APPENDIX FOR TII-PAPER DISTRIBUTIONALLY ROBUST JOINT EXPANSION PLANNING OF DISTRIBUTION NETWORK AND EV CHARGING SYSTEM CONSIDERING RELIABILITY BENEFIT

APPENDIX A

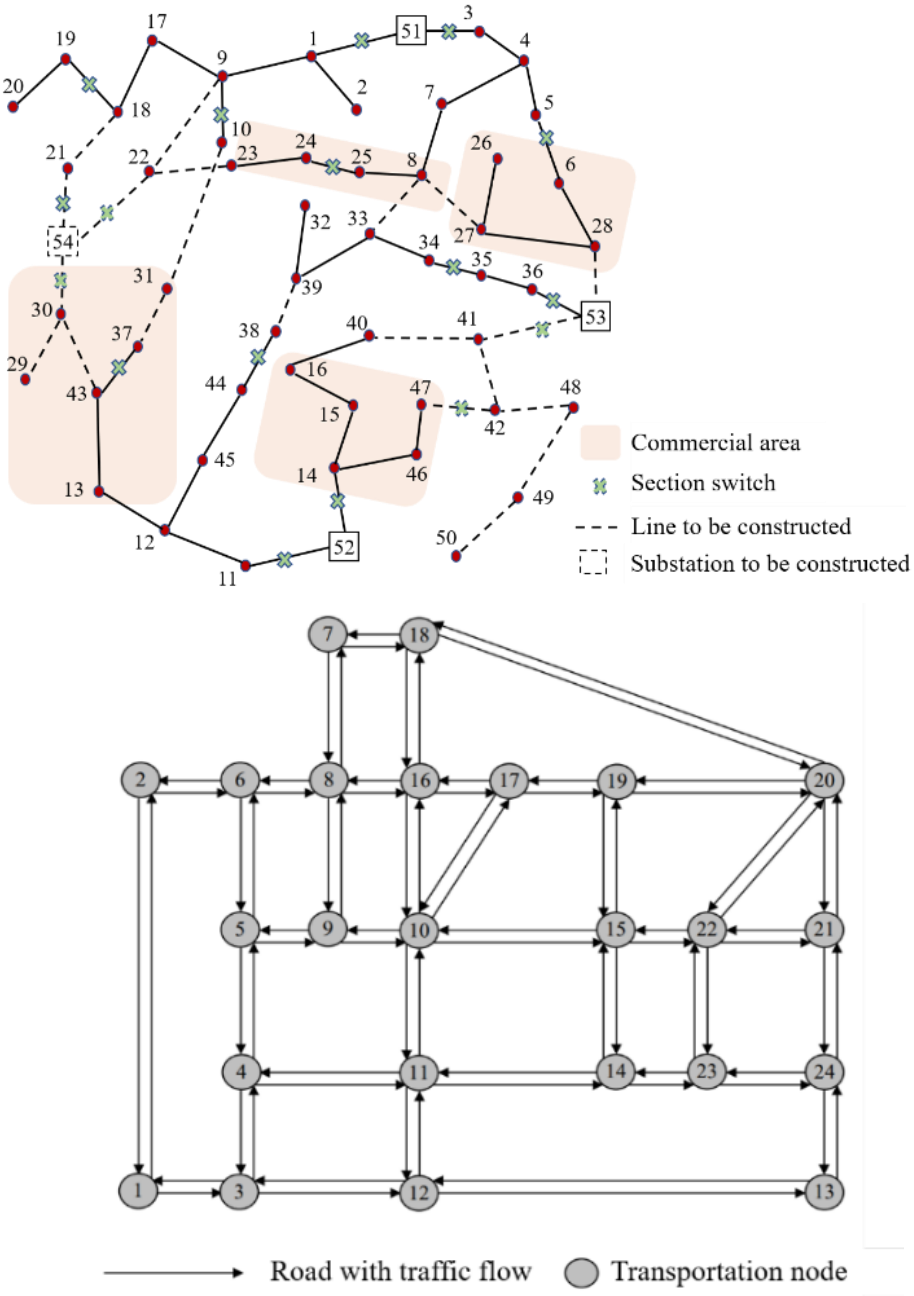


Fig.A1. The topology of distribution and transportation network.

