

# ENERGY AUDIT

## A TOOL OF ENERGY VIGILANCE FOR BETTER TOMMOROW

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*Abstract - Electrical Energy continues to be the most vital factor for the sustenance of human life and enrichment of its quality. The demand of electricity is ever increasing day-by-day. Similarly, the cost of electricity generation is rising with the increase in the cost of fuel, etc. In the present era of financial constraints, the Energy Audit has become must. Energy Audit is the most effective tool, which provides the balance between energy supplied, and energy billed.*

*This paper discusses the significance of the utilization of electrical energy by various types of consumers and stresses how the energy audit is necessary for a better future.*

### I. INTRODUCTION

Today electricity is one of the most convenient forms of energy gifted to mankind. Power sector is considered to be a very important and priority sector as it leads to overall development of the country. In past twenty years there has been an annual growth for Maharashtra in peak demand and energy consumption of about 7-10%. Large portion of our public resources are being spent on power sector on priority. Due to present financial constraints it is not possible to outlay more funds for energy generation by the State Electricity Board [1].

The Transmission and Distribution (T&D) losses in our country gradually increased to 21.4% in 1997-98. The rising trend of T&D losses is a matter of concern to the management of Electricity Boards. Energy Audit is the first step in identifying the areas of excessive losses and it also enables us to device measure to reduce these losses. The energy audit basically implies energy balance.

### II. NECESSITY OF ENERGY AUDIT

- ◆ The normal load growth all over the country has been 6 % to 8 % per year.
- ◆◆ The cost of installation of new generation is rising.
- ◆ The costs of fuels (Coal, oil, gas etc.) for generation are also rising.

◆ Huge investment is required for the installation/ construction of new sub-stations

◆ Increase in commercial losses i.e. thefts & pilferage

Energy Audit provides for means to identify the areas of leakages, wastage and inefficient energy usage. It is essentially a management tool and is applicable to industries (users) as well as Electricity Boards (utilities). It aims at accounting for energy generated and its consumption by various categories of consumer and the [2,3] energy required by system elements (losses). Energy Audit works in finding the balance:

$$\text{Energy Generated} = \text{Energy Used} + \text{Energy Lost.}$$

### III. TRANSMISSION AND DISTRIBUTION (T&D) LOSSES IN SYSTEM

In supplying electrical energy to the consumers, the energy losses are occurring on account of (i) Technical and (ii) commercial reasons [2,4].

The technical losses are due to :

- ◆ Inherent resistive properties of conductor and current passing through it.
- ◆ Inductive nature of Load ( Low power factor ).
- ◆ Poor Earthing in Transmission & Distribution Network.
- ◆ Negligence towards maintenance of Transmission & Distribution Elements.

The commercial (non-technical) losses in the system occur due to following reasons [1,2] :

- ◆ Improper functioning of energy meters.
- ◆ Meter reading errors.
- ◆ Un-metered connection on distribution network.
- ◆ High incidence of theft of energy, e.g. willful tampering of meters by consumers (i.e. pilferage).

Table 1

Sr.No.	Country	T&D losses
1	China	5.32%
2	Korea	5.87%
3	Thailand	6.90%
4	Pakistan	16.82%
5	India	21.40%

Compared to our neighboring countries, T&D losses are found to be maximum in our country as given in Table 1.

#### IV. ANALYSIS OF UTILIZATION OF ELECTRICAL ENERGY BY VARIOUS CONSUMERS

The (%) category wise consumer numbers, their connected loads in (%) of total loads, their consumption in (%) of total consumption are tabulated below in Table 2 for the system of Maharashtra State Electricity Board (MSEB) [1,2].

It is interesting to note that maximum number of consumers are in Domestic category, the maximum connected load is for the Agricultural consumers but maximum utilization is by the Industrial consumers.

