Engineering and Scientific International Journal (ESIJ)
Volume 6, Issue 4, October – December 2019
ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

Differential Tariffs as a Driving Force for Electrical Energy Conservation

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Abstract— India is on the threshold of a growth trajectory. However, it is also facing a shortage of the supply, which is increasing day by day. At the present rate of growth, the energy demand is set to increase by nearly two folds by 2020. Out of many available methods, the simplest and the most effective method of minimizing this gap would be promoting the energy conservation. The utilities are trying their best on both the supply side management (SSM) and the demand side management (DSM) by introducing the different types of tariffs. In this research paper, a comparative study of the High Tension (HT), Tariff structure of five Indian states is carried out. The components of the tariff structure that are compared are Billing Demand, Energy Charges, Time of Day (TOD) tariff, Power Factor Incentive/Penalty, Load Factor Incentive, Penalty for exceeding the Contract Demand (CD) and Harmonic Penalty.

Keywords *— Power Factor Penalty; Time of Day Tariff; Demand and Energy Charges*

1. Introduction

The gap I between the supply and the demand of energy is continuously increasing despite huge outlay for the energy sector since independence. Further, the burning of the fossil fuel is resulting in the green house gases, which are detrimental to the environment. The all India status of the energy in Million Units (MU) and the peak in Mega Watts (MW) for the year 2010-11 and 2011-12 is as given below.

Table 1: All India Status of Energy and Peak for 2010-11 and 2011-12

	2010-11		2011-2012	
	Energy (MU)	**Peak (MW)**	**Energy (MU)**	**Peak (MW)**
Requirement	861591	122287	933741	136193
Availability	788355	110256	837374	118676
Shortage	73236	12031	96367	17517
% Shortage	8.5%	9.8%	10.3%	12.9%

The conservation of the energy is important, as it can reduce the peak and the average demand, investment in the energy efficiency/energy conservation is highly cost effective, can be achieved at less than Rs. 10 Million/MW and it also avoids the investment in the fuel, mining, transportation etc. By keeping the factors in view and to provide the policy guidance, Government of India enacted the Energy Conservation Act, 2001. The shortage of the energy in India is growing very fast [2]. The Government has taken many steps like the Energy Conservation Act, 2001, Standards and Labeling Programme, Demand Side Management (DSM), Energy Conservation Building Code (ECBC), Bachat Lamp Yojana (BLY), Strengthening Institutional Capacity of State Designated Agencies (SDA's), State Energy Conservation Fund (SECF), Energy Efficiency in the Small and Medium Enterprises (SME's) and Designated Consumers, Professional Certification and Accreditation, to save the energy. The HT consumers include large industrial units that draw a large amount of power from the rid in order to support their manufacturing processes. The share of the HT consumers in a discom's total consumer base may not be considerable but the quantum of the electrical energy which is consumed by these users is significant. The sustained energy efficiency initiatives by these consumers can help reduce the energy costs as well as a state's power deficit [4]. Targeting the HT consumers for energy efficiency may be the quickest and the surest way in order to bridge the power deficits. While the state's power managers are looking at buying more power from the other states, the energy auditors are saying that the HT facilities within the states offer an important avenue in order to cut the power consumption and reduce the deficit [5]. Utilities manage demand through special programs for the several reasons. The utilities reaction was the introduction of the demand side management programs in order to overcome these problems. The DSM is an action which is taken by the utilities in order to influence the amount of timing of the customer energy consumption in order to utilize the energy resources which are most efficiently by using a technique which is called as the Differential Tariff or real time pricing. This technique is employed for the flattening the load curve [6]. The time of use electricity tariff is used as an input to the objective function in order to obtain a solution that minimizes the electricity costs and thus maximizes the load shifting. This case study has given promising results that show the potential of applying this optimal control model to the other industrial Demand Side

DOI: **10.30726/esij/v6.i4.2019.64001**

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

Management initiatives [7]. The economic principles have been applied to elicit the conditions under which there will be a benefit to power companies in offering the rebates to the consumers in order to encourage them to adopt an energy saving measures in Hong Kong [8]. The system demand during the different hours of the day is different. Since the demand is lower during the off-peak hours, it results in reducing the capacity utilization factor. The utilities would prefer to have a flat load curve during the entire day, as this would also ensure the capital investment required, and would also ensure a very high capacity utilization factor. But, this is not practicable. However, it is always possible to reduce the difference in between the demand existing during a peak hour and that existing during the off-peak hours. For reducing the difference in between the peak and the off-peak demand, the concept of Time of Day (TOD) charges has been successfully introduced [9].

