An Aggregator-Based Market Modelling with an Impact of Risk Under Uncertainty

Forecasted PV and wind output power Scenarios: Initially ARIMA forecasting is done based on available historical data on solar and wind output power.

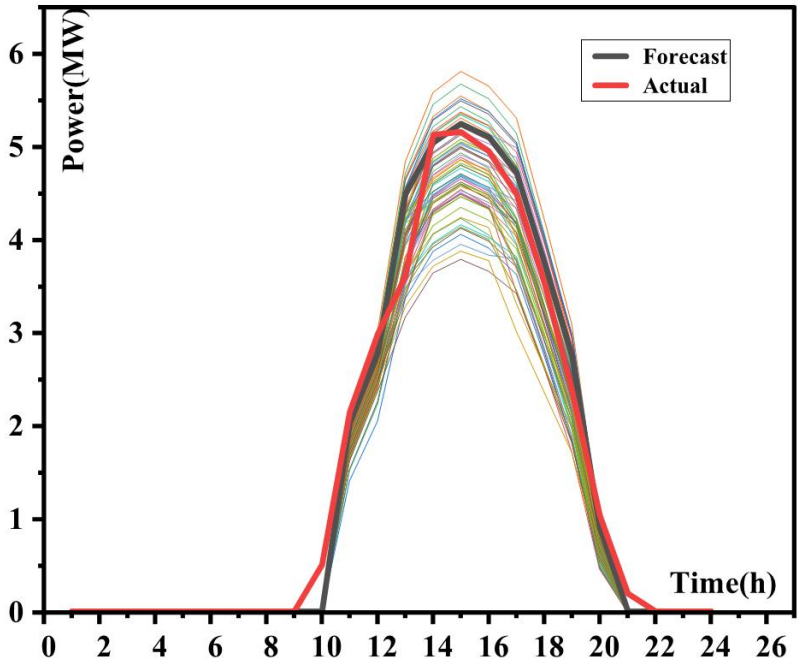

Fig 1: Forecasted solar output power Scenarios

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
60	0	0	0	0	0	0	0	0	0	0	1.533	2.26617	3.56653	3.92610	4.12607	3.98802	3.71113	2.80482	1.83220	0.47906	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	1.64733	2.42516	3.82338	4.32816	4.54234	4.36851	3.43475	2.63881	1.72203	0.46208	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	1.41275	2.05458	3.36852	3.87797	4.05985	3.91296	3.63015	2.75930	1.83593	0.49205	0	0	0	0
63	0	0	0	0	0	0	0	0	0	0	1.52389	2.23713	3.53920	4.06006	4.23254	4.05539	3.73869	2.84006	1.86376	0.49958	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0	1.72683	2.56954	3.58013	4.29750	4.58542	4.35316	3.71773	2.83942	1.89531	0.52335	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	1.72882	2.53891	3.79940	4.41242	4.60378	4.43806	4.06760	3.08173	2.06149	0.51379	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0	1.63772	2.40899	3.60518	3.96753	4.13363	4.02743	3.82018	2.91542	1.96038	0.53012	0	0	0	0
67	0	0	0	0	0	0	0	0	0	0	1.60444	2.34732	3.27162	3.16592	3.29976	3.20765	2.39156	1.85117	1.37129	0.51312	0	0	0	0

68	0	0	0	0	0	0	0	0	0	0	1.6 45491	2.4 02702	3.2 36875	3.8 44456	4.0 03057	3.8 7071	3.4 67059	2.6 49212	1.8 4801	0.5 43103	0	0	0	0
69	0	0	0	0	0	0	0	0	0	0	1.6 2724	2.3 71542	3.1 69682	3.6 43891	3.7 94045	3.6 64771	3.4 26055	2.6 23676	1.8 16531	0.5 50631	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	1.6 72344	2.4 51467	3.4 761	3.9 58092	4.1 37446	4.0 0577	3.4 62936	2.6 51696	1.8 59797	0.5 74399	0	0	0	0
71	0	0	0	0	0	0	0	0	0	0	1.7 69808	2.5 92279	4.0 45235	4.6 5003	4.8 62151	4.6 97639	4.3 3214	3.3 07805	2.2 28397	0.5 64843	0	0	0	0
72	0	0	0	0	0	0	0	0	0	0	1.6 92079	2.4 62359	3.4 86578	3.7 80067	3.9 53719	3.8 37328	3.8 0173	2.9 19294	2.0 1104	0.5 81158	0	0	0	0
73	0	0	0	0	0	0	0	0	0	0	1.6 58798	2.4 00793	3.6 31913	4.1 52326	4.3 5101	4.2 11846	3.9 07671	3.0 00081	1.9 84978	0.5 64172	0	0	0	0
74	0	0	0	0	0	0	0	0	0	0	1.6 99842	2.4 56063	3.7 19891	4.3 96789	4.5 95029	4.4 41881	4.1 41155	3.1 70479	2.1 46092	0.5 94149	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	1.6 81591	2.4 24903	3.6 11731	4.3 16882	4.5 02911	4.3 39887	4.0 40333	3.1 08089	2.1 14576	0.6 01676	0	0	0	0
76	0	0	0	0	0	0	0	0	0	0	1.7 26695	2.5 04827	3.7 14056	4.4 79942	4.6 82723	4.5 23029	4.1 72338	3.2 01989	2.1 76798	0.6 25444	0	0	0	0
77	0	0	0	0	0	0	0	0	0	0	1.8 24159	2.6 45639	4.0 67212	4.7 35396	4.9 38218	4.7 69282	4.2 37162	3.2 61781	2.2 58996	0.6 15888	0	0	0	0
78	0	0	0	0	0	0	0	0	0	0	1.7 4643	2.5 1572	3.7 35536	4.2 98273	4.5 04181	4.3 69645	4.1 68054	3.2 16089	2.2 11421	0.6 32203	0	0	0	0
79	0	0	0	0	0	0	0	0	0	0	1.7 13149	2.4 54153	3.2 84563	3.7 18893	3.8 81806	3.7 77978	3.0 16871	2.3 66692	1.7 14338	0.6 15218	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	1.7 54193	2.5 09423	3.7 03855	4.5 15539	4.7 02941	4.5 41414	3.9 60384	3.0 6255	2.1 38206	0.6 45194	0	0	0	0
81	0	0	0	0	0	0	0	0	0	0	1.7 35942	2.4 78263	3.3 85834	4.3 02583	4.4 89944	4.3 41389	3.7 69562	2.9 26216	2.0 67419	0.6 52722	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0	1.7 81046	2.5 58188	3.4 28209	4.2 80227	4.4 67403	4.3 32515	3.9 46358	3.0 63992	2.1 54972	0.6 7649	0	0	0	0
83	0	0	0	0	0	0	0	0	0	0	1.8 7851	2.6 99	4.2 12477	4.8 02238	5.0 05498	4.8 38075	4.5 18333	3.4 90219	2.4 25324	0.6 66934	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	1.8 00781	2.5 6908	3.7 58955	4.3 27775	4.5 32764	4.4 04186	4.1 94367	3.2 60969	2.2 69763	0.6 83249	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	1.7 675	2.5 07513	4.0 83707	4.2 67548	4.4 67289	4.3 32144	3.7 82965	2.9 78766	2.0 71941	0.6 66263	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	1.8 08544	2.5 62783	4.2 15185	4.5 213	4.7 13416	4.5 62429	4.1 68061	3.2 52044	2.2 89538	0.6 9624	0	0	0	0
87	0	0	0	0	0	0	0	0	0	0	1.7 90292	2.5 31623	4.1 19785	4.4 68759	4.6 56779	4.4 97674	4.1 94525	3.2 73158	2.2 92161	0.7 03767	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	1.8 35397	2.6 11548	3.9 43346	4.6 01533	4.8 09423	4.6 63692	4.2 22235	3.3 03252	2.3 25336	0.7 27536	0	0	0	0
89	0	0	0	0	0	0	0	0	0	0	1.9 32861	2.7 5236	4.2 0395	4.9 43958	5.1 51195	4.9 87404	4.6 07567	3.5 80189	2.5 14157	0.7 1798	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	1.8 55132	2.6 2244	4.2 06675	4.4 54767	4.6 62372	4.5 32325	4.3 45886	3.4 01173	2.4 03278	0.7 34295	0	0	0	0
91	0	0	0	0	0	0	0	0	0	0	1.8 21851	2.5 60874	3.6 42544	4.0 70017	4.2 42698	4.1 33826	3.3 12649	2.6 28642	1.9 80408	0.7 17309	0	0	0	0

