CS_k in the l-th time horizon
$C_{k,t}$	Charging price or discharging subsidy for recruited EV_j at time t
$C_{k,t}^{\mathrm{res}}$	Recruitment subsidy for unit response electricity from CS_k at time t
$D_{j,k,t}$	Distance between EV_j and CS_k at time t
$I_{j,k}^{\mathrm{wait}}$	Waiting subsidy for EV_j from CS_k
$I_{k,l}$	Revenue of CS_k in l-th time horizon
$I_{k,l}^{\mathrm{res}}$	Revenue of CS_k from EVs participating in DR task in the l-th time horizon
$I_{k,l}^{\mathrm{unres}}$	Revenue of CS_k from EVs not participating in DR task in the l-th time horizon
$N_{k,l}$	Cumulative number of EVs at CS_k in the l-th time horizon
$N_{k,l}^{\mathrm{newres}}$	Number of EVs starting to participate in DR task at CS_k in the l-th time horizon
$N_{k,l}^{\mathrm{oldres}}$	Number of EVs that continue to participate in DR task at CS_k in the l-th time horizon
$N_{k,t}^{\mathrm{recruit}}$	Number of EVs planned to recruit for DR task of CS_k at time t

$N_{k,t}^{\text{res}}$ Number of EVs participating the DR task of CS_k at time t
P_{k}^{goal} Required response power of CS_k
$P_{k,i,j,t}^{\text{ch}}$ Charging power of EV_j at CP_i of CS_k at time t
$P_{k,i,j,t}^{\text{dc}}$ Discharging power of EV_j at CP_i of CS_k at time t
$P_{k,i,j,t}^{\text{resgoal}}$ Expected response power of EV_j at CP_i of CS_k at time t
$P_{k,i,j,t}^{\text{res}}$ Charging or discharging power of EV_j at CP_i of CS_k at time t
$P_{k,i,j,t}^{\text{res}}$ Response power of EV_j at CP_i of CS_k at time t
$P_{k,i,j,t}^{\text{unres}}$ Charging power of EV_j at CP_i of CS_k at time t
$P_{k,t}^{\text{effectres}}$ Total effective response power of CS_k at time t
$P_{k,t}^{\text{res}}$ Total response power of EVs of CS_k at time t
$P_{k,t}^{\text{unres}}$ Total charging power of EVs not participating in DR tasks of CS_k at time t
$Q_{j,t}$ Battery power of EV_j at time t
$Q_{j,t}^{\text{unitconsum}}$ Electricity consumption per unit mileage of EV_j at time t
$Q_{k,i,j,l}^{\text{res}}$ Amount of response electricity of EV_j at CP_i of CS_k in the l-th time horizon
$Q_{k,i,j,l}^{\text{unres}}$ Amount of charging electricity for EV_j that does not participate in DR tasks at CP_i of CS_k in the l-th time horizon
$Q_{k,i,j}^{\text{res}}$ Amount of response electricity of EV_j at CP_i of CS_k
$Q_{k,l}^{\text{effectres}}$ Amount of effective response electricity of CS_k in the l-th time horizon
$Q_{k,l}^{\text{goal}}$ Expected amount of effective response electricity of CS_k in the l-th time horizon
$T_{j,k,t}^{\text{plan}}$ Estimated travel time of EV_j departing for CS_k at time t
$T_{j,k}^{\text{wait}}$ Total waiting time of EV_j at CS_k
$T_{k,i,j}^{\text{resbeg}}$ Demand response start time of EV_j at CP_i of CS_k
$T_{k,i,j}^{\text{resend}}$ Demand response end time of EV_j at CP_i of CS_k
$T_{k,i,j}^{\text{unresbeg}}$ Charging start time of EV_j that does not not participate in DR task at CP_i of CS_k
$T_{k,i,j}^{\text{unresend}}$ Charging end time of EV_j that does not not participate in DR task at CP_i of CS_k
$T_{k,j}^{\text{res}}$ Moment when EV_j accepts recruitment from station CS_k
$X_{k,j,t}$ It is 1 if EV_j accepts recruitment from CS_k at time t, else is 0

