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.

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 *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 *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.

H. General Checks & Balances

i. 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.

ii. 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.

iii. 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

iv. 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.

v. 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.

vi. 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).

vii. 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.

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Annexure-I

Input Data Format

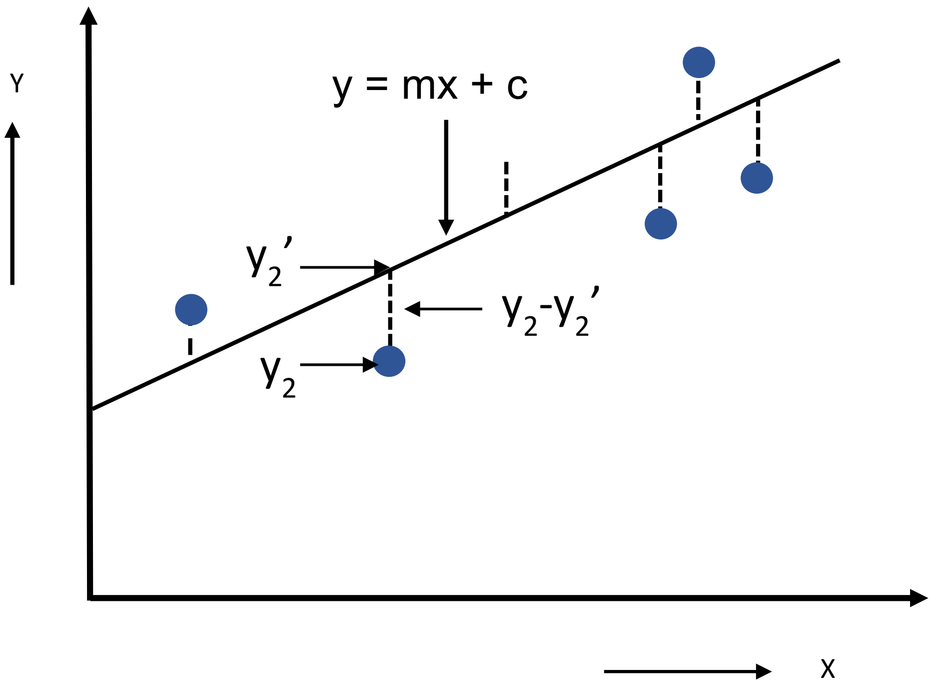
	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Energy Consumption (in MU)											
1. Domestic											
2. Commercial											
3. Public lighting											
4. Public Water Works											
5. Irrigation											
6. LT Industries											
7. HT Industries											
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-II

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								

Selection of the method – A hybrid approach:

1. If minor difference is observed in the two aforementioned growth rates for any category of data, the growth rate arrived through least square method should be considered as the future growth rate.
2. In case of appreciable deviations between the two growth rates, causes of deviations in the later year's data should be examined thoroughly.
3. If deviation between the two growth rates is driven by sudden policy/developmental changes (ex – Metro rail) or technological changes (ex. LED in public lighting) in the later years, then also, the future growth rates should be taken as the growth rate arrived through least square method.
4. If causes of deviation between the two growth rates are not identifiable or it appears that such deviation is occurring due to natural development, then the future growth rates should be taken as per the growth rate arrived through the weighted average method.

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Annexure-III

Parameters need to be considered for the different forecasting scenarios:

Parameters	**Optimistic Scenario**	**Business As Usual Scenario**	**Pessimistic Scenario**
Partial End Use Method:			
Government Targets	Full Achievement	Realistic Assessment	Pessimistic Assessment
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
Additional Parameter for Econometric Method:			
Gross Domestic Product (GDP)/Gross State Domestic Product (GSDP)	Maximum GDP/GSDP growth projected by reputed agencies such as Reserve Bank of India.	Average GDP/GSDP growth in the past.	Minimum GDP/GSDP growth projected by reputed agencies such as Reserve Bank of India.

Annexure-IV

Impact of Weather Conditions on Power Demand Forecast

The electricity demand is dependent on weather conditions also. In the traditional Partial End Use Method (PEUM), weather parameters are not considered separately as such factors are assumed inherent in the time series past energy consumption data. However, weather parameters could be considered separately 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.

Note – More 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 degree day approach as explained below:

i. Yearly HDDs/CDDs represent 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:

HDD_d = Heating Degree Day = Max (0, T – T)*
CDD_d = Cooling Degree Day Max (0, Tt – 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. 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 the most parts of India except for the hilly regions where HDD plays the major role.

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

$HDD_Y = \sum HDD_d$
$CDD_Y = \sum CDD_d$

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.

v. Once the extreme weather condition year is identified, impact on Power Demand is estimated as:

a. The normal growth rate till the extreme year is calculated and it is applied to the immediate last year data to arrive at notional energy demand during the extreme weather year. This could be the demand likely to be observed in absence of extreme weather conditions in that particular year.

b. The impact of extreme weather conditions on power demand is estimated by calculating % deviation of the notional demand from the actual demand observed during the year.

c. This % deviation is then applied on the Business As Usual energy requirement forecast to arrive at optimistic and pessimistic scenarios.

Similar approach could 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 approach could also be extended at more granular level to analyse the month/day wise impact.

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Annexure-V

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.

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