2. Research Methodology

The different HT tariff components studied, for five states of India are the Billing Demand, Continuous and Non-Continuous industries, Energy Charges for the agricultural, industrial, commercial and educational institutes and hospitals, railways, Time of Day (TOD) tariff, Power Factor incentives/penalties, Load Factor Incentives, Penalty for Exceeding the Contract Demand (CD), Penalty for the Harmonics beyond a certain limit. The five states which are under the study are Maharashtra (MH), Madhya Pradesh (MP), Andhra Pradesh (AP), Tamil Nadu (TN) and Gujarat (GJ). The data for these states was collected and then analyzed. After analyzing and comparing these parameters, a few observations are recorded.

Table 2: Details of the five states under study

State	A	B	C	D	E
MH	112373	83471	24351.61	934.43	190.310
MP	25353	27250	8668.70	580.34	45.810
AP	84666	60458	15601.93	723.10	10.350
TN	72139	72993	16050.75	976.81	97.970
GJ	60384	63961	17599.27	1283.77	90.650

Note: A indicates the population (2011) in thousands, B indicates the per capita income in Rs., C indicates the installed capacity in MW, D indicates the per capita consumption in kWh, and E indicates the Gross Domestic Product (GDP) in billions of USD

3. Description of Terms

Some definitions with respect to the tariff of the electricity of Maharashtra State Electrical Distribution Company Limited (MSEDCL) are as under.

3.1 Billing Demand

The amount of energy required, demanded or desired at any given time by a customer, which is used, for the purpose of billing.

3.2 Continuous and Non-Continuous Industries

The industrial consumers who are subjected to the load shedding and are not on the express feeder are classified as “Non-Continuous Industries”. The industrial consumers who are exempted from the load shedding, being on an express feeder are classified as “Continuous Industries”.

3.3 Contract Demand

It is a demand in Kilowatt (kW)/Kilo-Volt Ampere (kVA), which are mutually agreed in between the MSEDCL and the consumer has entered into in the agreement or agreed through the other written communication.

3.4 Load Factor

It is the ratio of the total number of units (kWh) consumed during a given period to the total number of units (kWh) which may have been consumed had the Contract Demand/Sanctioned Load been maintained throughout the same period, subject to the availability of the power supply from the MSEDCL and is usually be expressed as a percentage.

3.5 Maximum Demand

The Maximum Demand (MD) is the maximum instantaneous power which is consumed over a specified window of time.

3.6 Sanctioned Load

It means that the load in Kilowatt (kW)/Horse Power (HP) mutually agreed in between the MSEDCL and the consumer.

3.7 Demand Charges

It is a charge which is based on the highest kVA demand, during any 15 to 30-minute interval, which is measured in a billing period, such as a month. As it is a fixed amount per kVA per month, it is also called as a fixed charge.

3.8 Energy Charges

The energy charge is based on the total kilowatt-hours (kWh) which is used during the billing period. The

DOI: 10.30726/esij/v6.i4.2019.64001

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

Kilowatt-hour is the unit of electricity which is measured by the electric energy meter. As it varies according to the user, it is also called as the variable charge.

3.9 Time of Day Tariff

The method of charging different rates during the different hours of the day is called as the Time of the Day (TOD) charges (in addition to the base energy charges) are levied on the energy consumed during the peak hours, and a rebate is given on the energy which is consumed during the off-peak hours.

3.10 Electricity Duty

The electricity duty is charged as per the Government guidelines from time to time. The rate and the reference number of the Government Resolution/Order vide which it is made effective, is stated in the bill.

3.11 Power Factor Incentive

Whenever the average power factor is maintained at or above specified point, the incentives are given at some percent of the amount of the monthly energy bill.

3.12 Power Factor Penalty

Whenever the average power factor is less than the specified point, the penal charges are levied at some percent of the amount of the monthly energy bill.

3.13 Fuel Cost Adjustment

This term is used to refer to a change which is made to the price the electricity or the natural gas which is based on the changes in the market price of the fuel. A fuel adjustment charge is a surcharge which is added to the compensation for increases, usually unanticipated, in the price of the energy.