APPENDIX B
MODEL CONSTRUCTION AND SOLUTION

A. Operation Model of CS

$$
\begin{aligned}
\max \quad & I_{k,l} = I^{\text{res}}_{k,l} + I^{\text{unres}}_{k,l} \\
s.t. \quad & I^{\text{res}}_{k,l} = \min\{Q^{\text{effectres}}_{k,l}, Q^{\text{goal}}_{k,l}\} \cdot C^{\text{o}} + \sum_{i=1}^{N_k} \sum_{j=1}^{N_{k,l}} Q^{\text{res}}_{k,i,j,l} \cdot (C^{\text{s}}_k - C^{\text{res}}_{k,j,l}) - \max\{Q^{\text{goal}}_{k,l} - Q^{\text{effectres}}_{k,l}, 0\} \cdot C^{\text{p}} \\
& Q^{\text{effectres}}_{k,l} = \int_{l+L}^{l+L+\tau} P^{\text{effectres}}_{k,t} dt \\
& Q^{\text{goal}}_{k,l} = \int_0^{l+L+\tau} P^{\text{goal}}_k dt - \int_0^{l+L} P^{\text{effectres}}_{k,t} dt \\
& C^{\text{s}}_k = \begin{cases} C^{\text{sell}}_k - C^{\text{pur}}_k, & S_k = 1, \\ 0, & S_k = -1 \end{cases} \\
& P^{\text{effectres}}_{k,t} = \begin{cases} P^{\text{base}}_{k,t} - P^{\text{unres}}_{k,t} - P^{\text{res}}_{k,t}, S_k = -1, \\ P^{\text{res}}_{k,t} + P^{\text{unres}}_{k,t} - P^{\text{base}}_{k,t}, S_k = 1 \end{cases} \\
& \alpha_1 \cdot P^{\text{goal}}_k \le P^{\text{effectres}}_{k,t} \le P^{\text{goal}}_k \cdot \alpha_2 \\
& P^{\text{res}}_{k,t} = \sum_{i=1}^{N_k} \sum_{j=1}^{N_{k,t}} P^{\text{res}}_{k,i,j,t}, \quad 0 \le |P^{\text{res}}_{k,i,j,t}| \le P^{\max}_{k,i} \\
& P^{\text{res}}_{k,i,j,t} = \begin{cases} P^{\text{dc}}_{k,i}, & t \in [T^{\text{resbeg}}_{k,i,j}, T^{\text{resend}}_{k,i,j}], S_k = -1, \\ P^{\text{ch}}_{k,i}, & t \in [T^{\text{resbeg}}_{k,i,j}, T^{\text{resend}}_{k,i,j}], S_k = 1, \\ 0, & \text{else} \end{cases} \\
& P^{\text{unres}}_{k,t} = \sum_{i=1}^{N_k} \sum_{j=1}^{N_{k,t}} P^{\text{unres}}_{k,i,j,t}, \quad 0 \le P^{\text{unres}}_{k,i,j,t} \le P^{\max}_{k,i} \\
& P^{\text{unres}}_{k,i,j,t} = \begin{cases} P^{\text{ch}}_{k,i}, & t \in [T^{\text{unresbeg}}_{k,i,j}, T^{\text{unresend}}_{k,i,j}], \\ 0, & \text{else} \end{cases} \\
& C^{\text{res}}_{k,j,l} = \sum_{t'=0}^{l} X_{k,j,t'} \cdot C^{\text{res}}_{k,t'}, \quad C^{\text{resmin}}_k \le C^{\text{res}}_{k,t} \le C^{\text{resmax}}_k \\
& X_{k,j,t} = \begin{cases} 1, & T^{\text{res}}_{k,j} = t, \\ 0, & \text{else} \end{cases} \\
& N^{\text{newres}}_{k,l} = \sum_{i=1}^{N_k} \sum_{j=1}^{N_{k,l}} W(l+L, l+L+\tau, T^{\text{resbeg}}_{k,i,j}) \\
& N^{\text{oldres}}_{k,l} = \sum_{i=1}^{N_k} \sum_{j=1}^{N_{k,l}} W(T^{\text{resbeg}}_{k,i,j}, T^{\text{resend}}_{k,i,j}, l+L) \\
& Q^{\text{res}}_{k,i,j} = \int_{T^{\text{resbeg}}_{k,i,j}}^{T^{\text{resend}}_{k,i,j}} |P^{\text{res}}_{k,i,j,t}| dt, \quad Q^{\text{res}}_{k,i,j} \ge Q^{\text{resthre}}_k \\
& I^{\text{unres}}_{k,l} = \sum_{i=1}^{N_k} \sum_{j=1}^{N_{k,l}} Q^{\text{unres}}_{k,i,j,l} \cdot (C^{\text{sell}}_k - C^{\text{pur}}_k) \\
& Q^{\text{unres}}_{k,i,j,l} = \int_{l+L}^{l+L+\tau} P^{\text{unres}}_{k,i,j,t} dt \\
& N^{\text{newres}}_{k,l} \le N^{\text{recruit}}_{k,t} \\
& N^{\text{newres}}_{k,l} \le f_{k,t}(C^{\text{res}}_{k,t})
\end{aligned}
$$

B. Proof of Proposition 1

***Proposition** 1:* For the adjusted optimization problem, when it takes the optimal value, $N^{\text{recruit}}_{k,t} - a_{k,t} - b_{k,t} \cdot C^{\text{res}}_{k,t} = 0$.

Proof Proof of Proposition 1. Transform the adjusted optimization problem into a standard-constrained optimization problem.

$$\min \quad -I_{k,l}, \tag{A.1}$$
$$s.t. \quad g_i(\mathbf{x}) \leq 0, i = 1, ..., m, \tag{A.2}$$
$$h_j(\mathbf{x}) = 0, j = 1, ..., n. \tag{A.3}$$

Due to space limitations, the constraints are not expanded here. For the specific expression of constraints, see Eq. A.1. Define the Lagrangian function:

$$L(N_{k,t}^{\text{recruit}}, C_{k,t}^{\text{res}}, \lambda_i, \mu_j) = -I_{k,l} + \sum_{i=1}^{m} \lambda_i g_i(\mathbf{x}) + \sum_{j=1}^{n} \mu_j h_j(\mathbf{x}). \tag{A.4}$$

Then, calculate the partial derivative of the subsidized price $C_{k,l-1}^{\text{res}}$. Based on the Karush-Kuhn-Tucker (KKT) condition [28], the following results can be obtained.

