

Hydro-Thermal-Wind Generation Scheduling Considering Economic and Environmental Factors Using Heuristic Algorithms

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Table S1. Optimal generation schedule of the hydro-thermal-wind system obtained using the PSO method.

Time Period	Load (MW)	Hydro Generation (MW)				Thermal Generation			Wind Generation	
		Ph1	Ph2	Ph3	Ph4	P _{g1} (MW)	P _{g2} (MW)	P _{g3} (MW)	W ₁ (MW)	W ₂ (MW)
1	750	87.6319	65.8697	40.6322	200.0937	92.9137	138.4262	79.9345	14.1907	30.3075
2	780	58.1569	62.8352	0	187.7553	74.0746	243.9233	120.1592	10.8267	22.2688
3	700	53.6107	59.8003	13.7472	176.6969	75.1426	202.4674	52.5283	23.9704	42.0362
4	650	97.3225	64.6089	0	159.5966	95.1968	109.8464	85.9414	14.2912	23.1962
5	670	61.784	50.7588	24.5912	173.197	108.9504	103.7714	102.352	16.229	28.3663
6	800	60.9951	54.122	29.6431	193.8604	154.6035	176.5285	50	40.9751	39.2723
7	950	53.1246	52.6733	43.249	207.882	154.3058	259.0829	113.8503	17.2303	48.6019
8	1010	72.3356	57.7966	15.3338	218.8914	175	274.2052	138.5558	29.0752	28.8063
9	1090	57.3242	63.0103	44.4979	224.7796	175	269.0094	204.7197	28.559	23.1
10	1080	71.9193	59.7288	25.8074	231.1391	175	273.4323	186.506	26.8441	29.6229
11	1100	95.1807	75.2067	24.9714	246.2267	174.9869	266.353	173.8468	16.4776	26.7502
12	1150	56.9126	83.7286	39.6764	258.9339	162.2946	286.5904	214.9543	26.5913	20.3178
13	1110	96.2659	72.5906	45.3612	246.9826	149.6133	269.4264	161.3291	31.4741	36.9568
14	1030	104.5156	73.5993	44.8853	255.556	159.5	197.6856	137.9822	21.4765	34.7995
15	1010	92.5775	58.3076	41.9826	228.5196	171.324	248.5042	104.0175	36.6518	28.1151
16	1060	88.6939	66.0836	53.4984	268.6876	144.8472	259.1537	113.2143	19.3038	46.5176
17	1050	80.0344	47.3423	55.3682	262.5892	175	256.3493	119.7291	40.823	12.7644
18	1120	87.9641	60.3018	47.7057	289.8134	158.8382	292.4646	120.6801	27.4715	34.7606
19	1070	68.6652	63.2785	56.0149	264.633	167.978	254.9508	125.0617	35.2554	34.1624
20	1050	65.4264	53.7697	44.7484	279.2649	104.4473	274.8064	175.3483	25.5128	26.6758
21	910	70.2324	70.6549	57.611	232.2104	120.0021	212.9478	84.0086	28.371	33.9618
22	860	56.5178	59.7912	57.639	257.4907	175	159.0882	54.7781	18.9983	20.6967
23	850	63.7842	54.2802	59.4093	262.7098	159.3492	130.6533	63.5529	18.7365	37.5246
24	800	103.5463	50.0532	49.4568	260.9238	117.6877	99.1431	55.107	23.6136	40.4684

Table S2. Hourly water discharge and reservoir storage volume obtained using the PSO method.

