Residential electricity tariff concept based on load factor

by H Grover and J E Calmeyer, Department of Electrical, Electronic and Computer Engineering, University of Pretoria

Improvements in the load factor hold benefits for the supplier in terms of constant system loading, improved sales and essentially a cost saving for the supplier dependant on their tariff structure.

Irrespective of any specific tariff structure, a supplier will insist that a constant profit margin is maintained when passing incentives through to demand-side customers. If the percentage is maintained, then surplus savings can be passed through to the customers as an incentive for customers to assist the supplier and in-turn doing so can reduce their own costs.

Load factor

The load factor (LF) is expressed as the ratio of the average demand to the maximum demand. Simply put, the load factor is a ratio between the actual energy consumption during a period and the energy that would have been consumed had the demand remained at the maximum demand for the same period [1].

Load factor in a period is calculated by the following equation:

\[ LF = \frac{\text{Energy Consumed}_{\text{period}}}{\text{Maximum Demand}_{\text{period}}} \times \frac{1}{\text{Hours}_{\text{period}}} \]  

(1)

The load factor can never be greater than 1, and the maximum demand should be measured in kW in order to cancel out the energy unit.

Electricity distribution and sales

Electricity is transferred from supplier to utility to customer similar to the way that an on-shelf product transfers hands from manufacturer to wholesaler to retailer. The utility sells electricity to the customer at a marginal profit price.

As with any other commodity, the more items brought, the greater a chance of a bulk purchase discount on buying price. If the customer uses his electricity more efficiently and at a constant rate, then that customer could be eligible to a discount. The measure of a customer efficient use of electricity is through their load factor.

This form of discount incentive for better load factor is common among the utility’s large customers, whose meters are designed to read off energy consumption and maximum demand.

Example of utility incentive

Tshwane City Council purchases electricity on the Eskom Megaflex tariff. Large Power Users purchase electricity from Tshwane on a two-part tariff at a cost of 12.01 c/kWh and R51.51/kVA in 2003.

Tshwane offers an incentive of a reduced energy rate of 11.15 c/kWh if the customer is able to use more than 13 kWh on average per day per kVA at peak demand. The formula used by the council is as follows.

This equation when considered over a month relates to a load factor of 54%.

\[ \text{Load Factor} = \frac{\text{Total Energy Consumed}}{\text{Total Number of Days}} \times \frac{1}{\text{Maximum Demand}} \]  

(2)

In other words, customers on a two part tariff and with a load factor greater than 54% pay forenergy at a rate of 11.15 c/kWh instead of the usual rate of 12.01 c/kWh. By improving their load factor the client saves the utility on electricity cost.

Advantage of benchmarking with load factor

Improvement of load factor can come as a direct result of reduction of maximum demand – shifting some of the load to off-peak times. Lowering of the load factor does not necessarily mean a reduction in energy consumption.

Utility cost is the cost that is incurred by the city council to purchase electricity from the supplier (Eskom in this case).

Maintaining marginal % profit

The aim of discount incentives is that the savings that the utility incurs with the improved load factor of the customer is not taken in as an addition to the present percentage profit of the utility, but is then given back to the customer as a discount, which is an incentive to maintain a better Load Profile.
Rsavings = Re – Ri

Thus the savings from the utility side as a result of a customers profile:

\[ R_{\text{savings}} = R_e - R_i \]  

(3)

Thus lowered energy rate available to the customer is:

\[ \text{EnergyRate}_{\text{new}} = \frac{R_{\text{new}}}{\text{EnergyConsumption}} \]

(4)

In this way the utility maintains a percentage marginal profit, this is important to maintain this incentive for high load factor existing as it creates a win-win situation for both the customer and the utility. In this system the utility reduces their expenditure as a result of low demand and improved usage of energy in off-peak times.

Application of this system to the residential sector

The residential sector is a relatively difficult sector to manage or model, mainly due to its large customer base. There is however a need to apply such a scheme to the residential sector because residential homes have historically had a relatively poor load factor and also because the residential sector makes large contributions to the national system peak demand.