$$N_{k,t}^{\text{recruit}} \cdot Q_{k,l}^{\text{resthre}} - \mu \cdot b_{k,t} = 0, \tag{A.5}$$

$$\mu(N_{k,t}^{\text{recruit}} - a_{k,t} - b_{k,t} \cdot C_{k,t}^{\text{res}}) = 0, \tag{A.6}$$

when there is a need for recruitment, Eq. A.5 shows that μ is not equal to 0, therefore, for the optimal solution of the optimization problem, the following relationship exists:

$$N_{k,t}^{\text{recruit}} - a_{k,t} - b_{k,t} \cdot C_{k,t}^{\text{res}} = 0. \tag{A.7}$$

C. Proof of Proposition 2

***Proposition** 2:* The optimization objective $I_{k,l}$ increases with the increase of $b_{k,t}$.
Proof Proof of Proposition 2. Combining Eq. A.7 with Eq. A.1, the partial derivative of $I_{k,l}$ with respect to $b_{k,t}$ is as follows:

$$\frac{\partial I_{k,l}}{\partial b_{k,t}} = C_{k,t}^{\text{res}} \cdot Q_k^{\text{resthre}}(C^{\text{o}} + C_k^{\text{s}} + C^{\text{p}} - C_{k,t}^{\text{res}}), \tag{A.8}$$

since the CSs aim to obtain DR regulation profits, the recruitment subsidy of the CS is less than $(C^{\text{o}} + C_k^{\text{s}} + C^{\text{p}})$, then the partial derivative is greater than 0. It can be concluded that the objective function increases with the increase of $b_{k,t}$.

APPENDIX C
RESPONSE MODEL FOR EV OWNER

According to the updated recruitment plan, the CS sends out invitations to nearby EVs to participate in the DR task. For EV_j around CS_k, after receiving the invitation at time t, the driver decides whether to participate in the task based on the battery power of EV, location of EV, subsidy level, etc. For EV_j, its battery power at time t is $Q_{j,t}$, and $D_{j,k,t}$ represents the distance between EV_j and CS_k, $Q_{j,t}^{\text{unitconsum}}$ represents the electricity consumption per unit driving distance of EV_j, and Q_j^{safe} represents the lowest level of battery power for EV_j that the driver will not feel range anxiety. Due to the different travel plans and charging preferences of drivers, there are certain differences in Q_j^{safe} for different EVs. Q_j^{max} is the maximum battery power of EV_j, and $C_{k,t}$ is the received price of EV_j for unit electricity consumption or supply at time t.

$$Q_{j,t} - D_{j,k,t} \cdot Q_{j,t}^{\text{unitconsum}} > 0, \tag{A.9}$$

$$Q_{j,t} - D_{j,k,t} \cdot Q_{j,t}^{\text{unitconsum}} - Q_k^{\text{resthre}} > Q_j^{\text{safe}}, S_k = -1, \tag{A.10}$$

$$Q_{j,t} - D_{j,k,t} \cdot Q_{j,t}^{\text{unitconsum}} + Q_k^{\text{resthre}} < Q_j^{\text{max}}, S_k = 1, \tag{A.11}$$

$$C_{k,t} = \begin{cases} C_k^{\text{sell}} - C_{k,t}^{\text{res}}, & S_k = 1, \\ C_{k,t}^{\text{res}}, & S_k = -1. \end{cases} \tag{A.12}$$

Considering the diversity of drivers' preferences, their willingness to charge or discharge varies [27]. Let $\text{Pr}_{j,k,t}^{\text{ch}}$ and $\text{Pr}_{j,k,t}^{\text{dc}}$ represent the charging and discharging probabilities of EV_j at time t, respectively. P_j^{chmin} and P_j^{dcmin} refer to the minimum unit price for EV_j to charge or discharge. P_j^{chmax} and P_j^{dcmax} refer to the maximum unit price of EV_j for charging or discharging. K_j represents the type of price sensitivity for the driver of EV_j, where 1 indicates the driver is price-sensitive, 0 indicates the driver is neutral, and -1 indicates the driver is price-insensitive. Since drivers usually have range anxiety, it is assumed that when the battery power of the EV is less than Q_j^{safe}, the driver is eager to charge the vehicle.

$$\text{Pr}_{j,k,t}^{\text{dc}} = \frac{A_{j,t}^{\text{dc}} + B_{j,k,t}^{\text{dc}}}{2}, \tag{A.13}$$

$$A_{j,t}^{\text{dc}} = \frac{Q_{j,t} - Q_j^{\text{safe}}}{Q_j^{\max} - Q_j^{\text{safe}}}, \tag{A.14}$$

$$b_{j,k,t}^{\text{dc}} = \frac{C_{k,t} - C_j^{\text{chmin}}}{C_j^{\text{chmax}} - C_j^{\text{chmin}}}, \tag{A.15}$$

$$B_{j,k,t}^{\text{dc}} = \begin{cases} \ln(b_{j,k,t}^{\text{dc}} \cdot (e-1) + 1), & K_j = 1, \\ b_{j,k,t}^{\text{dc}}, & K_j = 0, \\ \frac{e^{b_{j,k,t}^{\text{dc}}} - 1}{e-1}, & K_j = -1, \end{cases} \tag{A.16}$$

where $A_{j,t}^{\text{dc}}$ and $B_{j,k,t}^{\text{dc}}$ represent the preference of the driver controlling EV$_j$ to participate in the DR task regarding battery power level and discharging subsidy level.