#### V. CONSTRAINTS IN CARRYING OUT ENERGY AUDIT

There are following operating constraints for carrying out the energy audit program for T and D network:

- ◆ Inadequate accuracy of meters provided in Sub-Stations and at Consumer ends.
- ◆ Non-metering at certain class of consumers e.g.: agricultural, streetlights etc.
- ◆ Difficulty in arranging simultaneous meter readings at all EHV & HV Sub-Stations and at Consumer ends.
- ◆ Billing on average if consumer meters are not read or if meters are faulty.
- ◆ Non-availability of system data and standard computerised facilities for simulation of Energy Audit Program.
- ◆ Dynamically changing data.

Table 2

Sr. No.	Type of Consumer	% Con.	% CL. No.	% Ut.
1	Domestic	67.7	19.2	16.1
2	Commercial	9.8	4.1	6.4
3	Industrial	2.7	34.2	42.4
4	Agricultural	18.7	35.1	24.3
5	Others	1.1	7.4	10.8

Con. - Consumers  
CL - Connected Load  
Ut. - Utilization

#### VI. COMPUTER APPLICATIONS IN ENERGY AUDIT PROGRAM

There are 350 plus EHV and 1000 plus HV Sub-Stations in MSEB grid supplying about 1.2 crore consumers all over the state [5]. Considering the enormous data volume of the metering system, it is proposed to use computers at Circle level for Financial Energy Management System (FEMS) for Energy Audit Program. With computerisation, it is possible to have a good database for entire metering / billing information in the Circle[1]. Following are the salient features of this computerisation:

- ◆ The Energy Audit analysis has to be carried out section wise / feeder wise, Basic data viz. Distribution Transformers, the number of consumers with their types e.g. Domestic, Commercial, Industrial etc. on each feeder / section and their connected loads, energy billed information has to be stored in the data base as feeder / section specific information [2].
- ◆ The monthly Sub-Station meter readings, consumer readings, feeder wise Distribution Transformer (DT) failure data have to be fed to the computer.
- ◆ It is proposed to develop the software on open system concept using Unix operating system or other system conforming to international standards. The software should be totally user friendly and having interactive capabilities.

In fact, the database is an interface getting information from Sub-Station on one side and from billing section on the other side. Thus, the main purpose of energy audit is to bridge the gap between energy supplied & energy billed by minimising the losses [6].

The general flow chart for energy audit is shown in figure 1.