92	0	0	0	0	0	0	0	0	0	0	1.862895	2.616144	3.954947	4.585658	4.770878	4.627144	4.180271	3.271977	2.363095	0.747285	0	0	0	0
93	0	0	0	0	0	0	0	0	0	0	1.844643	2.584984	3.754083	4.445846	4.625227	4.482017	4.083542	3.207717	2.318824	0.754813	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	1.889748	2.664908	3.686639	4.604909	4.804325	4.6686	4.179909	3.279786	2.381216	0.778581	0	0	0	0
95	0	0	0	0	0	0	0	0	0	0	1.987212	2.805722	4.330899	5.095168	5.311165	5.148727	4.799693	3.751201	2.648258	0.769025	0	0	0	0
96	0	0	0	0	0	0	0	0	0	0	1.909483	2.675801	4.0599	4.489433	4.690311	4.568394	4.422238	3.476424	2.492294	0.785334	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0	1.876202	2.614234	4.180404	4.409632	4.606712	4.483326	4.134677	3.270478	2.294713	0.768355	0	0	0	0
98	0	0	0	0	0	0	0	0	0	0	1.917245	2.695404	4.038966	4.800036	5.000378	4.853482	4.552867	3.574748	2.583835	0.798331	0	0	0	0
99	0	0	0	0	0	0	0	0	0	0	1.898994	2.638344	4.031256	4.693932	4.887158	4.735951	4.465707	3.519902	2.508966	0.805859	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	1.944099	2.718269	4.178921	4.833193	5.044063	4.900028	4.580824	3.605617	2.567376	0.829627	0	0	0	0
101	0	0	0	0	0	0	0	0	0	0	2.041563	2.859081	4.569765	5.215706	5.432327	5.269612	4.883184	3.798096	2.7310 9	0.820071	0	0	0	0
102	0	0	0	0	0	0	0	0	0	0	1.963833	2.729161	4.188833	4.702535	4.915709	4.789919	4.661502	3.679 39	2.636	0.836386	0	0	0	0
103	0	0	0	0	0	0	0	0	0	0	1.930553	2.667594	3.940917	4.391688	4.577943	4.467467	3.686439	2.963957	2.236721	0.8194	0	0	0	0
104	0	0	0	0	0	0	0	0	0	0	1.971596	2.722864	4.190971	4.932001	5.132622	4.983922	4.449707	3.560435	2.596794	0.849377	0	0	0	0
105	0	0	0	0	0	0	0	0	0	0	1.953345	2.691704	3.986288	4.787675	4.983392	4.837332	4.378077	3.476183	2.552434	0.856904	0	0	0	0
106	0	0	0	0	0	0	0	0	0	0	1.98445	2.771629	4.076122	4.878185	5.085024	4.949085	4.501063	3.573778	2.618581	0.880672	0	0	0	0
107	0	0	0	0	0	0	0	0	0	0	2.095914	2.912441	4.662688	5.327494	5.546243	5.384654	5.052287	3.983436	2.867674	0.871116	0	0	0	0
108	0	0	0	0	0	0	0	0	0	0	2.018184	2.782521	4.268074	4.8078	5.023066	4.899981	4.723878	3.751092	2.723044	0.874331	0	0	0	0
109	0	0	0	0	0	0	0	0	0	0	1.984904	2.720955	4.283422	4.625364	4.826807	4.707153	4.219939	3.391339	2.470681	0.870446	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	2.025947	2.776225	4.482305	5.035982	5.240001	5.093771	4.711902	3.747595	2.737002	0.900422	0	0	0	0
111	0	0	0	0	0	0	0	0	0	0	2.007696	2.745065	4.324322	4.930606	5.130099	4.981009	4.683813	3.730892	2.717481	0.90795	0	0	0	0
112	0	0	0	0	0	0	0	0	0	0	2.052801	2.824989	4.274751	5.051746	5.267549	5.128922	4.748012	3.784466	2.766263	0.931718	0	0	0	0
113	0	0	0	0	0	0	0	0	0	0	2.150265	2.965801	4.717692	5.454327	5.676167	5.516372	5.145952	4.077593	2.965565	0.922162	0	0	0	0
114	0	0	0	0	0	0	0	0	0	0	2.072535	2.835882	4.503452	4.938918	5.157961	5.034386	4.884355	3.895665	2.849097	0.938477	0	0	0	0
115	0	0	0	0	0	0	0	0	0	0	2.039255	2.774315	4.235527	4.669672	4.864412	4.753504	4.021676	3.253618	2.488464	0.921491	0	0	0	0

116	0	0	0	0	0	0	0	0	0	0	2.080298	2.829585	4.484741	5.142535	5.346288	5.203207	4.782157	3.815748	2.829923	0.951468	0	0	0	0
117	0	0	0	0	0	0	0	0	0	0	2.062047	2.798425	4.296143	5.01694	5.215317	5.071711	4.679733	3.747488	2.789359	0.958995	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	2.107152	2.8783	4.262437	5.144958	5.360194	5.252579	4.7884	3.829634	2.851933	0.982763	0	0	0	0
119	0	0	0	0	0	0	0	0	0	0	2.204616	3.019162	4.839498	5.585153	5.811803	5.653278	5.312043	4.272285	3.088157	0.973207	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	2.126886	2.889242	4.562029	5.039438	5.258327	5.138149	4.991659	3.960 2	2.950598	0.989522	0	0	0	0
121	0	0	0	0	0	0	0	0	0	0	2.093606	2.827675	4.566517	4.848418	5.0532	4.938529	4.505477	3.645104	2.685923	0.972537	0	0	0	0
122	0	0	0	0	0	0	0	0	0	0	2.134649	2.882945	4.637826	5.285874	5.496069	5.353408	5.023286	4.022456	2.965341	1.002513	0	0	0	0
123	0	0	0	0	0	0	0	0	0	0	2.116398	2.851785	4.548204	5.169592	5.374302	5.229447	4.945195	3.972093	2.935646	1.010041	0	0	0	0
124	0	0	0	0	0	0	0	0	0	0	2.161502	2.9317 1	4.545608	5.296587	5.551799	5.381843	5.048586	4.045147	2.992683	1.033809	0	0	0	0
125	0	0	0	0	0	0	0	0	0	0	2.258966	3.072522	4.959529	5.710126	5.939544	5.781822	5.399842	4.315233	3.188983	1.024253	0	0	0	0
Actual(110)	0	0	0	0	0	0	0	0	0.55	1.3	2.14	2.98	3.6	5.12	5.15	4.94	4.48	3.53	2.37	1.03	0.19	0	0	0
110	0	0	0	0	0	0	0	0	0	0	2.025947	2.776225	4.482305	5.035982	5.240001	5.093771	4.711902	3.747595	2.737002	0.900422	0	0	0	0