$$\text{Pr}_{j,k,t}^{\text{ch}} = \begin{cases} \frac{A_{j,t}^{\text{ch}} + B_{j,t}^{\text{ch}}}{2}, & Q_{j,t} \geq Q_j^{\text{safe}}, \\ 1, & Q_{j,t} < Q_j^{\text{safe}}, \end{cases} \tag{A.17}$$

$$A_{j,t}^{\text{ch}} = 1 - \frac{Q_{j,u} - Q_j^{\text{safe}}}{Q_j^{\max} - Q_j^{\text{safe}}}, \tag{A.18}$$

$$b_{j,k,t}^{\text{ch}} = \frac{C_{k,t} - C_j^{\text{chmin}}}{C_j^{\text{chmax}} - C_j^{\text{chmin}}}, \tag{A.19}$$

$$B_{j,k,t}^{\text{ch}} = \begin{cases} \ln((1 - b_{j,k,t}^{\text{ch}}) \cdot (e-1) + 1), & K_j = 1, \\ 1 - b_{j,k,t}^{\text{ch}}, & K_j = 0, \\ \frac{e^{1 - b_{j,k,t}^{\text{ch}}} - 1}{e-1}, & K_j = -1, \end{cases} \tag{A.20}$$

where $A_{j,t}^{\text{ch}}$ and $B_{j,k,t}^{\text{ch}}$ represent the preference of the driver controlling EV$_j$ to participate in the DR task regarding battery power level and charging subsidy level.

If the driver of EV$_j$ accepts the invitation of CS$_k$, it will go to CS$_k$ to perform the task, and then CS$_k$ will settle the bill according to the agreed price once the task is completed.

Appendix D
Experimental Results

This section provides a detailed presentation of the relevant simulation results. For the sake of completeness, some results previously included in the main text are also reiterated here.

A. Experiment Setup

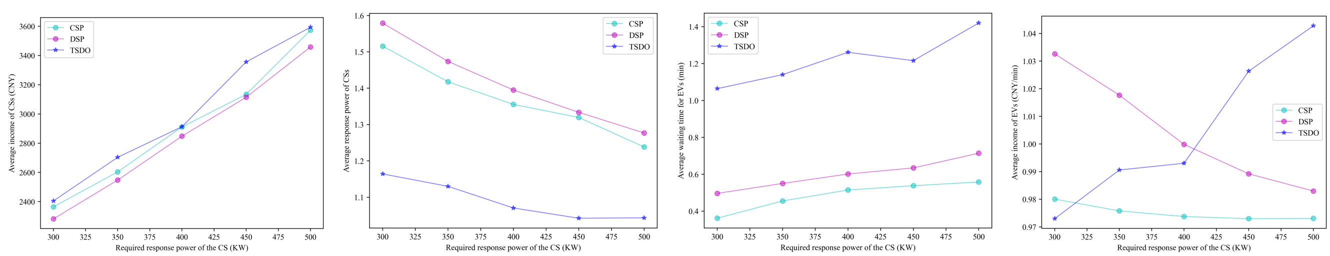
Table A1 shows the detailed information of the 10 CSs involved in the simulation experiment.

TABLE A1
Detailed Information of CSs for Simulation

ID	Location of CSs		Number of CPs
	Longitude	Latitude	
CS_1	110.3055	20.0141	32
CS_2	110.3239	19.9928	60
CS_3	110.2698	19.9795	29
CS_4	110.2616	20.0069	24
CS_5	110.2887	19.9766	30
CS_6	110.2911	19.9935	36
CS_7	110.2617	19.9959	32
CS_8	110.3171	19.9761	22
CS_9	110.3393	19.9768	38
CS_{10}	110.2738	19.9620	22

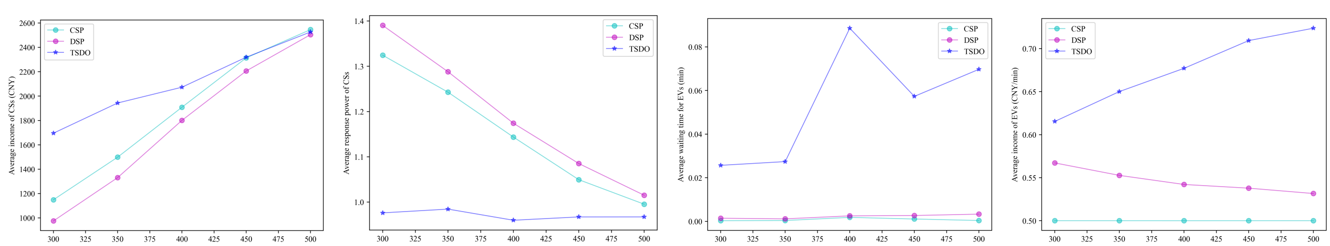
B. Simulation Results Under Different DR Tasks

The simulation results of the proposed TSDO under different DR tasks are shown in Tables A2 and A3. Figs. A1 and A2 intuitively shows the performance of the proposed TSDO under different indicators. Figs. A3 and A4 show the response power performance of the proposed TSDO under specific tasks in detail.



(a) Average income of CSs (b) Average response power of CSs (c) Average waiting time for EVs (d) Average income of EVs

Fig. A1. Performance variation of CSs with increasing task power of peak shaving.



(a) Average income of CSs (b) Average response power of CSs (c) Average waiting time for EVs (d) Average income of EVs

Fig. A2. Performance variation of CSs with increasing task power of valley filling.

C. Simulation Results Under Different Planning Lead Time

This part presents the simulation results of the TSDO under different planning lead time L. Tables A4 and A5 show the performance results of the TSDO, and the intuitive demonstration of the TSDO performance under different planning lead time L are shown in Figs. A5 and A6.

