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Study of Various Billing Systems for Energy Savings

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Abstract - *The Paper has study of different types of Consumers, Tariff Structure, Terms used in Electricity Bill and various Electrical Billing System. In Paper, the more focus is on the KVAH billing system. Paper also has the Comparision between kWh Billing and kVAh Billing, also has the Advantages due to kVAh Billing to Consumers as well as to Utility, Probable Impact of kVAh Billing respectively*.

Key Words: **Electricity Consumers, Energy saving, Tariff Structure, Billing, kWh Billing, kVAh Billing, kVARh Billing.**

INTRODUCTION

Electricity billing system mainly focuses on the calculation of unit consumed during the specified time and money to be paid to the electricity offices. State electricity regulatory commissions in various states have already introduced kVAh based tariff for various categories. In the state of Maharashtra, as per MERC order, the migration from existing kWh billing system is to be done to the kVAh billing system. Then the simultaneous study for the billing system, analysis and comparison is provided in the paper respectively.

This Paper mainly has 3 Phases and those are:

1. Types of electricity consumers
2. Understanding the electricity billing format.
3. Types of electricity billing system.

1. ELECTRICITY CONSUMERS

Different Electricity Consumers are as mention below:

I. Domestic Consumers :

Domestic Consumers consumes electricity due to Domestic load which is nothing but the energy consumed in household work. It mainly depends upon the living standard, weather and type of residence. These loads consume very little power and also independent of frequency. This load largely consist of Lighting, Cooling and Heating. About 20% of the total connected load is the domestic load.

II. General Purpose :

This category relates to supply of power to premises, which are used for office, business, general purpose or other purposes not covered under any other category where the non-Domestic load exceeds 20% of the total connected load.

III. Public Lighting :

This category relates to supply of power to the government, a local authority or any other public body for providing street lighting, for traffic signalling and for lighting of Public Park.

IV. Railway Traction :

This category relates to supply of power for Railway Traction.

V. Irrigation Pumping and Agriculture :

This category relates to supply of power for pumping of water in lift irrigation, flow-irrigation, and for lifting of water from wells, nallahs, streams, rivulets, rivers, ponds, dug wells exclusively for agricultural purposes.

VI. Public Water Works and Sewerage Pumping Installation :

This category relates to supply of power for public water supply and sewerage pumping installations owned and operated by the State Government, local bodies or their agencies.