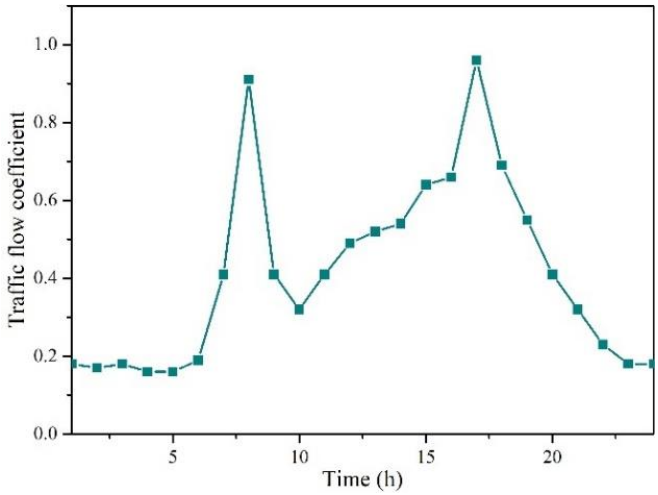


Fig.A2. The traffic flow coefficient in a typical day.

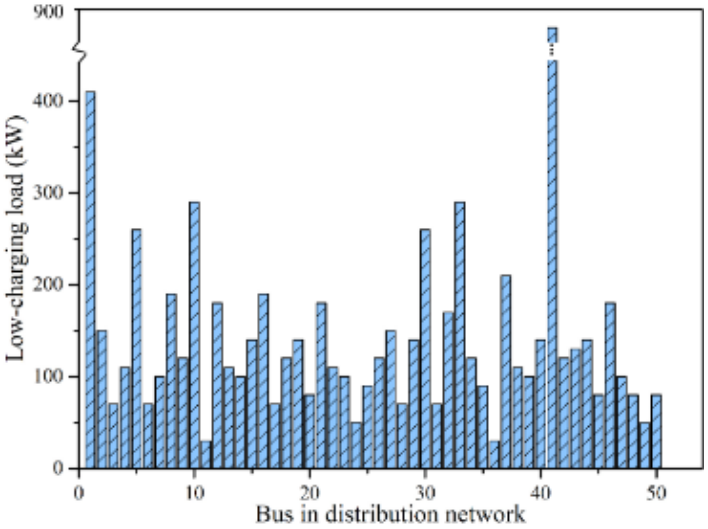


Fig. A3. Low-charging load forecast.

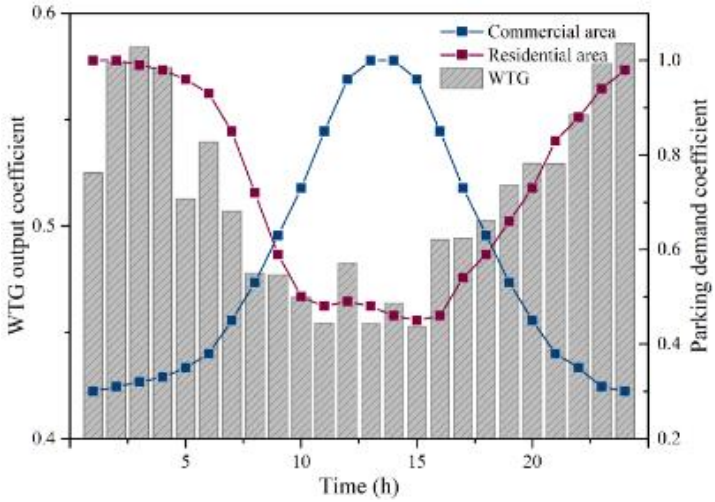


Fig. A4. WTG output forecast.

