C.3 In cases where DISCOMs/States are hopeful of reducing T&D drastically over a shorter period of time due to some planned measures such as extensive meter installations, reduction in losses should not be considered in complete isolation as some of the unmetered load then, would be expected to come up under metered load of different consumer categories. Accordingly, adjustments should be made by taking appropriate assumptions.

C.4 The impact of emerging aspects expected in future should be factored in additionally as explained in Part D.

Note - The impact of ongoing government policies/ schemes, technological advances should not be factored in additionally if they are already in vogue for quite some time in the past and expected to follow similar trajectories in future as such impacts are already captured intrinsically in the past time series data.

C.5 The impact of energy efficiency should not be considered additionally if it is expected to follow similar trajectories in future as seen in the past as in such cases, the impacts are already captured intrinsically in the past time series data. However, if some major changes on account of energy efficiency are expected in future due to various factors such as some major technological breakthroughs or implementation of some major government policies, then the impact should be factored in additionally. In such cases, the impact in a definite quantum of electric energy should be assessed.

C.6 The methodology adopted should be assessed on the criterion of out-of-sample validation (pls refer **para A.6** above). For doing this, the forecast for the first two years immediately after the base year should be compared with actual data recorded for the year.

Note - In case of deviations (such as MAPE[1] is more than 2%), necessary course correction in the growth rates adopted should be done after detailed examination. Some of such corrective measures could be filtering the outline data from the input data, changing the base year, changing the assigned weights etc.

[1] MAPE (Mean Absolute Percentage Error) = $(1 / \text{sample size}) \times \sum [(|actual - forecast|) / |actual|] \times 100$

C.7 The energy requirement of a DISCOM/State should be arrived at by adding T&D losses to their total energy consumption. The concepts of accounting T&D losses to arrive at energy requirement figures at DISCOM and State levels are explained in **Part E** and **Part F** respectively.

C.8 The energy requirement of a state incident upon the Ex-Bus of the generators should also be estimated (refer **Part F)**.

C.9 The peak demand forecast of a DISCOM/State should be derived from the energy requirement figure by applying appropriate load factor as explained in **Part G**.

C.10 The forecast under BAU scenario should be derived first and based on that, forecasting under other scenarios should be done. A broad list of the parameters which may be considered for creating different forecasting scenarios is given in **Annexure IV**.

C.11 The electricity demand depends on weather conditions also. In the traditional PEUM, weather parameters are not considered separately as those are assumed to be inherent in the past energy consumption data. However, appropriate weather parameters should be considered for developing more than one forecasting scenarios as suggested in **para A.10**.

C.12 The basic concept and a simple approach for factoring in weather parameters are discussed in **Annexure-V** which could be adopted in forecasting power demand. Advanced statistical tools like Multivariate Regression Analysis should also be used for this purpose.

Box C.3: For arriving at power demand inclusive of CPPs, as the energy exported by CPPs to grid is already accounted for in respective DISCOM/State consumptions, the growth trend of self-consumption of CPPs (i.e. Net Generation – Energy Exported to the grid) only should be analysed and added separately.

Impact of Emerging Aspects

D: Impact of Emerging Aspects

D.1 The impact of emerging aspects should be quantified in sync with the targets set by the government. In case of non-availability of any target, suitable assumptions should be taken that should be spelled out clearly.

D.2 In cases where government targets are available on yearly basis only, month/day/hour/time-block wise demand impact assessment should be done by arriving at the annual impact assessment first and then spreading it over to each month/day/hour/time-block appropriately. Estimating expected monthly/daily/hourly/time-block wise impact profile due to an emerging aspect could be one such possible way. For example, solar roof top impact profile could be similar to any solar power generation project profile of the concerned geographical area. Another example is the impact of green hydrogen production which could have a straight line profile throughout the year.

D.3 As far as possible, the impact of the emerging effects should be apportioned to the corresponding pre-defined consumption categories only (For example, Electric Vehicle penetration could impact domestic and commercial consumptions, Green Hydrogen production could impact Industrial consumption, Solar pump penetration could impact irrigational consumption). In absence of any such suitable category, a new category could be created if the impact is substantial. Otherwise, it could be clubbed in "Others" category.

(Note: The methodology adopted during 20th EPS for assessing impact of electric vehicles on energy demand is given in **Annexure-VI** for reference).

