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Geeta Laxmanrao Kale
Department of Energy Technology, Shivaji University, Kolhapur, geetakale6000@gmail.com

N.N. Shinde
Department of Energy Technology,Shivaji University, Kolhapur., energyunishivaji@gmail.com

Modelling District Energy Distribution System For Least Load Shedding

[1]Geeta.Laxmanrao.Kale, [2]N.N.Shinde
Department of Energy Technology
– Shivaji University, Kolhapur. –
E-mail : geetakale6000@gmail.com,energyunishivaji@gmail.com

ABSTRACT : ***The secondary energy consumption is forurban & rural sectors. The electricity generated at power plants at 11KV is transmitted & distributed to end utilities through 11/220, 220/110/33, 110/33, 33/11 transformers. In urban areas the major district energy distribution is planned by on demand through LT, HT distribution system. On an average LT HT consumer is further classified as Residential, Commercial, Industrial, & Agricultural/ others having consumptions of 25% , 13%, 53%, & 9% respectively. In urban areas the micro level preliminary studies shows that Agricultural (1%), Street light (2%) Water works 4%, Shopping malls / Advertising /Temporary supply etc. (2%), cumulatively contributes 9% energy consumptions.***

Due to deficiencies in energy supply side management demand is not met & load shedding & equivalent measures are taken. A case study for local energy distribution company urban division was taken & evaluated for shortfall in Electrical energy supply. A mathematical model is developed taking into consideration the objectives like least load shedding, supply & demand side management,& was analyzed for consumption patterns in end utilities & was optimized for decision making . The model helps to forecast demand side load management system including growth rate analysis.

Keywords:-
District energy distributed system, Energy modeling, demand side management, multi objective modeling, and linear regression in energy modeling.

1. Introduction:-

The electrical energy produced at the generating station is conveyed to the consumers through a network of transmission and distribution systems. In general, distribution system is that part of power system which distributes power to the consumers for utilization.

Generation Planning, Transmission Planning, System Expansion, Installation, Operation Control and Maintenance of Electrical Energy Systems, Fault Calculations, Network Calculations, Load Flow Studies have become very essential functions. Electrical Energy management System ensures supply of energy to every consumer at all times at rated voltage, rated frequency and specified wave form, at lowest cost and with minimum environmental degradation.

The secondary energy consumption is for urban & rural sectors. The electricity generated at power plants at 11KV is transmitted & distributed to end utilities through 11/220, 220/110/33, 110/33, 33/11KV transformers. In urban areas the major district energy distribution is planned by on demand through LT, HT distribution system. On an average LT HT consumer is further classified as Residential, Commercial, Industrial, & Agricultural / others having consumptions of 25%, 13%, 52%, & 10% respectively. In urban areas the micro level preliminary studies shows that Agricultural (2%), Street light (2%) Water works 4%, Shopping malls /Advertising / Temporary supply etc. (2%), cumulatively contributes 10% energy consumptions. Due to deficiencies in energy supply side management demand is not met & load shedding & equivalent measures are taken. A case study for, Urban division Kolhapur was taken & evaluated for shortfall in Electrical energy supply. A mathematical model is developed taking into consideration the objectives like least Load shedding, supply & demand side management, & was analyzed for consumption patterns in end utilities & was optimized for decision making. The model helps to forecast demand side load management system including growth rate analysis.
This division started functioning with 20,000 numbers of consumers way back in the year 1966 and presently it is looking after 1,43,589 numbers of consumers of various categories, spread over 150 Sq.Kms.

2. Body of Paper:-

STRUCTURE OF ELECTRIC POWER SYSTEM:-

The function of an electric power system is to connect the power station to the consumer's loads by means of interconnected system of transmission and distribution networks. Therefore, an electric power system consists of three principal components: the power station, the transmission lines and distribution systems. The transmission lines are

the connecting link between the power station and the distribution systems. A distribution system all the individual loads in a given locality to the transmission lines and

In practice, the following distribution circuits are generally used:

Radial System: - In this system, separate feeders from single substation and feed the distributors at one end only.

Ring main system: - In this system, the primaries of distribution transformers form a loop. The loop circuit starts from the substation bus-bars, makes a loop through the area to be served, and returns to the substation.

Interconnected system: - When the feeder ring is energized by two or more than two generating stations or substations, it is called inter-connected system.

Fig:1.1 - geographical map of Kolhapur District.

