Climakosh Analytics
Central Electricity Authority
Long-Term National Resource Adequacy Plan
2026-27 - 2035-36

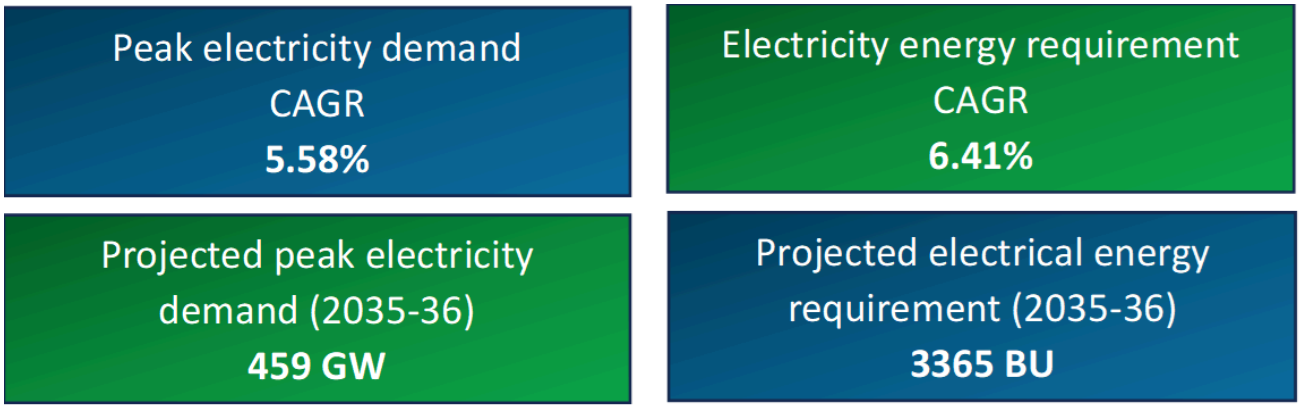
Background and Introduction

The transition towards green energy has gained momentum in the past two decades. Countries are optimizing their energy generation to reduce carbon emissions and mitigate climate change impacts. Energy alternates that are non-fossil fuel based such as solar, wind, hydro, nuclear and geothermal; assisted by Energy Storage Systems are the primary choices of countries.

India's commitment towards the green energy transition has been demonstrated with a record 43 GW of generation capacity installed in 2025-26 up to January 2026 from renewable energy sources.

The Long-term National Resource Adequacy Plan (LT-NRAP) is developed by the Central Electricity Authority under the notified Electricity (Amendment) Rules 2022, Rules 16 (1) stipulating to assess the adequacy of electricity resources over a ten-year planning horizon with a purpose to facilitate coordinated planning, policy formulation, and investment decisions.

Key Projections



The CAGR has been calculated for the period of 2024-25 to 2035-36. The 20th Electric Power Survey has been utilised for these projections

Definitions

- **Resource Adequacy** is defined as a mechanism to ensure an adequate supply of generation resources to reliably meet the projected electricity demand at the least cost. A crucial aspect of resource adequacy planning is ensuring that sufficient generation capacities are available round the clock, capable of reliably serving electricity demand under various scenarios, while considering factors such as extreme weather events, plant availability, etc.
- **Coincident Peak** refers to the share of different distribution utilities in the national peak demand. The occurrence of peak demand varies across months and times of day. Therefore, the top 5% or 10% of demand hours of the national load should be considered for the determination of the coincident peak.
- **Capacity Credit** refers to the dependable contribution of a power source or generation technology to meet peak electricity demand reliably. It is typically expressed as a percentage of the nameplate capacity that can be counted on during peak demand periods.

Source	Capacity Credit (Solar Hours)	Capacity Credit (Non -Solar Hours)
Coal	0.8	0.8
Gas	0.3	0.5
Nuclear	0.7	0.7
Hydro	0.5	0.6
Biomass & MSW	0.2	0.2

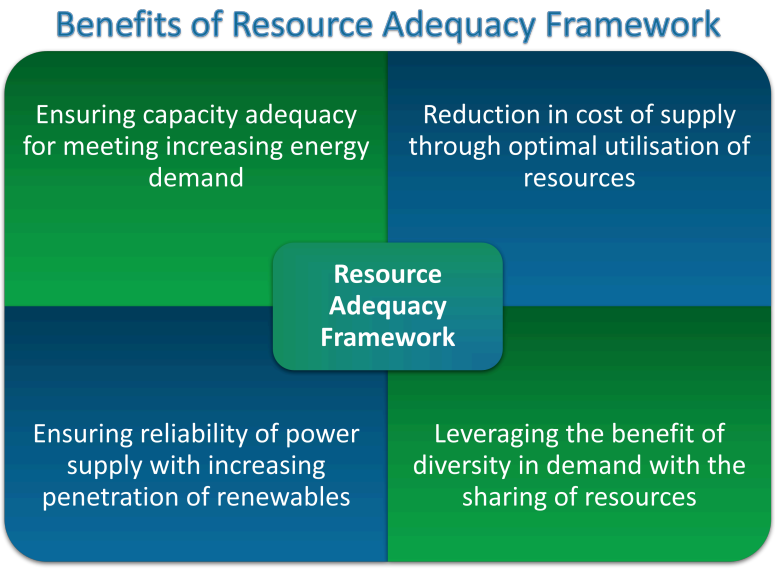
Note: A lower value of the capacity credit of Gas based Generation during solar hours has been considered based on the historical trend of utilisation of gas-based generation. In case of availability of gas, a higher value may be considered.

Objective and Methodology

Through LT-NRAP CEA envisages to minimize the total system cost of generation (including future investment costs, operating costs of generation fleet and others) while ensuring that all the technical parameters associated with different technologies are satisfied.