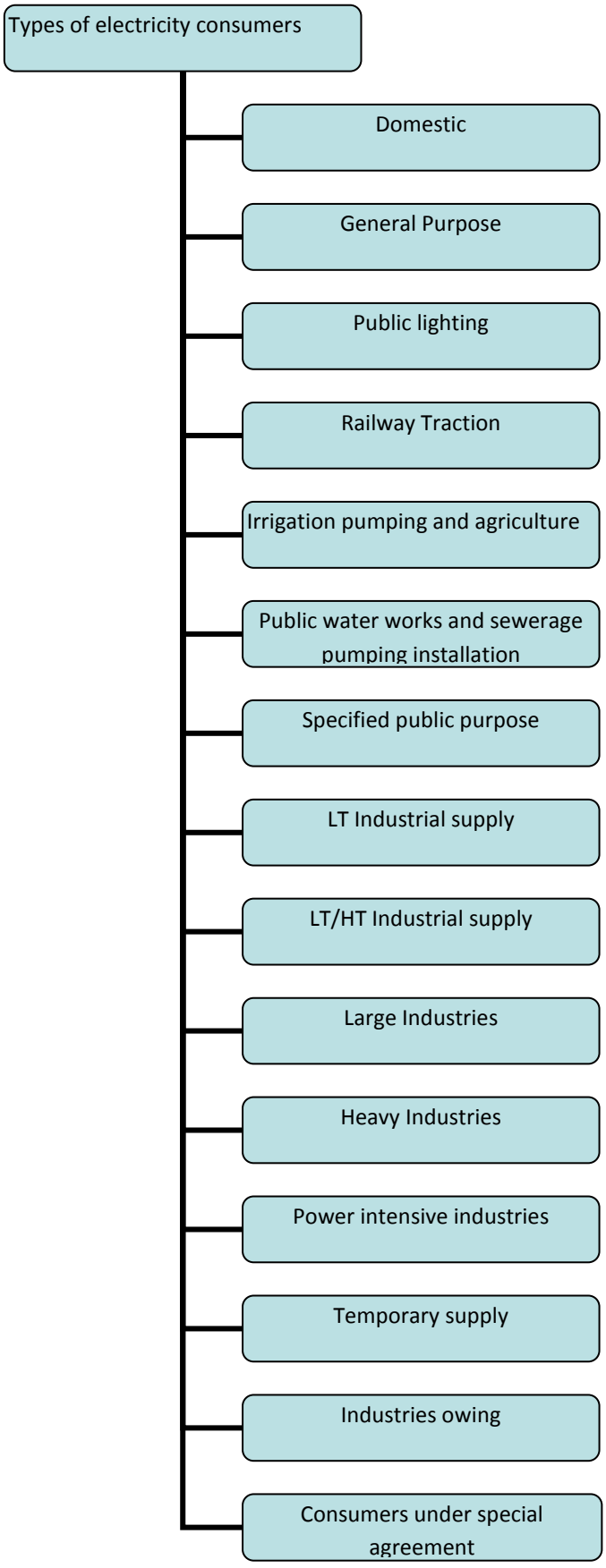

Chart -1: Types of Electricity Consumers

VII. Specified Public Purpose :

This category relates to supply of power to:

- Religious institutions.
- Educational institutions (including their hostels).
- Hospitals, dispensaries and primary health centres owned by government, local bodies and charitable institutions (recognised as such by Income Tax Dept.), Electric crematorium Non-commercial sports organisations. The term 'educational institution' does not include vocational training or coaching centres.

VIII. LT Industrial (S) Supply :

This category relates to supply of power for industrial purpose with a contract demand below 22 KVA.

IX. LT/HT Industrial (M) Supply :

This category relates to supply of power for industrial production with a contract demand of 22 KVA and above but below 110 KVA, where power is generally utilised as motive force.

X. Large Industries :

This category relates to supply of power to industries with a contract demand of 110 KVA and above but below 25000 KVA, where power is substantially utilized as motive force for industrial production.

XI. Heavy Industries :

This category relates to supply of power to industries with a contract demand of 25000 KVA and above where power is substantially utilized as a motive force.

XII. Power Intensive Industries :

This category relates to supply of power to industries where power is substantially utilised as raw material involving electro-chemical or electro-metallurgical processes with a contract demand of and above 2000 KVA.

XIII. Temporary supply :

This category relates to supply of power to meet temporary needs on special occasions including marriage or other ceremonial functions, fairs, festivals, religious functions or seasonal business or for construction of residential houses, complexes, commercial complexes, industrial premises provided that such power supply does not exceed a period of six months.

XIV. Industries owning :

This category relates to supply of power to industries with generating stations including Captive Power Plants only for start-up of the unit or to meet their essential auxiliary and survival requirements in the event of the failure of their generation capacity. Such emergency assistance shall be limited to 100 % of the rated capacity of the largest unit in the Captive Power Plant of Generating Stations

XV. Consumers under Special Agreement :
The licensee may, having regard to the nature of supply and purpose for which supply is required, fix special tariff and conditions of supply for the consumers not covered by the classification enumerated in this Code. For such purpose licensee may enter into special agreements with the approval of the Commission with suitable modifications in the Standard Agreement Form. The tariff in such cases shall be separately approved by the Commission.