3.14 Load Factor Incentive

This incentive is for those consumers, who have maintained the load factor above a certain specified percentage.

3.15 Penalty for Exceeding Contract Demand

If a high-tension consumer exceeds, the Contract Demand that the consumer will be billed at the appropriate Demand charges for the Demand which is actually recorded and will be charged at some higher rate of the prevailing Demand Charges for the excess Demand over the Contract Demand.

4. Result and Discussions

The different methods of billing demands which are followed in the different states are as tabulated as below.

Table 3: Billing Demand

State	Monthly Billing Demand will be the higher of the following
Maharashtra	[1] Actual MD recorded in between 0600-2200 hrs in a month [2] 75% of the highest billing demand recorded during the preceding 11 months [3] 50% of the contract demand
Madhya Pradesh	[1] Actual MD recorded during the month [2] 90% of the contract demand
Andhra Pradesh	[1] Actual MD recorded during the month [2] 90% of the contract demand
Tamil Nadu	[1] Actual MD recorded during the month [2] 90% of the contract demand
Gujarat	[1] Actual MD recorded during the month [2] 85% of the contract demand [3] 100 kVA

From the above table, it can be concluded that only Maharashtra considers the MD recorded during 0600-2200 hrs of the day. This will encourage the consumers to use their maximum load during the other time that is 2200-0600 hrs of the day. This will help the utility to fill up the valleys during off peak, reduce the peak during the peak hours of the load curve and improve the utilization factor of the equipments.

4.1 Continuous and Non-Continuous Industries

By the process of categorization of the load shedding which is applicable and the load shedding exemption for the consumers is as shown in the table below.

Table 4: Express and Non-Express Feeder

State	Concept of Express and Non-Express Feeder
Maharashtra	[1] Load Shedding Exemption-Express Feeder [2] Load Shedding Applicable-Non-express Feeder
Madhya Pradesh	Not Introduced
Andhra Pradesh	Not Introduced
Tamil Nadu	Not Introduced
Gujarat	Not Introduced

DOI: 10.30726/esij/v6.i4.2019.64001

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

From the above table, it can be concluded that, only Maharashtra has the concept of the express and non-express feeder for the load shedding which is applicable/exempted category. This attracts big industrial companies in order to set up their plant in Maharashtra. The other states need to address this factor.

4.2 Energy Charges

All the five states which are under study have different tariff rates for different categories of consumers, different voltage levels etc. The comparison of a few categories is as shown below.

4.3 Agriculture

Table 5: Tariff for Agricultural Consumers

State	Demand Charges (Rs. /kVA/Month)	Energy Charges (Rs. kWh)
Maharashtra	25	2.15
Madhya Pradesh	140	2.9
Andhra Pradesh	0	0
Tamil Nadu	0	0
Gujarat	-	-

From the above table, it can be concluded that, the agriculture is costlier in Madhya Pradesh as compared to the other four states. Maharashtra has at least possible charge. Tamil Nadu and Andhra Pradesh are providing free electricity, where there is a risk of misuse/theft/wastage.

4.4 Industrial

Table 6: Tariff for Industrial Consumers

State	Demand Charges (Rs. /kVA/Month)	Energy Charges (Rs. /kWh)	
		Up to 50% L. F.	Above 50% L. F.
Maharashtra	150	5.00^{+}	
Madhya Pradesh	391	4.78 (Average)*	3.88 (Average)*
Andhra Pradesh	250	3.24 (Average)*	
Tamil Nadu	300	5.50	
Gujarat	165**	3.95**	

Note: + indicates the express and the non-express category, * indicates the different rates for the different levels of the voltage, and ** indicates the different rates for the different kVA demand

From the above table, it can be concluded that Madhya Pradesh is charging with a reduced rate for the consumers which are having a L.F. which is above 50% also they are providing a L.F. factor incentive for the consumers which are having a L.F. above 75%. This is giving a double benefit to the consumers, but for the utility side it is not economical. Tamil Nadu has both demand and the energy charges on a higher side. Gujarat is attractive for industrial organizations.

4.5 Commercial

Table 7: Tariff for Commercial Consumers

State	Demand Charges (Rs. /kVA/Month)	Average Energy Charges (Rs. /kWh)	
		Up to 50% L. F.	Above 50% L. F.
Maharashtra	150	7.70 (Average)$^{+}$	
Madhya Pradesh	290*	5.13*	4.43*
Andhra Pradesh	250	4.40*	
Tamil Nadu	300	7.00	
Gujarat	188**	4.10	

Note: + indicates the average of express/non-express category, * indicates the average of the different rates for the different voltage level, and ** indicates the average of the different rates which are applicable to the different billing demand.

