COMPUTATION OF POWER FOR A NEW CITY

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Abstract— This paper describes the Electrical Power Computation of a new city. A model for Computation of power demand has been presented here based on the available data of average power consumption or demand of various categories of consumers at already existing city. The area under study is Dholera located in Gujarat, India. The load demand has been calculated based on the type of various categories of load divided as per the town planning scheme of the city considering the load factor and diversity factor. Also, Weighted Arithmetic Mean (WAM) methodology has been incorporated in the calculations for the power computation of mixed plots. Based on this model, the power demand of TP2E of Dholera city would be 960.77MVA which would be supplied with a 400kVMRSS and three 220kV Substations through H.T cables.

Index Terms— Diversity factor, Dholera (TP2E), Load Prediction, Load demand, Load Factor, Power computation, WAM (Weighted Arithmetic Mean).

I. INTRODUCTION

Electrical Load Prediction is the estimation for future load by an electrical utility. Prediction of load is an important and central process in the planning of transmission and distribution system. Load forecasting is vitally important for the electric utilities in the deregulated economy. It involves the accurate prediction of both the magnitudes and geographical locations of electric load over the different periods of the planning time [1]. Accurate power demand prediction holds a great saving potential for electric utility corporations. The accuracy of load prediction has a significant effect on power system operations, as economy of operations and control of power systems may be quite sensitive to errors due to load prediction. The present scenario of various cities power demand is raising an alarming issue. The inaccurate load prediction is leading to many problems [2]. Some of them are:

- Overloading
- Instability in the system
- Power cuts and power shortage
- Power theft
- High dependency on Conventional sources of Energy
- Increased amount of CO2 in the atmosphere due to losses in distribution system
- Poor reliability and safety issues

These are just few to be listed out. All these result in load shedding and blackouts. So there is need of proper estimation of load demand so that even if the demand increases in the nearby future the city doesn't fail to supply the same or cope up with it.

II. STUDY AREA

The study area is a part of Dholera Special Investment Region (DSIR) which will be a new Industrial hub located around 100km south of Ahmedabad and around 130km from Gandhinagar. The DSIR covers an area of about

920sq.km.and contains 19 villages of Dhandhuka Taluka and 3 villages of 3 Barwala Taluka; total 22 villages of Ahmedabad district, making it the largest investment nodes proposed so far in the Delhi-Mumbai Industrial Corridor (DMIC) influential area. The site is strategically situated between the main industrial centres of Surat, Vadodara, Ahmedabad, Bhavnagar and Rajkot. It is linked to the major ports of Gujarat by State Highways but yet has no direct rail connection [12].

The study area of this project, however, is Town Planning 2East [TP2E]. The figure shows the area of TP2E. It covers an area of about 57sq.km.

Fig.1 TP2E Area (Study area)

Now Dholera is being named under the "Smart City" of India. So it will require bulk amount of power for its infrastructure and development. So load prediction for this city needs to be computed considering the increase in power demand in the nearby future with all the smart technologies and smart appliances being used. Thus a proper system for power computation is required for such a city that not only fulfils the present power demand but also of future thus taking a sustainable development approach.

Thus, the main objective of the paper is to compute the load demand or do the load forecasting of the city in a way that it not only meets the present demand of the system but also its future demand without compromising the needs of future expansion. The system designed on such a basis will be reliable and healthy so that during any contingency it will be able to supply the same required power without any failure.

III. POWER COMPUTATION

A. Various categories of plots as per usage according to the town planning

The town planning map provides clues to the establishments which are planned in a given area. The total plots involved in TP2E are classified in various categories [12]:

- Residential
- High Access Corridor
- Industrial
- Recreation, Sports and entertainment.
- Strategic Infrastructure
- Roads
- Public Facility Zone
- Tourism and Resorts
- Village Buffer
- Original Village (Gamtal)
- River/Water Body
- Coastal Region Zone

Again, as these individual categories have mixed type of usage (i.e. total area of every type of plot is subdivided under different land use) defined as under.

Residential

Residential plots consist of Residential, Commercial office/Retail, Leisure and hospitality, Public/Community facility, Local Public open space, local roads, utilities and Information Communication Technology Devices usage.

High Access Corridor

High Access corridor plots consist of Residential, Commercial office/Retail, Leisure and hospitality, Public/Community facility, Local Public open space, local roads, utilities and Information Communication Technology Devices usage.

Industrial

Total Industrial plots are primarily divided into actual industry type as per Development Plan (DP) report [12]. The bifurcation is as follows.