Water Discharge($\times 10^4$ m ³ /h)				Reservoir Storage Volume($\times 10^4$ m ³)			
Qh1	Qh2	Qh3	Qh4	Vh1	Vh2	Vh3	Vh4
10.4022	8.7686	20.1285	13	99.5978	79.2314	157.9715	109.8
5.5856	8.2536	29.9964	13	103.0122	78.9778	136.1751	99.2
5	7.5958	22.8932	13.4295	106.0122	80.382	127.6841	87.3705
14.19	8.3382	25.3171	13.5264	98.8222	81.0438	118.7212	73.8441
6.1568	6	19.9311	13	98.6653	83.0438	114.926	87.3762
6.0255	6.4334	19.4556	13	99.6399	83.6105	121.2562	104.3726
5.0114	6.2449	15.5626	13.358	102.6284	83.3656	123.1886	113.9078
7.4026	7.001	21.704	13.1222	104.2258	83.3647	115.5101	126.1027

5.3697	7.8098	12.0987	13	108.8561	83.5549	115.8562	133.0338
7.099	7.1155	19.3038	13.0086	112.7572	85.4393	111.1999	139.4808
11.1118	9.952	18.906	14.5328	113.6453	84.4873	105.6646	140.5105
5.2125	13.0394	14.3486	15.2742	118.4328	79.4479	108.2248	146.9403
11.0802	10.4349	12.0926	14.1421	118.3526	77.013	118.3595	144.8969
14.081	11.0046	14.418	14.5974	116.2716	75.0084	122.1061	149.6033
10.3396	7.7805	17.3132	11.2715	116.932	76.2279	131.9126	157.2378
9.568	9.3615	11.4953	15.3921	117.3641	74.8664	146.9332	156.1942
8.1239	6.1333	10.6448	15.002	118.2401	75.7331	159.6325	153.2849
9.457	8.4702	18.4978	19.3247	116.7831	73.2629	160.4833	148.3781
6.5958	9.352	10.0632	15.5875	117.1873	70.9109	168.9055	150.1038
6.2005	7.5653	19.725	18.5479	116.9867	71.3455	165.7709	143.0512
6.7943	11.3895	14.9065	13	117.1924	68.956	167.9305	140.6959
5.1603	8.9305	15.2426	15.4804	120.0321	69.0255	169.8558	143.7133
5.9541	7.9142	12.9904	17.1134	123.0779	69.1113	172.2251	136.6631
13.0779	7.1113	18.775	16.3881	120	70	170	140

Table S3. Fuel cost, rate of pollutant emission, and wind generation penalty cost of the optimal generation schedule-PSO method.

Time Period	Fuel Cost (\$/h)	Emission (lb/h)	Wind Generation Penalty Cost (\$/MWh)		
			Underestimation, $C_{u,i}$	Overestimation, $C_{o,i}$	Total penalty cost (\$/MWh)
1	1344.4059	0.1795	8254.3242	6211.225	14465.5492
2	2735.9707	1.9954	10434.003	3242.2573	13676.2602
3	1527.066	0.6264	4741.5886	13706.8922	18448.4809
4	1242.5755	0.1291	9455.1813	3944.7634	13399.9446
5	1454.3057	0.1397	8114.2175	5851.6775	13965.8949
6	1529.7418	0.4293	2563.2645	19136.6985	21699.9629
7	3028.1687	3.2306	5527.3646	16043.6983	21571.0629
8	3660.2428	5.1727	5600.7483	9394.2228	14994.9711
9	5085.8676	4.4898	6687.1903	7447.8781	14135.0684
10	4678.815	5.0994	5841.1369	8930.9098	14772.0467
11	4308.389	4.1137	8332.5467	5359.2559	13691.8026
12	5524.2427	7.6394	7559.4612	6098.1472	13657.6083
13	3993.758	4.4402	4054.8936	13631.2221	17686.1156
14	2836.8684	0.6858	6066.4457	9478.8738	15545.3195
15	2826.0516	2.4028	4624.446	12262.9588	16887.4048
16	2990.6736	3.2201	5248.4195	15151.2173	20399.6368
17	3146.7514	3.0286	7201.2558	10744.5688	17945.8246
18	3514.0417	9.0725	4978.9519	11191.2705	16170.2224
19	3196.7793	2.8946	3886.2748	13951.624	17837.8988
20	4210.1572	5.1881	6562.2093	7510.5706	14072.7799
21	2052.3989	0.8629	4938.2204	11149.5224	16087.7428
22	1494.704	0.3729	8923.6757	4172.915	13096.5906
23	1324.2709	0.2465	6268.3028	10105.0702	16373.373
24	940.5546	0.1342	4970.8931	12767.0512	17737.9443
Total	68646.801	65.7942	150835.0157	237484.4907	388319.5058

Table S4. Optimal generation schedule of the hydro-thermal-wind system obtained using the GA method.

