

Table S1. Temperature coefficients of provinces

DMUs	ICEV	HEV	PHEV	EV
Beijing	1.042	1.076	1.093	1.141
Tianjin	1.042	1.076	1.094	1.143
Hebei	1.037	1.065	1.079	1.118
Shanxi	1.042	1.081	1.101	1.157
Neimenggu	1.060	1.116	1.145	1.228
Liaoning	1.059	1.111	1.138	1.215
Jilin	1.068	1.129	1.161	1.251
Heilongjiang	1.078	1.148	1.185	1.289
Shanghai	1.032	1.050	1.059	1.081
Jiangsu	1.034	1.055	1.064	1.091
Zhejiang	1.033	1.051	1.060	1.082
Anhui	1.034	1.056	1.067	1.098
Fujian	1.028	1.038	1.042	1.051
Jiangxi	1.035	1.052	1.060	1.079
Shandong	1.036	1.062	1.075	1.112
Henan	1.035	1.058	1.069	1.100
Hubei	1.037	1.058	1.068	1.095
Hunan	1.034	1.053	1.062	1.085
Guangdong	1.028	1.038	1.041	1.049
Guangxi	1.023	1.032	1.034	1.041
Hainan	1.032	1.043	1.046	1.053
Chongqing	1.029	1.044	1.051	1.067
Sichuan	1.019	1.035	1.043	1.066
Guizhou	1.020	1.037	1.047	1.074
Yunnan	1.009	1.018	1.022	1.035
Shaanxi	1.033	1.059	1.071	1.107
Gansu	1.045	1.085	1.106	1.166
Qinghai	1.059	1.114	1.143	1.224
Ningxia	1.049	1.091	1.113	1.176
Xinjiang	1.065	1.124	1.154	1.240

Table S2. Congestion coefficient of provinces

DMUs	ICEV	HEV	PHEV	EV
Beijing	1.334	1.334	1.141	1.023
Tianjin	1.171	1.171	1.071	1.010
Hebei	1.203	1.203	1.086	1.014

Shanxi	1.177	1.177	1.074	1.010
Neimenggu	1.212	1.212	1.088	1.012
Liaoning	1.127	1.127	1.053	1.007
Jilin	1.115	1.115	1.049	1.008
Heilongjiang	1.114	1.114	1.051	1.012
Shanghai	1.129	1.129	1.055	1.010
Jiangsu	1.115	1.115	1.048	1.007
Zhejiang	1.241	1.241	1.100	1.013
Anhui	1.149	1.149	1.064	1.011
Fujian	1.182	1.182	1.075	1.009
Jiangxi	1.361	1.361	1.152	1.024
Shandong	1.194	1.194	1.083	1.015
Henan	1.162	1.162	1.067	1.009
Hubei	1.144	1.144	1.060	1.008
Hunan	1.150	1.150	1.064	1.012
Guangdong	1.165	1.165	1.071	1.013
Guangxi	1.139	1.139	1.058	1.009
Hainan	1.128	1.128	1.054	1.008
Chongqing	1.165	1.165	1.071	1.013
Sichuan	1.273	1.273	1.113	1.014
Guizhou	1.176	1.176	1.073	1.011
Yunnan	1.140	1.140	1.059	1.008
Shaanxi	1.169	1.169	1.072	1.013
Gansu	1.162	1.162	1.069	1.012
Qinghai	1.161	1.161	1.067	1.010
Ningxia	1.287	1.287	1.124	1.024
Xinjiang	1.228	1.228	1.095	1.014

Table S3. First-stage DEA data of provinces

DMUs	First stage input		Middle input/output		
	Thermal power ratio	Emissions of energy production per unit	Electricity self-sufficiency ratio	Electricity consumption emission	ICE emission
Beijing	0.961	87.038	0.399	206.5	22.197
Tianjin	0.964	45.188	0.794	242.0	21.421
Hebei	0.845	81.723	0.738	231.0	22.706
Shanxi	0.881	24.492	0.918	240.4	22.808