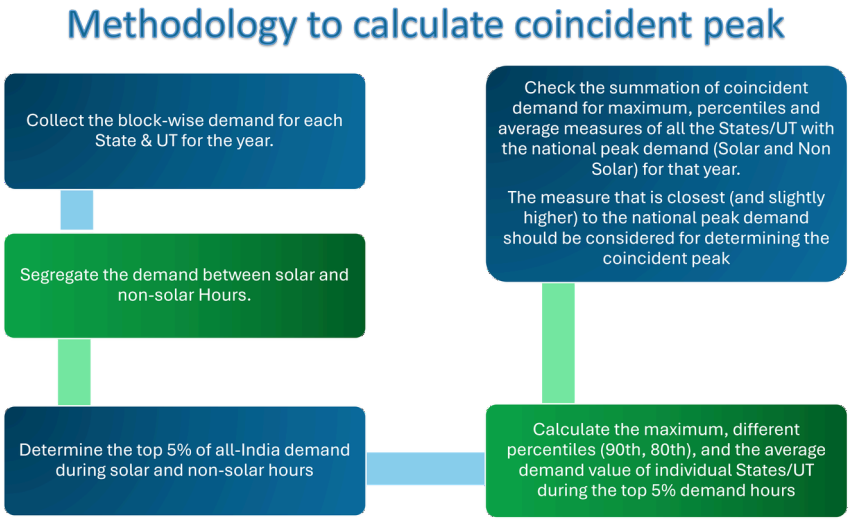
CEA has utilised the mid-term review of the 20th Electric Power Survey to estimate electricity demand projections, peak electricity demand growth rates and electricity energy requirement growth rates.

As part of the Resource Adequacy Planning framework, State-wise coincident peak requirement for 2026-27 and 2027-28 with generator-source-wise capacity credit has been estimated. Year-wise solar and non-solar Planning Reserve Margin (PRM) has also been estimated.



Key aspects in the methodology are as follows:

- **Electricity Demand Projection:** A detailed demand projection using historical data, economic growth models, and demographic projections. This includes estimating State-wise peak electricity demand and annual electrical energy requirements for multiple timeframes, typically spanning twenty years.
- **Generation Capacity Assessment:** This considers existing capacity, new capacity additions, potential retirements and upgrades to ensure that the generation mix is able to meet the projected electricity demand in different scenarios.
- **Optimisation and Sensitivity Analysis:** Optimisation techniques, such as MILP (Mixed Integer Linear Programming), linear programming and Monte Carlo simulations, are used to identify the most cost-effective and reliable energy mix. Sensitivity analysis is conducted to evaluate the system's resilience to variations in electricity demand.
- **Policy and Regulatory Alignment:** Incorporates national policies, such as renewable energy targets, electrification goals, etc., ensuring that the proposed plans align with long-term policy objectives.
- **Stakeholder Engagement:** Discussions are carried out with stakeholders such as government agencies, utilities, industry associations, etc., to ensure that all perspectives are considered in the plan.



- **Loss of Load Probability (LOLP)** is the probability that projected electricity demand will exceed available generation capacity.
- **Expected Energy Not Served (EENS)** is the amount of energy demand that cannot be met due to insufficient generation.

- **Planning Reserve Margin (PRM)** represents the total available firm capacity above the expected peak demand to ensure reliability in the face of uncertainties. Estimating PRM is essential for maintaining system adequacy, especially as power systems integrate more variable resources like renewables.

Fundamental steps involved in Resource Adequacy study

- **Generation Expansion Planning Studies** are the process to evaluate the most economically feasible generation capacity additions to meet the projected electricity demand. It takes into account factors such as the electricity demand projection, existing and planned capacity additions, evolving demand patterns, renewable energy profiles, cost trends of various investment options, operational characteristics of different generation technologies, phasing out of older capacity, etc.
- **Production Cost Analysis** also known as Economic Dispatch studies, is essential to carry out economic (least-cost) dispatch, adhering to unit commitment and other model inputs and constraints. This is typically carried out for a 1-year horizon with the time interval of Hourly (60 min)/sub-hourly (15 min) resolution. It gives information about the following:
    - Generator-wise annual generation, fuel cost, start-up cost, etc
    - Start- Stop of thermal generators
    - Renewable energy curtailment, if any
    - Unserved Energy- demand blocks
    - Reserve Requirement in the system
    - Ramping Constraints of thermal generators
- **System Reliability Analysis** involves the use of advanced probabilistic methods, such as Monte Carlo simulation and stochastic modelling, to capture the uncertainties that impact the power system. The analysis allows for the estimation of key reliability indices such as LOLP and EENS. These methods help evaluate how the system behaves under various uncertain conditions, including:
    - Scheduled and unscheduled outages or maintenance of generating units
    - Unforeseen fluctuations in renewable energy (RE) generation
    - Unexpected changes in electricity demand
    - Variations in hydroelectric generation, depending on hydrological conditions
- **ORDENA**, a mixed-integer linear optimisation model that minimises the net present value of investment and operating costs subject to constraints and **STELLAR**, an indigenous generation expansion planning tool that integrates long-term capacity planning, economic dispatch, and reliability analysis into a unified framework are the Generation Expansion Planning Tools.

Demand Complementarity and Correlation among States

- **Demand complementarity** refers to the compensating or balancing relationship between the electricity demand of different States where an increase in demand in one State coincides with a decrease or lower demand in another.
- **Demand correlation** denotes the statistical degree of association between electricity demand patterns across sectors, regions, or time intervals. A positive correlation indicates that the demands in different States move in the same direction, such as electricity demand in hilly States in the winter months.
- Analysing demand correlation both spatially (across regions) and temporally (across time) allows system planners to identify divergent demand patterns, assess load diversity, and design strategies that ensure reliable and balanced power system operation.