TABLE A2
EXPERIMENTAL RESULTS OF PEAK SHAVING TASKS

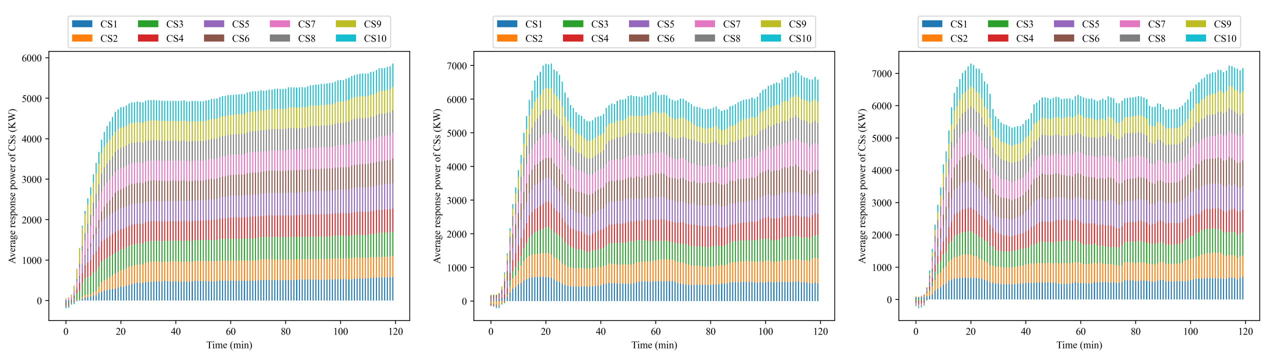
Task Power (kW)	Approach	Income of CSs (CNY)		Response Power of CSs		Waiting Time for EVs (min)		Income of EVs (CNY/min)	
		Average	**Variance**	**Average**	**Variance**	**Average**	**Variance**	**Average**	**Variance**
300	CSP	2364.3652	58.0094	1.5158	0.0632	**0.3617**	0.1480	0.9801	0.0080
	DSP	2281.8517	73.2286	1.5789	0.0744	0.4962	0.1782	**1.0326**	0.0135
	TSDO	**2404.7239**	152.1891	**1.1642**	0.0731	1.0642	0.2467	0.9730	0.0613
350	CSP	2603.8159	86.8887	1.4176	0.0588	**0.4552**	0.1505	0.9758	0.0082
	DSP	2547.7102	84.1984	1.4738	0.0733	0.5502	0.1695	**1.0177**	0.0113
	TSDO	**2703.5301**	158.2229	**1.1300**	0.0568	1.1402	0.2761	0.9906	0.0481
400	CSP	2911.3059	113.3455	1.3555	0.0507	**0.5146**	0.1373	0.9738	0.0070
	DSP	2847.9933	106.2594	1.3950	0.0520	0.6014	0.1493	**0.9998**	0.0097
	TSDO	**2912.8470**	211.4107	**1.0705**	0.0656	1.2613	0.3054	0.9930	0.0524
450	CSP	3134.8762	161.1543	1.3195	0.0533	**0.5379**	0.1411	0.9730	0.0068
	DSP	3114.9202	112.9452	1.3337	0.0414	0.6344	0.1776	0.9892	0.0128
	TSDO	**3356.5290**	150.1364	**1.0423**	0.0326	1.2161	0.2382	**1.0264**	0.0486
500	CSP	3573.8977	149.2931	1.2383	0.0503	**0.5579**	0.1621	0.9731	0.0080
	DSP	3458.7848	149.6886	1.2768	0.0428	0.7142	0.1562	0.9830	0.0082
	TSDO	**3593.8757**	155.4868	**1.0434**	0.0308	1.4202	0.2222	**1.0428**	0.0337

* The response power represents the ratio of the target power.

TABLE A3
EXPERIMENTAL RESULTS OF VALLEY FILLING TASKS

Task Power (kW)	Approach	Income of CSs (CNY)		Response Power of CSs		Waiting Time for EVs (min)		Income of EVs (CNY/min)	
		Average	**Variance**	**Average**	**Variance**	**Average**	**Variance**	**Average**	**Variance**
300	CSP	1148.9125	85.3962	1.3245	0.0407	**0.0003**	0.0011	0.5000	0.0000
	DSP	975.1546	100.7143	1.3903	0.0464	0.0014	0.0049	0.5672	0.0088
	TSDO	**1695.5672**	55.7468	**0.9761**	0.0067	0.0257	0.0286	**0.6154**	0.0461
350	CSP	1499.0062	97.5822	1.2427	0.0333	**0.0004**	0.0014	0.5000	0.0000
	DSP	1331.1526	106.0163	1.2879	0.0431	0.0011	0.0021	0.5527	0.0087
	TSDO	**1943.5201**	73.9494	**0.9844**	0.0108	0.0274	0.0187	**0.6501**	0.0509
400	CSP	1908.5660	133.6327	1.1436	0.0487	**0.0018**	0.0040	0.5000	0.0000
	DSP	1800.8232	146.3049	1.1741	0.0392	0.0025	0.0055	0.5421	0.0067
	TSDO	**2072.9863**	56.1451	**0.9598**	0.0048	0.0886	0.0814	**0.6771**	0.0366
450	CSP	2313.8063	121.5313	1.0494	0.0456	**0.0011**	0.0022	0.5000	0.0000
	DSP	2206.3390	121.1399	1.0851	0.0376	0.0027	0.0049	0.5378	0.0068
	TSDO	**2319.0694**	60.9840	**0.9671**	0.0067	0.0573	0.0307	**0.7094**	0.0333
500	CSP	2545.7672	95.2274	**0.9953**	0.0305	**0.0004**	0.0009	0.5000	0.0000
	DSP	2504.4970	114.0116	1.0151	0.0296	0.0033	0.0057	0.5316	0.0085
	TSDO	**2526.4447**	70.5901	0.9672	0.0082	0.0697	0.0343	**0.7238**	0.0165

* The response power represents the ratio of the target power.