Table I Different types of industries considered in industrial load prediction

Sr.no.	Types of Industries	% of plot
1	General manufacturing	5.37
2	Electronics	16.59
3	Automobile	24.27
4	Agro & Food processing	4.15
5	Heavy Engineering	27.44
6	Metal & Metallurgical Products	5.85
7	Pharmaceutical & Biotechnology	13.66
8	Logistics	2.67

Again, industrial plots consist of Industrial, Public/Community facility, Local Public open space, local roads and Information Communication Technologies Devices usage.

Recreation, Sports and Entertainment

Recreation Sports and Entertainment plots consist of Leisure and hospitality, Local Public open space, Recreation Sports & Entertainment, local roads, Utilities and Information Communication Technology Devices usage.

Strategic Infrastructure

Strategic Infrastructure plots consist of residential, commercial office/Retail, Industry, Leisure and hospitality, Public/Community facility, Recreation Sports and Entertainment, Utilities and Information Communication Technology Devices usage.

Roads

Roads consist of Residential, Commercial offices/Retails, Leisure and hospitality, Public/ Community facilities, Local Public open space, local roads, Utilities and Information Communication Technology Devices usage.

As per the categories of usages or plots, the power consumption for different purposes like lightning load, power load, workstation load, HVAC load, lifts load and load for common area/parking are calculated. The power consumption for different usage is then calculated using individual load factor for each type of usage [3]-[17]. The data used here is of Vadodara city using the confidential data collected from various places and MGVCL (Madhya Gujarat Vij. Company Limited).

Table II- Load demand of various categories of load considering load factor

Type of usage	Power consumption (watt/sq.m)
Residential	46.10
Commercial Offices/Retail	124.80
Leisure/Hospitality	83.80
Light Service Industry	31.40
Industry	151.90
Education	50.00
Public Facility/ Community Facility	20.00
Local Public Open Space	3.00
Recreation Sports & Entertainment	40.30
Roads	2.00
Utilities	2.00

IV. COMPUTATION OF POWER FOR MIXED PLOTS

Next step was calculation of power consumption of mixed plots. Mixed plot means an area covered by two or more types of plots. For example a plot shared by residential as well as public facility zone is computed under mixed plot. The percentage of mixed plotting is as per the town planning scheme.

Built up area (BUA) of each plot was calculated baesd on the town planning scheme and same is calculated based on Floor Space Index (FSI) norms. It is uncertain that particular plot will be dedicated for the specific purpose at the stage of load forecasting. Hence, it is difficult to calculate the Wattage per square meter based

on specific use of individual plot. It is better to calculate the Wattage per Square meter on the basis of mixed plot usage and same can be arrived by working a methodology of Weighted Arithmetic Mean. The method used here is Weighted Arithmetic Mean (WAM).For example assume a Residential zone which is allotted for 54% residential, 2% commercial offices, 1 % leisure & hospitality, 10% community, 10% local public open space, 22% local roads, 1% utilities. Let the total sq.m area under residential be denoted by "Y".

Uniform Watt/sq.m by means of Weighted Arithmetic Mean (WAM) =

(54%*Y*46.1+2%*Y*124.8+1%*Y*83.8+ 10%*Y*20+10%*Y*2+22%*Y*2+1%*Y*2)/Y

Same way the power consumption for every other plot is calculated and has been summarized in the table below

Table III Load demand after considering mixed type of plots

Type of usage	Power demand (watt/sq.m.)
Residential	30.89
High access corridor	32.75
Industrial	120.96
Recreation Sports and Entertainment	43.13
Strategic Infrastructure	32.95
Roads	2.00
Public facility zone	26.68
Tourism & resorts	58.27
Village buffer	26.45
Gamtal	46.10
River / water body	2.00
Coastal region zone	0.16

DIVERSITY FACTOR

The power consumption varies at day and night time. It depends on the type of usage system and the amount of power consumed. For example, a public facility area may need power from morning till evening whereas an industry will need power for the whole day round. For this purpose, diversity factor was used to calculate the total power consumption of the whole area. The Power consumption was calculated as:

$$\text{Total Power Demand (MW)} = \frac{\text{Diversity Factor} \times \text{Power Demand obtained from mixed plots}}{\text{Total area covered by that usage} \times \text{land use factor}}$$

Thus the total power consumption of TP2E considering the diversity factor is as shown in the Table 5 below.