2. ELECTRICITY BILLING FORMAT

In electricity bill, various electrical terms are used which are:

i. Tariff/category :
Tariff and Category determine the rate structure applicable to the bill.
EX :Typical tariff codes start with LT (Low Tension 230V single phase or 400 V three phases) or HT (High Tension 11kV and above).

ii. Type of supply and connected load :
Connected (or Sanctioned) Load is the total pool of supply that is given to a meter. This is calculated in kW (or Kilo-Watts). This is the permissible total peak kW given to a meter based on the appliances connected to the meter.

iii. Units consumed :
Units consumed is the number of kWh (Kilo-Watt-Hour) consumed in a month. 1 kWh is equivalent to keeping a 100 Watts bulb on for 10 hrs. This is the total monthly consumption by all the appliances that are connected to the meter. This is the value that needs to come down in order to reduce the electricity bill.

iv. Tariff structure :
It is very important to note the tariff structure on your bill, as this is the best indicator of how the bill can be reduced.

v. Fuel adjustment charge :
This is the additional cost of power incurred due to fuel price increments during a year.

vi. Electricity duty/ Taxes :
Every state is having an Electricity (Duty) Act wherein the applicable taxes for different tariff structure is defined.

vii. Contract demand :
Contract demand in KVA is nothing but the maximum demand which is used during billing period.

viii. Sanctioned load :
Sanctioned load in KW is the maximum amount of wattage.

ix. Bill demand :
Bill demand is the maximum demand observed in the month of billing period.

x. Wheeling charges :
A wheeling charge is the charge per KWH amount that a transmission owner receives for the use of its system to export energy.

3. ELECTRICITY BILLING SYSTEMS

The different Electricity Billing Systems are classified as :

i. kWh Billing
ii. kVAh Billing
iii. kVARh Billing

kWh Billing
A kilowatt-hour, otherwise known as a kWh, is a way to measure how much energy you are using.

A KWH Billing is billed for the active charges only.

A kWh equals the amount of energy you would use by keeping a 1,000-watt appliance running for one hour.

For instance, if you turned on a 100-watt bulb, it would take 10 hours to use one kilowatt-hour of energy. A 2,000-watt appliance, on the other hand, would only take half an hour. It all comes down to dividing the number of watts in an appliance into 1,000.

- Calculation of KWh :

Example :
Appliance: Refrigerator
Number of Watts: 100 watts
Hours used per day: 24 hours
100 watts X 24 hours = 2,400 watt-hours per day
2,400 watt-hours per day / 1000 = 2.4 kWh per day
2.4 kWh per day X 30 days in a month = 72 kWh per month
Now assume for 1 kWh the charges are 7Rs
Therefore,
Total charges = 72*7= 504 Rs.

In this way we can calculate the KWH Billing.
Previously, consumers are billed on Active energy consumption measured in KWh with the fixed charges. KWh consumption when multiplied by the applicable tariff for consumer will give energy charges payable by the consumer.

- Scenario in case of kWh-based billing :

i. Utilities supply both active and reactive power. In kWh tariff active power consumption is billed whereas the reactive power supplied by the utilities remains unbilled.
ii. The PF incentives are normally available in this tariff regime and this encourages consumers to improve PF and reduce their reactive power consumption. In an ideal case when PF is maintained close to unity the PF incentive is highest and reactive power consumption is negligible. In

such a case entire reactive power requirement of load is catered by the consumer himself by capacitors or other means such as active power compensation.

iii. If load power factor at a consumer premises is poor and is not improved by consumer the utility has to cater to the reactive power needs of load which requires utility company to strengthen its reactive power installation. The utilities in India charge PF penalty for PF values below 0.9. Wherever the PF incentives are either negligible or non-existent the consumers target for achieving somehow 0.9 PF instead of an ideal value of unity. This leaves a very large chunk of reactive power needs of the consumers to be taken care by utility company.

iv. The power factor incentive is based on average monthly value which is easier to achieve through a mix of fixed and auto compensation thus enabling consumers to get maximum incentive.

v. Some utilities overlook leading PF values while computing average power factor. This tempts consumers to use capacitors indiscriminately for availing PF incentive but it does more harm than good to the installations of both utilities and of consumers.

vi. The low power factor penalties to consumers do not adequately compensate the utilities for unaccounted consumption of reactive energy by consumers.

kVAh Billing

Electrical energy has two components viz. Active energy (kWh) and Reactive Energy (kVArh). Vector sum of these two components is called as apparent energy and is measured in terms of kVAh.