Electrical Energy Requirement of a DISCOM

E. Electrical Energy Requirement of a DISCOM

E.1 The total electrical energy requirement of a DISCOM should be worked out by adding its Distribution losses & Intra-State Transmission losses attributed to that particular DISCOM to its total category wise electrical energy consumption.

E.2 Distribution losses of a DISCOM should be computed as the difference between the net input energy to its system and the total energy consumed by its own consumers as well as by open access consumers if such energy is wheeled through its network.

E.3 Intra State Transmission losses for the whole state should be apportioned to each DISCOM in the ratio of their respective energy requirement (i.e. Energy Consumption + Distribution losses) if more than one DISCOM is present in any state.

Electrical Energy Requirement of a State

F. Electrical Energy Requirement of a State

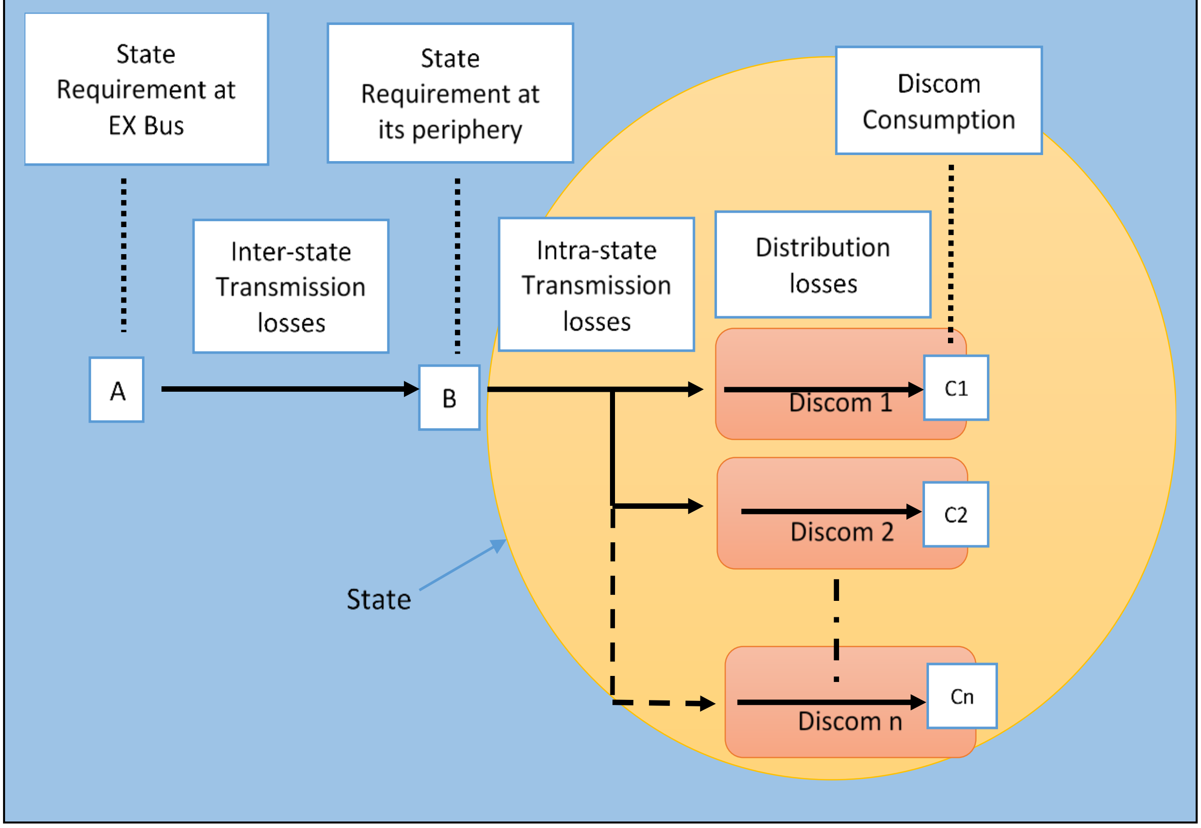
F.1 Electrical energy requirement of a State at its periphery should be worked out by summing up the T&D losses of its each DISCOM and adding it to the electrical energy consumption of the state.

F.2 Electrical energy consumption of a State should be worked out by summing up electrical energy consumption of all its DISCOMs.