Neimenggu	0.839	32.816	0.957	236.7	21.552
Liaoning	0.712	64.665	0.772	205.1	22.799
Jilin	0.767	83.477	0.879	203.0	23.191
Heilongjiang	0.820	36.443	1.000	212.9	21.723
Shanghai	0.970	100.253	0.511	170.6	16.460
Jiangsu	0.865	140.929	0.801	201.3	22.525
Zhejiang	0.707	127.347	0.709	171.6	21.891
Anhui	0.923	76.959	0.869	235.0	23.909
Fujian	0.547	98.358	0.999	135.1	21.550
Jiangxi	0.800	153.272	0.888	188.1	24.406
Shandong	0.898	80.657	0.833	239.2	23.708
Henan	0.884	78.186	0.776	238.5	23.905
Hubei	0.497	103.228	0.955	133.1	22.466
Hunan	0.587	85.755	0.806	149.2	23.101
Guangdong	0.680	92.001	0.735	138.5	22.914
Guangxi	0.545	83.226	0.906	124.0	23.462
Hainan	0.614	62.510	0.953	143.6	19.122
Chongqing	0.683	73.023	0.673	134.1	22.852
Sichuan	0.130	19.859	0.971	31.6	20.374
Guizhou	0.607	53.822	1.000	172.8	23.825
Yunnan	0.091	17.149	1.000	18.4	24.570
Shaanxi	0.848	23.087	0.908	223.6	21.925
Gansu	0.483	49.925	0.824	129.2	23.410
Qinghai	0.121	21.063	0.935	39.7	22.190
Ningxia	0.818	69.497	0.840	209.2	23.133
Xinjiang	0.771	44.899	0.997	227.2	23.509

Table S4. Second-stage DEA output of provinces

DMUs	ICEV	HEV	PHEV	EV
Beijing	276.807	178.677	205.8249403	197.066
Tianjin	241.628	156.512	213.9547397	213.727
Hebei	250.997	161.726	211.1888098	201.719
Shanxi	247.176	160.633	217.1486235	212.040
Neimenggu	254.040	166.999	209.6919512	208.730
Liaoning	240.280	158.073	188.3176182	186.994
Jilin	240.799	159.570	215.1491544	219.122
Heilongjiang	238.467	159.089	231.7019769	248.199
Shanghai	217.400	138.956	168.1840907	163.037

Jiangsu	232.012	148.862	192.2357281	181.636
Zhejiang	255.257	163.146	177.2286419	160.246
Anhui	242.822	155.988	229.8024358	218.931
Fujian	241.392	153.389	136.9880103	119.991
Jiangxi	288.275	183.975	224.1611502	191.232
Shandong	251.918	162.172	218.0725023	204.851
Henan	245.695	157.849	210.4212036	198.123
Hubei	238.203	152.853	134.8391864	120.586
Hunan	240.652	154.110	165.4482858	152.670
Guangdong	242.045	153.789	146.964759	120.630
Guangxi	237.353	150.642	151.0125566	131.175
Hainan	224.927	142.886	155.985959	152.726
Chongqing	242.124	154.465	153.719178	125.125
Sichuan	254.371	162.137	62.3128333	40.286
Guizhou	245.176	156.831	153.8031604	134.494
Yunnan	237.847	151.036	55.16644889	26.673
Shaanxi	241.076	155.084	200.1535278	191.677
Gansu	246.311	160.397	130.8558076	111.881
Qinghai	245.405	161.525	60.42315593	36.974
Ningxia	271.796	176.738	210.8561115	190.485
Xinjiang	264.283	174.059	212.0811009	205.186

Table S5. First stage DEA regulation of pure electric model in provinces

DMUs	First stage input			Middle	Efficiency
	Thermal power ratio	Emissions of	Electricity self- sufficiency ratio	input/output	
		energy production per unit		Electricity consumption emission	
Beijing	0.000	0.000	0.000	0.000	1.000
Tianjin	0.013	2.082	0.000	0.000	0.970
Hebei	0.000	0.000	0.000	0.000	1.000
Shanxi	0.000	0.000	0.000	0.000	1.000
Neimenggu	0.000	0.000	0.000	0.000	1.000
Liaoning	0.000	0.000	0.000	0.000	1.000
Jilin	0.030	60.221	0.048	0.000	0.649
Heilongjiang	0.000	12.458	0.118	12.179	0.676
Shanghai	0.169	26.551	0.112	0.000	0.494