In kVAh based billing, fixed/demand charges are levied on apparent power (kVA) and energy charges are levied on apparent energy (kVAh). Presently, energy charges are levied based on this apparent energy (KVAh) consumption which eliminates requirement of charging active and reactive energy separately.

Both Active (kWh) and Reactive (kVArh) energies are consumed simultaneously. Reactive energy (kVArh) occupies the capacity of electrical network and reduce the useful capacity of the system for generation and distribution and hence its consumption also needs to be billed. kWh based billing is associated with PF incentive /penalty mechanism and separate mechanism for the same is no more required; instead of billing two energies separately, billing of kVAh energy is preferred as a commercial inducement.

- Scenario in case of kVAh based billing :

i. Utilities prefer kVAh billing where in consumers need to maintain PF close to unity for optimum kVAh consumption. This encourages consumers to generate their own reactive power.

ii. Reactive power consumption charges are built in the kVAh tariff regime.

iii. PF incentive is built in the tariff structure thus no separate PF incentive is given.

iv. Utilities maintain kVAh tariff cheaper than the kWh tariff.

v. The computation of kVAh is based on RMS current and thus Harmonics affects kVAh consumption. The distortion power factor increases with increase in harmonic content which reduces true power factor and increases kVAh consumption.

vi. Some utilities have declared migration to kVAh billing but in actual practice they continue to treat leading power factor as unity and the billing remains same as that for kWh regime if the average PF is maintained unity or any leading PF value.

vii. To optimise the billing consumers, need to have a relook at their reactive power installation. There has to be less reliance on fixed compensation. Automatic compensation both on LT and HT can only provide optimisation.

- Advantages to consumer :

a. KVAh billing will ensure that the consumers who will utilize the power efficiently will be paying less energy charges as compared to others who are not using the power efficiently.

b. The kVAh billing methodology will be much simpler to understand as number of parameters viz. PF, KVAh (lead/lag), kWh units) will be reduced.

- Advantages to utility :

a. Good system stability, improved power quality, improved voltage profile and reduced capital expenditure.

b. Complete recovery of cost of active and reactive powers.

c. Zero/minimal drawl of reactive power by consumers.

d. Reduction in power purchase cost.

Thus, considering the larger benefit of consumers as well as the utility, kVAh billing is more beneficial than the kWh billing.

- **Probable Impact of kVAh Billing :**

1. A Case Study :

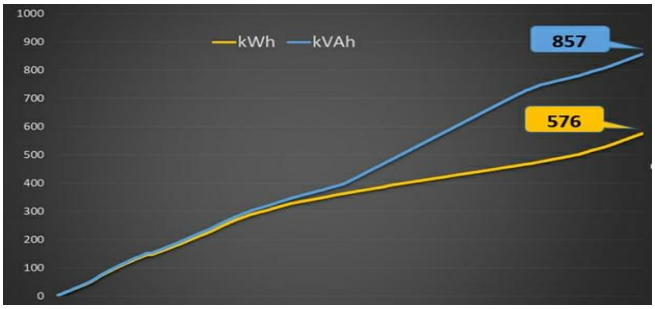

Chart – 2 : Graph for Time VS kWh & kVAh

The above graph shows unit consumptions of a HT Consumer for one day. It can be seen that after 24 hours kWh recorded is 576 units and KVAh recorded is 857 units. Thus, there is difference of 281 units. The customers average rate is Rs. 15/- per unit (Considering all bill components). So, per day increase for this customer is Rs.15/- X 281 = Rs. 4215/- which amounts to monthly increase of 1, 26,450/- and yearly increase of 15, 17,400/-.