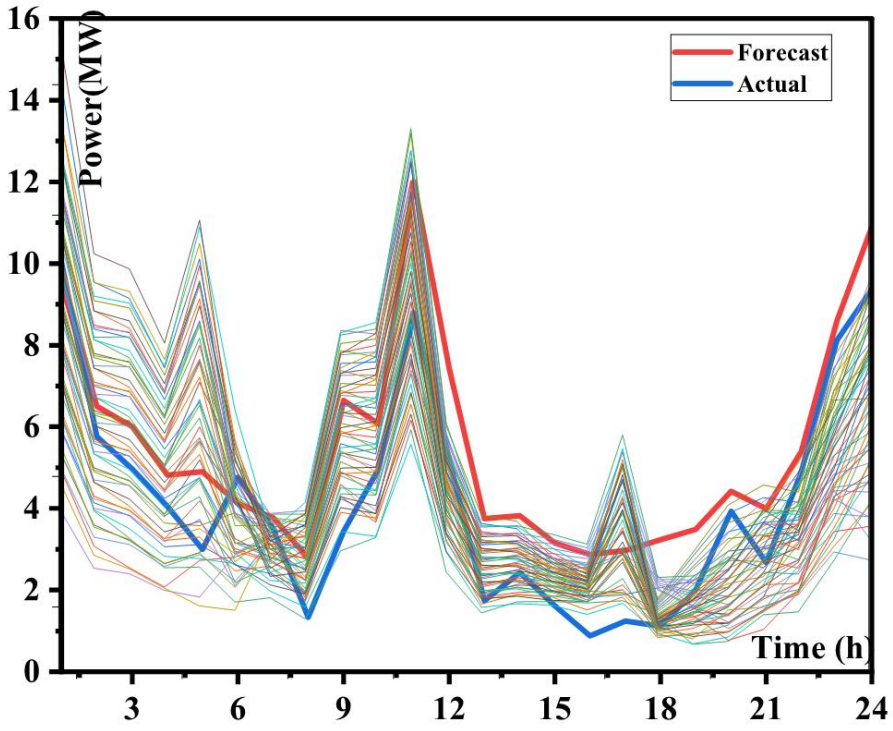

Fig2: Forecasted wind output power Scenarios

Day	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h	24h
31	1.04	0.09	0.15	0.24	0.88	0.73	0.68	0.38	1.22	1.23	2.22	0.49	0.94	0.80	0.91	1.50	2.11	1.31	0.51	0.21	0.92	2.20	7.03	6.69
32	3.97	2.48	1.97	1.52	0.81	1.65	1.34	1.00	2.38	2.46	5.10	3.51	1.55	1.91	2.04	2.11	3.08	1.15	1.74	1.63	1.66	4.46	7.08	8.45
33	6.92	4.41	3.70	2.68	2.46	1.01	1.61	1.52	3.55	4.28	8.18	3.13	3.16	3.19	2.35	2.94	3.73	3.25	2.38	2.08	2.31	5.47	10.54	11.39
34	11.35	5.95	4.71	3.24	2.15	2.73	3.26	1.83	5.13	3.63	5.84	4.17	1.37	2.01	2.31	1.75	0.68	1.37	0.87	1.20	1.14	1.56	4.09	2.41
35	4.07	2.53	2.11	1.57	1.53	1.80	3.56	1.54	4.52	3.64	7.34	4.94	1.97	2.53	3.17	2.85	3.20	2.77	3.00	1.48	1.54	1.92	5.76	4.80
36	7.23	3.65	2.90	2.32	1.67	0.63	3.45	2.36	6.10	5.57	9.34	4.97	2.21	2.10	2.03	1.58	1.94	1.45	1.44	0.67	0.34	1.33	2.81	3.13
37	2.92	2.31	1.67	1.05	0.74	1.42	0.46	0.28	0.78	0.30	1.04	1.54	1.47	1.88	1.94	1.79	2.11	1.78	1.85	1.75	1.98	4.12	6.74	4.60
38	7.94	4.83	4.01	3.27	4.29	4.41	4.94	2.97	6.76	5.75	9.66	5.27	2.87	3.05	3.13	2.70	3.36	1.95	2.17	1.23	1.65	3.06	5.39	5.58
39	9.51	6.50	6.00	4.81	4.90	4.12	3.77	2.78	6.65	6.06	12.00	7.42	3.75	3.82	3.15	2.87	2.97	3.23	3.49	4.42	4.00	5.40	8.58	10.91
40	11.58	6.18	5.13	4.01	4.03	2.69	2.86	2.05	4.65	5.17	9.29	3.83	2.28	2.70	2.71	2.66	2.75	2.22	1.08	1.19	2.20	2.32	4.29	6.44
41	6.31	4.00	3.78	3.14	2.89	4.50	5.17	2.84	7.20	6.20	11.57	6.88	2.98	3.37	3.84	4.03	4.53	3.71	2.49	1.69	2.31	3.46	6.96	5.16
42	7.39	4.49	3.96	3.23	2.55	2.37	5.28	2.89	7.19	5.83	10.64	6.00	2.81	2.96	2.93	2.94	3.04	1.63	1.29	2.39	2.49	3.03	7.14	8.53
43	10.06	6.22	5.51	4.45	4.36	4.16	3.12	2.51	5.39	5.20	8.74	4.60	2.49	2.63	2.57	2.22	2.64	1.49	1.09	1.36	2.36	4.09	5.34	7.37
44	8.56	5.65	5.05	4.16	4.59	6.81	3.82	3.06	6.73	6.37	10.72	5.27	3.04	3.34	3.31	2.92	3.17	1.75	1.37	1.54	2.39	3.13	6.74	7.58
45	11.44	7.68	7.14	5.72	5.62	6.12	4.58	3.52	8.07	7.46	13.67	7.29	4.08	4.10	3.33	3.12	3.06	2.40	3.50	4.29	4.25	5.64	10.43	10.48
46	12.95	7.28	6.36	5.06	5.18	3.89	4.07	2.72	6.13	5.91	10.27	5.07	2.62	2.98	2.89	2.39	2.89	1.32	1.50	1.57	2.33	3.09	4.82	6.37
47	7.99	5.19	4.89	4.06	4.51	3.50	4.97	3.08	7.52	6.98	12.70	7.13	3.31	3.65	4.02	3.83	4.51	3.16	2.58	1.93	2.54	2.97	4.61	4.31
48	8.86	5.57	5.09	4.17	4.59	3.26	4.91	3.21	7.69	6.79	11.84	6.39	3.13	3.25	3.12	3.16	4.58	1.90	2.22	2.87	3.26	4.90	9.77	11.99
49	11.33	7.28	6.64	5.38	5.79	4.12	3.35	3.01	6.31	6.08	9.88	4.63	2.82	2.91	2.75	2.71	4.22	1.62	1.82	1.88	2.88	5.62	9.23	12.19
50	10.07	6.75	6.19	5.11	6.57	4.74	4.30	3.54	7.65	7.23	11.88	5.82	3.36	3.62	3.49	3.03	4.58	1.73	1.94	1.90	2.80	3.41	6.58	7.26
51	12.90	8.77	8.28	6.66	7.46	4.96	4.72	3.91	8.76	8.35	14.83	7.65	4.41	4.38	3.51	3.22	4.57	2.50	3.65	4.65	4.80	5.26	9.78	11.49
52	14.40	8.38	7.50	6.00	6.72	3.44	4.06	3.12	6.83	6.80	11.43	5.52	2.94	3.27	3.07	2.69	3.60	1.40	1.44	1.81	2.90	3.17	5.09	7.99
53	9.47	6.28	6.03	5.00	5.87	3.32	5.10	3.52	8.32	7.86	13.86	7.38	3.63	3.93	4.20	4.10	5.34	3.22	2.45	2.16	3.08	3.88	6.64	5.95
54	10.29	6.65	6.22	5.12	5.51	4.54	5.15	3.65	8.50	7.68	13.00	6.78	3.45	3.53	3.30	3.27	4.53	1.97	2.80	3.40	3.66	5.02	8.80	10.67
55	12.78	8.37	7.78	6.33	7.43	4.57	3.53	3.43	7.06	6.97	11.04	4.97	3.14	3.20	2.94	2.72	4.34	1.70	1.94	2.20	3.34	6.18	7.48	10.33
56	11.54	7.84	7.33	6.05	8.13	5.12	4.41	3.96	8.40	8.11	13.04	6.23	3.69	3.90	3.68	3.18	4.78	1.80	2.32	2.24	3.30	4.22	7.23	8.53
57	14.35	9.87	9.41	7.60	8.98	6.10	4.86	4.33	9.53	9.24	15.99	7.98	4.73	4.66	3.69	3.37	4.53	2.57	3.94	5.12	5.26	5.63	10.78	11.78

58	15.86	9.47	8.63	6.94	8.35	4.64	4.24	3.54	7.60	7.68	12.59	5.89	3.26	3.55	3.25	2.77	4.37	1.47	1.69	2.20	3.35	3.41	5.53	7.94
59	10.92	7.37	7.16	5.95	7.48	4.56	5.27	3.94	9.08	8.74	15.02	7.73	3.95	4.21	4.38	4.19	6.07	3.29	2.93	2.61	3.54	4.30	6.08	5.96
60	11.75	7.75	7.36	6.06	7.36	4.23	5.30	4.07	9.26	8.56	14.16	7.16	3.78	3.81	3.48	3.42	5.38	2.04	2.23	3.58	4.16	5.30	9.93	12.41
61	14.24	9.46	8.91	7.27	8.85	6.73	3.67	3.85	7.83	7.85	12.20	5.33	3.46	3.48	3.12	2.91	5.00	1.76	1.87	2.51	3.82	6.21	9.06	12.37
62	12.99	8.93	8.46	7.00	9.40	6.52	4.57	4.38	9.17	9.00	14.20	6.60	4.01	4.18	3.86	3.32	5.44	1.87	2.12	2.58	3.77	4.30	7.47	8.72
63	15.81	10.96	10.55	8.55	10.34	6.45	5.02	4.76	10.30	10.12	17.15	8.34	5.05	4.95	3.87	3.51	5.39	2.64	4.04	5.37	5.74	5.83	10.80	12.56
64	17.31	10.57	9.77	7.89	9.73	4.97	4.39	3.97	8.37	8.56	13.75	6.26	3.59	3.83	3.43	2.93	4.79	1.54	1.94	2.54	3.83	3.76	5.87	8.91
65	12.38	8.47	8.30	6.89	8.96	6.11	5.43	4.36	9.85	9.62	16.18	8.09	4.27	4.49	4.56	4.35	6.47	3.36	3.02	2.91	4.02	4.92	6.96	6.90
66	13.20	8.84	8.49	7.01	8.79	4.92	5.46	4.50	10.03	9.44	15.32	7.53	4.10	4.09	3.66	3.56	6.10	2.11	2.82	3.97	4.63	5.70	9.90	12.32
67	15.69	10.55	10.05	8.21	10.39	6.60	3.83	4.28	8.60	8.73	13.36	5.69	3.78	3.76	3.30	3.03	5.84	1.83	2.29	2.88	4.30	6.52	8.79	12.10
68	14.44	10.03	9.60	7.94	11.11	8.21	4.73	4.81	9.93	9.88	15.36	6.96	4.33	4.46	4.04	3.46	6.24	1.94	2.50	2.92	4.25	4.77	7.91	9.55
69	17.26	12.05	11.69	9.49	11.98	7.85	5.18	5.18	11.06	11.00	18.31	8.70	5.37	5.23	4.05	3.65	6.10	2.71	4.23	5.73	6.22	6.17	11.37	13.04
70	18.77	11.66	10.91	8.83	11.31	5.93	4.55	4.39	9.13	9.44	14.91	6.62	3.91	4.11	3.61	3.06	5.55	1.61	2.02	2.87	4.31	3.99	6.27	9.28
71	13.83	9.56	9.43	7.84	10.45	5.97	5.58	4.79	10.61	10.50	17.34	8.45	4.60	4.77	4.74	4.49	7.27	3.43	3.11	3.25	4.50	5.13	7.07	7.28
72	14.66	9.93	9.63	7.95	10.23	5.62	5.61	4.92	10.79	10.32	16.48	7.89	4.42	4.37	3.84	3.70	6.50	2.18	3.06	4.33	5.11	6.44	10.49	13.32
73	17.15	11.65	11.18	9.16	11.91	6.78	3.99	4.70	9.36	9.61	14.52	6.05	4.11	4.04	3.48	3.18	6.21	1.90	2.40	3.21	4.78	7.09	9.50	13.21
74	15.90	11.12	10.73	8.88	12.52	7.49	4.88	5.23	10.70	10.76	16.52	7.32	4.65	4.74	4.22	3.60	6.65	2.00	2.72	3.27	4.72	5.08	8.26	10.00
75	18.72	13.14	12.82	10.44	13.43	7.57	5.33	5.61	11.83	11.88	19.47	9.06	5.70	5.51	4.23	3.79	6.50	2.78	4.44	6.09	6.69	6.50	11.64	13.70
76	20.22	12.75	12.04	9.78	12.80	5.99	4.71	4.82	9.90	10.32	16.07	6.99	4.23	4.39	3.79	3.21	6.13	1.68	2.24	3.22	4.79	4.31	6.64	10.01
77	15.29	10.65	10.57	8.78	11.98	6.07	5.74	5.21	11.38	11.38	18.50	8.81	4.92	5.06	4.92	4.63	7.82	3.50	3.41	3.61	4.98	5.69	7.58	8.00
78	16.11	11.03	10.76	8.89	11.83	6.60	5.77	5.35	11.56	11.20	17.64	8.25	4.74	4.65	4.02	3.84	7.31	2.25	2.97	4.65	5.59	6.57	10.76	13.67
79	18.60	12.74	12.32	10.10	13.39	7.19	4.14	5.13	10.13	10.49	15.68	6.41	4.43	4.32	3.66	3.32	6.98	1.97	2.50	3.55	5.25	7.21	9.71	13.49
80	17.35	12.21	11.87	9.83	14.04	7.83	5.04	5.65	11.47	11.64	17.67	7.68	4.98	5.02	4.40	3.74	7.40	2.07	2.75	3.61	5.20	5.38	8.65	10.68
81	20.17	14.24	13.96	11.38	14.94	8.41	5.49	6.03	12.60	12.76	20.63	9.42	6.02	5.79	4.41	3.93	7.31	2.85	4.59	6.42	7.17	6.90	12.07	14.25
82	21.68	13.85	13.18	10.72	14.30	6.88	4.86	5.24	10.67	11.21	17.23	7.35	4.55	4.67	3.98	3.35	6.72	1.75	2.44	3.56	5.26	4.70	7.02	10.52
83	16.74	11.74	11.70	9.72	13.48	6.92	5.89	5.64	12.15	12.27	19.66	9.17	5.24	5.34	5.10	4.77	8.43	3.57	3.54	3.94	5.45	5.95	7.89	8.52
84	17.57	12.12	11.90	9.84	13.28	6.73	5.93	5.77	12.32	12.08	18.80	8.61	5.07	4.93	4.20	3.98	7.85	2.32	3.34	5.00	6.06	7.13	11.19	14.41
85	20.06	13.83	13.45	11.05	14.92	8.61	4.30	5.55	10.90	11.37	16.84	6.78	4.75	4.60	3.84	3.46	7.57	2.04	2.78	3.90	5.73	7.66	10.17	14.27