> **Box F.1**: Open Access consumptions should be added at state level consumption additionally if DISCOMs had not accounted for such energy at their level. In such case, the state transmission losses applicable on quantum of open access consumption should also be added additionally to arrive at total T&D loss figure of the state.

F.3 The energy requirement of a state incident upon the Ex-Bus of the generators should be arrived at by adding the inter-state transmission losses to the electrical energy requirement of the state at its periphery.

Box F.2: Concept of factoring in T&D losses in Energy Requirement



F.4 The inter-state transmission losses should be calculated by multiplying such losses in % term calculated by GRID-INDIA at the national level with the electrical energy the states are expected to import from the national grid which in turn should be based on the ratio of the energy the states had imported against their energy requirement in past.

Peak Demand

G. Peak Demand

G.1 The peak demand forecast of a DISCOM/State should be derived from the energy requirement by applying appropriate load factor.

G.2 The Load Factor is calculated by dividing total electrical energy requirement for a given period of time by the product of maximum demand and that specific period of time. The formulae for calculating load factor on monthly and yearly basis are:

*Monthly Load Factor (in %) = (Energy Requirement in MU *1000*100) / (Peak Demand in MW * No. of days in the Month * No. of hours in a day).*

*Yearly Load Factor (in %) = (Energy Requirement in MU *1000*100) / (Peak Demand in MW * No. of days in the year * No. of hours in a day).*

G.3 The appropriate load factors in the upcoming years should be estimated on its past trend. However, any expected change in specific consumer mix should also be accounted for. For example, in case of increase in industrial consumption share, an increase in load factor could be expected.

G.4 If the pattern of specific consumer mix is expected to differ from the past, the expected load factor should be derived by examining load factors of other DISCOMs with similar consumer mix.

G.5 If the pattern of specific consumer mix is not expected to differ appreciably from the past, then it should be assumed that the load factor trend observed in the past may continue.

G.6 Peak electricity demand of the state should be estimated by applying suitable diversity factor, as per the past trends, to the sum of peak electricity demand of its all DISCOMs. The diversity factor within a state for peak demand should be calculated as -

Diversity factor = Sum of Peak Demand of Individual DISCOMs in a State/ Peak demand of State.

General Checks & Balances

H. General Checks & Balances

H.1 The Load Factor of a DISCOM/state should not be more than 1. The Load Factors for the DISCOMs/States were observed in the range of 40% to 80% in the past.

H.2 If the system feeds block industrial loads like aluminium and other process industries etc. having high electric load factor, the overall system load factor should ideally be high.

H.3 Diversity factor of the peak demand of a state calculated on the peak demand of its each DISCOM should be more than 1. Otherwise, it indicates wrong reporting of peak demand by any/all of the DISCOM or some loads are being missed in overall calculation. The typical range of diversity factors observed in the past is given in the table below. The states are expected to witness lower diversity factors than their respective region.

Northern Region	Western Region	Southern Region	Eastern Region	North Eastern Region	All India
1.13	1.09	1.05	1.07	1.07	1.13

H.4 T&D losses of a state (excluding Inter State Transmission Loss component) should be equal to the sum of T&D losses of all its DISCOMs.

H.5 Every consumption should be accounted for. Examples of some consumptions observed to be left out by the DISCOMs/States in their consumptions are –

a) Small DISCOMs
b) Franchisees
c) Temporary connection category
d) Special categories (ex- Center-State Category in Jammu & Kashmir) etc.

H.6 The possibility of double accounting of any energy across the concerned utilities should be checked and rectified. Some examples of double accounting observed in case of –