At present 12 Nos.of Taluka along with 1214 Nos.of villages are in Kolhapur District. There are total 767267 HT & LT consumers Under Kolhapur circle, Kolhapur. There are total 80 numbers of 33/11 KV Sub-Stations and 16 numbers of EHV substations under Kolhapur circle, Kolhapur. There are 10668 Nos. of distribution transformers of 11/0.4 KV feeding the Secondary distribution system.

The Urban Division Kolhapur is getting supply on 11 KV level from 13 numbers of 33/11 KV Sub-Stations and two numbers of 110/33/11 KV EHV substations. There are 1282 Nos. of distribution transformers of 11/0.4 KV feeding the Secondary distribution system. Secondary Distribution System is 0.4 KV with 3 Phase 5 Wire and 0.220 KV 1 Phase 2 Wire.[5]

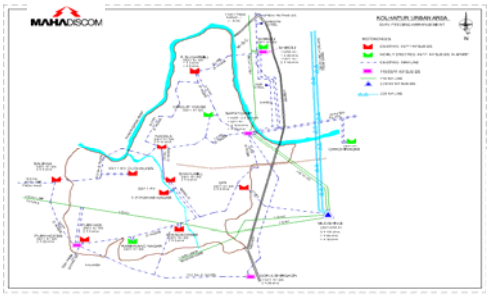
ENERGY DISTRIBUTION- KOLHAPUR

KOLHAPUR CITY HISTORY:-

The city is situated geographically on the Ghatmatha of Sahyadri Mountains and climatic condition of this city in summer 30^0 C. to 40^0 C, in winter $l3^0$ C. to 25^0 C. the average rainfall is about 900 to 1000 mm. The total area covered by the city connects

is 150 Sq. Kms. Kolhapur is now growing industrially. Numbers of Industries are being established and industrialists prefer Kolhapur for starting their new industries. There are 3 Number of MIDCs in Kolhapur i.e. MIDC, Shiroli, MIDC Gokulshirgaon and 5 Star MIDC at Kagal. The new Companies like Raymond's, Indocount, Bharat Forge, Karera Group are coming up. Menon and Menon, Kolhapur Steel are established nearby Kolhapur which has substantially increased the potential of the residential as well as commercial business of the city. [9]

The Road, Rail and Air transportation is available and communication network is also established in the city with National grid. A new IT park is established in the city recently. The IT industries are also coming up during recent days.



The maximum demand registered in the month of April-2009 is to the tune of 103 MW.

Fig: 1.2- The Network of Extra high voltage and minor 33/11KV sub-stations under Urban division, Kolhapur.[5]

The electrical distribution network catering the power supply to the area consists of 13 numbers of 33/11 KV Sub Stations fed from 220/110/33 KV Kolhapur-II S/Stn. Gadmudshingi, 110/33/11 KV Bapat Camp S/Stn., 110/33/11 KV Shiroli S/Stn., 110/33 KV Puikhadi S/Stn.and 110/33KV Gokulshirgaon S/Stn..Total maximum power demand of this urban division Kolhapur on the

above EHV Sub Stations is over the order of 100 MW at present.

At present five numbers of Sub-divisions along with 25 numbers of Section offices are functioning under Urban Division, Kolhapur. The area of five Sub-divisions are shown in Fig. and The Minor Substations 33/11 KV under jurisdiction of five sub-divisions are interconnected as shown in Fig 1.2

Administrative System:-
Urban Division, Kolhapur is part of Kolhapur Circle. At present 5 Nos. of Sub-divisions along with 25 Nos. of Section offices are functioning under Urban Division, Kolhapur.

The area around Kolhapur city is developing at a very fast rate and the power demand is increasing day by day. Due to the boom in industries the requirement of power in MIDC Shiroli has increased tremendously and so also due to the high growth rate of the commercial complexes, apartments, buildings, shops are increasing at a very fast rate. The power demand of Kolhapur City is increasing every year and in order to cope up with this demand new 33/11 KV S/Stn are proposed under five year infrastructure plan.

Importance of Load Shedding
The demand of the electric supply is increasing day by day in the jurisdiction of Maharashtra State Electricity Distribution Co.Ltd. There is great difference between electric supply and the actual demand. The difference is up to 4500MW. In the month August 2009, the demand of power was above 13000 MW where as the supply was up to 8500MW only..