TABLE A1. The coupling between buses in distribution network and nodes in transportation network

Bus	Node	Bus	Node	Bus	Node
6	7	26	8	33	10
31	11	30	12	13	13
15	15	27	16	28	18
47	19	14	22		

TABLE A2. The upgrading scheme for substation 52 and 53

	Expanded Capacity/MW	Cost/(10^7 yuan)
Scheme a	5	5
Scheme b	10	9

TABLE A3. The constructing scheme for substation 54

	Expanded Capacity/MW	Cost/(10^7 yuan)
Scheme a	2.5	2.6
Scheme b	5	5
Scheme c	10	9

TABLE A4. The parameter of investment and operation

Parameter	Value
Discount rate	0.1
WTG Investment cost/(x 10^6 yuan)	1.55
Charging pile investment cost/yuan	10000
Line investment cost per unit length in a year/(x 10^5yuan)	9
Line operation cost per unit length in a year /yuan	4600

TABLE A5. The fixed and variable cost for the candidate EVCS scheme

Bus	6	26	33	31	30	13	15	27	28	47
Fixed cost	228	176	293	247	163	130	260	293	293	228
Variable cost	75	70	81	77	68	65	78	81	81	75

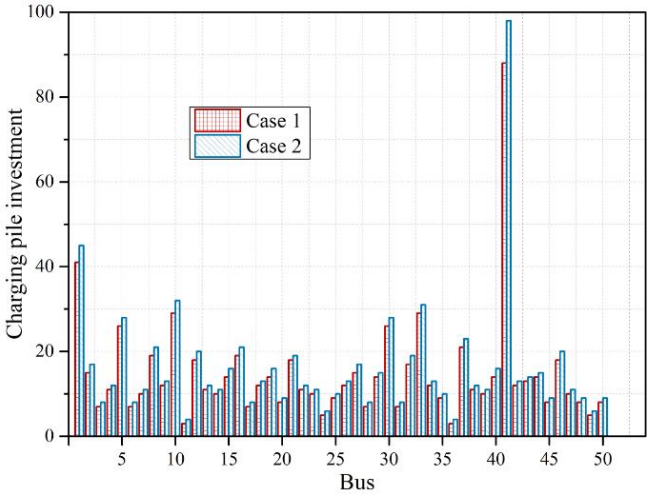
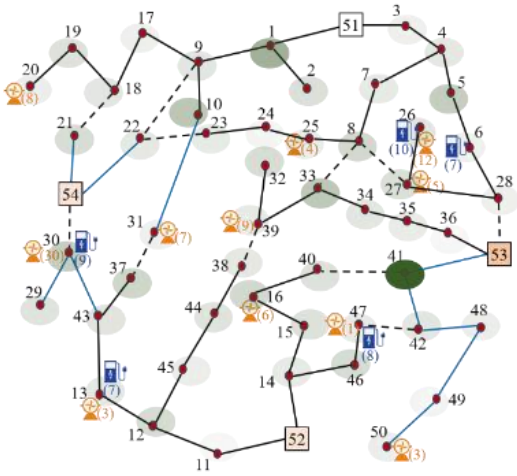
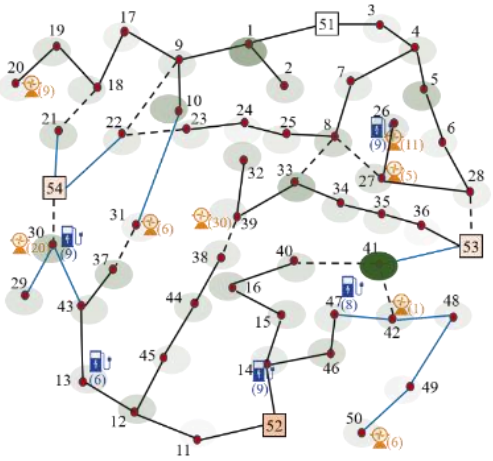