Time Period	Load (MW)	Hydro Generation (MW)				Thermal Generation			Wind Generation	
		Ph1	Ph2	Ph3	Ph4	Pg ₁ (MW)	Pg ₂ (MW)	Pg ₃ (MW)	w ₁ (MW)	w ₂ (MW)
1	750	91.6178	73.1563	56.1872	200.1352	81.7391	119.1166	69.9799	20.6211	37.4467
2	780	52.98	75.4181	0	187.7489	148.8575	205.3327	61.2763	24.6195	23.767
3	700	60.4404	47.0735	42.7175	173.7265	20	245.5681	54.0231	30.2401	26.2107
4	650	53.6998	50.712	52.9007	157.1406	55.2008	152.2444	85.4846	20.7164	21.9008
5	670	89.113	49.887	0	100.4955	57.6543	249.1436	82.9026	24.3511	16.4529
6	800	78.2844	53.6716	44.7462	188.6759	124.035	203.2649	56.8581	20.7285	29.7354
7	950	66.452	64.7168	43.4111	194.477	167.7162	253.6165	100.3177	26.2262	33.0666
8	1010	89.1908	52.421	34.4264	192.2482	163.3673	230.6066	135.7443	76.4878	35.5075
9	1090	77.3122	74.4202	41.2908	211.2851	175	275.6298	179.8793	25.3651	29.8175
10	1080	83.7304	61.2663	51.6342	215.3487	175	275.7152	157.1786	23.4967	36.6299
11	1100	77.1458	49.6297	50.001	236.1301	154.7558	265.8949	192.8522	43.3328	30.2578
12	1150	78.7738	65.5104	54.1612	243.784	175	286.8324	152.0697	79.9399	13.9285
13	1110	73.923	73.9588	50.773	226.5506	175	276.3908	192.7123	17.917	22.7746
14	1030	96.0447	65.8727	48.2253	237.2892	172.6527	200.5736	133.2468	35.0536	41.0414
15	1010	71.8348	52.415	54.9331	240.6528	154.5897	258.0838	139.1462	20.4874	17.8572
16	1060	80.8564	50.4779	25.5288	233.5811	175	265.6983	180.4144	17.3278	31.1153
17	1050	66.3951	70.192	44.782	235.0086	175	271.5225	120.551	37.162	29.3868
18	1120	75.9268	62.965	57.0403	265.2454	166.0559	285.9215	119.6509	40.9771	46.2171
19	1070	81.1115	61.2593	50.2917	226.9578	137.8864	258.0294	206.9443	14.9697	32.5499
20	1050	55.0999	79.5916	58.2066	253.6029	174.9378	280.2647	122.8636	1.2834	24.1494
21	910	91.974	65.699	58.6924	244.8351	116.4769	192.1243	66.1771	46.671	27.3504
22	860	84.1165	52.9604	28.9651	232.1498	70.5246	237.277	92.174	40.9009	20.9317
23	850	81.0613	52.2929	19.3258	236.1777	162.2247	172.1838	62.2757	36.8358	27.6224
24	800	88.5552	63.9919	58.8847	251.6933	116.9976	77.5214	102.0578	37.1333	3.1648

Table S5. Hourly water discharge and reservoir storage volume obtained using the GA method.