Jiangsu	0.000	76.312	0.260	0.000	0.579
Zhejiang	0.000	75.701	0.156	0.000	0.604
Anhui	0.040	47.299	0.000	0.000	0.720
Fujian	0.074	77.349	0.328	0.000	0.449
Jiangxi	0.000	92.826	0.353	0.000	0.532
Shandong	0.000	35.707	0.000	0.000	0.813
Henan	0.000	8.176	0.000	0.000	0.955
Hubei	0.037	82.284	0.288	0.000	0.481
Hunan	0.060	64.279	0.101	0.000	0.567
Guangdong	0.058	30.223	0.337	0.000	0.500
Guangxi	0.111	62.584	0.260	0.000	0.436
Hainan	0.103	41.219	0.261	0.000	0.476
Chongqing	0.081	12.880	0.274	0.000	0.545
Sichuan	0.068	2.270	0.542	0.000	0.208
Guizhou	0.000	29.834	0.230	0.000	0.601
Yunnan	0.080	0.013	0.601	0.000	0.016
Shaanxi	0.000	0.000	0.000	0.000	1.000
Gansu	0.038	29.111	0.166	0.000	0.544
Qinghai	0.032	3.207	0.486	0.000	0.324
Ningxia	0.051	45.330	0.000	0.000	0.688
Xinjiang	0.000	0.000	0.000	0.000	1.000

Table S6. First stage DEA regulation of non-pure electric model in provinces

DMUs	First stage input		Middle input/output		Efficiency	
	Thermal power ratio	Emissions of energy production per unit	Electricity self-sufficiency ratio	Electricity consumption emission	ICE emission	
Beijing	0.000	0.000	0.000	0.000	0.000	1.000
Tianjin	0.013	2.082	0.000	42.391	0.000	0.856
Hebei	0.000	0.000	0.000	0.000	0.000	1.000
Shanxi	0.000	0.000	0.000	0.000	0.000	1.000
Neimenggu	0.000	0.000	0.000	0.000	0.000	1.000
Liaoning	0.000	0.000	0.000	0.000	0.000	1.000
Jilin	0.000	50.143	0.000	0.000	0.000	0.748
Heilongjiang	0.023	12.858	0.000	62.622	0.000	0.640
Shanghai	0.169	26.551	0.112	128.010	0.000	0.352
Jiangsu	0.000	62.375	0.268	0.000	0.000	0.610

Zhejiang	0.000	60.668	0.144	0.000	0.000	0.662
Anhui	0.000	32.851	0.000	0.000	0.000	0.817
Fujian	0.057	77.346	0.198	0.000	0.000	0.533
Jiangxi	0.000	83.396	0.000	48.388	0.000	0.690
Shandong	0.000	22.772	0.000	0.000	0.000	0.880
Henan	0.000	0.000	0.000	0.000	0.000	1.000
Hubei	0.000	82.278	0.012	27.483	0.000	0.620
Hunan	0.000	45.064	0.000	0.000	0.000	0.781
Guangdong	0.000	27.485	0.146	0.000	0.267	0.719
Guangxi	0.058	57.806	0.000	0.000	0.000	0.668
Hainan	0.103	41.219	0.261	25.340	0.000	0.441
Chongqing	0.000	8.175	0.090	0.000	0.459	0.814
Sichuan	0.033	2.265	0.280	0.000	0.000	0.463
Guizhou	0.000	19.942	0.004	0.000	0.000	0.816
Yunnan	0.000	0.000	0.000	0.000	0.000	1.000
Shaanxi	0.000	0.000	0.000	0.000	0.000	1.000
Gansu	0.000	2.121	0.000	0.000	0.000	0.978
Qinghai	0.000	0.000	0.000	0.000	0.000	1.000
Ningxia	0.000	32.992	0.000	0.000	0.040	0.788
Xinjiang	0.000	0.000	0.000	0.000	0.000	1.000