The demand of power is increasing day by day due to urbanization, Growth in industrial sector & electrification in rural areas. If we purchase the power from other states or from any other Generation company in the state the rate is not affordable. The rates for purchase of power are on higher side. Due to this there is limitation in purchase of power. There is also limitation for transmission of power from one state to other state. It is also to state here that as per Indian Electricity should be of correct Voltage & correct frequency. In case if the Generation is less and demand from consumers is high then the frequency dips down may cause failure of Generators and may damage entire power grid of the state.

In order to avoid failure of Extra High Voltage (EHV) Grid system and in order to protect the Generating Sets of Generating Stations. The demand of power cut off by means of load shedding i.e. the load of the consumer is cut off.

DATA COLLECTION AND ANALYSIS OF KOLHAPUR DISTRICT ENERGY DISTRIBUTION SYSTEM (URBAN)

Table1.1–CATEGORY-WISENUMBEROF CONSUMERSASONMARCH-2009 [5]

SR. NO.	CATEGORY	NUMBER OF CONSUMERS
1	RESIDENTIAL	115132
2	COMMERCIAL	23416
3	INDUSTRIAL	3646
4	AGRICULTURAL	1109
5	OTHER	286
	TOTAL	143589

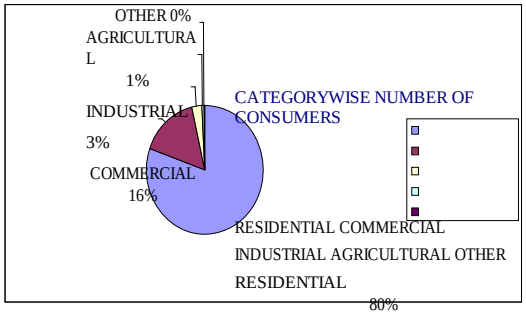


Fig 1.3:- Category wise number of consumers under Urban Division, Kolhapur.[5]
The above graph shows category wise number of consumers under Urban Division, Kolhapur. Out of Total number of consumers 80% consumers are residential,16% consumers are commercial and only 3% consumers are Industrial.

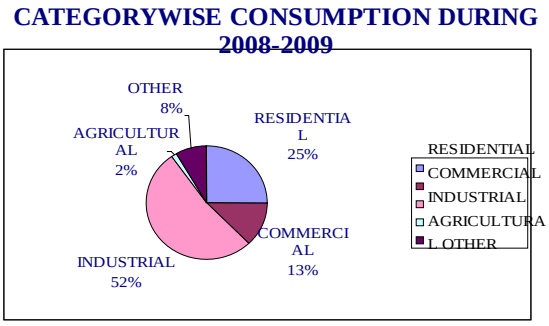


Fig1.4:- Category wise consumption during 2008-2009 under Urban Division, Kolhapur.[5]
Here, Billing to LT consumers is done at Sub-division level. For HT consumers billing is done

centrally at Circle office, Kolhapur. Out of total consumption 52% Industrial consumption but total number industrial consumers are only 3%. Similarly Residential consumption is 25% and Commercial consumption is 13%.

ENERGY EFFICIENCY IN DISTRIBUTION SYSTEM

ADMINISTRATION –POLICIES

As per Circular No. 28 dated 20.08.2009 further following guidelines are considered while preparing division wise load shedding plan (as per MERC directives):

The local distribution co is also trying to manage the demand through Demand Side Management Measures e.g.

- Ø Akshya Prakash Yojana
- Ø Voluntary Load Reduction Scheme in Small Cities
- Ø Single Phase Supply in Goathans Voluntary Load Reduction Scheme in Small Cities
- Ø Scheme of Separate Feeders for Goathans
- Ø Increased availability of power in 6 to 12 months
- Ø Other DSM Measures
- Ø Purchase of Expensive Power from Outside the State
- Ø Theft Reduction Drive.[6]

NEEDFORMODELINGFORLEASTLOAD SHEDDINGANDRESCHEDULING

Energy is vital to the delivery of urban services and its role can be considered at many stages in the Urban energy design process. This begins with the planning, optimization of different available energy sources, energy conversion technologies, environmental aspects and economy. Therefore it is necessary to develop energy modeling.

The Energy planning Model aids in the process of load estimation, load forecasting, identifying the energy mix and cost benefit analysis which are the major steps in the energy planning. Load estimation and load forecasting which are vital for the energy planning, are carried out with the help of modified end use forecasting method using primary data available from a detailed energy survey at the Urban level.[6],[7],[8].