Water Discharge($\times 10^4$ m ³ /h)				Reservoir Storage Volume($\times 10^4$ m ³)			
Qh1	Qh2	Qh3	Qh4	Vh1	Vh2	Vh3	Vh4
11.5988	10.4865	15.1377	13.0053	98.4012	77.5135	162.9623	109.7947
5	11.7095	29.481	13	102.4012	73.804	141.6814	99.1947
5.8225	6	17.9313	13	104.5787	76.804	139.3489	87.7947
5	6.2849	11.0907	13.054	106.5787	79.5191	145.7446	74.7407
10.5405	6	29.9647	6.3879	102.0382	81.5191	136.312	83.4904
8.493	6.501	16.6843	13	100.5452	82.0181	134.6277	99.9714
6.6637	8.5293	17.4509	13	101.8815	79.4887	137.0023	104.9027
10.7297	6.4924	19.5631	13	100.1518	79.9964	133.9322	102.9934
8.2635	10.8401	17.3918	13	101.8883	77.1562	130.705	119.958
9.2988	8.0812	12.3335	13.0192	103.5895	78.0751	138.6305	123.6231
7.9985	6	14.9166	15.1374	107.591	81.0751	139.4698	125.9366
8.1856	8.5555	13.1614	15.5524	109.4054	80.5195	148.4473	129.9473
7.3665	10.6097	16.5216	13.0561	113.0388	77.9099	152.0054	134.2831
11.3236	8.9176	17.4773	14.4814	113.7153	77.9923	151.7138	132.1352
6.9933	6.4433	10.255	14.8732	117.7219	80.5489	160.3809	132.1786
8.219	6	23.2014	14.1691	119.503	82.5489	161.1126	131.1709

6.2648	9.4967	19.2535	14.0426	122.2382	80.0523	159.77	133.6498
7.4648	8.4291	11.1664	18.0855	122.7734	77.6231	165.2659	133.0416
8.2159	8.2734	17.6986	13.5964	121.5575	76.3497	160.8321	129.7002
5	14.164	12.7252	15.8391	122.5575	70.1857	166.0684	137.0625
10.1092	10.1589	14.5717	14.2	119.4482	69.0268	171.4821	142.116
8.7435	7.5274	22.7972	13.0378	118.7047	70.4994	163.9583	140.2446
8.2507	7.3443	24.3664	13	119.4539	71.155	164.8651	144.9432
9.4539	9.7202	13.7676	15.2311	120	70	170	140

Table S6. Fuel cost, rate of pollutant emission, and wind generation penalty cost of the optimal generation schedule-GA method.

Time Period	Fuel Cost (\$/h)	Emission (lb/h)	Wind Generation Penalty Cost (\$/MWh)		
			Underestimation, $C_{u,i}$	Overestimation, $C_{o,i}$	Total penalty cost (\$/MWh)
1	1086.8101	0.1302	5895.0179	10487.1113	16382.1292
2	1836.8942	0.7527	7243.3911	6376.1947	13619.5858
3	1821.1972	2.0711	5853.5616	8956.1796	14809.7411
4	1421.5581	0.2075	8339.7407	4853.5262	13193.2669
5	2249.5285	2.308	8763.7902	4626.5949	13390.3851
6	1699.417	0.6804	6956.5903	7266.3351	14222.9254
7	2819.4915	2.7714	5428.1398	10069.229	15497.3688
8	3119.1063	1.4774	2149.2269	45305.7339	47454.9608
9	4546.3732	5.442	6069.1654	8541.1282	14610.2936
10	4046.7376	5.4326	5441.6695	10833.8409	16275.5104
11	4694.8402	4.0355	3543.9928	16479.7343	20023.7271
12	4063.8553	7.653	6233.3996	42546.2738	48779.6734
13	4861.5254	5.5847	8745.0585	4469.9602	13215.0187
14	2809.7233	0.7535	3077.5615	17170.8108	20248.3723
15	3441.7714	3.1532	9203.1247	3888.8064	13091.9311
16	4452.0973	4.0421	7442.2753	7054.9232	14497.1985
17	3320.6553	4.7555	4353.4846	12947.4751	17300.9597
18	3439.5785	7.393	1889.6244	23016.8349	24906.4593
19	4917.8893	3.1925	7742.1734	7205.0517	14947.2251
20	3451.7106	6.2192	12509.831	3181.7858	15691.6168
21	1668.8311	0.5181	3729.3498	17439.4731	21168.8229
22	2269.2181	1.6296	5439.6346	12303.9988	17743.6334
23	1623.8193	0.4147	4683.6459	12183.1742	16866.8201
24	1354.3436	0.1278	10006.8409	8124.2554	18131.0963
Total	71016.9724	70.7457	150740.2904	305328.4315	456068.7218

Table S7. Optimal generation schedule of the hydro-thermal-wind system obtained using the IHS method.