Complementary demand of States (month-wise peak demand) (Solar Hours) in 2025-26 (till 31.01.2026)

States/UTs	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Chandigarh	323	446	465	432	403	381	352	326	225	287
Delhi	5983	7711	8401	8170	7515	6955	7055	944	4393	5468
Haryana	9720	12539	13637	14714	14189	13015	12849	11385	8859	9573
Himachal Pradesh	1911	2356	2613	2170	1892	2292	1796	1991	2347	2240
Jammu & Kashmir & Ladakh	2941	2885	2824	2667	2800	2853	2835	3350	3363	3381
Punjab	10484	13685	15234	15929	15403	15887	14343	9916	10670	11181
Rajasthan	15357	17502	18520	16644	16982	15967	17393	17835	18903	19253
Uttar Pradesh	26042	29375	30263	29573	29760	28362	28448	22378	21010	22453
Uttarakhand	2240	2489	2551	2538	2619	2587	2493	2576	2681	2734
Chhattisgarh	6985	6309	5503	5980	6209	6122	5998	5201	5892	6244
DNH & DD	1322	1438	1455	1354	1408	1386	1498	1422	1394	1424
Gujarat	25134	26413	26743	20040	21345	23150	25049	24032	22659	19260
Goa	683	639	715	675	703	639	634	705	713	702
Madhya Pradesh	14328	15243	14918	12387	13241	12489	14013	15431	18524	19632
Maharashtra	30452	30635	30018	25145	26435	26315	26348	27652	28402	29853
Andhra Pradesh	14324	14123	13645	11088	11284	12185	12502	11843	11438	10712
Karnataka	17849	17351	15342	14648	15148	13511	16483	13156	15293	15832
Kerala	5542	5439	4512	4137	4321	4382	4503	4631	4601	4712
Puducherry	534	545	541	492	523	514	534	499	483	472
Tamil Nadu	21543	21213	21845	18471	19284	18854	19842	19561	17300	16853
Telangana	14819	10572	11692	13485	14834	16630	15868	12937	11143	14627
Bihar	6892	7082	7466	7605	7941	7835	8347	7142	5469	6351
DVC	3479	3329	3245	3575	4369	3260	3458	3304	3068	3260
Jharkhand	2002	1965	2047	2066	1848	2226	2134	2064	2137	2081
Odisha	6698	6694	6854	6207	6578	6980	6729	6340	5881	5589
Sikkim	114	103	101	94	100	172	101	103	115	134
West Bengal	12948	12239	12842	11296	11842	11342	11674	11342	9714	8015
Arunachal Pradesh	182	174	189	163	174	182	194	181	174	198
Assam	2132	2543	2485	2498	2614	2734	2785	2343	2014	1674
Manipur	116	165	234	211	224	228	248	238	248	285
Meghalaya	258	289	438	327	343	352	326	401	412	352
Mizoram	134	138	128	125	134	171	168	143	153	161
Nagaland	173	191	192	188	199	191	185	183	184	195
Tripura	384	396	358	459	483	342	393	341	326	252

Complementary demand of States (month-wise peak demand) (Non Solar Hours) in 2025-26 (till 31.01.2026)