(a) TSDO (b) CSP (c) DSP

Fig. A3. Performance of the response power of each CS under the peak shaving tasks during the task period when task power is 500 KW.

D. Simulation Results With Vehicle Arrival Time Fluctuations

Tables A6 and A7 demonstrate the simulation results under EV arrival time fluctuations, and the specific response power performance of the TSDO are shown in Figs. A7 and A8.

TABLE A4
EXPERIMENTAL RESULTS OF PEAK SHAVING TASKS UNDER DIFFERENT PLANNING LEAD TIME

L (min)	Income of CSs (CNY)		Response Power of CSs		Waiting Time for EVs (min)		Income of EVs (CNY/min)	
	Average	**Variance**	**Average**	**Variance**	**Average**	**Variance**	**Average**	**Variance**
1	3179.1640	218.2191	1.1375	0.0531	1.8688	0.3208	0.9783	0.0513
2	3410.2535	203.1438	1.0924	0.0343	1.6230	0.2917	0.9931	0.0477
3	3481.1058	173.4344	1.0597	0.0402	1.4438	0.2856	1.0192	0.0440
4	3563.9650	180.6830	1.0527	0.0348	1.3568	0.2687	1.0229	0.0495
5	3607.7215	184.8545	**1.0405**	0.0296	1.3705	0.2597	1.0243	0.0447
6	3593.8757	155.4868	1.0434	0.0308	1.4202	0.2222	1.0428	0.0337
7	**3630.6677**	175.2095	1.0411	0.0258	**1.3568**	0.2978	1.0560	0.0440
8	3627.4461	159.8161	1.0441	0.0281	1.3635	0.1996	1.0580	0.0421
9	3609.5116	167.8137	1.0570	0.0268	1.4626	0.2352	1.0579	0.0480
10	3617.2775	161.6867	1.0557	0.0286	1.4986	0.2355	**1.0609**	0.0446

* The task power in experiments is set to 500 KW.
** The response power represents the ratio of the target power.

TABLE A5
EXPERIMENTAL RESULTS OF VALLEY FILLING TASKS UNDER DIFFERENT PLANNING LEAD TIME

L (min)	Income of CSs (CNY)		Response Power of CSs		Waiting Time for EVs (min)		Income of EVs (CNY/min)	
	Average	**Variance**	**Average**	**Variance**	**Average**	**Variance**	**Average**	**Variance**
1	1650.8371	99.6245	0.9713	0.0097	0.2740	0.3683	0.5142	0.0413
2	1656.9358	74.5996	0.9660	0.0070	0.0873	0.0841	0.5515	0.0479
3	1685.2243	62.3695	0.9707	0.0059	0.0438	0.0532	0.5669	0.0434
4	1681.2062	62.2920	0.9737	0.0092	0.0466	0.0489	0.5947	0.0485
5	1678.9928	64.5997	0.9733	0.0085	0.0319	0.0328	0.6096	0.0478
6	1695.5672	55.7468	0.9761	0.0067	0.0257	0.0286	**0.6154**	0.0461
7	1703.2800	49.9565	0.9781	0.0060	0.0207	0.0318	0.6106	0.0514
8	1710.3155	56.9154	0.9794	0.0089	0.0177	0.0240	0.6134	0.0417
9	1711.2301	48.7931	**0.9822**	0.0094	0.0255	0.0329	0.6081	0.0401
10	**1720.7100**	45.5344	0.9821	0.0093	**0.0164**	0.0241	0.5967	0.0407

* The task power in experiments is set to 300 KW.
** The response power represents the ratio of the target power.