Time Period	Load (MW)	Hydro Generation (MW)				Thermal Generation			Wind Generation	
		Ph1	Ph2	Ph3	Ph4	P_{g1} (MW)	P_{g2} (MW)	P_{g3} (MW)	w_1 (MW)	w_2 (MW)
1	750	74.886	53.7124	0	200.0937	107.7775	190.3432	65.5483	20.3422	37.2967
2	780	78.3164	55.1482	5.0597	187.7553	101.0112	179.9587	112.1653	37.3906	23.1947
3	700	92.642	69.6987	16.1725	173.7333	66.215	147.3684	90.6064	22.6931	20.8707
4	650	62.0638	62.6589	0	156.7917	82.1642	203.382	50	15.3338	17.6057
5	670	92.3253	52.9913	22.6174	122.7543	45.9865	225.3237	50	27.3377	30.6639
6	800	51.4928	56.8876	34.4431	195.6489	150.2536	197.1343	80.7813	9.8728	23.4858

7	950	75.5815	69.6995	11.6439	206.1082	155.3907	246.3309	128.4548	25.3156	31.475
8	1010	53.2158	70.8951	45.0682	222.9127	174.6496	256.4929	155.5783	12.8219	18.3654
9	1090	68.7839	74.5107	33.7877	238.7803	175	281.0871	176.9134	17.5835	23.5534
10	1080	69.052	62.0885	39.6965	236.5195	175	266.5832	189.4757	31.9086	9.676
11	1100	99.7181	64.544	44.6823	252.7939	169.6933	265.2779	182.1093	21.1813	0
12	1150	81.4175	53.06	48.0783	250.7842	175	277.1845	209.236	32.1936	23.0458
13	1110	65.1093	53.7937	52.1762	269.5646	151.0621	269.777	192.0982	17.7654	38.6534
14	1030	85.5658	76.2957	30.8175	247.9675	158.89	248.175	120.6715	32.3155	29.3016
15	1010	83.473	64.6001	52.709	242.4055	173.5114	217.4372	139.0704	23.5281	13.2653
16	1060	72.2294	50.9239	53.6437	260.7314	158.8785	274.1546	124.4614	30.1031	34.8742
17	1050	71.3806	57.266	55.7996	239.1161	173.1408	266.2742	137.1341	18.7573	31.1315
18	1120	95.5724	80.4704	53.4858	246.0255	139.517	295.0799	167.7017	18.0662	24.0811
19	1070	89.7851	60.8301	52.6193	255.0506	109.268	275.966	175.4488	24.1566	26.8754
20	1050	63.4208	78.1274	57.5781	290.6425	166.6153	255.5682	61.7404	27.4679	48.8395
21	910	59.7151	50.6895	55.7103	235.7199	175	211.7934	50	31.5468	39.825
22	860	60.7167	46.2269	54.7209	267.406	72.4127	206.6597	64.3736	42.224	45.2594
23	850	62.4538	71.6739	57.6074	247.2842	138.7658	121.3074	105.8022	38.7839	6.3214
24	800	85.7968	65.097	28.9221	282.803	79.6469	142.2612	50	19.2159	46.257

Table S8. Hourly water discharge and reservoir storage volume obtained using the IHS method.