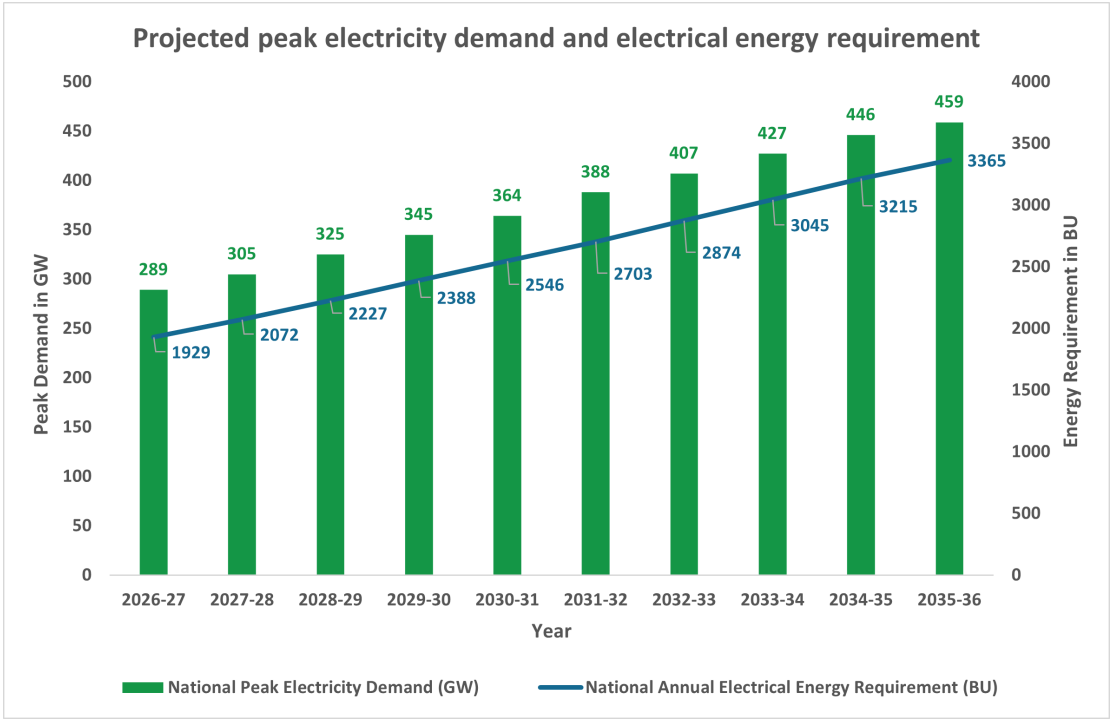
States/UTs	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Chandigarh	302	390	439	399	353	338	317	210	248	304
Delhi	5899	7505	8409	7505	6956	7016	5716	4070	4471	4836
Haryana	10094	11520	12713	13270	12442	12153	10715	7572	8214	8953
Himachal Pradesh	1823	1733	1838	1759	1649	1668	1526	1992	1987	1921
Jammu & Kashmir & Ladakh	2873	2753	2758	2698	2513	2751	2844	2843	3298	3313
Punjab	9623	11442	14349	14992	14842	14234	11342	7015	7454	7482
Rajasthan	12842	16234	16341	14342	12398	14842	14442	15234	15842	15943
Uttar Pradesh	25134	29314	30214	29842	28532	28834	26143	18423	19342	21342
Uttarakhand	2142	2314	2442	2383	2398	2393	2184	2198	2314	2398
Chhattisgarh	6342	5934	5431	5984	5484	5892	5842	4673	4892	5642
DNH & DD	1214	1314	1314	1314	1242	1314	1342	1298	1314	1284
Gujarat	21342	22342	22014	18642	18942	20143	19143	16842	17843	17842
Goa	634	614	684	663	614	584	614	593	614	603
Madhya Pradesh	12842	13543	13142	12342	11342	12342	12642	14842	14842	14942
Maharashtra	28143	28142	27432	24842	24143	23842	25142	24234	24842	26432
Andhra Pradesh	10842	11234	10342	9842	10143	10014	9742	9143	8432	9432
Karnataka	13234	12842	11432	10842	10143	12014	10143	10742	11014	12642
Kerala	5514	5742	4342	4083	4014	4142	4298	4293	4298	4398
Puducherry	514	523	514	498	498	514	478	414	414	398
Tamil Nadu	19503	18699	19321	19542	18466	18449	17373	17234	16644	17173
Telangana	14325	9340	11599	14500	16019	15531	12536	10403	13299	14078
Bihar	7368	7717	8291	8714	8336	8705	7667	5338	6316	6639
DVC	3424	3385	3293	3999	3316	3292	3097	3073	3298	3297
Jharkhand	2036	2014	2137	1968	2488	2115	2047	1916	2080	2149
Odisha	6614	6692	6984	6214	5514	6692	6242	5098	4892	5298
Sikkim	91	88	92	78	79	80	89	92	108	119
West Bengal	12614	12614	12342	11642	10498	11842	11342	8542	6742	7482
Arunachal Pradesh	163	137	167	155	168	185	157	150	175	182
Assam	1954	2342	2342	2484	2514	2642	2198	1714	1454	1463
Manipur	107	140	193	183	170	180	195	199	236	254
Meghalaya	242	242	384	313	312	297	317	324	364	155
Mizoram	121	115	108	113	152	114	108	115	141	147
Nagaland	141	165	171	168	169	178	156	157	155	162
Tripura	357	374	337	433	323	349	318	276	217	245