86	18.81	13.31	13.00	10.77	15.58	8.78	5.20	6.08	12.23	12.52	18.83	8.05	5.30	5.31	4.58	3.88	8.00	2.14	3.03	3.95	5.68	5.68	9.02	11.22
87	21.63	15.33	15.09	12.32	16.47	8.85	5.65	6.45	13.36	13.65	21.79	9.79	6.34	6.07	4.59	4.07	7.85	2.92	4.77	6.76	7.65	7.21	12.42	14.87
88	23.13	14.94	14.31	11.66	15.83	7.33	5.02	5.66	11.43	12.09	18.39	7.71	4.88	4.96	4.16	3.49	7.39	1.82	2.58	3.90	5.74	5.05	7.39	11.16
89	18.20	12.84	12.84	10.67	14.99	8.06	6.05	6.06	12.91	13.15	20.82	9.54	5.56	5.62	5.28	4.91	9.10	3.63	3.69	4.28	5.93	6.36	8.30	9.16
90	19.02	13.21	13.04	10.78	14.81	7.33	6.08	6.19	13.09	12.97	19.96	8.98	5.39	5.22	4.38	4.12	8.46	2.39	3.50	5.34	6.54	7.48	11.54	14.91
91	21.51	14.93	14.59	11.99	16.42	8.90	4.46	5.97	11.66	12.26	18.00	7.14	5.07	4.88	4.02	3.60	8.15	2.11	2.92	4.24	6.21	8.04	10.50	14.75
92	20.26	14.40	14.14	11.71	17.06	10.03	5.35	6.50	13.00	13.40	19.99	8.41	5.62	5.59	4.76	4.03	8.58	2.21	3.20	4.29	6.16	6.04	9.40	11.84
93	23.08	16.42	16.23	13.27	17.96	9.89	5.80	6.88	14.13	14.53	22.95	10.15	6.66	6.35	4.78	4.21	8.46	2.98	4.96	7.11	8.13	7.58	12.81	15.45
94	24.59	16.03	15.45	12.61	17.32	8.13	5.18	6.09	12.20	12.97	19.55	8.07	5.20	5.24	4.34	3.63	7.98	1.89	2.78	4.25	6.22	5.43	7.77	11.72
Average	13.94	9.27	8.81	7.19	9.13	5.57	4.52	4.13	8.90	8.77	14.23	6.75	3.96	4.05	3.64	3.33	5.44	2.23	2.63	3.24	4.17	5.01	8.18	9.92
Forecast	9.51	6.50	6.00	4.81	4.90	4.12	3.77	2.78	6.65	6.06	12.00	7.42	3.75	3.82	3.15	2.87	2.97	3.23	3.49	4.42	4.00	5.40	8.58	10.91
Actual	10	5.76	4.96	4.05	3	4.76	3.51	1.33	3.44	2.97	5.79	2.2	0.74	0.43	0.61	0.88	1.24	1.11	1	0.93	0.67	0.89	1.11	1.37

Forecasted Scenarios are reduced to five scenarios using the k-means clustering algorithm

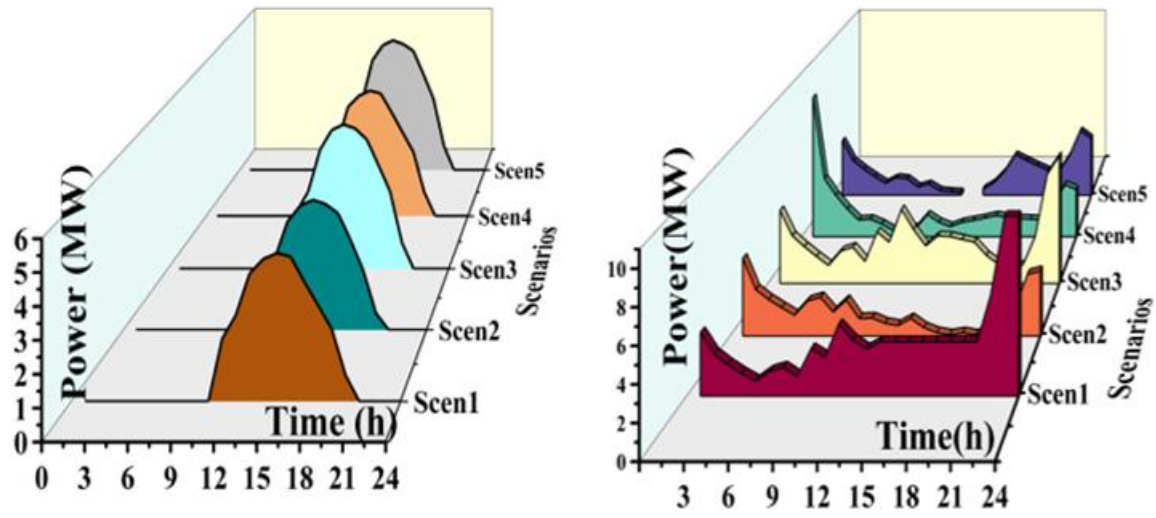

Fig3: Reduced Scenarios of solar and wind output power

Table of wind reduced Scenarios

Time	Scen1	Scen2	Scen3	Scen4	Scen5
1h	3.53	4.61	4.62	9.34	3.86
2h	2.34	2.76	3.01	3.9	2.45