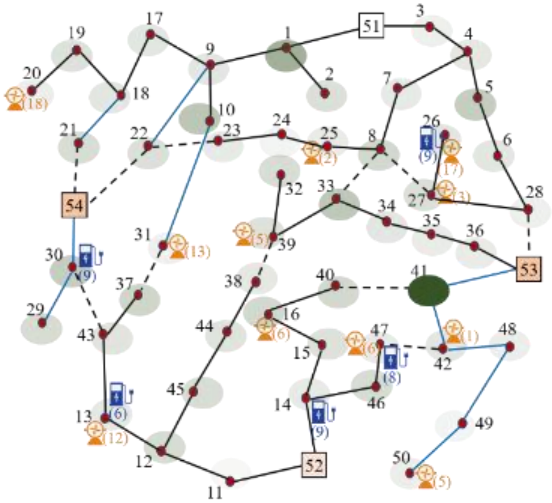
Fig. A5. Planning results of charging pile based on deterministic optimization and DRO methods.



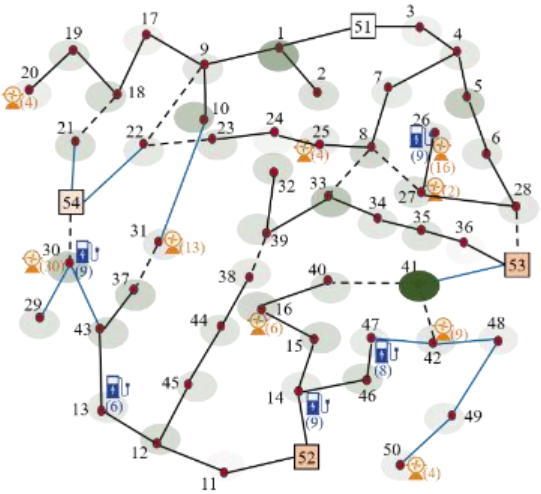
a) 0.1 is set as EV penetration ignoring reliability benefit



b) 0.1 is set as EV penetration considering reliability benefit



c) 0.2 is set as EV penetration ignoring reliability benefit



d) 0.2 is set as EV penetration considering reliability benefit

Fig. A6. Planning results based on different EV penetrations.

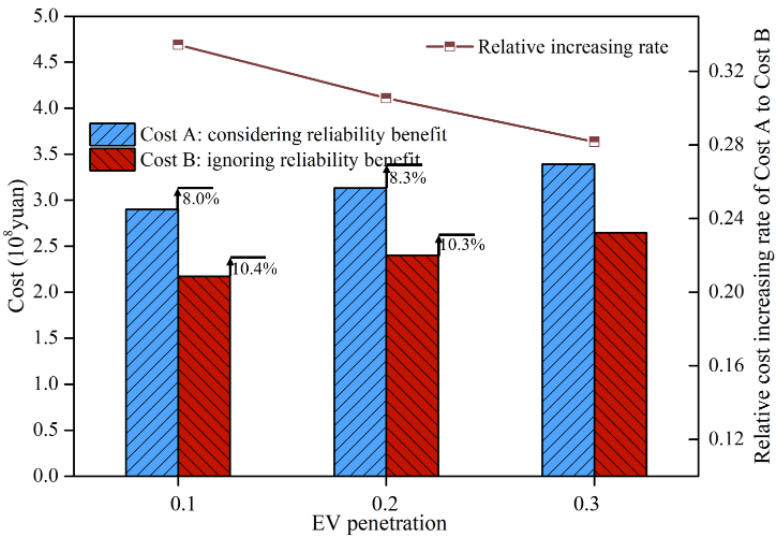
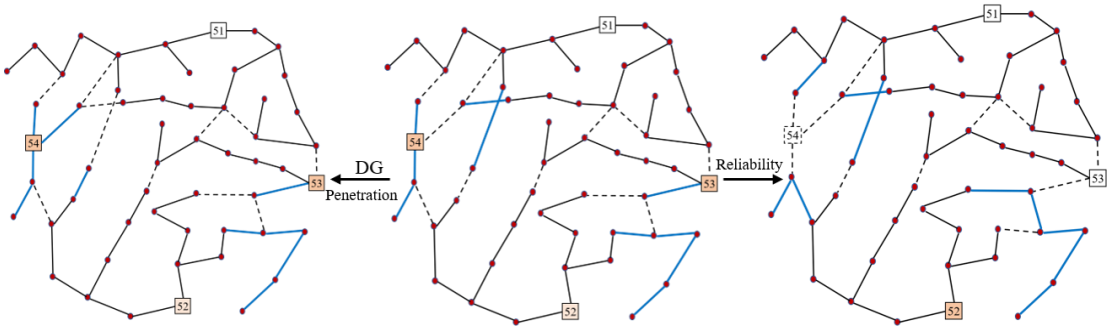