Gujarat seems to be more attractive for the commercial consumers whereas in the other states if the demand charge is higher than the energy charges are lower and vice versa.

4.6 Educational Institutes and Hospitals

Table 8: Tariff for Educational Institutes and Hospitals

State	Demand Charges (Rs. /kVA/Month)	Average Energy Charges (Rs. /kWh)	
		Up to 50% L. F.	Above 50% l. F.
Maharashtra	150	7.40 (Average)$^{+}$	
Madhya Pradesh	305*	5.12*	4.43*
Andhra Pradesh	250	4.40*	
Tamil Nadu	300	4.50	
Gujarat	110	3.60	

Note: + indicates the average of the express/ non-express feeder category, and * indicates the average of different rates for different voltage level

From the above table, it can be concluded that the educational organizations in Madhya Pradesh and Andhra Pradesh are charged at the same rate of the commercial consumers. Maharashtra and Gujarat are charging Rs. 0.50 per unit less than their commercial consumers whereas the rates in Tamil Nadu is attracting for the educational organizations.

DOI: 10.30726/esij/v6.i4.2019.64001

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

4.7 Railways

Table 9: Tariff for Railways

State	Demand Charges (Rs. /kVA/Month)	Energy Charges (Rs. kWh)
Maharashtra	0	5.80
Madhya Pradesh	265	5.00
Andhra Pradesh	0	4.45
Tamil Nadu	250	5.50
Gujarat	160	4.55

From the above table, it can be concluded that the railway tariff is at a minimum in Andhra Pradesh, this is helpful for tourism development.

4.8 Time of Day Tariff

The different time of the day tariff for the different states is tabulated as below.

Table 10: Time of Day (TOD) Tariff

State	Hours of the day	Charges
Maharashtra	0600-0900	+ Rs. 0.00/kWh
	0900-1200	+ Rs. 0.80/kWh
	1200-1800	+ Rs. 0.00/kWh
	1800-2200	+ Rs.1.10/kWh
	2200-0600	-Rs.0.85/kWh
Madhya Pradesh	1800-2200	+15% of Energy Charge (not for HV 1, 6 and 7 categories)
	2200-0600	-7.5% of energy charge (not for HV 1, 6 and 7 categories)
Andhra Pradesh	1800-2200	+Rs.1.00/kWh (only for HT-1A)
Tamil Nadu	0600-0900	+20% of the energy charge
	1800-2100	+20% of the energy charge
Gujarat	0700-1100 (for CD < 500 kVA)	+Rs.0.75/kWh
	1800-2200 (for CD < 500 kVA)	+Rs.0.75/kWh
	2200-0600 (for CD < 500 kVA)	-Rs.0.50/kWh

From the above table, it can be concluded that Gujarat is providing the TOD tariff only for the big consumers. A Few states are encouraging the consumers to shift their load during the off peak (2200-0600 hrs) period by paying the consumers some amount, like Maharashtra, Madhya Pradesh and Gujarat. Andhra Pradesh and Tamil Nadu can think over this point, as this helps to flatten the load curve. Even Maharashtra is not charging any extra amount during 0600-0900 and 1200-1800 hrs.

4.9 Power Factor Incentive

The incentives for maintaining a good power factor in the different states is as tabulated below.

Table 11: Power Factor Incentives

State	Power Factor	Incentive
Maharashtra	0.95	1%
	0.96	2%
	0.97	3%
	0.98	4%
	0.99	5%
	1.00	7%
Madhya Pradesh	0.95-0.96	1%
	0.96-0.97	2%
	0.97-0.98	3%
	0.98-0.99	5%
	0.99 and Above	7%
Andhra Pradesh	-	-
Tamil Nadu	-	-
Gujarat	0.95	1%
	0.96	2%
	0.97	3%
	0.98	4%
	0.99	5%
	1.00	6%

From the above table, it can be concluded that except Andhra Pradesh and Tamil Nadu the other states are encouraging the consumers in order to maintain their pf 0.95 and as above as possible. Andhra Pradesh and Tamil Nadu need to think over this factor, as the available power can be utilized optimally by maintaining a good pf.