Table of solar reduced Scenarios

Scen	1	2	3	4	5
1h	0	0	0	0	0
2h	0	0	0	0	0

3h	1.75	2.17	2.32	2.78	1.84	**3h**	0	0	0	0	0
4h	1.25	1.69	1.7	1.86	1.31	**4h**	0	0	0	0	0
5h	0.82	1.23	1.13	1.12	0.84	**5h**	0	0	0	0	0
6h	1.37	2.08	2.03	1.18	1.25	**6h**	0	0	0	0	0
7h	1.59	2.3	2.29	0.86	1.16	**7h**	0	0	0	0	0
8h	1.09	1.42	1.38	0.43	0.58	**8h**	0	0	0	0	0
9h	2.63	2.14	3.25	0.72	0.79	**9h**	0	0	0	0	0
10h	2.15	1.04	2.6	0.58	0.32	**10h**	0	0	0	0	0
11h	3.98	1.08	4.68	1.48	0.24	**11h**	1.93	1.7	2.06	2.03	2.11
12h	3.13	0.76	3.4	0.97	0.2	**12h**	2.66	2.4	2.79	2.77	2.85
13h	2.6	0.63	2.37	0.67	0..2	**13h**	3.94	3.6	4.29	4.23	4.54
14h	3	1.04	3	0.95	0.43	**14h**	4.39	4.2	5.01	4.66	5.16
15h	3	0.5	2.96	1.09	0.88	**15h**	4.57	4.4	5.21	4.86	5.37
16h	3	0.2	2.78	1.24	1.68	**16h**	4.46	4.2	5.07	4.75	5.22
17h	3	0.07	2.61	1.42	2.88	**17h**	3.68	3.9	4.67	4.02	4.94
18h	3	0.2	1.76	1.29	2.47	**18h**	2.96	3	3.74	3.25	3.97
19h	3	0.06	1.19	1.21	2.1	**19h**	2.23	2	2.78	2.48	2.93
20h	3	0.45	0.84	1.18	1.76	**20h**	0.81	0.6	0.95	0.92	1.01
21h	3	0.62	1.16	1.13	1.62	**21h**	0	0	0	0	0
22h	5.66	1.56	2.95	2.04	2.82	**22h**	0	0	0	0	0
23h	10	3.66	6.89	3.48	4.58	**23h**	0	0	0	0	0
24h	10	3.86	8.07	3.17	4.01	**24h**	0	0	0	0	0

For the Reduced scenarios a mathematical market modelling is performed in GAMS software which is a bi-level formulation where aggregators submit their energy bids to an operator and the operator then clears the market and generates price signals. To assess risk incurred in this modelling risk assessment is done using VaR, CVaR method,

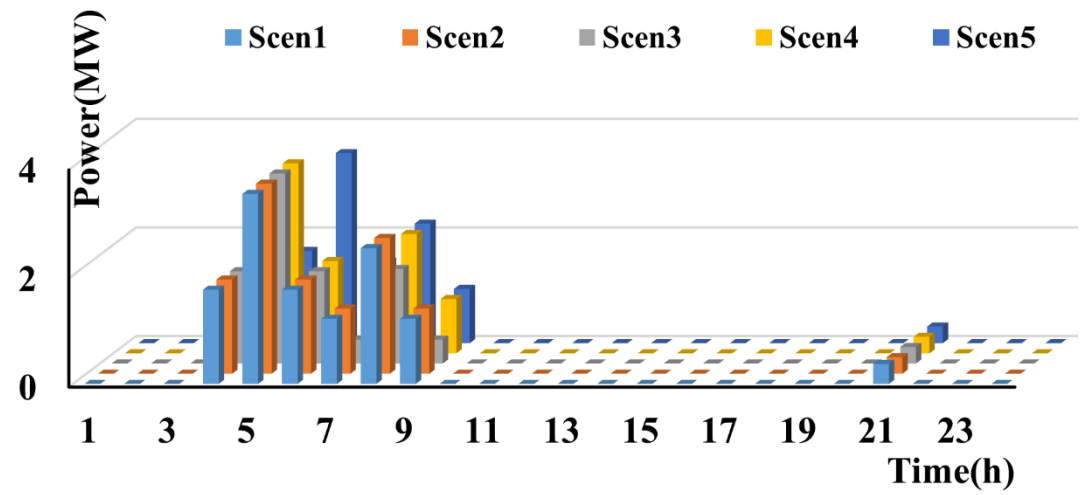

Fig 4: Diesel Generator Production of A1

Table of Diesel Generator Production of A1

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Scen 1	0	0	0	1.735	3.5	1.735	1.2	2.5	1.2	0	0	0	0	0	0	0	0	0	0	0	0.368	0	0	0
Scen 2	0	0	0	1.735	3.5	1.735	1.2	2.5	1.2	0	0	0	0	0	0	0	0	0	0	0	0.305	0	0	0
Scen 3	0	0	0	1.7	3.5	1.7	0.44	1.74	0.44	0	0	0	0	0	0	0	0	0	0	0	0.304	0	0	0
Scen 4	0	0	0	1.7	3.5	1.7	1.5	2.2	1	0	0	0	0	0	0	0	0	0	0	0	0.305	0	0	0
Scen 5	0	0	0	0	1.7	3.5	1.5	2.2	1	0	0	0	0	0	0	0	0	0	0	0	0.305	0	0	0

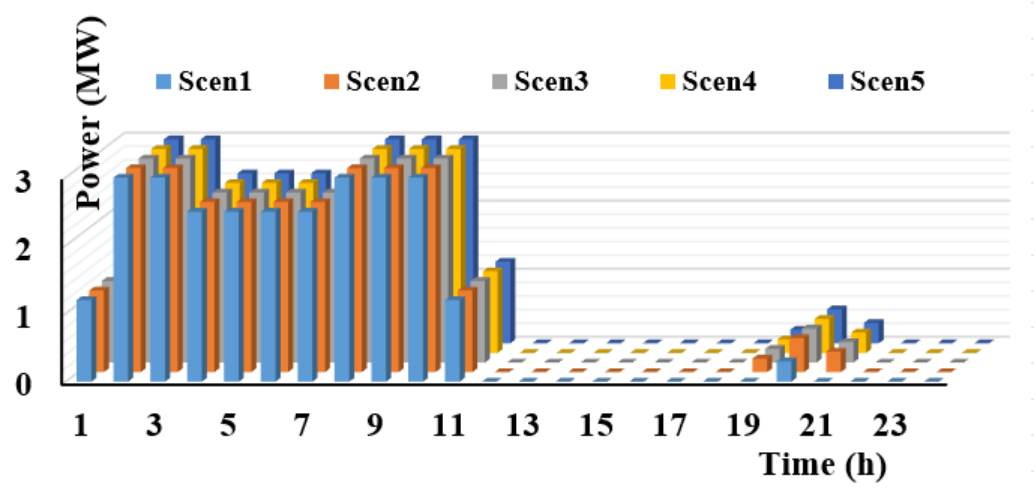

Fig 5: Diesel Generator Production of A2

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Scen 1	1.2	3	3	2.5	2.5	2.5	2.5	3	3	3	1.2	0	0	0	0	0	0	0	0	0.3	0	0	0	0
Scen 2	1.2	3	3	2.5	2.5	2.5	2.5	3	3	3	1.2	0	0	0	0	0	0	0	0.2	0.5	0.3	0	0	0
Scen 3	1.2	3	3	2.5	2.5	2.5	2.5	3	3	3	1.2	0	0	0	0	0	0	0	0.2	0.5	0.3	0	0	0
Scen 4	1.2	3	3	2.5	2.5	2.5	2.5	3	3	3	1.2	0	0	0	0	0	0	0	0.2	0.5	0.3	0	0	0
Scen 5	1.2	3	3	2.5	2.5	2.5	2.5	3	3	3	1.2	0	0	0	0	0	0	0	0.2	0.5	0.3	0	0	0