TABLE A6
EXPERIMENTAL RESULTS OF PEAK SHAVING TASKS UNDER DIFFERENT VEHICLE ARRIVAL FLUCTUATIONS

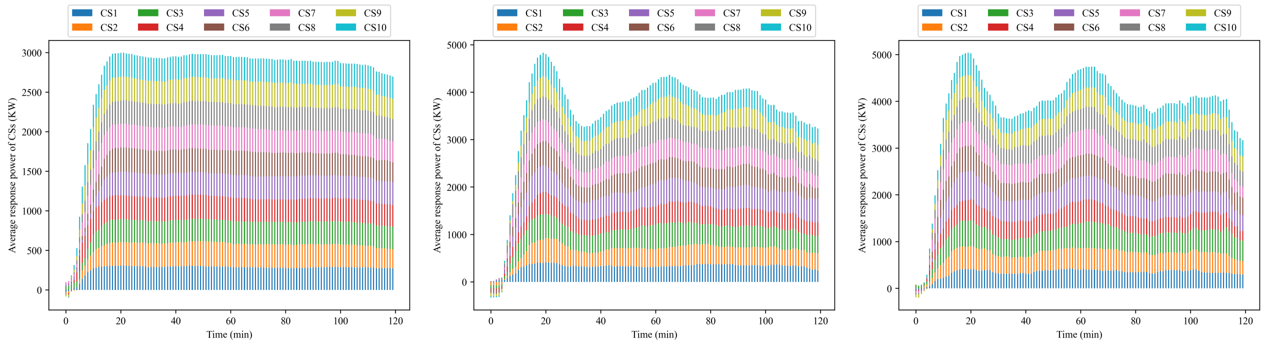
Uncertainty Factor u	Approach	Income of CSs (CNY)		Response power of CSs		Waiting time for EVs (min)		Income of EVs (CNY/min)	
		Average	**Variance**	**Average**	**Variance**	**Average**	**Variance**	**Average**	**Variance**
0	CSP	3573.8977	149.2931	1.2383	0.0503	**0.5579**	0.1621	0.9731	0.0080
	DSP	3458.7848	149.6886	1.2768	0.0428	0.7142	0.1562	0.9830	0.0082
	TSDO	**3593.8757**	155.4868	**1.0434**	0.0308	1.4202	0.2222	**1.0428**	0.0337
0.1	CSP	3532.7029	169.0941	1.2543	0.0496	**0.6335**	0.1782	0.9701	0.0086
	DSP	3457.1936	93.9359	1.2731	0.0346	0.6958	0.1598	0.9818	0.0098
	TSDO	**3635.0965**	159.6190	**1.0477**	0.0277	1.3268	0.2285	**1.0405**	0.0445
0.2	CSP	3526.9497	158.1189	1.2458	0.0418	**0.5634**	0.1599	0.9733	0.0079
	DSP	3503.7680	132.2629	1.2607	0.0412	0.6637	0.1738	0.9818	0.0103
	TSDO	**3712.1710**	155.9660	**1.0339**	0.0279	1.2765	0.2639	**1.0359**	0.0456

* The task power in experiments is set to 500 KW, the planning lead time L is set to 6 min, and the horizon size τ is set to 5 min.
** The response power represents the ratio of the target power.

TABLE A7
EXPERIMENTAL RESULTS OF VALLEY FILLING TASKS UNDER DIFFERENT VEHICLE ARRIVAL FLUCTUATIONS

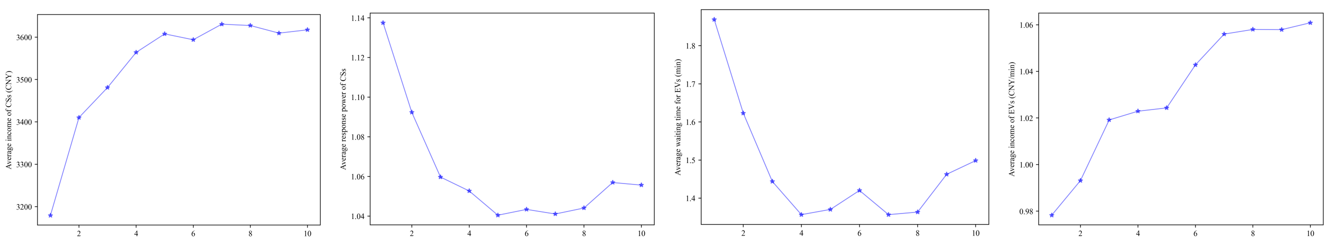
Uncertainty Factor u	Approach	Income of CSs (CNY)		Response power of CSs		Waiting time for EVs (min)		Income of EVs (CNY/min)	
		Average	**Variance**	**Average**	**Variance**	**Average**	**Variance**	**Average**	**Variance**
0	CSP	1148.9125	85.3962	1.3245	0.0407	**0.0003**	0.0011	0.5000	0.0000
	DSP	975.1546	100.7143	1.3903	0.0464	0.0014	0.0049	0.5672	0.0088
	TSDO	**1695.5672**	55.7468	**0.9761**	0.0067	0.0257	0.0286	**0.6154**	0.0461
0.1	CSP	1181.1583	87.5877	1.3146	0.0391	**0.0000**	0.0000	0.5000	0.0000
	DSP	974.1737	102.8721	1.3996	0.0476	0.0044	0.0087	0.5662	0.0081
	TSDO	**1699.4020**	43.0630	**0.9769**	0.0080	0.0192	0.0252	**0.6073**	0.0374
0.2	CSP	1168.7188	106.2983	1.3221	0.0513	**0.0000**	0.0000	0.5000	0.0000
	DSP	991.0283	92.3594	1.3829	0.0474	0.0024	0.0063	0.5658	0.0094
	TSDO	**1703.3203**	66.7425	**0.9774**	0.0075	0.0197	0.0282	**0.6102**	0.0503

* The task power in experiments is set to 300 KW, the planning lead time L is set to 6 min, and the horizon size τ is set to 5 min.
** The response power represents the ratio of the target power.