Water Discharge($\times 10^4$ m ³ /h)				Reservoir Storage Volume($\times 10^4$ m ³)			
Qh1	Qh2	Qh3	Qh4	Vh1	Vh2	Vh3	Vh4
7.8664	6.5563	26.7304	13	102.1336	81.4437	151.3696	109.8
8.3878	6.6525	24.6334	13	102.7458	82.7912	134.9362	99.2
11.8629	9.076	22.275	13	98.8828	82.7152	124.5276	87.8
6.1586	7.7088	28.9748	13	99.7243	84.0064	112.4969	74.8
12.8598	6.0894	20.2233	7.2496	92.8645	85.917	113.789	94.2807
5.0217	6.6177	17.6093	13	94.8428	86.2992	115.4143	105.9142
8.3779	9.0101	22.3945	13	94.4648	83.2891	116.5884	115.1892
5.1237	9.5494	12.1678	13	98.3412	80.7397	117.5317	131.164
7.0014	10.7218	17.8303	14.0494	101.3398	78.0178	115.697	137.3379
6.9028	8.1345	15.7314	13.3592	105.437	78.8833	114.9981	141.5881
14.9803	8.5116	13.6448	14.2837	102.4567	79.3717	118.9041	149.6989
8.8768	6.5108	11.5829	14.2795	103.5799	80.8609	126.9458	147.5873
6.3136	6.4889	13.0689	16.3117	108.2663	82.3721	140.9918	149.1059
9.2582	10.7305	20.8785	13.6237	111.0081	80.6416	140.5017	151.2135
8.8088	8.3052	11.1742	13	113.1993	81.3364	144.6548	151.8584
7.0723	6	14.0246	15.3553	116.127	83.3364	148.3773	148.086
6.927	6.9153	11.1466	13.0011	118.2001	83.4211	158.77	148.1537
11.1114	12.562	16.2864	13	115.0887	76.8591	159.8611	156.0322
10.01	8.2879	16.3829	14.2	112.0787	75.5713	157.4052	153.0064
6.0312	13.5739	13.3548	19.6462	112.0475	69.9973	163.0771	147.3848
5.5744	6.9978	16.573	13.0038	113.4731	71.9995	171.0761	144.4071
5.6609	6.0434	16.9588	16.698	115.8122	74.9561	170.4363	143.9954
5.8293	11.0875	10.0961	14.025	118.9829	71.8686	180.4885	146.3533
8.9829	9.8686	23.1472	19.7081	120	70	170	140

Table S9. Fuel cost, rate of pollutant emission, and wind generation penalty cost of the optimal generation schedule-IHS method.

Time Period	Fuel Cost (\$/h)	Emission (lb/h)	Wind Generation Penalty Cost (\$/MWh)		
			Underestimation, $C_{u,i}$	Overestimation, $C_{o,i}$	Total penalty cost (\$/MWh)
1	1618.4539	0.4889	5969.1074	10350.4174	16319.5249
2	2084.1882	0.3983	5403.7013	11110.5921	16514.2934
3	1475.0149	0.1947	8157.0861	5094.5854	13251.6715
4	1529.9647	0.6449	10340.7615	2812.008	13152.7695
5	1654.6263	1.147	5593.953	9476.529	15070.482
6	1973.75	0.6322	10432.3907	3464.8739	13897.2646
7	3126.0843	2.2388	5822.3415	9151.4773	14973.8188
8	3807.526	3.0674	10748.3725	2585.9475	13334.32
9	4537.5786	6.4266	8668.9588	4614.5351	13283.4939
10	4676.872	4.1599	9067.2427	6263.043	15330.2857
11	4472.6674	3.9811	13423.1366	2393.3713	15816.5079
12	5295.3913	5.743	6132.2662	8790.0582	14922.3244
13	4706.719	4.5246	6336.8265	10458.5571	16795.3836
14	3030.8036	2.3615	5021.6752	10794.1778	15815.853
15	3077.2005	1.0914	9625.9291	3884.6966	13510.6257
16	3365.5732	5.1179	4535.1613	12162.3166	16697.4778
17	3543.3567	4.0658	7139.713	7348.2641	14487.9771
18	4392.1377	9.8627	8469.4234	4857.3934	13326.8168
19	4241.0651	5.383	6772.9844	7176.7442	13949.7286
20	2401.2409	2.9219	3550.7881	18852.797	22403.5851
21	1878.4496	0.9327	3706.3228	15073.151	18779.4738
22	1661.8493	0.6966	1841.1343	23113.6932	24954.8275
23	1692.998	0.2029	8991.2702	9069.9092	18061.1794
24	1057.4604	0.1792	5287.1855	14972.3001	20259.4857
Total	71300.9716	66.463	171037.7321	213871.4385	384909.1707

Table S10. Optimal generation schedule of the hydro-thermal-wind system obtained using the JAYA method.