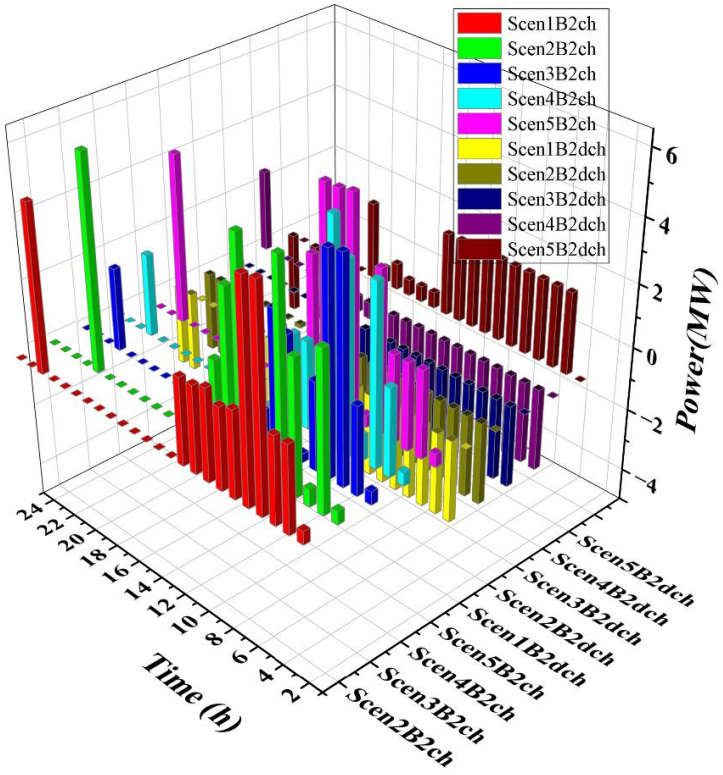

Fig 6: Battery2 of A2 Charging discharging levels

Time	Scen1BS2ch	Scen2BS2ch	Scen3BS2ch	Scen4BS2ch	Scen5BS2ch	Scen1BS2dch	Scen2BS2dch	Scen3BS2dch	Scen4BS2dch	Scen5BS2dch
1	0.388	0.388	0.388	0.388	0.388	0	0	0	0	0
2	2.583	4.656	2.583	2.583	2.583	-2.5	-2.5	-2.5	-2.5	2.5
3	2.583	0.51	6.5	5.327	2.583	-2.5	-2.5	-2.5	-2.5	2.5
4	6.5	3.976	6.42	0.745	2.583	-2.5	-2.5	-2.5	-2.5	2.5
5	6.42	6.5	2.583	5.513	4.81	-2.5	-2.5	-2.5	-2.5	2.5
6	2.583	0.897	0.258	6.5	0.356	-2.5	-2.5	-2.5	-2.5	2.5
7	2.432	0.5	3.476	2.583	6.5	-2.5	-2.5	-2.5	-2.5	2.5
8	2.733	6.5	4.014	2.583	6.42	-2.5	-2.5	-2.5	-2.5	2.5
9	2.583	4.878	0.85	2.583	6.42	-2.5	-2.5	-2.5	-2.5	2.5
10	2.583	2.583	4.315	2.583	4.233	-2.5	-2.5	-2.5	-2.5	2.5
11	0	0	0	0	0	-2.5	-2.5	-2.5	-1.583	2.5
12	0	0	0	0	0	0	-2.5	-1.852	-2.5	0.485
13	0	0	0	0	0	0	-2.205	-2.5	-1.962	0.485
14	0	0	0	0	0	-2.5	-0.12	-0.238	-0.507	0.485
15	0	0	0	0	0	0	-0.12	-0.238	-0.507	0.802
16	0	0	0	0	0	-2.5	-0.12	-0.238	-0.507	0.485
17	0	0	0	0	0	-0.085	-0.02	-0.02	0	2.343
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	-0.039	-0.039	-0.039	-0.039	-0.039
20	0	6.5	0	0	0	-0.02	0	-0.02	0	0
21	0	0	2.521	2.501	5.104	0	0	0	0	0

22	5.125	0	0	0	0	0	0	0	0	-2.5
23	0	0	0	0	0	-2.5	-2.5	0	0	0
24	0	0	0	0	0	-2.5	-2.5	-2.5	2.5	-2.5

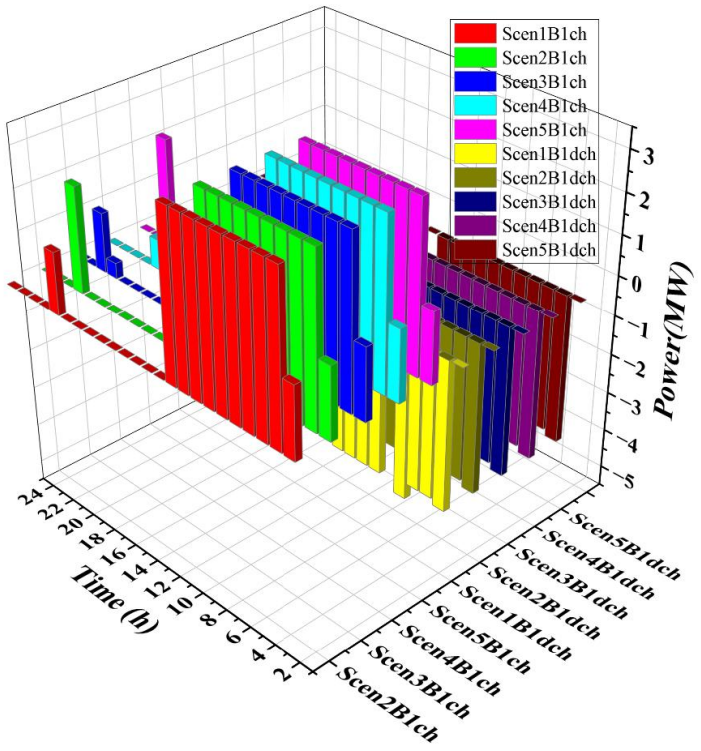

Fig 7: Battery1 of A2 Charging and discharging levels

Time	Scen1B1ch	Scen2B1ch	Scen3B1ch	Scen4B1ch	Scen5B1ch	Scen1B1dch	Scen2B1dch	Scen3B1dch	Scen4B1dch	Scen5B1dch
1	1.684	1.684	1.684	1.684	1.684	0	0	0	0	0
2	4	4	4	4	4	-3.724	-3.724	-3.724	-3.724	-3.724
3	4	4	4	4	4	-3.583	-3.583	-3.583	-3.583	-3.583
4	4	4	4	4	4	-3.589	-3.589	-3.589	-3.589	-3.589
5	4	4	4	4	4	-4	-4	-4	-4	-4
6	4	4	4	4	4	-1.372	-1.372	-1.768	-2.812	-3.603
7	4	4	4	4	4	-3.724	-3.724	-3.724	-4	-1.493
8	4	4	4	4	4	-3.724	-3.724	-3.724	-2.008	-3.724
9	4	4	4	4	4	-3.724	-3.724	-3.724	-3.724	-3.724
10	4	4	4	4	4	-3.724	-3.724	-3.724	-3.724	-3.724
11	0	0	0	0	0	0	-2.352	0	0	-2.352
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	-2.352	0	-2.352	-2.352	0
18	0	0	0	0	0	0	0	0	0	0

19	0	0	0	0.865	0	0	0	0	0	0
20	1.499	0	0	0.719	0	0	0	0	0	0
21	0	2.526	0.373	0	0	0	0	0	0	0
22	0	0	1.422	0	2.526	0	-2.352	0	-1.475	0
23	0	0	0	0	0	-1.395	0	0	0	0
24	0	0	0	0	0	0	0	-1.672	0	-2.352

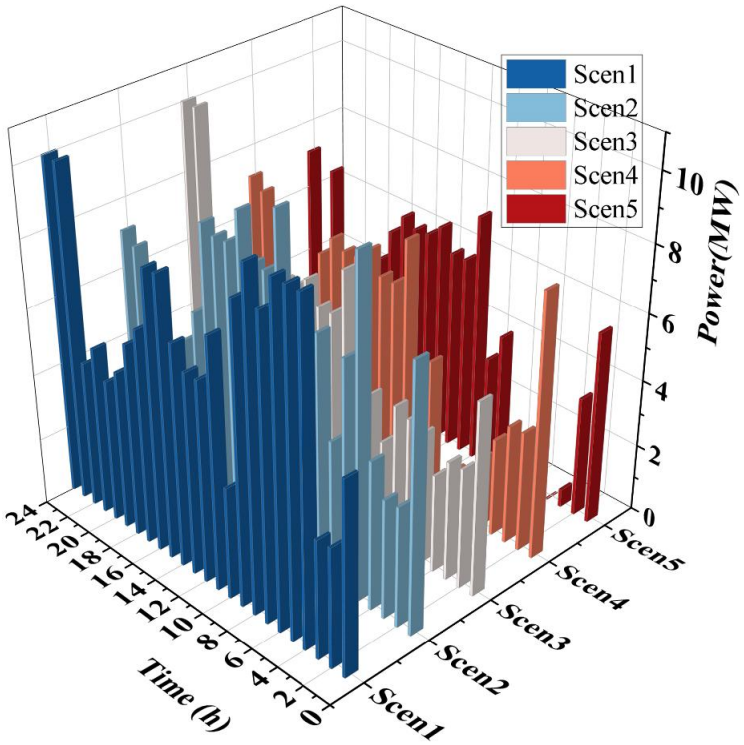

Fig 8: Total Production of A1

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Sc	5.	3.	3.				8.		8.	3.		6.	6.	6.	8.	8.	6.	5.	4.		5.	4.		
en	79	6	58				96		87	35	7.	03	02	64	38	34	42	79	7	4.	04	39	1	1
1	8	2	4	10	10	10	4	10	2	8	48	3	9	2	6	8	3	4	6	27	6	4	0	0
Sc	7.	3.	3.	4.		6.	4.		4.	3.		8.	8.	9.	8.	8.	8.	5.	4.		3.	4.	6.	7.
en	92	6	58	46		92	34	7.	25	35		15	15	42	38	34	54	79	7	4.	47	39	7	0
2	4	2	4	5	10	2	4	2	2	8	10	9	5	4	6	8	9	4	6	27	4	4	9	8
Sc	5.	3.	3.	2.		4.	4.		4.	3.		6.	6.	6.		6.	6.	5.	4.		3.	4.		
en	79	6	58	94	3.	17	34	3.	25	35	7.	03	02	64	6.	22	42	79	7	4.	47	39	1	1
3	8	2	4	8	98	6	4	04	2	8	48	3	9	2	26	2	3	4	6	27	4	4	0	0
Sc	7.	3.	3.	2.		1.	1.		4.	3.		6.	6.	6.		6.	6.	5.	4.		0.	4.	6.	7.
en	92	6	58	94	2.	13	30		25	35	7.	03	02	64	6.	22	42	79	7	1.	43	39	7	0
4	4	2	4	8	16	6	4	0	2	8	48	3	9	2	26	2	3	4	6	23	4	4	9	8
Sc	5.	3.	0.		1.	1.		4.	3.		6.	6.	6.			6.	5.		1.	0.	4.			7.
en	79	6	54		13	30		25	35	7.	03	02	64	6.	6.	42	79	4.	2	43	39	6.		0
5	8	2	4	0	6	4	1	2	8	48	3	9	2	26	22	3	4	76	3	4	4	79		8