Fig. A7. Cost of planning scheme based on different EV penetrations.



a) Set WTG penetration as 0.5 considering reliability benefit

b) Set WTG penetration as 0.6 considering reliability benefit

c) Set WTG penetration as 0.6 ignoring reliability benefit

Fig.A8 Planning results of network topology based different conditions.

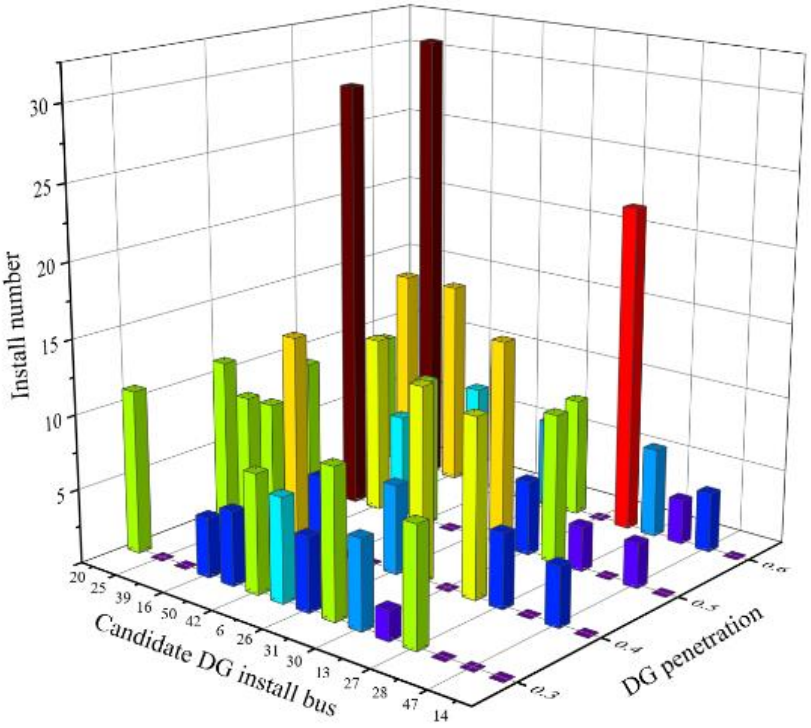


Fig. A9. WTG planning results based on different WTG penetrations.