Time Period	Load (MW)	Hydro Generation (MW)				Thermal Generation			Wind Generation	
		Ph1	Ph2	Ph3	Ph4	Pg ₁ (MW)	Pg ₂ (MW)	Pg ₃ (MW)	w ₁ (MW)	w ₂ (MW)
1	750	79.8214	62.6983	47.7939	129.0269	151.2781	62.9835	153.4242	41.0654	21.9084
2	780	96	60.1328	41.5687	125.7437	167.611	51.5898	164.376	44.3833	28.5947
3	700	89.389	51.0708	53.4248	122.7197	167.6819	53.3771	107.4891	37.8609	16.9868
4	650	60.4217	52.7691	51.683	148.2069	81.0577	44.1519	172.5169	18.0521	21.1407
5	670	50.8585	53.5277	0	124.798	170.6342	45.9075	175.1167	22.5245	26.6327
6	800	51.3772	56.209	36.3175	141.2959	134.1238	205.0216	126.1668	24.8436	24.6446
7	950	57.7976	53.8795	39.6008	219.8936	23.3348	293.6938	204.2532	35.9851	21.5615
8	1010	55.9839	59.034	52.236	155.4938	154.5365	299.9874	180.3162	21.5544	30.8578
9	1090	93.6398	55.0471	50.1509	270.789	93.1987	299.345	129.3084	30.9895	67.5317
10	1080	53.4173	56.5707	51.9567	302.3044	62.1382	297.024	202.3078	21.0604	33.2205
11	1100	54.3971	57.9074	44.9241	286.0593	158.555	208.5027	213.8082	45.8714	29.9747
12	1150	94.8408	86.5313	52.7113	248.0206	125.8666	241.5103	245.2733	35.0702	20.1756
13	1110	59.1028	91.7883	51.566	287.4892	86.8987	274.5461	218.963	13.0049	26.6411
14	1030	88.6065	57.3139	51.3962	285.8885	134.1443	155.0224	169.3849	45.7154	42.528
15	1010	76.1947	59.8638	0	206.3604	171.1905	281.5848	164.4163	24.5473	25.8421
16	1060	71.1573	81.742	53.56	292.7957	65.8744	202.0107	247.6394	29.1417	16.0788
17	1050	83.7703	81.8484	47.5482	242.8586	152.8046	200.6035	168.2076	26.0716	46.2873
18	1120	97.7591	54.5609	43.4728	289.2153	160.1263	292.6991	160.0864	0.8958	21.1842

19	1070	102.2895	52.8419	54.1726	298.369	122.7322	53.0612	316.6386	48.9936	20.9013
20	1050	54.9708	76.0232	56.2317	274.4567	152.4597	286.9297	99.428	33.4707	16.0296
21	910	102.9687	77.3998	38.0333	271.6009	174.7575	122.3424	58.4659	27.456	36.9754
22	860	62.1098	86.4789	48.0756	292.6396	20.4561	148.6294	157.2212	26.8108	17.5785
23	850	78.7467	79.9131	57.6471	287.4425	70.8678	74.4603	143.3392	23.4554	34.1279
24	800	54.8916	71.5894	57.5977	273.769	119.8164	128.4386	50	28.7715	15.1257

Table S11. Hourly water discharge and reservoir storage volume obtained using the JAYA method.