4.10 Power Factor Penalty

The penalty for having a poor power factor in the different states is as tabulated below.

Table 12: Power Factor Penalty

State	Power Factor	Penalty
Maharashtra	< 0.9	2%
	0.89	3%
	0.88	4%
	0.87	5%

DOI: 10.30726/esij/v6.i4.2019.64001

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

Madhya Pradesh	< 0.9	1%
Andhra Pradesh		
Tamil Nadu	0.9-0.85	1% for every reduction of 0.01 from 0.9
	0.85-0.75	1.5% for every reduction of 0.01 from 0.9
	Below 0.75	2% for every reduction of 0.01 from 0.9
Gujarat	0.9-0.85	1% for every 1% drop of part thereof
	Below 0.85	2% for every 1% drop of part thereof

From the above table, it can be concluded that except Andhra Pradesh all the other states are charging the penalty for a lower pf which is as low as 0.9. Andhra Pradesh needs to think over this factor.

4.11 Load Factor Incentive

The incentives for keeping a good load factor is as tabulated below.

Table 13: Load Factor Incentives

State	Load Factor	Incentive
Maharashtra	75-85%	0.75% for every % point increase from 75% (only for HT-I)
	Above 85%	0.75% for every % point increase from 75% (only for HT-I)
Madhya Pradesh	75% and less	0%
	Above 75%	0.10% for every 1% increase above 75%
Andhra Pradesh	-	-
Tamil Nadu	-	-
Gujarat	-	-

From the above table, it can be concluded that, only Maharashtra and Madhya Pradesh are providing the LF incentive. The others need to think over this point, as higher load factor means more output and a lower cost per unit. Madhya Pradesh is giving an incentive for a higher LF and also the rate per unit is set lower for the consumers which are having the LF more than 50%. Here, the consumers are getting a double benefit, Madhya Pradesh needs to see whether the utility is suffering.

4.12 Penalty for Exceeding Contract Demand

The penalty for those who exceed their contract demand is as tabulated below.

Table 14: Penalty for Exceeding the Contract Demand

State	Penalty
Maharashtra	1.5 times the Demand Charge
Madhya Pradesh	1.3 times the energy charge if the MD exceeds up to 105% of the CD
	1.3 times the demand charge if the MD exceeds up to 115% of 105% CD
	2 times the demand charge if the MD exceeds 115% of the CD
Andhra Pradesh	2 times the normal demand charge if the MD is 100-120% of the CD
	2 times the normal demand charge and 15 % energy charge if the MD is 120-200% of the CD
	2 times the normal charge and 20 % energy charge if the MD is 200% and above of the CD
Tamil Nadu	-
Gujarat	Rs. 335/kVA/month for HTP-I
	Rs. 360/kVA/month for HTP-II A
	Rs. 350/kVA/month for HTP-II B
	Rs. 500/kVA/month for HTP-III
	Rs. 400/kVA/month for Railway Traction
	Nil for HTP-IV

From the above table, it can be concluded that except Tamil Nadu all the others are penalizing for exceeding the CD. Tamil Nadu needs to address this point.

4.13 Harmonics Penalty

The penalty for the consumers who cross the limits which are specified by the CEA is as tabulated below.

Table 15: Harmonic Penalty

State	Penalty
Maharashtra	Nil
Madhya Pradesh	Nil
Andhra Pradesh	Nil
Tamil Nadu	If the harmonics which are introduced by the load exceeds the limits which are set by the CEA, they shall be charged by 15% respective tariff
Gujarat	Nil

From the above table, it can be concluded that only Tamil Nadu is penalizing the consumers for exceeding the harmonics limit which is specified by the CEA. The other states are required to include this in their respective tariff structure, as the harmonics will hamper the quality of the supply. In the present time, the use of electronic

DOI: 10.30726/esij/v6.i4.2019.64001

ISSN 2394-7187(Online)
ISSN 2394 - 7179 (Print)

components is increasing, and it is resulting in the increase of the harmonic level.

5. Conclusion

After analyzing the different components of the tariff structure of the five states of India it can be concluded that all the five states which were under the study are trying their best to charge their consumers with due care to the interest of the utility and conservation of energy. However, few states have some components better as compared to the other states. If all of these states look at the positive things of each other and try to implement to the best of their state situations, conditions would result in a better tariff structure.

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DOI: **10.30726/esij/v6.i4.2019.64001**