This clearly indicates that for those customers who do not take care of their reactive power will have to pay high amount after introduction of KVAh Billing.

- Steps to be taken by Customers: -

i. Study of existing electricity bills.
ii. Get the Energy Profiling done.
iii. Get the Reactive Power Survey.
iv. Design of New Reactive Compensation.
v. Checking for Harmonics.
vi. Install/Modify Reactive Compensation System.
vii. Install Energy Monitoring System.
viii. Monitoring kVAH daily.

2. Effect of Power Factor on Load Current and Transformer Capacity :

Table -1: Effect of P.F. on Load current and Transformer Capacity

PARAMETER	Computed Values for V = 440 Volts				
kW	100	100	100	100	100
P.F. (Lag/Lead)	1	0.9	0.8	0.7	0.6
kVARh (Lag/Lead)	0	48	75	100	133
KVA	100	111	125	142	167
Load Current	131	145	164	186	219
Transformer Capacity (KVA)	125	150	150	200	200

Conclusion from Table:
So, For same load of 100 KW of consumer with 0.7 P.F. transformer capacity required is 200 KVA and with improved power factor of Unity, Capacity required is 125 KVA only.

- Benefits of kVAh billing :

1. Complete recovery of costs of utility for active and reactive power: Since reactive power is also a useful and integral part of the power supplied by the distribution licensee, charges for supplying the same are also recovered from the kVAh tariff.
2. Zero/ Minimal drawl of reactive power from consumers by use of Capacitor Banks: Under kVAh billing, it would automatically become the responsibility of the consumer to generate reactive power locally through installation of capacitors banks.
3. Reduction in power purchase cost : Under kVAh billing, the distribution licensee does not have to buy the additional power in order to compensate for the reactive power which goes unaccounted at present.
4. Improvement in system voltage: As decrease in reactive power causes voltage to fall while increasing reactive power causes voltage to rise. Thus, generation of reactive power using capacitor banks by the consumers would help in the improvisation of supply voltage also.

Table -2: Comparison between kWh and kVAh billing

Particular	kWh Billing	kVAh Billing
Billing parameters	kwh	kVAh
Type of tariff	` Two- part tariff	Two- part tariff
Meter standard	IEC 687	IEC 687
Billing format	Demand charge + energy charge for Kwh + ED + FAC	Demand charge + energy charge for KVAh + ED + FAC
Power factory monitoring	Required for P.F incentive/Penalty.	Not required as P.F is inbuilt.(Inbuilt Incentive/Penalty Mechanism).
Reactive power	Monitored through P. F	Consumer drawing and injecting more reactive power will have to pay extra and vice versa.
Basically Charged on	Charged on Active Power only.	Charged for both Active and Reactive Power which more often preferred as a Commercial Inducement

kVARH Billing

KVARH means Kilo volt ampere reactive hours, units of reactive energy consumption, which is used in industries. The basic principle is, If the power factor is low means reactive power consumption is higher in such a case charges will be extra in billing system. Mostly this is due to transformers, Motors, Relay etc.

CONCLUSIONS

i. As discussed above, it is imperative to have reactive power in the electricity distribution system but must be reduced to maintain the efficiency of electricity distribution infrastructure. The reactive power consumed remains unaccounted in the kWh-based tariff regime as the pf penalties do not adequately compensate the utility for unaccounted reactive energy.
ii. Whereas, under the kVAh based tariff regime the reactive power is compensated and consumers are encouraged to maintain their pf.
iii. Considering the above, many of the State in India have already migrated to the kVAh based tariff with certain States adopting the kVAh based tariff even for consumer categories other than HT as well. Such migration has resulted in the benefit to the consumers as well as utility as the billing disputes or abnormalities due to pf and penalties/ incentives thereof are eliminated.
iv. Thus, considering the larger benefit of consumers as well as the utility, it is important that the existing billing regime can be migrated to kVAh based billing.

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