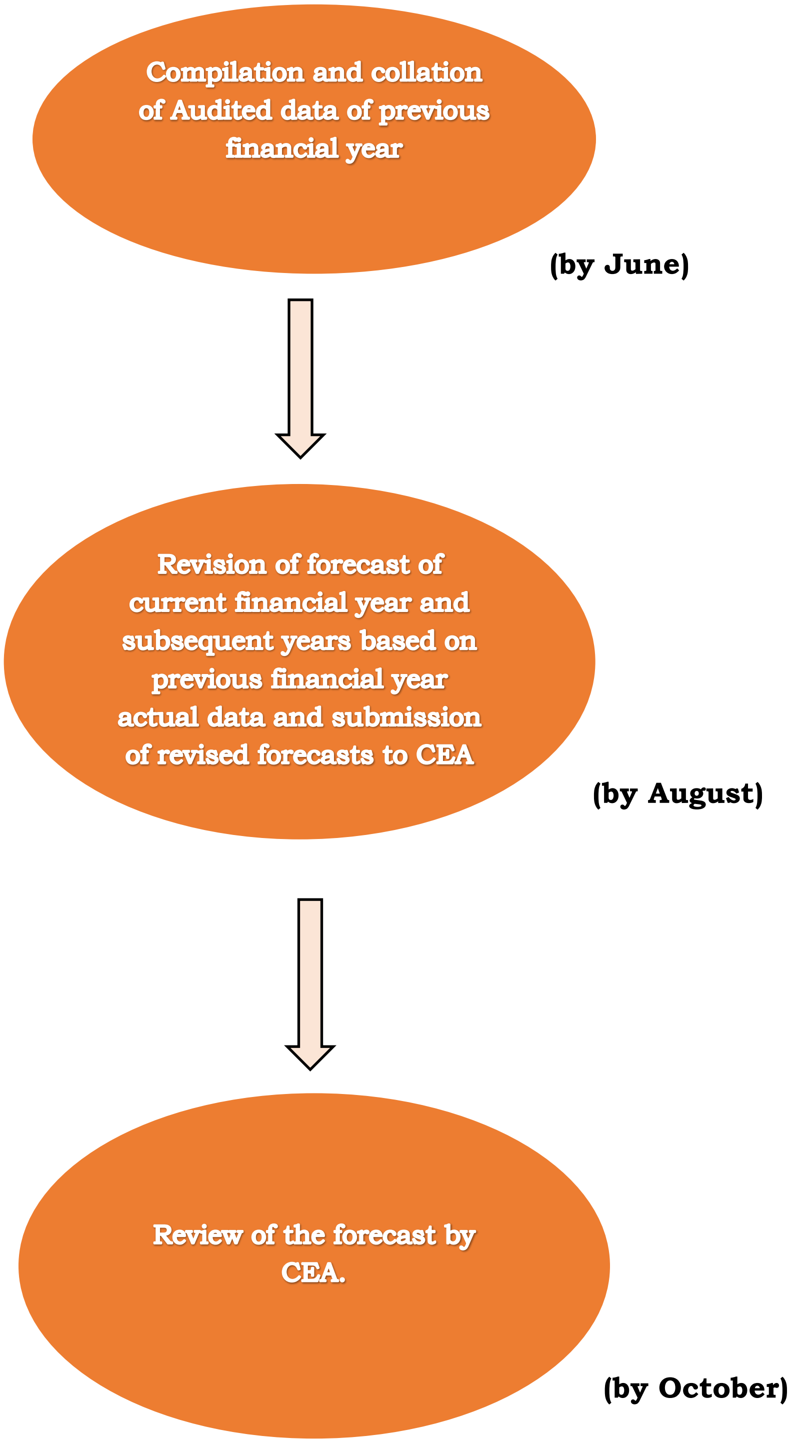
a) Creation of new States/DISCOMs
b) Merging of tariff slabs
c) Franchisees reflected in Bulk Supply Category
d) DVC (accounted in West Bengal as well as in Jharkhand).
e) Energy sold outside DISCOM/State

H.7 The consistency of the input data for energy requirement should be cross checked from demand as well as from supply side. For a state, the energy requirement met at its periphery should be equal to total net generation within the state from all sources feeding to the grid plus its net import from outside the state.