Demand Correlation matrix of all States based on the demand profile of 2025-26

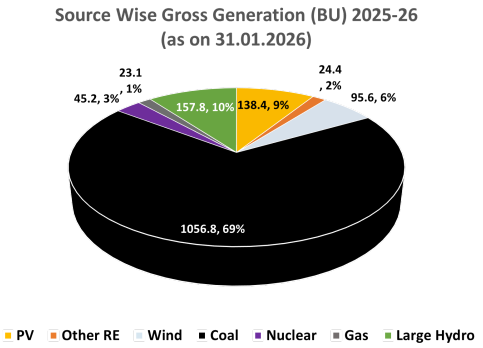
States	Chandigarh	Delhi	Haryana	HP	J&K & Ladakh	Punjab	Rajasthan	UP	Uttarakhand	Chhattisgarh	DD&DNH	Gujarat	Goa	Madhya Pradesh	Maharashtra	Andhra Pradesh	Karnataka	Kerala	Puducherry	Tamilnadu	Telangana	Bihar	DVC	Jharkhand	Odisha	Sikkim	West Bengal	Arunachal Pradesh	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
Chandigarh	1	0.93	0.84	0.32	0.11	0.78	0.43	0.73	0.58	0.37	0.37	0.45	0.33	-0.02	0.1	0.39	-0.02	0.08	0.59	0.6	0.15	0.65	0.25	0.41	0.61	0.19	0.67	0.58	0.63	0.28	0.6	0.19	0.38	0.5
Delhi	0.93	1	0.88	0.18	-0.02	0.79	0.41	0.77	0.46	0.41	0.38	0.45	0.31	-0.06	0.04	0.41	-0.04	0.02	0.61	0.6	0.15	0.69	0.19	0.4	0.67	0.05	0.75	0.52	0.67	0.19	0.59	0.08	0.4	0.56
Haryana	0.84	0.88	1	0.13	-0.02	0.89	0.35	0.74	0.43	0.27	0.41	0.28	0.16	-0.12	-0.08	0.26	-0.13	-0.08	0.47	0.47	0.1	0.63	0.1	0.3	0.56	-0.01	0.59	0.51	0.62	0.19	0.55	0.01	0.4	0.47
HP	0.32	0.18	0.13	1	0.69	0.2	0.62	-0.07	0.5	-0.01	0.25	0.48	0.18	0.57	0.45	0.37	0.63	0.03	0.07	0.32	0.36	-0.11	0.22	0.36	-0.12	0.75	-0.08	0.22	-0.14	0.36	-0.02	0.48	-0.09	-0.13
J&K & Ladakh	0.11	-0.02	-0.02	0.69	1	0.05	0.51	-0.2	0.29	-0.11	0.04	0.37	0.23	0.51	0.44	0.24	0.55	0.23	-0.08	0.12	0.22	-0.29	0.05	0.23	-0.24	0.68	-0.2	0.17	-0.18	0.33	-0.17	0.57	-0.08	-0.16
Punjab	0.78	0.79	0.89	0.2	0.05	1	0.36	0.58	0.32	0.25	0.33	0.28	0.08	-0.13	-0.11	0.26	-0.06	-0.22	0.37	0.43	0.19	0.53	0.05	0.24	0.5	0.05	0.5	0.46	0.53	0.25	0.55	0.02	0.43	0.37
Rajasthan	0.43	0.41	0.35	0.62	0.51	0.36	1	0.2	0.42	0.22	0.15	0.68	0.12	0.71	0.39	0.37	0.43	-0.04	0.06	0.19	0.29	0.08	0.2	0.4	0.06	0.49	0.1	0.18	-0.04	0.2	0.06	0.25	-0.05	-0.03
UP	0.73	0.77	0.74	-0.07	-0.2	0.58	0.2	1	0.45	0.36	0.24	0.18	0.23	-0.14	-0.06	0.17	-0.35	0.1	0.56	0.38	-0.16	0.84	0.33	0.47	0.62	-0.2	0.71	0.45	0.66	0.06	0.51	-0.11	0.26	0.59
Uttarakhand	0.58	0.46	0.43	0.5	0.29	0.32	0.42	0.45	1	0.27	0.38	0.33	0.28	0.25	0.31	0.2	0.07	0.34	0.41	0.43	0.04	0.39	0.38	0.48	0.19	0.41	0.23	0.43	0.27	0.35	0.3	0.38	0.12	0.26
Chhattisgarh	0.37	0.41	0.27	-0.01	-0.11	0.25	0.22	0.36	0.27	1	0.15	0.42	0.31	0.19	0.47	0.44	0.13	0.21	0.43	0.41	0.36	0.44	0.41	0.46	0.51	0.1	0.52	0.15	0.24	0	0.29	0.01	0.17	0.35
DD&DNH	0.37	0.38	0.41	0.25	0.04	0.33	0.15	0.24	0.38	0.15	1	0.35	0.31	-0.01	0.21	0.19	0.11	0.12	0.4	0.48	0.09	0.18	0.12	0.09	0.2	0.24	0.27	0.27	0.29	0.14	0.21	0.14	0.13	0.17
Gujarat	0.45	0.45	0.28	0.48	0.37	0.28	0.68	0.18	0.33	0.42	0.35	1	0.42	0.54	0.61	0.55	0.48	0.18	0.34	0.46	0.34	0.11	0.22	0.36	0.22	0.49	0.34	0.19	0.12	0.15	0.17	0.3	0.04	0.15
Goa	0.33	0.31	0.16	0.18	0.23	0.08	0.12	0.23	0.28	0.31	0.31	0.42	1	0.04	0.54	0.35	0.28	0.68	0.57	0.57	0	0.13	0.2	0.28	0.32	0.31	0.47	0.17	0.22	0.05	0.2	0.35	-0.03	0.35
Madhya Pradesh	-0.02	-0.06	-0.12	0.57	0.51	-0.13	0.71	-0.14	0.25	0.19	-0.01	0.54	0.04	1	0.63	0.35	0.64	0.05	-0.16	-0.01	0.43	-0.2	0.2	0.33	-0.27	0.55	-0.22	-0.05	-0.38	0.08	-0.25	0.27	-0.28	-0.27
Maharashtra	0.1	0.04	-0.08	0.45	0.44	-0.11	0.39	-0.06	0.31	0.47	0.21	0.61	0.54	0.63	1	0.51	0.66	0.5	0.27	0.38	0.41	-0.09	0.32	0.38	-0.02	0.61	0.09	0.05	-0.15	0.15	0.12	-0.07	0.41	-0.18
Andhra Pradesh	0.39	0.41	0.26	0.37	0.24	0.26	0.37	0.17	0.2	0.44	0.19	0.55	0.35	0.35	0.51	1	0.65	0.08	0.37	0.59	0.68	0.18	0.14	0.35	0.32	0.33	0.34	0.14	0.14	0.04	0.14	0.14	0.03	0.14