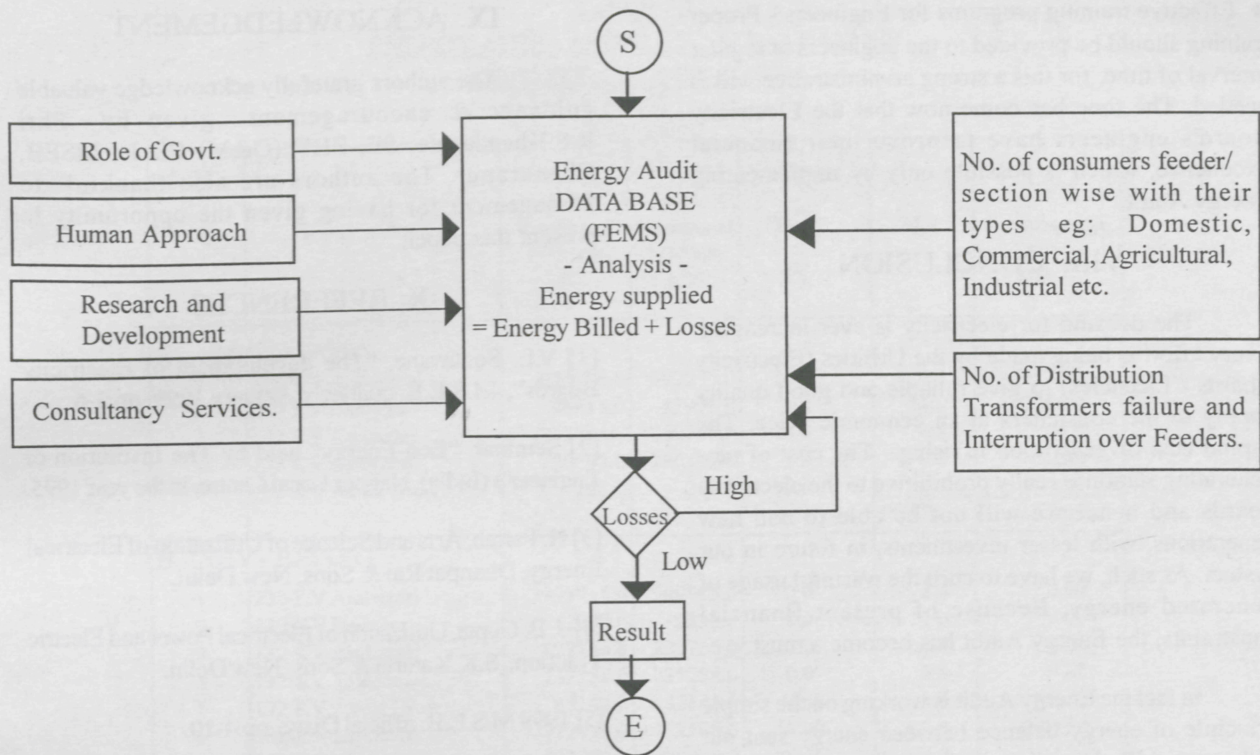


Fig. 1 - Flowchart for the Effective Energy Audit

## VII. EFFECTIVE ENERGY AUDITING

For carrying out Energy Audit Program effectively, following steps are suggested [1,2,6] :

◆ Calibration of all Sub-Station and Consumer's energy meters:- Every effort has to be made to calibrate and periodically test the energy meters at EHV, HV substations and HT consumers, LT Industrial and Commercial consumers. High-energy intensive consumers are to be dealt with as the first priority.

◆ EHV Transmission line losses computation:- If energy meters are available on both sides of transmission lines, then the transmission losses of EHV lines can be computed.

◆ Comparison of consumption by same class:- This comparison gives us an idea as to how consumers are paying for their use of electricity and it also indicates whether there is a possibility of theft / pilferage.

◆ Installation of CT operated meters:- CT operated meters have to be used for the LT Industrial and Commercial consumers whose load is more than 30 Amps. It has been instructed to tack weld the meter box containing the CT operated meters so that the possibility of tampering the meter by consumers is reduced.

◆ HT metering Kiosk:- Totally enclosed HT metering Kiosks housing metering CTs, PTs and meters with highly secured locking system are procured for the high consumption HT consumers. This system ensures: (a) minimum lead length between CTs, PTs and meters

and (b) the inaccessibility against unscrupulous elements.

◆ Use of tamper-proof meter seals:- The tamper-proof poly-propylene / SEBI seals are being used for sealing. These seals get disfigured if they are attempted to be removed.

◆ Data Logging:- Hourly Energy data logging should be done at all EHV/HV substations and replacement of faulty meters have to be done on priority.

◆ Correct Assessment of consumption by un-metered consumers e.g.: Agriculture consumer's assessment should be done on installed HP basis with regular and random inspection.

◆ The Energy Audit on Express feeders, Urban areas, MIDC feeders should be carried out monthly. The Sub-Station wise, Section wise, Sub-Division wise and Division wise Energy Audit can be carried out once in a quarter.

◆ Instrument Transformer Errors: - CT ratio should be selected such that it should match the load demand. At panel end separate instrument transformers (CTs & PTs) should be provided for metering.

◆ Static Meters:- They are used now a days because of following advantages:

- i. They are programmable ,
- ii. They are more sensitive, reliable and accurate,
- iii. Tampering data display & storage, etc.

◆ Effective training programs for Engineers:- Proper training should be provided to the engineers at regular interval of time, for this a strong administrative will is needed. The time has come now that the Electricity Board's engineers have to prove their financial excellence, which is possible only by implementing Energy Audit.