Annexures

Annexure-I

Timeline for review of forecast in a given financial year



Annexure-II

Input Data Format

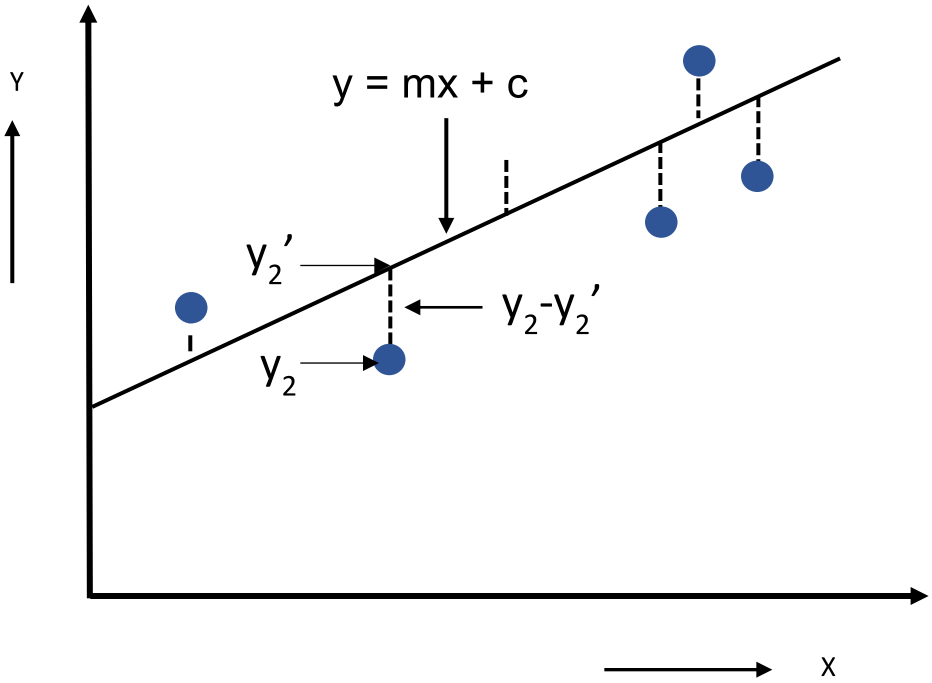
	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Energy Consumption (in MU)											
1. Domestic											
2. Commercial											
3. Public lighting											
4. Public Water Works											
5. Irrigation											
6. LT Industries											
7. HT Industries											
8. Railway Traction											
9. Bulk Supply											
10. Open Access											
11. Others											
Total (Energy Consumption)											
T&D losses -MU											
T&D losses -in %											
Energy Requirement - MU											
Annual Load Factor - %											
Peak Load - MW											

Annexure-III

Least Square Method & Weighted Average Method

Least Square Method:

The least square method is used to find the best fitted linear curve for a set of data points by minimizing the sum of the squares of the offsets (residual part) of the points from the curve.



$$\text{Least Square Method} = \text{Minimize}\left(\sum_{i=1}^{n}(y_i - y_i')^2\right)$$

The slope (m) and y intercept(c) of the best fitted straight line are estimated in Microsoft Excel through the following formulae:

m = INDEX(LINEST(y_known), 1)

c= INDEX(LINEST(y_known),2)

Where y_known = range of dependent y values

For finding out the yearly energy consumption trend, the y axis may represent the energy consumption (i.e. y_known) whereas x axis may denote years. A calculation example is given below:

	Sl. No.	Year	Energy Requirement (in MU)	slope(m)	Y-Intercept (c)
INPUT	1	2020-21	100		
DATA	2	2021-22	110		
	3	2022-23	122		
	4	2023-24	135		
	5	2024-25	148		
	6	2025-26	160	=INDEX(LINEST(E4:E9),1)	=INDEX(LINEST(E4:E9),2)
FORECAST	7	2026-27	=$F$9*C10+$G$9		
	8	2027-28	=$F$9*C11+$G$9		

Value = 12.2
Value = 86.47
Value = 172
Value = 184

Weighted Average Method:

In the Weighted Average Method, the quantities which are needed to be averaged are assigned weight first as per their importance and then their average is calculated. The formula for weighted average is -

Weighted Average = ∑ *(Weights x Quantities)/*∑*Weights*

An example of using weighted average method in Microsoft Excel is given below wherein more weights are assigned to recent year data:

	Year	Energy Requirement (in MU)	Annual Growth Rate (in %)	Weight	Annual Growth Rate x Weight	Weighted Average Growth Rate (in %)
INPUT	2020-21	100				
DATA	2021-22	110	10.00	1	10.00	
	2022-23	122	10.91	2	21.82	
	2023-24	135	10.66	3	31.97	
	2024-25	148	9.63	4	38.52	
	2025-26	160	8.11	5	40.54	
FORECAST	2026-27	175		**15**	**142.84**	**9.52**
	2027-28	192				