Karnataka	-0.02	-0.04	-0.13	0.63	0.55	-0.06	0.43	-0.35	0.07	0.13	0.11	0.48	0.28	0.64	0.66	0.65	1	0.09	-0.02	0.33	0.66	-0.36	0.02	0.18	-0.18	0.65	-0.12	-0.08	-0.32	0.1	-0.2	0.35	-0.19	-0.24
Kerala	0.08	0.02	-0.08	0.03	0.23	-0.22	-0.04	0.1	0.34	0.21	0.12	0.18	0.68	0.05	0.5	0.08	0.09	1	0.41	0.35	-0.21	0.05	0.2	0.24	0.09	0.28	0.2	0.2	0.15	0.07	0.12	0.48	-0.04	0.28
Puducherry	0.59	0.61	0.47	0.07	-0.08	0.37	0.06	0.56	0.41	0.43	0.4	0.34	0.57	-0.16	0.27	0.37	-0.02	0.41	1	0.8	-0.03	0.54	0.31	0.34	0.57	0.09	0.65	0.33	0.55	0.13	0.5	0.15	0.23	0.56
Tamilnadu	0.6	0.6	0.47	0.32	0.12	0.43	0.19	0.38	0.43	0.41	0.48	0.46	0.57	-0.01	0.38	0.59	0.33	0.35	0.8	1	0.26	0.39	0.21	0.33	0.48	0.36	0.55	0.37	0.46	0.21	0.46	0.32	0.25	0.43
Telangana	0.15	0.15	0.1	0.36	0.22	0.19	0.29	-0.16	0.04	0.36	0.09	0.34	0	0.43	0.41	0.68	0.66	-0.21	-0.03	0.26	1	-0.05	0.03	0.18	0.08	0.4	0.02	0.04	-0.11	0.1	-0.03	0.11	0.11	-0.12
Bihar	0.65	0.69	0.63	-0.11	-0.29	0.53	0.08	0.84	0.39	0.44	0.18	0.11	0.13	-0.2	-0.09	0.18	-0.36	0.05	0.54	0.39	-0.05	1	0.36	0.57	0.68	-0.18	0.74	0.49	0.74	0.08	0.51	-0.06	0.41	0.67
DVC	0.25	0.19	0.1	0.22	0.05	0.05	0.2	0.33	0.38	0.41	0.12	0.22	0.2	0.2	0.32	0.14	0.02	0.2	0.31	0.21	0.03	0.36	1	0.55	0.27	0.19	0.3	0.19	0.12	0.15	0.17	0.1	0	0.21
Jharkhand	0.41	0.4	0.3	0.36	0.23	0.24	0.4	0.47	0.48	0.46	0.09	0.36	0.28	0.33	0.38	0.35	0.18	0.24	0.34	0.33	0.18	0.57	0.55	1	0.41	0.33	0.46	0.39	0.34	0.24	0.2	0.29	0.18	0.46
Odisha	0.61	0.67	0.56	-0.12	-0.24	0.5	0.06	0.62	0.19	0.51	0.2	0.22	0.32	-0.27	-0.02	0.32	-0.18	0.09	0.57	0.48	0.08	0.68	0.27	0.41	1	-0.15	0.78	0.42	0.63	0.08	0.5	0	0.42	0.62
Sikkim	0.19	0.05	-0.01	0.75	0.68	0.05	0.49	-0.2	0.41	0.1	0.24	0.49	0.31	0.55	0.61	0.33	0.65	0.28	0.09	0.36	0.4	-0.18	0.19	0.33	-0.15	1	-0.11	0.26	-0.11	0.38	0	0.64	0.01	-0.09
West Bengal	0.67	0.75	0.59	-0.08	-0.2	0.5	0.1	0.71	0.23	0.52	0.27	0.34	0.47	-0.22	0.09	0.34	-0.12	0.2	0.65	0.55	0.02	0.74	0.3	0.46	0.78	-0.11	1	0.38	0.71	0.04	0.46	0.03	0.36	0.73
Arunachal Pradesh	0.58	0.52	0.51	0.22	0.17	0.46	0.18	0.45	0.43	0.15	0.27	0.19	0.17	-0.05	0.05	0.14	-0.08	0.2	0.33	0.37	0.04	0.49	0.19	0.39	0.42	0.26	0.38	1	0.62	0.37	0.43	0.43	0.45	0.48
Assam	0.63	0.67	0.62	-0.14	-0.18	0.53	-0.04	0.66	0.27	0.24	0.29	0.12	0.22	-0.38	-0.15	0.14	-0.32	0.15	0.55	0.46	-0.11	0.74	0.12	0.34	0.63	-0.11	0.71	0.62	1	0.2	0.54	0.16	0.59	0.79
Manipur	0.28	0.19	0.19	0.36	0.33	0.25	0.2	0.06	0.35	0	0.14	0.15	0.05	0.08	0.12	0.04	0.1	0.07	0.13	0.21	0.1	0.08	0.15	0.24	0.08	0.38	0.04	0.37	0.2	1	0.27	0.43	0.34	0.15
Meghalaya	0.6	0.59	0.55	-0.02	-0.17	0.55	0.06	0.51	0.3	0.29	0.21	0.17	0.2	-0.25	-0.07	0.14	-0.2	0.12	0.5	0.46	-0.03	0.51	0.17	0.2	0.5	0	0.46	0.43	0.54	0.27	1	0.11	0.47	0.46
Mizoram	0.19	0.08	0.01	0.48	0.57	0.02	0.25	-0.11	0.38	0.01	0.14	0.3	0.35	0.27	0.41	0.14	0.35	0.48	0.15	0.32	0.11	-0.06	0.1	0.29	0	0.64	0.03	0.43	0.16	0.43	0.11	1	0.19	0.19
Nagaland	0.38	0.4	0.4	-0.09	-0.08	0.43	-0.05	0.26	0.12	0.17	0.13	0.04	-0.03	-0.28	-0.18	0.03	-0.19	-0.04	0.23	0.25	0.11	0.41	0	0.18	0.42	0.01	0.36	0.45	0.59	0.34	0.47	0.19	1	0.46
Tripura	0.5	0.56	0.47	-0.13	-0.16	0.37	-0.03	0.59	0.26	0.35	0.17	0.15	0.35	-0.27	0.01	0.14	-0.24	0.28	0.56	0.43	-0.12	0.67	0.21	0.46	0.62	-0.09	0.73	0.48	0.79	0.15	0.46	0.19	0.46	1