### VIII. CONCLUSION

The demand for electricity is ever increasing. Every effort is being made by the Utilities (Electricity Boards / Licencies) to give reliable and good quality supply to the consumers at an economic price. The capital cost of generation is rising. The cost of new generating station is really prohibitive to the electricity boards and hence we will not be able to add new generations, with lesser investments, in future in our system. As such, we have to curb the wasteful usage of generated energy. Because of present financial constraints, the Energy Audit has become a must.

In fact the Energy Audit is working on the simple principle of energy balance between energy sent out and energy billed to the consumers. Every effort has to be made in the National interest to curb the difference. Because of Energy Audit programs the consumer's attitude is bound to change. The theft and pilferage will be detected and the quantum is bound to reduce..

The Energy Audit conducted at 220KV Amaravati Sub-Station is given in appendix.

### IX. ACKNOWLEDGEMENT

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### APPENDIX

#### TABLE - I

#### ENERGY AUDIT AT 220 KV AMARAVATI & AMBAZARI S/S

Sr.No.	Date	AMARAVATI (IMPORT) Avaialbe Energy (MU)	AMBAZARI (EXPORT) Energy Sentout (MU)	Difference  (MU)	% E
1	1.8.99	1482	1542.8	60.8	3.94
2	2.8.99	1526	1556.1	30.1	1.93
3	3.8.99	1212	1303.4	91.4	7.01
4	4.8.99	1590	1609.3	19.3	1.19
5	5.8.99	1576	1675.8	99.8	5.95
6	6.8.99	1616	1582.7	-33.3	-2.1
7	7.8.99	1550	1582.7	32.7	2.06
8	8.8.99	1600	1662.5	62.5	3.75
9	9.8.99	1612	1649.2	37.2	2.25
10	10.8.99	1518	1609.3	91.3	5.67

TABLE - II  
ENERGY AUDIT AT 220 KV AMARAVATI S/S  
FOR THE DAY 1st OF AUG-99

S.No.	Name of Feeder	Current day's Reading at 9:00 hrs. MU	Previous day's Reading at 9:00 hrs. MU	Difference (3)-(4) MU	M.F.	Consumption MU
1	2	3	4	5	6	7
<b>A. EHV - IMPORT</b>						
1	220 KV Ambazari	693996.0	693255.0	741.0	2.0	1482.00
2	220 KV Badnera	48015.0	47991.0	24.0	24.0	576.00
3	132 KV Ambazari	252746.0	252746.0	0.0	0.8	0.00
4	132 KV Talegaon	296142.0	296142.0	0.0	0.8	0.00
5	132 KV Akola (New)	265.0	265.0	0.0	4.8	0.00
					<b>TOTAL</b>	<b>2058.00</b>
<b>B. EHV - EXPORT</b>						
1	220 KV Ambazari	999915.0	999915.0	0.0	2.0	0.00
2	220 KV Badnera	2338.0	2338.0	0.0	10.0	0.00
3	132 KV Ambazari	822766.0	822766.0	0.0	0.8	0.00
4	132 KV Talegaon	737288.0	737288.0	0.0	0.8	0.00
5	132 KV Akola (New)	85164.0	85146.0	18.0	4.8	86.40
6	132 KV Lalkhedi	772573.0	772106.0	467.0	0.8	373.60
7	132 KV Morshi	607077.0	606985.0	92.0	4.0	368.00
8	132 KV Achalpur	24778.0	24760.0	18.0	19.2	345.60
9	132 KV Chandur Bazar	159953.0	159824.0	129.0	1.9	247.68
10	132 KV Asegaon	59030.0	58940.0	90.0	0.3	27.00
11	66 KV Murtizapur-I	10813.8	10801.6	12.2	20.0	244.00
12	66 KV Murtizapur-II	75495.8	75481.8	14.0	10.0	140.00
13	66 KV Pulgaon-I	2393.9	2393.9	0.0	10.0	0.00
14	66 KV Pulgaon-II	2432.2	2432.2	0.0	10.0	0.00
					<b>TOTAL</b>	<b>1832.28</b>
<b>C. 11KV - IMPORT</b>						
1	11KV Incomer - I	118418	118375	43.0	3.2	137.60
2	11KV Incomer - II	207957	207888	69.0	3.2	220.80
3	11KV Incomer - III	25457	25457	0.0	1.6	0.00
					<b>TOTAL</b>	<b>358.40</b>
<b>D. 11KV - EXPORT</b>						
1	Town -I	991223	991031	192.0	0.2	38.40
2	Town -II	94586	94194	392.0	0.133	52.14
3	Town -III	931866	931669	197.0	0.2	39.40
4	Mansingha	801986	801821	165.0	0.2	33.00
5	Laxmi	417596	417500	96.0	0.2	19.20
6	Tiwsa	409523	408668	855.0	0.04	34.20
7	Essential	79881	79706	175.0	0.15	26.25
8	Badnera	180464	180196	268.0	0.2	53.60
9	Wadoli	350852	350404	448.0	0.1	44.80
					<b>TOTAL</b>	<b>340.99</b>