Sum of Weights
Sum of Average Growth Rate X Weight

	A	B	C	D	E	F	G	H
1								
2								
3			Year	Energy Requirement (in MU)	Annual Growth Rate (in %)	Weight	Annual Growth Rate x Weight	Weighted Average Growth Rate (in %)
4		INPUT	2020-21	100				
5		DATA	2021-22	110	=((D5/D4)-1)*100	1	=E5*F5	
6			2022-23	122	=((D6/D5)-1)*100	2	=E6*F6	
7			2023-24	135	=((D7/D6)-1)*100	3	=E7*F7	
8			2024-25	148	=((D8/D7)-1)*100	4	=E8*F8	
9			2025-26	160	=((D9/D8)-1)*100	5	=E9*F9	
10		FORECAST	2026-27	=D9*(1+$H$10/100)		=SUM(F5:F9)	=SUM(G5:G9)	=G10/F10
11			2027-28	=D10*(1+$H$10/100)				
12								
13						Sum of Weights		Sum of Average Growth Rate X Weight
14								

****

Annexure-IV

Parameters need to be considered for the different forecasting scenarios:

Parameters	Optimistic Scenario	Business As Usual Scenario	Pessimistic Scenario
PEUM Method			
Government Targets (if it drives power demand upwards such as Green Hydrogen Mission).	Full Achievement	Realistic Assessment	Pessimistic Assessment.
Government Targets (if it drives power demand downwards such as in case of solar roof top).	Pessimistic Assessment.	Realistic Assessment	Full Achievement.
Weather	factoring extreme weather conditions driving power demand upwards such as lesser rainfall.	Normal weather conditions (weather parameters need not required to be factored in separately).	factoring extreme weather conditions driving power demand downwards such as heavy rainfall.
T&D losses trajectory	Liberal	Moderate	Aggressive
Energy Efficiency	Liberal	Moderate	Aggressive
Econometric Method			
Gross Domestic Product (GDP)/Gross State Domestic Product (GSDP)	Optimistic Assessment of GDP/GSDP	Average GDP/GSDP growth in the past.	Pessimistic Assessment of GDP/GSDP

Annexure-V

Impact of Weather Conditions on Power Demand Forecast

The electricity demand is dependent on weather conditions also. Therefore, weather parameters should be considered while developing more than one forecasting scenario such as -

a) Business As Usual (BAU) Scenario – Normal weather conditions (weather parameters need not required to be factored in separately).
b) Optimistic scenarios - factoring extreme weather conditions driving power demand upwards such as lesser rainfall.
c) Pessimistic scenarios - factoring extreme weather conditions driving power demand downwards such as heavy rainfall.

More such scenarios could also be built up considering different permutations and combinations of extreme (favourable or harsh) weather conditions. Some typical such scenarios could be – (i) extreme hot temperature scenario only (ii) extreme cold temperature scenario only (iii) higher rainfall scenario only (iv) lesser rainfall scenario only (v) extreme hot temperature and lesser rainfall scenario.

The weather conditions could be analysed on two main parameters viz. Temperature and Rainfall. The extreme condition of weather in terms of temperature could be analysed with Heating Degree Day (HDD) & Cooling Degree Day (CDD)[2] approach as explained below:

i. Yearly HDD_Y/CDD_Y represents the number of days in a year on which the temperature is respectively below/above the threshold cooling /heating point and by how many degrees. The threshold is a point over or under which the heating or cooling appliances are expected to be switched on. HDD, CDD and threshold points are all measured in degree Celsius.

ii. Yearly HDDs/CDDs figures could be arrived at by analysing CDD for each day of summer season and HDD for each day of winter season by using the following formulae:

---

[2] The Heating Hour Day & Cooling Hour Day approach may also be adopted in place of HDD/CDD on similar lines if such granular level data is available.

HDD = Max (0, T – T)*
CDD = Max (0, T – T)*

Where,

T = Threshold Temperature of cold and heat. As it could vary from place to place, its appropriate value as per specific geographical areas should be ascertained. Also, different values for threshold temperatures for HDD & CDD may be considered as per applicability. The threshold temperature for India was assumed 21°C during 19th EPS based on literature review.*

T = Average Temperature Observed during the day.

Note – Based on the climatic conditions of a specific geographical region, only one of dominant parameters (HDDs or CDDs) could also be analysed leaving out the other non-applicable parameter. For example, power demand is more dependent on CDDs in most parts of India except for the hilly regions where HDD plays a major role.

iii. HDD and CDD values of each day could be further summed up to arrive at yearly HDD & CDD values respectively.