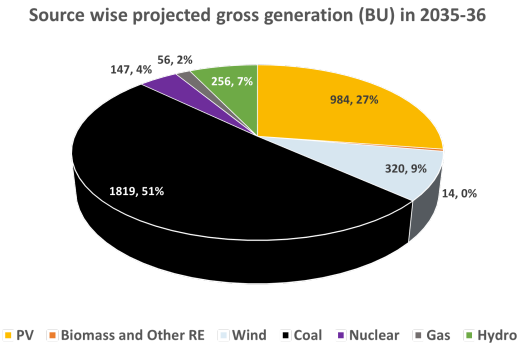
- States with **high positive correlation exhibit similar demand patterns,** indicating limited potential for resource sharing or banking. Conversely, **States with low or negative correlation demonstrate complementary demand profiles,** which can be leveraged to enhance system reliability through coordinated resource planning or banking.

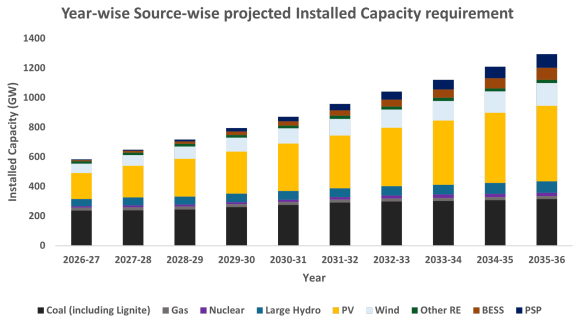
Inputs and Outcomes (Scenario 1) [Electricity Demand Projections as per mid-term review of 20th EPS]

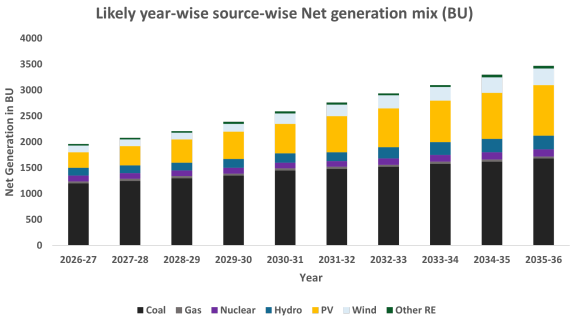


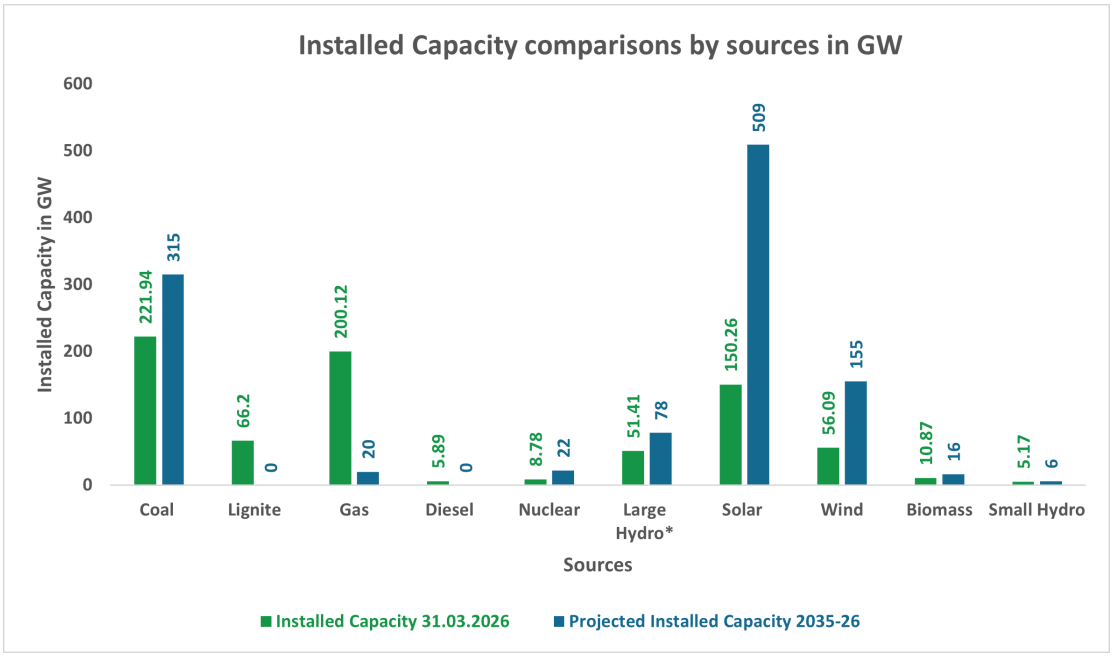
The midterm review of the 20th EPS demand projections by CEA indicates that peak electricity demand on an all-India basis is expected to increase at a CAGR of 5.58% during FY 24-25 to FY 35-36. The annual electricity energy requirement is expected to grow at a CAGR of 6.41% during the same period. The demand projections incorporate the demand estimates of the emerging sectors like electric vehicles and Green Hydrogen. The visual above showcase the electricity demand projections as per midterm review of the 20th EPS.



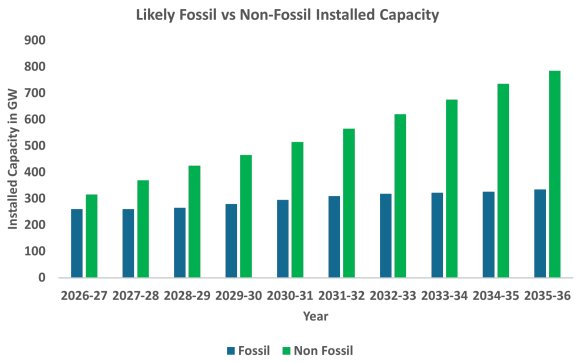


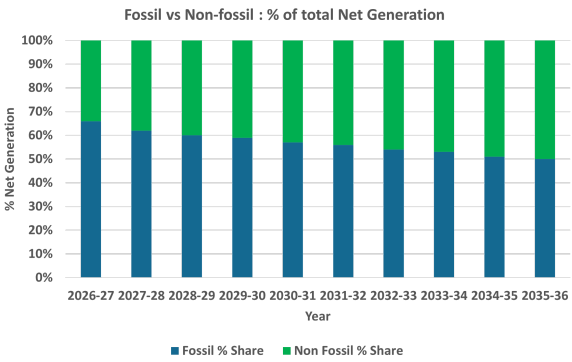






Large Hydro installed capacity figures for 2026 year also includes PSPs capacity. Lignite projected capacity is clubbed with coal for 2035-36





The study emphasizes the push towards non fossil fuel-based capacity addition, projecting the likely increase to be about 786GW by 2035-36 in capacity. It has also observed the need of storage (about 4-6 hours) to make higher RE penetration viable beyond 2030 and therefore places PSP as a comprehensive solution for meeting future storage capacity requirements at reasonable cost, along with ensuring grid reliability by providing frequency regulation, inertia and voltage support. The likely requirement of energy storage is about 174 GW/ 888 GWh by 2035-36 for energy shifting and facilitating increased RE integration. BESS is suitable for short-duration storage, and PSPs are suitable for long-duration storage.