Table IV Total Power Consumption without Considering Diversity Factor

Areas	Power Demand (MW)
Residential Zone	86.92
High Access Corridor	6.13
Industrial Zone	293.61
Recreation, Sports & Entertainment	200.91
Strategic Infrastructure	1.32
Public facility zone	2.82
Tourism & Resorts	115.81
Village buffer	9.31
River / Water Body	0.30
Coastal Region Zone	0.25
Total Wattage (MW)	717.38
METRO Rail & Other Miscellaneous Power Consumption (MW)	25.00

V. TOTAL POWER DEMAND USING

Table 5 Total load demand of TP2E after considering diversity factor

12 -- 8	8 -- 11	11 -- 6	6 -- 12	12 -- 8	8 -- 11	11 -- 6	6 – 12
Group Diversity Factor Considered				**Demand After Considering Group Diversity Factor**			
0.6	0.8	0.7	0.8	52.15	69.54	60.84	69.54
0.5	0.6	0.6	0.8	3.06	3.68	3.68	4.90
0.5	0.9	0.9	0.6	146.80	264.25	264.25	176.17
0.2	0.6	0.4	0.8	40.18	120.55	80.37	160.73
0.6	0.8	0.8	0.6	0.08	0.11	0.11	0.08
0.2	0.9	0.9	0.6	0.56	2.54	2.54	1.69
0.3	0.9	0.4	0.8	34.74	104.23	46.33	92.65
0.3	0.5	0.6	0.5	2.79	4.66	5.59	4.66
0.6	0.4	0.4	0.6	0.18	0.12	0.12	0.18
0.8	0.6	0.6	0.9	0.20	0.15	0.15	0.22
Tota l				280.76	569.81	463.96	510.82

Thus, the total maximum demand after considering diversity factor is 569.81 or 570MW.

The total load demand in MVA considering 0.85 power factor and taking load 10% higher than of that of actual (742.38MW) is computed as **960.77MVA**

VI. DISTRIBUTION PLANNING AS PER THE LOAD DEMAND

So according to the calculated load demand, a 400kV Main Receiving Substation (MRSS) will be required. As per the load demand and the major roads connecting the various plots, the whole area has been divided into clusters. There were 24 clusters that were formed as per the major roads connecting the plots.

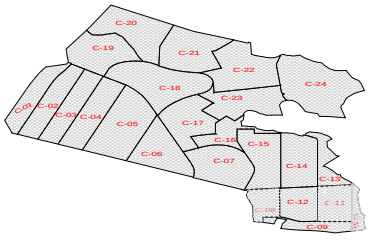

Fig.2 Cluster distribution of TP2E

The power consumption of each cluster is as shown below:

Table VI Power Consumption of Various Clusters

Cluster number	Power consumption in MVA (@ 10% rise)
1	48.418
2	61.78
3	36.27
4	68.78
5	111.21
6	61.99
7	44.52
8	16.31
9	12.17
10	6.01
11	24.19
12	25.19
13	11.65
14	34.79
15	37.12
16	12.73
17	30.29
18	60.24
19	18.15
20	25.09
21	27.06
22	47.62
23	38.07
24	68.88
25 (Metro)	32.35

Total	**960.77**

The power computation of each cluster has been done and these clusters were merged to form zones. Each zone will be requiring 220/66kV substation. Cable lines will be required to supply the same power through 400/220/66/11kV substation.

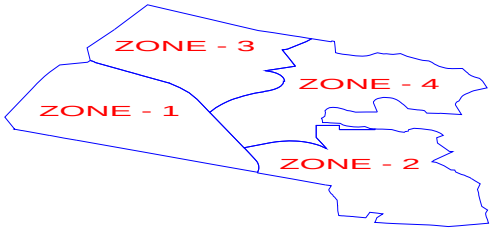

Fig.3 Zone distribution after merging various clusters

Table VII Zone Wise Power Consumption

Zone number	Power consumption in MVA (@ 10% rise)
1	388.25
2	212
3	130.56
4	197.61
Total	(928.41+32.35)=**960.77**

All the 220/66kV substations will be interconnected to form a Ring Main. The industrial load will be fed through 66/11kV feeders depending upon the predicted load of the plots.

VII. CONCLUSIONS

It is concluded that based on demand supply matrix of various categories of consumers in existing cities, the comprehensive planning of power infrastructure for a new upcoming city may be computed. A model for such computation for upcoming city at Dholera is presented. The load demand has been computed taking ten percent higher margin as it would be prudent keeping in view of increase in future demand. Based on this model, the power demand of TP2E of Dholera city would be 960.77MVA which would be supplied with a 400kVMRSS and three 220kV Substations through H.T cables.

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