Water Discharge($\times 10^4$ m ³ /h)				Reservoir Storage Volume($\times 10^4$ m ³)			
Qh1	Qh2	Qh3	Qh4	Vh1	Vh2	Vh3	Vh4
8.7187	8.1333	18.4015	6	101.2813	79.8667	159.6985	116.8
15	7.6685	19.1568	6	95.2813	80.1982	148.7417	113.2
11.9317	6.0342	13.9903	6.0894	91.3496	83.164	147.4701	108.7106
6.2216	6.0428	16.626	8.9334	92.128	86.1212	155.9774	99.7772
5	6	29.1018	6	93.128	88.1212	149.4758	112.1787
5	6.3265	20.1355	6	95.128	88.7946	145.5961	131.0942
5.6956	6	18.933	12.5451	97.4324	88.7946	140.7059	132.5395
5.3767	6.7128	11.275	6.3608	101.0557	89.0818	142.4309	142.8047
12.22	6	15.0163	15.6273	98.8357	91.0818	140.4368	156.2792
5	6.0081	12.8449	20	104.8357	94.0737	139.9686	156.4147
5	6	17.5639	17.3249	111.8357	97.0737	142.3375	158.0228
11.2528	11.2625	12.7262	13.1913	110.5829	93.8112	142.6114	156.1065
5.4744	13.9365	14.5693	18.23	116.1085	87.8747	143.0502	152.8927
9.5085	6.3567	15.5928	18.964	118.5999	90.518	147.7102	146.7736
7.51	6.5445	29.7547	9.5504	122.0899	92.9735	137.6924	154.787
6.8235	10.6062	14.2656	20	125.2664	90.3673	148.8718	147.5132
8.5441	11.2211	17.247	13.3258	125.7223	86.1462	147.4915	148.7567
11.2137	6.3184	18.252	19.9803	122.5086	85.8278	144.6076	144.3691
12.9935	6	10.5461	19.6814	116.5151	86.8278	154.2117	154.4424
5.0088	10.0916	15.0363	16.5534	117.5064	84.7362	162.6103	152.1546
15	10.6161	21.0394	16.0537	109.5064	83.1201	162.8828	153.3479
5.8812	15	18.1358	19.0724	111.6251	77.1201	157.7557	152.5275
8.0791	13.9524	15.0451	19.901	112.546	71.1678	168.8022	143.1726
5	12.0695	15.2995	18.2088	120	70	170	140

Table S12. Fuel cost, rate of pollutant emission, and wind generation penalty cost of the optimal generation schedule-JAYA method.

Time Period	Fuel Cost (\$/h)	Emission (lb/h)	Wind Generation Penalty Cost (\$/MWh)		
			Underestimation, C _{u,i}	Overestimation, C _{o,i}	Total penalty cost (\$/MWh)
1	2273.3048	0.2067	5231.1681	12631.7671	17862.9352
2	2502.9885	0.249	3713.6197	16486.5608	20200.1806
3	1483.6545	0.2073	6596.2393	9919.9144	16516.1537
4	2400.6196	0.1437	9032.5794	4083.0691	13115.6485
5	2726.6482	0.2672	7120.4965	6654.2659	13774.7625
6	2607.6422	0.7463	7041.7117	6691.3388	13733.0505
7	4931.0615	9.4125	5893.3692	10030.7618	15924.1309
8	4786.3986	11.5755	6619.0271	7883.9794	14503.0065

9	3539.5309	11.216	2503.8186	34765.6294	37269.448
10	5028.6208	10.4664	6366.8448	8703.0344	15069.8792
11	4668.8346	0.9436	3364.6507	17864.2725	21228.9231
12	5841.2114	2.0491	6288.0232	9288.7211	15576.7442
13	5282.1494	5.1895	9126.5946	4772.9297	13899.5242
14	3074.2418	0.3352	1772.8607	23555.3735	25328.2342
15	4254.3155	6.5032	6881.2076	6963.2295	13844.4372
16	5369.7987	0.7847	8020.5286	6096.1987	14116.7273
17	3458.3603	0.7416	3980.0824	16794.2668	20774.3492
18	4260.6315	9.1736	13178.8014	2397.6575	15576.4589
19	7098.1075	0.4304	4745.617	17085.2092	21830.8262
20	3122.3029	7.5929	7376.8742	7762.8182	15139.6925
21	1265.0245	0.2653	4694.2617	12193.6489	16887.9107
22	2457.6886	0.2394	8086.4	5585.3546	13671.7546
23	1895.5243	0.1171	5779.7363	9702.7361	15482.4724
24	1065.3664	0.1792	8290.062	5804.1717	14094.2337
Total	85394.027	79.0354	151704.5748	263716.9091	415421.484



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