DISTRICTENERGY:-

District energy systems provide heating, hot water, cooling and electricity to two or more buildings. They include the energy conversion technologies together with the distribution networks. District energy plants are usually located in large urban areas and supply downtown customers. District energy systems produce steam, hot water or chilled water at a central plant and then pipe that energy out to buildings in the district for space heating, domestic hot water heating and air conditioning. Individual buildings do not need their own boilers or furnaces, chillers or air conditioners.

BENEFITSOFDISTRICTENERGYSYSTEM

Economic

- Reduces upfront capital costs because the equipment necessary to tie into the DES system costs less than stand-alone systems
- Lower overall building operating, maintenance, and labor costs
- Passes along economies of scale when purchasing fuel

Environmental

- A central plant serving multiple customers is more efficient than individual small plants, thereby reducing overall energy consumption
- Virtually 100% of the steam and chilled water energy delivered to the customer is available for use within his facility whereas smaller in-building boilers and air-cooled chiller systems can require up to
  50% more energy to deliver the same heating or cooling benefit
- Chilled water services from a central plant reduces peak electric power demand for air conditioning

Convenient

- Removes combustion and refrigerant equipment from buildings, saving space in the buildings for other uses

- Eliminates need for boilers and chillers resulting in less maintenance, monitoring and equipment permitting
- Energy professionals at central plants operate around the clock and have backup systems available, with reliability rates near 99.9 percent
- Building operators can manage and control their own indoor environments because district energy is available whenever heating or cooling is needed [2]

URBAN DIVISION, KOLHAPUR.

Table – Computation of Reliability Charges

No.	Particulars	Units	Amount		
			4 Hrs.	5 Hrs.	6 Hrs.
1	MW required	MW	20	20	20
2	Load shedding hours	hours	4	5	6
3	Proportion of effective Load Shedding hours	%	70%	70%	70%
4	Effective Load Shedding hours	hours	2.8	3.5	4.2
5	MWh required per day to mitigate load shedding	MWh	56	70	84
6	MWh required per month to mitigate load shedding	MWh	1680	2100	2520
7	MWh required per year to mitigate load shedding	MWh	20440	25550	30660
8	Additional MU required per year	MU	20.44	25.55	30.66
9	MU required to be purchased considering distribution loss of 7.67 % and intra-State transmission loss of 4.85%	MU	23.27	29.08	34.90
10	Unit rate for purchase of electricity	Rs/k.Wh	10.0	10.0	10.0
11	Expenditure on additional power purchase	Rs Cr	23.27	29.08	34.90
12	Additional Sales	MU	20.44	25.55	30.66
13	Total actual MU billed in Kolhapur town	MU	445.20	445.20	445.20
14	Total actual sales considering 1 yr. CAGR @ 6.31%	MU	473.47	473.47	473.47
15	Average Billing rate	Rs/k.Wh	4.20	4.20	4.20
16	Total revised sales, including additional sales	MU	493.91	499.02	504.13
17	Revenue earned through additional sales	Rs Cr	8.585	10.781	12.977
18	Additional expenditure for power purchase	Rs Cr	14.682	18.352	22.022
19	Sales to domestic consumers < 300 units per month and AG assessed units per month	MU	99.84	99.84	99.84
20	Balance MU	MU	394.07	399.18	404.29
21	Reliability Charges	Rs/kWh	0.37	0.45	0.54

Conclusion:

The district energy system presently though based on demand, supply side and demand side management. It is observed that both are weak in view of energy management and its monitoring. The case study for Kolhapur district suggest that electricity generate at power plants at 11KV is transmitted and distributed to end utilities through 11/220, 220/110/33, 110/33, 33/11 KV transformers. This district energy distribution is planned by LT, HT distribution system. Through a vigorous data collected for last one year, It is observed that LT,HT consumers namely Residential, Commercial, Industrial, and The overall observations shows that each zone further requires microanalysis considering thermodynamics, available technologies for integration, locations, levels, type of building and the multiscales of cooling , heating etc. Development of mathematical model considering all design aspects and unsolved environment aspects and the economics is a very complex process, which may take time. The present need is to match demand side and supply side management to avoid load shedding. Therefore short term a mathematical model is suggested for least load shedding based on social and economical consideration. This also have its pros and cons however corresponding approvals on supply and demand side management are must. The scheduling of approvals as to match with schedule load shedding is challenging and times only decide its usefulness.

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