TABLE A6. The cost of planning scheme based different WTG penetration

WTG Penetration	Objective Function (x10^8 元)			
	Reliability Cost	Investment Cost	Operation Cost	Total
0.3	0.7283	0.4642	1.6735	2.8677
0.4	0.7283	0.4577	1.5245	2.7122
0.5	0.7283	0.4362	1.426	2.5922
0.6	0.7508	0.4812	1.2452	2.4772

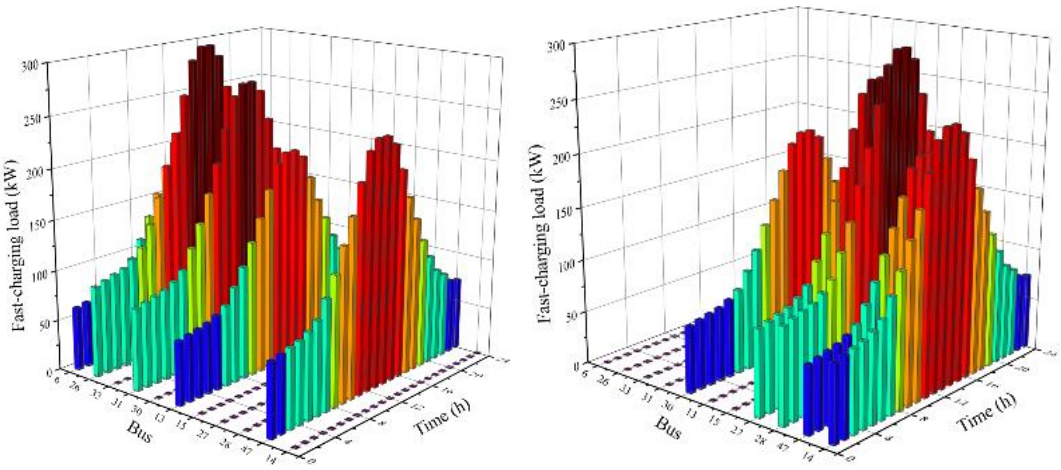
APPENDIX B : ANALYSIS OF EVCS PLANNING SCHEME

According to the traffic flow assignment model proposed in this study, 19 possible EVCS configuration schemes are obtained, including EVCS planning location and the number of chargers in the station, as shown as follows:

TABLE B1. The candidate planning schemes of EVCS

Scheme	Bus in Distribution Network										
	6	**26**	**33**	**31**	**30**	**13**	**15**	**27**	**28**	**47**	**14**
1	7	10	0	9	0	7	0	0	0	8	0
2	7	9	0	9	0	7	0	0	0	0	9
3	7	9	0	9	0	0	0	0	0	8	9
4	7	10	0	0	9	7	0	0	0	8	0
5	7	10	0	0	9	7	0	0	0	0	9
6	7	9	0	0	9	0	0	0	0	8	9
7	7	10	0	0	0	7	0	0	0	8	9
8	7	0	0	9	0	6	0	10	0	0	9
9	7	0	0	9	0	7	0	0	0	8	10
10	7	0	0	9	0	0	0	10	0	8	9
11	7	0	0	0	9	6	0	10	0	0	9
12	7	0	0	0	9	7	0	0	0	8	10
13	7	0	0	0	8	0	0	10	0	8	9
14	0	9	0	9	0	6	0	0	0	8	9
15	0	9	0	0	9	6	0	0	0	8	9
16	0	0	0	9	0	6	0	10	0	8	9
17	0	0	0	8	0	0	0	9	10	7	8
18	0	0	0	0	8	6	0	10	0	8	9
19	0	0	0	0	7	0	0	9	10	7	8

Nineteen EVCS-optimized schemes meet the charging demand based on the traffic flow. The corresponding fast-charging load can be estimated according to the planning scheme. For example, for Scheme 1 and Scheme 19, the estimated fast-charging load can be seen from Fig. 6. The fast-charging load within 1 day is basically in a normal distribution, as the EVCSs are all located in the business district where the charging peak is concentrated from 12:00 to 15:00. The EVCS candidates are applied to the distribution network optimization problem, and the planning results are shown in the next part.



a) Scheme 1 b) Scheme 19

Fig. B1. Fast-charging load estimation under EVCS schemes.