Summary on Reliability Analysis Results

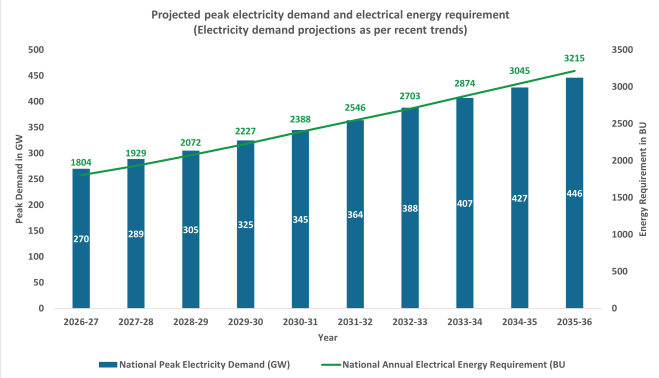
Using the Monte Carlo simulation i.e. a probabilistic modelling technique that uses repeated random sampling to evaluate the impact of uncertainty in complex systems. It captures the full range of possible scenarios and their probabilities, providing a more realistic picture. of system performance has been undertaken.
Value of Loss of Load Probability (LoLP) and Normalised Energy Not Served (NENS) at 0.2% and 0.05% respectively has been considered. These values are the same as taken for the preparation of the National Electricity Plan, brought out in May 2023. The analysis has been done for chart of Year-wise Source-wise projected Installed Capacity requirement. The following variations have been considered in the reliability-sensitive parameters. The results of the reliability analysis are also mentioned below

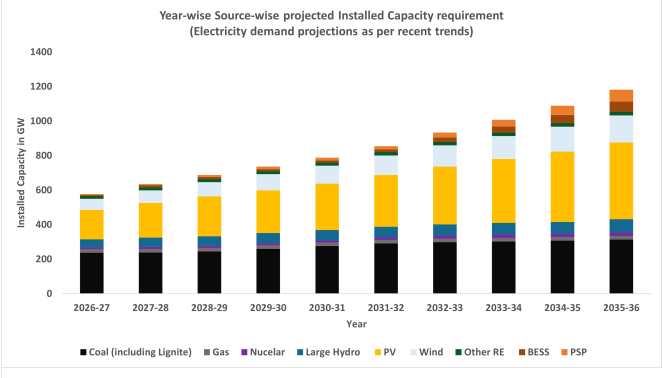
Variations Considered for Monte Carlo Simulation		
Parameter	**Standard Deviation (σ)**	**Range of Variation (3σ)**
Forced Outage of thermal generators (Coal and Gas)	3.33%	±10%
Block - wise Demand	3.33%	±10%
Block - wise Solar Generation	3.33%	±10%
Block - wise Wind Generation	10%	±30%
Block - wise Hydro Generation	3.33%	±10%

Results of Reliability Analysis	
Parameter	**2035-36**
LoLP - Average	0.18
NENS - (%) - Average	0.01
Max ENS over iterations - MU	12457
Min ENS over iterations - MU	0
Max NENS over iterations - %	0.37
Min NENS over iterations - %	0
Max LoLP over iterations (% of total hours)	3.52
Min LoLP over iterations (% of total hours)	0

Scenario II: Electricity demand projections as per recent trends

An additional scenario is envisaged for carrying out resource adequacy studies, wherein the recent trend of lower electricity demand growth has been considered. As a part of this scenario, the peak electricity demand and the annual electricity energy requirement projections as projected by the mid-term review of the 20th EPS study have been shifted by one year for the entire study horizon.





In this scenario, the projected peak electricity demand in 2035-36 reduces from 459 GW to 446 GW, while the electrical energy requirement reduces from 3365 BU to 3215 BU. Correspondingly, the total installed capacity requirement in 2035-36 is about 1054 GW compared to 1121 GW The requirement of storage in this scenario is lower at about 128 GW compared to 174 GW in the scenario where demand had been considered as per mid-term review of 20th EPS.

Conclusions

- 315 GW of coal-based generation capacity, which will continue to serve as the backbone of the power system for baseload supply.

- On the renewable front, significant capacity expansions to accelerate the clean energy transition are observable. This includes 78 GW of hydroelectric power, which offers both renewable energy and grid balancing capabilities, 509 GW of solar photovoltaic (PV) capacity, and 155 GW of wind power.
- The plan also recognises the need for energy storage systems to shift the energy generated in high RE generation periods for use during low/no RE generation and high demand periods. Specifically, 94 GW of Pumped Storage Plants (PSP) and 80 GW of Battery Energy Storage Systems (BESS) are projected to be added.

Recommendations

- Planned Expansion of Non-Fossil Capacity
- Progressive Development of Energy Storage
- Maintaining Adequate Planning Reserve Margins (PRM)
- Enhancing Grid Flexibility and Infrastructure
- Ensuring Reliability through Resource Diversity
- Focus on Nuclear Capacity Development