$HDD_Y = \sum HDD$
$CDD_Y = \sum CDD$

iv. The extreme weather year could be identified as:

a. Year with extreme unfavourable weather conditions = Year with maximum values of HDD_Y & CDD_Y.
b. Year with extreme favourable weather conditions = Year with minimum values of HDD_Y & CDD_Y.

Once the extreme weather condition year is identified, the power demand scenario of that particular year may serve as the reference to estimate impact on power demand. The simplest way may be to estimate % deviation of the notional demand (i.e. demand estimated under normal weather conditions) from the actual demand observed during the year and apply this % deviation on the Business As Usual energy requirement forecast to arrive at corresponding weather dependent power demand scenarios. An alternate way could be to set up an appropriate equation considering energy requirement as a dependent variable and various weather parameters (i.e. HDD, CDD, Rainfall, Humidity etc.) as independent variables using statistical tools and then arriving at energy requirement in future under various extreme weather scenarios.

Similar approach could also be adopted to identify other extreme weather conditions (highest and lowest rainfall years) and to assess their impact on power demand. Also, the approach discussed above, although, is for estimating forecasts on yearly basis, the same could be extended at more granular level to analyse the month/day wise impact.

Annexure-VI

Electric Vehicle – Impact on Power Demand

The assumptions and the methodologies adopted for assessing impact of electric vehicles on all India power demand during 20th EPS were as follows:

Assumptions:

i. Weighted Average annual growth of vehicles sold for last 20 years (i.e. 2001-02 to 2020-21) was calculated as 5% and the same growth rate was assumed for future.
ii. Any vehicle sold would be de-registered after 15 years.
iii. By 2030, 30% of total vehicle sales would be BEVs as per the projection made by NITI Aayog.
iv. The vehicles considered in two segments with the following parameters:

Type	Efficiency (in Wh/km)	Avg Km Travel in a Year	Charging Time (in Hrs)	Ratio of Vehicle charged in Night
2 Wheeler	33	12800	4	0.3
4 Wheeler	96.8	12000	8	0.7

Methodology:

i. The total vehicle sales (including EV sales) in 2021-22 were estimated as 1.95 crores.
ii. The total vehicle sale by 2029-30 was estimated by applying 5% annual growth rate on 1.95 crores vehicles sold during 2021-22 and it was assumed that 30% of those would be EVs.
iii. The base value of electric vehicles sold was assumed as total number of registered EVs estimated by 2021-22 i.e. 10.5 lakhs.
iv. Based on the above assumptions, CAGR for EV sales was calculated for the period of 2021-22 to 2029-30.
v. Based on CAGR thus calculated, year wise expected EV sales were estimated for the period of 2021-22 to 2029-30.
vi. Energy Requirement is calculated as (Total number of vehicles on road*Efficiency * Average Km Travel in a Year).
vii. Peak Demand in MW is calculated as ((Energy Requirement in MU * 1000)/ (Charging Time*365)).

Based on the above assumptions and the methodologies adopted, the following results have been obtained:

- For FY 2029-30 -
  - BEV sale – 71 lakhs.
  - Total BEV on Road – 2.9 crores.
  - EV share out of all vehicles – 8.7% of all vehicles.
  - Energy Requirement – 15 BU.
  - Peak Demand - 3 GW.

The following methodologies were adopted for apportioning All India energy requirement to the States & DISCOMs on account of EVs:

i. The additional energy requirement was apportioned among various states in the ratio of number of vehicles registered in 2018-19.

ii. It is assumed that the additional energy requirement would be incident on two categories viz. Domestic and Commercial, in the ratio of 70:30.

iii. The additional energy requirement for a state was apportioned among various DISCOMs as –

   a. For each DISCOM, the ratio of their total energy requirement for domestic and commercial categories out of state's total energy requirement for domestic and commercial categories was calculated.

   b. EV Energy requirement of the state was distributed among DISCOMs in their respective ratio of total energy requirement for domestic and commercial categories.

   c. Then, EV Energy requirement of a DISCOM was distributed into domestic and commercial categories in the ratio of 70:30.

****

योजना स्कंध

Planning Wing

विद्युत शक्ति सर्वेक्षण और भार पूर्वानुमान प्रभाग

Power Survey & Load Forecasting