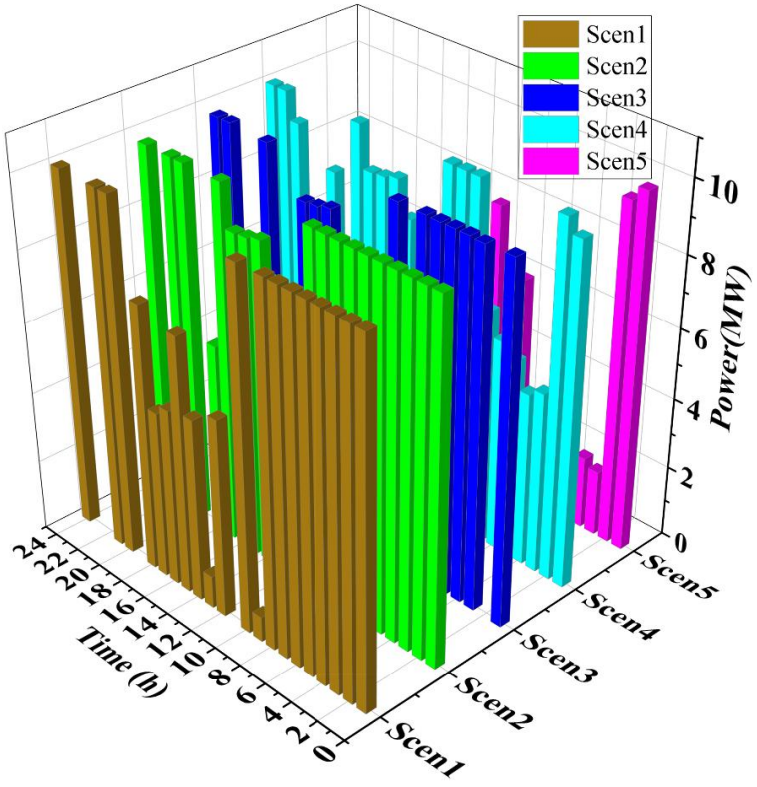

Fig9: Total Production of A2

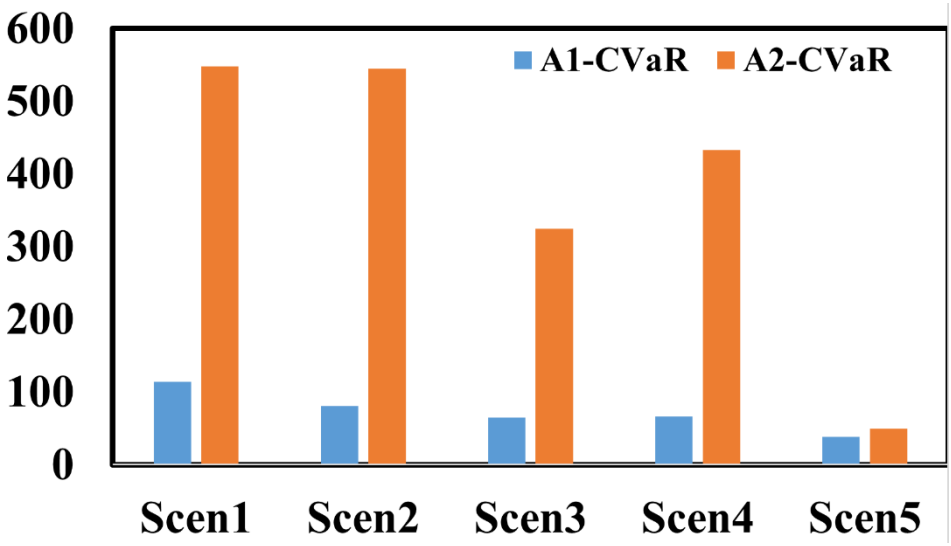

Fig 10: Comparison of CVaR of A1 and A2

Table of VaR and CVaR

	A1-VaR(95%)	AG2-VaR(95%)		A1-CVaR	A2-CVaR
Scen1	32.25	0	Scen1	114.28	548.24
Scen2	31.25	0	Scen2	80.65	544.9
Scen3	28.43	-7.08	Scen3	64.55	324.57

Scen4	26.45	-12.5	**Scen4**	65.93	432.77
Scen5	6.87	-61.54	**Scen5**	38.48	49.92

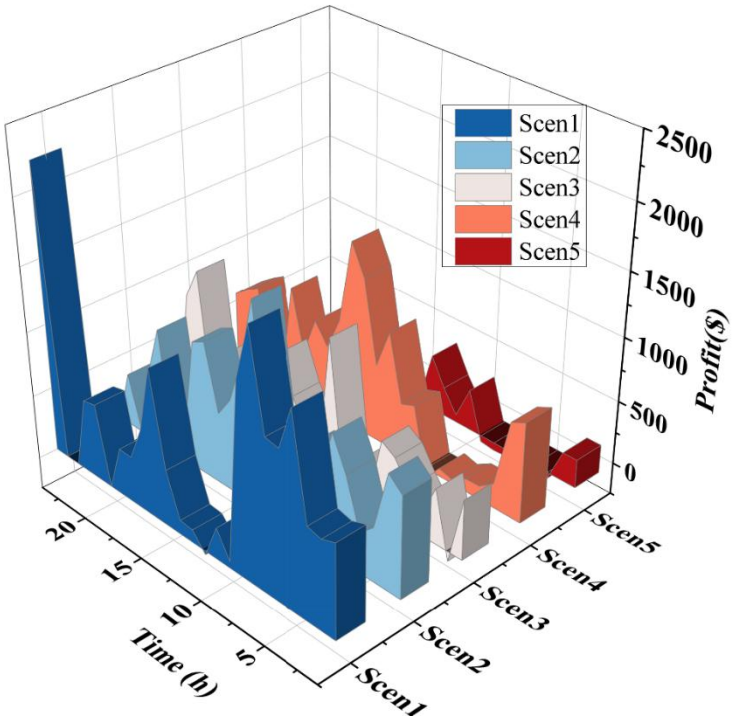

Fig 11: Profit of A1

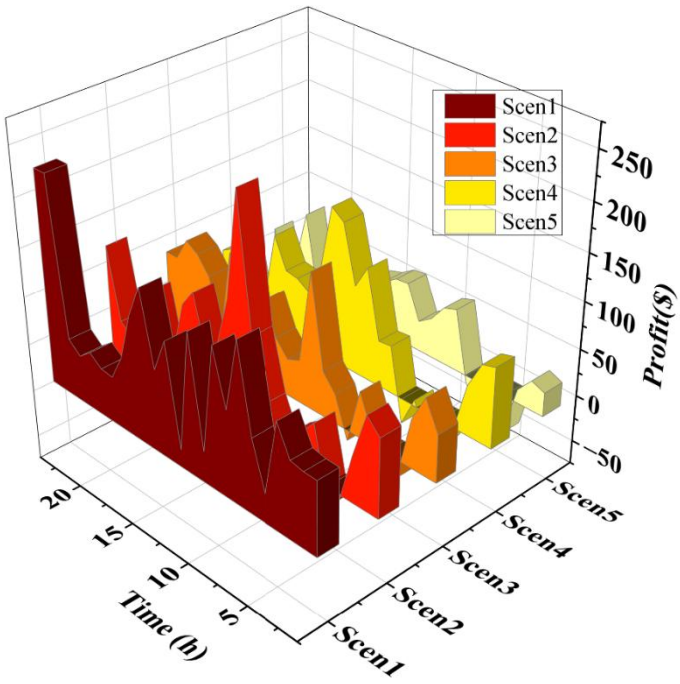

Fig 12: Profit of A2

Table for Profit of Aggregators

Time	Scen1	Scen2	Scen3	Scen4	Scen5
1	46.8078	47.84719	39.98148	99.90998	16.8296
2	50.29472	73.78308	66.5511	86.7321	20.97935
3	41.0974	30.10441	25.94112	3973.176	48.1804
4	1.678538	8.1529	-27.835	16.6467	14.62368
5	-36.5842	-20.2129	-49.4895	1.858358	-7.2777
6	-8.51731	29.1512	5.723	4.915579	-3.90973
7	37.11727	31.97	24.38541	-11.2044	-14.5594
8	-4.54858	1.470629	-52.3183	-31.0822	12.56214
9	51.52554	8.98428	10.13265	-12767.2	5.638365
10	20.6486	-7.38656	36.9876	-19.3784	-76.0486
11	113.9862	24.04725	129.435	46.2536	-26.3922
12	17.37	94.8	46.19597	58.00366	30.71821
13	131.127	68.99922	43.00362	124.3032	44.8325
14	95.12408	43.99044	66.19464	137.546	50.23174
15	144.481	36.30225	115.0745	85.09095	52.2125
16	112.6385	61.08416	85.2096	60.29941	48.6729
17	78.93756	45.6027	46.88756	57.17808	37.1982
18	49.83156	23.808	133.0797	55.24945	37.75895
19	54.8627	2.11095	23.71281	79.78887	83.12075
20	53.3019	23.6638	26.78578	50.1675	43.85741
21	33.72	-18.5714	70.9	49.8975	33.61164
22	77.07788	-23.5477	75.87438	33.70368	11.9145
23	221.1	21.2776	54.97738	32.69808	75.53336
24	220.63	63.3812	66.23049	25.11591	29.73415