Table S7. Second stage DEA regulation of ICEVs in provinces

DMUs	Middle input/output		Second stage input		Final output	Efficiency	Overall efficiency
	Electricity	ICE	Temperature	Congestion	WTW		
	consumption	emission			carbon emissions		
Beijing	0.000	0.000	0.000	0.050	44.597	0.197	0.197
Tianjin	0.000	0.000	0.000	0.000	0.000	1.000	0.856
Hebei	0.000	0.000	0.000	0.012	10.849	0.767	0.767
Shanxi	0.000	0.000	0.000	0.002	4.023	0.909	0.909
Neimenggu	0.000	0.000	0.000	0.007	15.883	0.679	0.679
Liaoning	0.000	0.000	0.001	0.000	6.844	0.871	0.871
Jilin	0.000	0.000	0.004	0.000	2.610	0.937	0.701
Heilongjiang	0.000	0.000	0.004	0.000	1.837	0.950	0.609
Shanghai	0.000	0.000	0.000	0.000	0.000	1.000	0.352
Jiangsu	0.000	0.000	0.000	0.000	0.000	1.000	0.610
Zhejiang	0.000	0.000	0.000	0.029	24.851	0.557	0.369

Fujian	0.000	0.000	0.000	0.014	6.427	0.816	0.435
Jiangxi	0.000	0.000	0.000	0.000	0.000	1.000	0.690
Shandong	0.000	0.000	0.000	0.007	4.568	0.822	0.723
Henan	0.000	0.000	0.000	0.000	0.000	1.000	1.000
Hubei	0.000	0.000	0.000	0.000	5.256	0.855	0.531
Hunan	0.000	0.000	0.000	0.004	5.036	0.852	0.666
Guangdong	0.000	0.000	0.000	0.011	4.499	0.862	0.619
Guangxi	0.000	0.000	0.000	0.004	0.085	0.994	0.664
Hainan	0.000	0.000	0.000	0.000	0.000	1.000	0.441
Chongqing	0.000	0.000	0.000	0.009	5.644	0.833	0.678
Sichuan	0.000	3.604	0.000	0.029	12.623	0.765	0.354
Guizhou	0.000	0.000	0.000	0.011	2.874	0.896	0.731
Yunnan	0.000	0.000	0.000	0.000	0.000	1.000	1.000
Shaanxi	0.000	0.000	0.000	0.005	2.343	0.921	0.921
Gansu	0.000	0.000	0.002	0.000	12.032	0.660	0.646
Qinghai	0.000	1.400	0.009	0.000	12.819	0.665	0.665
Ningxia	0.000	0.000	0.000	0.031	27.399	0.204	0.161
Xinjiang	0.000	0.000	0.000	0.006	24.435	0.287	0.287

Table S9. Second stage DEA regulation of PHEVs in provinces

DMUs	Middle input/output		Second stage input		Final output	Efficiency	Overall efficiency
	Electricity consumption emission	ICE emission	Temperature	Congestion	WTW carbon emissions		
Beijing	0.000	0.771	0.000	0.004	27.957	0.492	0.492
Tianjin	0.000	0.000	0.000	0.000	0.000	1.000	0.856
Hebei	0.000	1.280	0.000	0.000	9.899	0.708	0.708
Shanxi	0.000	0.000	0.003	0.000	5.813	0.712	0.712
Neimenggu	0.000	0.252	0.007	0.000	3.655	0.861	0.861
Liaoning	0.000	0.000	0.015	0.000	2.740	0.922	0.922
Jilin	0.000	0.000	0.019	0.000	30.867	0.340	0.254
Heilongjiang	0.000	0.000	0.021	0.000	38.017	0.000	0.000
Shanghai	0.000	0.000	0.000	0.000	0.000	1.000	0.352
Jiangsu	0.000	0.000	0.003	0.000	8.863	0.813	0.495
Zhejiang	0.000	0.000	0.000	0.002	21.670	0.712	0.471
Anhui	0.000	0.000	0.000	0.000	0.000	1.000	0.817
Fujian	0.000	0.000	0.000	0.000	3.695	0.962	0.513