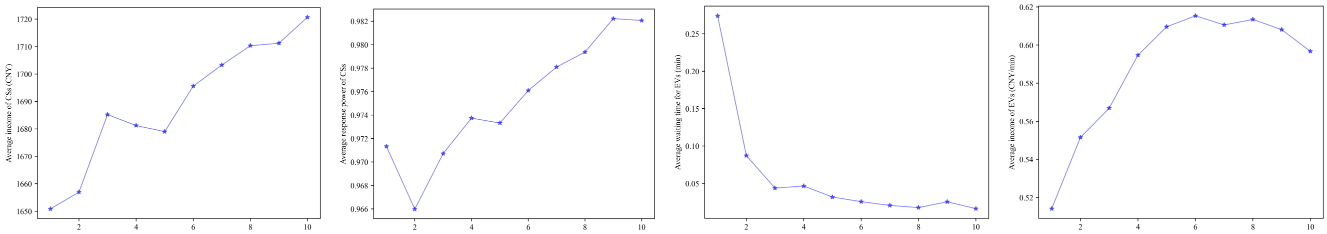
(a) TSDO (b) CSP (c) DSP

Fig. A4. Performance of the response power of each CS under the valley filling tasks during the task period when task power is 300 KW.



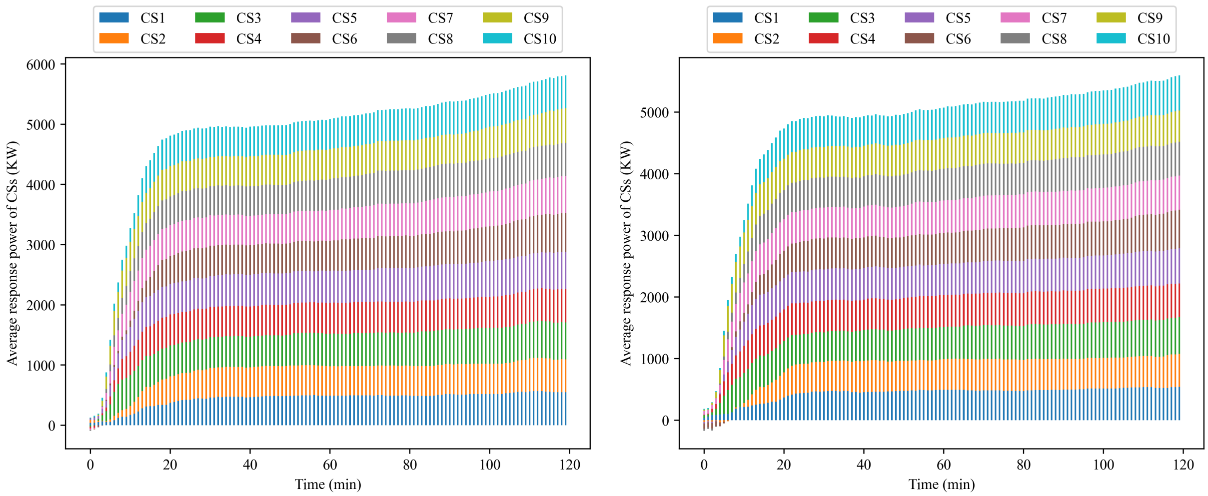
(a) Average income of CSs (b) Average response power of CSs (c) Average waiting time for EVs (d) Average income of EVs

Fig. A5. Performance of TSDO for peak shaving tasks under different planning lead time.



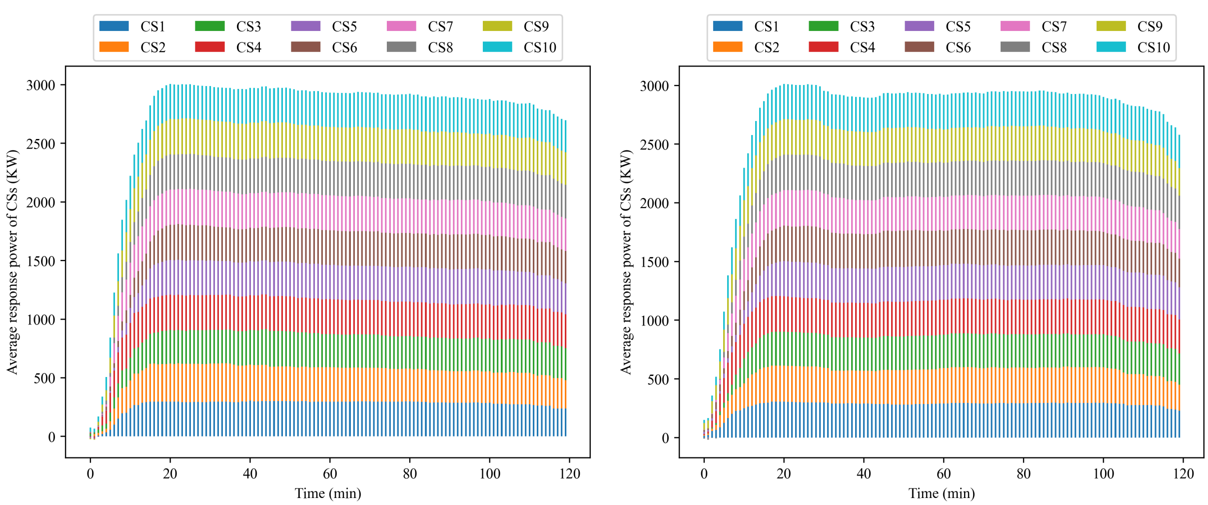
(a) Average income of CSs (b) Average response power of CSs (c) Average waiting time for EVs (d) Average income of EVs

Fig. A6. Performance of TSDO for valley filling tasks under different planning lead time.



(a) $u = 0.1$ (b) $u = 0.2$

Fig. A7. Performance of TSDO for peak shaving tasks under different vehicle arrival fluctuations.



(a) $u = 0.1$ (b) $u = 0.2$

Fig. A8. Performance of TSDO for valley filling tasks under different vehicle arrival fluctuations.