(1) OVERALL DIFFERENCE :  
TOTAL IMPORT : 2058.00  
TOTAL EXPORT : 1832.28 + 358.4 = 2190.68  
DIFFERENCE : 2058.00 - 2190.68 = - 132.68  
% ERROR : - 6.44

(2) 11KV DIFFERENCE :  
TOTAL IMPORT : 358.40  
TOTAL EXPORT : 340.99  
DIFFERENCE : 358.40 - 340.99 = + 17.41  
% ERROR : + 4.85

TABLE - III

ENERGY AUDIT - DATEWISE FOR 220KV AMARAVATI S/S

DATE	<u>OVERALL(EHV+11KV)</u>				<u>11KV</u>			
	IMPORT	EXPORT	DIFF	LOSS	IMPORT	EXPORT	DIFF	LOSS
	MU	MU	MU	%	MU	MU	MU	%
1 AUG 99	2058.00	2190.68	-132.68	-6.45	358.40	340.99	17.41	4.86
2 AUG 99	2294.00	2328.66	-34.66	-1.51	348.80	330.52	18.28	5.24
3 AUG 99	1956.00	2200.90	-244.90	-12.52	313.60	277.05	36.55	11.65
4 AUG 99	2454.00	2395.60	58.40	2.38	310.40	333.74	-23.34	-7.52
5 AUG 99	2248.00	2461.92	-213.92	-9.52	358.40	325.61	32.79	9.15
6 AUG 99	2312.00	2307.80	4.20	0.18	352.00	340.94	11.06	3.14
7 AUG 99	2198.00	2280.10	-82.10	-3.74	352.00	336.63	15.37	4.37
8 AUG 99	2176.00	2289.40	-113.40	-5.21	352.00	330.01	21.99	6.25
9 AUG 99	2236.00	2255.00	-19.00	-0.85	320.00	305.10	14.90	4.66
10 AUG 99	1998.00	2019.44	-21.44	-1.07	300.80	285.64	15.16	5.04

TABLE - IV

ENERGY AUDIT - MONTHWISE 220KV AMARAVATI S/S

Sr.No.	MONTH 1998-1999	IMPORT MU	EXPORT MU	DIFF MU	LOSS %
1	SEPT	66573.20	69261.34	-2688.14	-4.04
2	OCT	76197.60	83625.14	-7427.54	-9.75
3	NOV	77636.50	80656.56	-3020.06	-3.89
4	DEC	84050.60	86822.00	-2771.40	-3.30
5	JAN	89860.80	91229.02	-1368.22	-1.52
6	FEB	77553.80	81584.90	-4031.10	-5.20
7	MAR	98649.20	103674.90	-5025.70	-5.09
8	APR	88983.80	94534.70	-5550.90	-6.24
9	MAY	82887.40	83111.04	-223.64	-0.27
10	JUN	74236.00	74952.34	-716.34	-0.96
11	JUL	68596.40	71523.56	-2927.16	-4.27