Jiangxi	0.000	0.000	0.000	0.000	0.000	1.000	0.690
Shandong	0.000	0.239	0.000	0.001	8.278	0.626	0.551
Henan	0.000	0.000	0.000	0.000	0.000	1.000	1.000
Hubei	0.000	0.000	0.000	0.000	5.389	0.947	0.587
Hunan	0.000	0.000	0.001	0.000	26.121	0.716	0.560
Guangdong	0.000	0.000	0.000	0.000	13.831	0.860	0.618
Guangxi	0.000	0.000	0.000	0.000	26.557	0.752	0.503
Hainan	0.000	0.000	0.000	0.000	10.545	0.878	0.387
Chongqing	0.000	0.000	0.000	0.000	24.160	0.763	0.621
Sichuan	0.000	0.000	0.000	0.000	0.000	1.000	0.463
Guizhou	0.000	0.000	0.000	0.000	0.000	1.000	0.816
Yunnan	0.000	0.000	0.000	0.000	0.000	1.000	1.000
Shaanxi	0.000	1.506	0.000	0.000	3.092	0.973	0.973
Gansu	0.000	0.000	0.006	0.000	6.836	0.929	0.909
Qinghai	0.000	0.000	0.000	0.000	0.000	1.000	1.000
Ningxia	0.000	0.000	0.000	0.000	34.869	0.374	0.294
Xinjiang	0.000	0.000	0.010	0.000	16.360	0.538	0.538

Table S10. Second stage DEA regulation of EVs in provinces

DMUs	Middle	Second stage		Final output	Efficiency	Overall
	input/output	input				efficiency
	Electricity			WTW		
	consumption emission	Temperature	Congestion	carbon emissions		
Beijing	0.000	0.011	0.000	33.295	0.598	0.598
Tianjin	0.000	0.000	0.000	0.000	1.000	0.970
Hebei	0.000	0.004	0.000	12.250	0.788	0.788
Shanxi	0.000	0.009	0.000	6.161	0.846	0.846
Neimenggu	0.000	0.032	0.000	13.164	0.724	0.724
Liaoning	0.000	0.034	0.000	20.514	0.722	0.722
Jilin	0.000	0.042	0.000	55.014	0.330	0.214
Heilongjiang	0.000	0.050	0.000	75.424	0.001	0.001
Shanghai	0.000	0.002	0.000	30.011	0.737	0.364
Jiangsu	0.000	0.002	0.000	18.887	0.777	0.449
Zhejiang	0.000	0.002	0.000	27.188	0.762	0.461
Anhui	0.000	0.000	0.000	24.044	0.548	0.395
Fujian	0.000	0.000	0.000	8.986	0.931	0.418
Jiangxi	0.000	0.000	0.000	41.726	0.574	0.306

Shandong	0.000	0.001	0.000	7.685	0.848	0.689
Henan	0.000	0.000	0.000	0.000	1.000	0.955
Hubei	0.000	0.009	0.000	13.384	0.896	0.431
Hunan	0.000	0.004	0.000	35.010	0.728	0.413
Guangdong	0.000	0.000	0.000	6.581	0.945	0.472
Guangxi	0.000	0.000	0.000	26.308	0.811	0.354
Hainan	0.000	0.000	0.000	35.730	0.725	0.345
Chongqing	0.000	0.000	0.000	18.251	0.871	0.474
Sichuan	0.000	0.006	0.000	5.552	0.967	0.201
Guizhou	0.000	0.000	0.000	0.000	1.000	0.601
Yunnan	0.000	0.000	0.000	0.000	1.000	0.016
Shaanxi	0.000	0.002	0.000	9.065	0.859	0.859
Gansu	0.000	0.026	0.000	8.294	0.915	0.498
Qinghai	0.000	0.000	0.000	0.000	1.000	0.324
Ningxia	0.000	0.019	0.000	24.345	0.689	0.473
Xinjiang	0.000	0.036	0.000	19.245	0.665	0.665