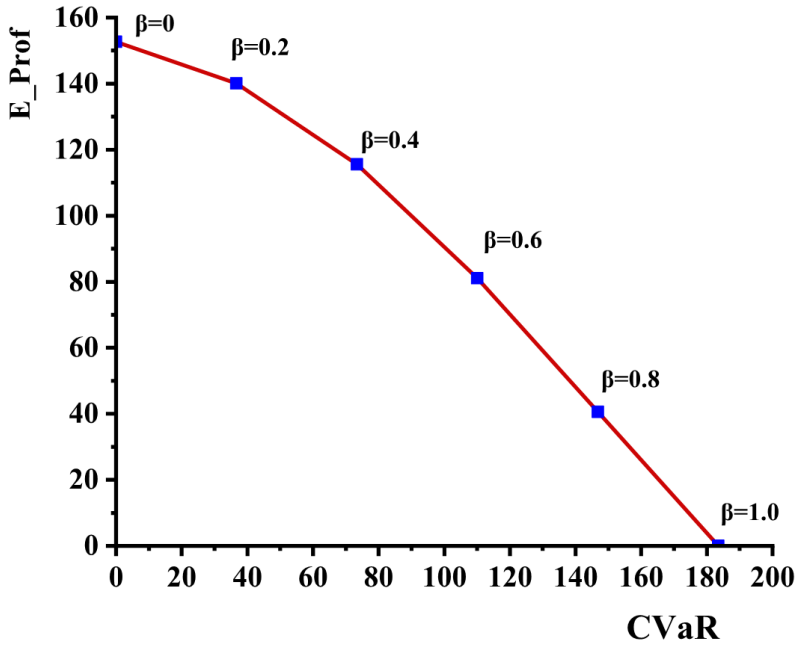

Fig 13: Comparison of CVaR and Profit of aggregator

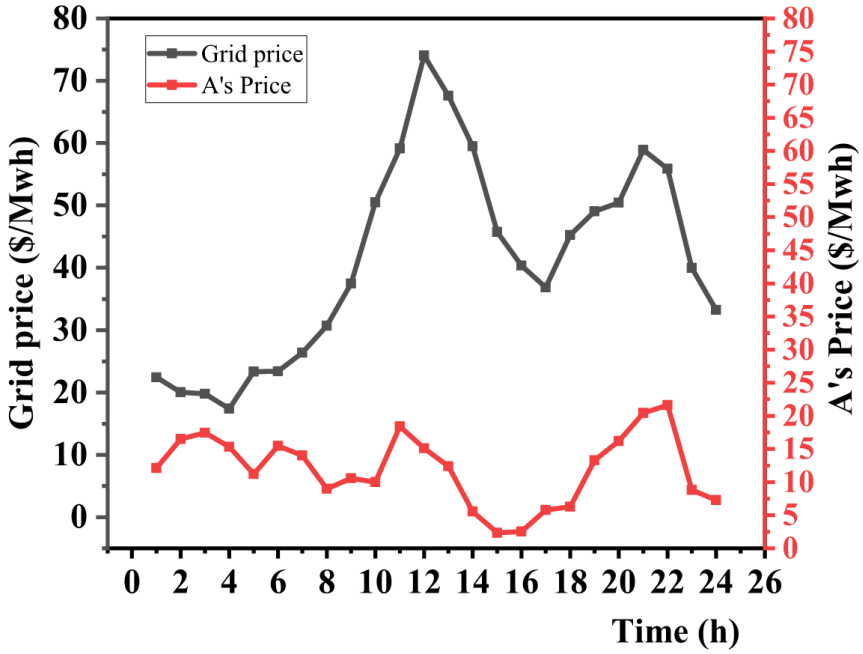

Fig 14: Day-ahead aggregator price signal in comparison with grid price

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Grid Price	22.45	20.044	19.792	17.3855	23.332	23.375	26.369	30.715	37.494	50.487	59.162	74.05	67.585	59.499	45.739	40.356	36.868	45.266	49.073	50.443	58.895	55.895	39.971	33.241
A's price	12.115	16.651	17.451	15.326	11.212	15.454	14.027	9.008	10.563	9.986	18.416	15.126	12.411	5.564	2.356	2.536	5.768	6.265	13.311	16.193	20.447	21.616	8.883	7.277

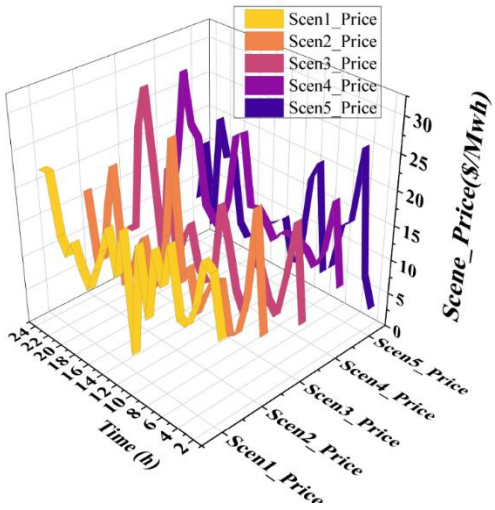

Fig 15: Scenario-based Price signals

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Scen1	13.26	21.34	22.324	15.614	12.213	12.401	21.87	15.44	19.88	9.604	19.287	3	20.05	12.872	19.086	15.099	11.817	8.361	10.49	13.999	11.24	13.618	22.11	22.063
Scen2	10.379	26.733	13.873	8.432	7.531	14.54	13.9	11.089	7.603	13.932	10.825	30	16.197	8.476	7.485	14.272	11.693	7.444	5.285	22.095	16.058	7.112	6.08	16.42
Scen3	8.654	22.111	14.162	7.72	9.335	13.174	14.174	5.1288	7.878	14.226	19.204	7.4633	6.4557	8.2644	14.085	11.095	7.292	20.411	5.973	18.925	30	24.199	8.219	8.207
Scen4	10.697	22.239	14.292	11.645	13.478	14.073	14.432	14.214	12.32	14.358	15.862	15.509	25.368	24.518	14.301	9.7736	10.768	12.305	21.623	23.025	30	17.312	9.3966	7.923
Scen5	4.36	8.563	26.185	15.12	14.183	7.299	5.8951	21.473	18.651	5.5682	5.292	11.133	9.8754	8.9886	8.3544	6.009	5.02	6.683	16.525	15.833	21.072	4.2255	16.492	7.4155

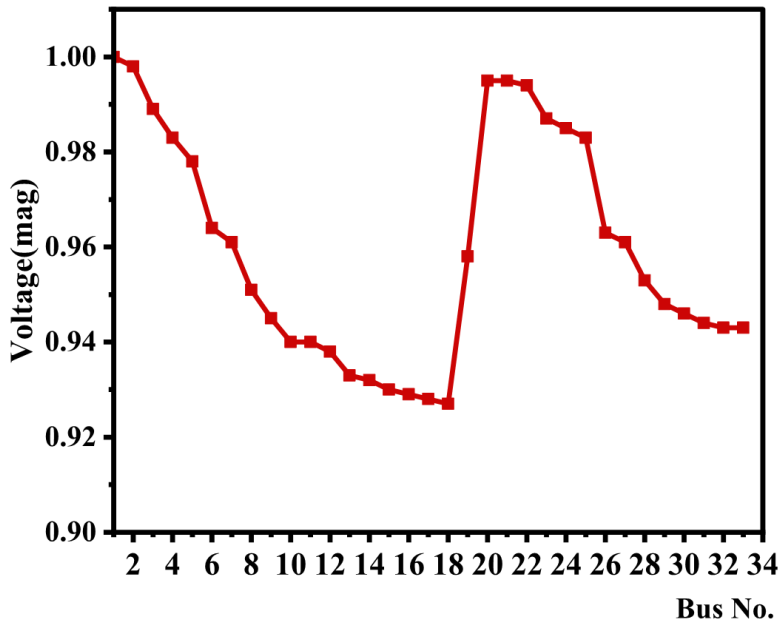

Fig 16: Voltage magnitude of opf execution for modified IEEE 33 bus test system

Table for opf execution

Bus No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Volt (mag)	1	0.998	0.989	0.983	0.978	0.964	0.961	0.951	0.945	0.944	0.94	0.938	0.933	0.932	0.93	0.929	0.928	0.927	0.958	0.995	0.995	0.994	0.987	0.985	0.983	0.963	0.961	0.953	0.948	0.946	0.944	0.943	0.943