The first and most obvious advantage with such a venture is that it would most definitely improve national system peakload especially at peak times. This system would also allow more energy available at peak times for carrying out more important industrial applications.

The greatest challenge with such a system applied to the residential sector is the large number of homes, and dwellings throughout the country. It would be extremely difficult to bring this type of a system out to the end-users, and encourage them to use Demand Side Management (DSM) techniques to improve their load factor, as a very small fraction of users understand electricity consumption.

Added to this is the shortage at demand and energy metering data.

The residential end-users are charged for only energy consumption, and thus their meter is only designed to measure energy consumption and not maximum demand, which would then have to be estimated, intern ending up in an inaccurate load factor for the sector.

Estimating residential load factor

To calculate the load factor for any electricity user, energy consumption, maximum demand and period usage need to be known. For the residential sector only electricity consumption and time usage are known, and the load factor and maximum demand

Load Factors essentially as the ratio of energy consumed to energy demanded. In the case with these unknowns, energy going into a home can be measured off the in-feeder and the energy consumed is known from the electricity accounts. Thus the load factor can be determined as:

\[ LF = \frac{E_{\text{consumed}}}{E_{\text{demand}}} \]

(5)

As stated earlier it is not practically possible to measure off energy going into each home in the country so therefore it would be easier to just estimate data.

Is it feasible to estimate?

Estimation would involve either estimating the maximum demand or estimating the load factor itself, although neither would be accurate. Collecting monthly electricity data for each customer and developing a load profile for a year of electricity usage could allow an estimation of the maximum demand, but this demand would be over a year not a month, and thus it would not be accurate. Using "utilisation factor"

The utilisation of power for an average connection can be estimated by calculating the average for all municipality connections and this value can be used as a benchmark for evaluating customer energy usage. So if the average energy usage for the connection is above this average, then the customer is eligible to a discount, if not then no discount is given.

In this scheme the average ‘utilisation of power’ per year can be calculated from the electricity accounts as follows:

\[ \text{Utilisation of Energy} = \frac{\text{Energy used}}{\text{Hours used}}(8760) \]

(6)

Assuming that the average of all the connections is 350 kW then any connection that has an average energy consumption per year greater than 350 kW is eligible to a discount.

This discount is calculated as:

\[ \text{Savings} = \text{Cost}_{\text{energy}} - \text{Cost}_{\text{adjusted}} \]

(7)

Therefore new rate due to UF is calculated as:

\[ \text{EnergyRate}_{\text{new}} = \frac{R_{\text{new}}}{\text{EnergyConsumption}} \]

(8)

This system encourages the user to keep his utilisation factor as high as possible.

Utilisation factor is easier to use than using load factor, in that all the variables that need to be calculated are available. This paper looks at how the application of the incentives given to large customers for improved load factor can be applied to the residential sector, but is this practically feasible?

Conclusion

The primary challenge with applying this idea in a practical sense is the awareness and the education of energy utilisation needs to be done. In other words if we strive to make the users use their electricity more efficiently, we need to make them understand how the system works and how it will benefit themselves and the utility.

The downside of this incentive drive is that energy efficient customers will suffer. By using energy more efficiently, with a lowered base load and peak demands off-peak times, the customer is lowering his load factor. Although this customer has a high efficient energy usage, they could have a low load factor and thus will not be eligible for discounts.

Once the incentive is applied, customers will be driven to use more electricity from the utility so that their utilisation is above the benchmark average. In this way the average consumption per household moves up. In other words, this system will ultimately encourage strategic growth, which is not the best option for DSM. The system should encourage customers for peak clipping rather than strategic growth.

The theory introduced in this paper is one possible method to improve load factor in the residential sector. More practical methods can and need to be developed, to motivate efficient use of energy and improvement of load factor within the residential sector.

References

