LOAD MANAGEMENT USING MULTIFUNCTIONAL ELECTRICITY METERS

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SUMMARY

This paper shows the concept of active load management for household customers using multifunctional electronic electricity meters. The concept is based on available power limitation during load management periods. The basis of the suggested concept lies in setting a contractual partnership between supplier and consumer, which defines both of their roles in load management. Further, this paper also suggests incentives for consumers which may be included in a future tariff policy manual to facilitate implementation of the concept.

1. INTRODUCTION

Load management for the household sector has changed somewhat under the liberalised electricity market. Namely, load profiles in former vertically integrated power utilities have been exclusively used to optimise production, transmission and distribution capacities. The major goal was to minimise investment in new production capacities. Today, under liberalised market conditions, this goal has been formally changed. The modification of load profiles depends on changes in the electricity market price. Whether an electricity utility company is vertically integrated or completely deregulated becomes irrelevant.

In both cases, the basic motivation for load management is purely economic. The main goal is to avoid energy purchase on a daily basis, when prices are at their highest, and even to reduce a customer's load, thus possibly creating a surplus which can be sold at peak market price. Power utility companies using a load management system, accompanied by accurate long and short term energy needs forecasts, will have a significant edge on the market – creating profit for the company, as well as incentives for the customer.

Besides generating extra profit for the company and its consumers, this type of load management provides high efficiency in already overloaded transmission and distribution networks, especially in regions where these represent critical parameters.

In general, there are two types of load management system: passive and active (1, 2).

Passive load management, realised through tariff policy (a two-tariff system in Serbia) which uses low prices to encourage consumers to use energy during specific times of the day (e.g. during the night) or week, is still the dominant load management method, even in power utility companies in developed countries. These methods are still being continually improved (2).
The main advantage of this system is the simplicity and the low cost of its approach, based primarily on two or multi-tariff electricity meters already installed in households. A crucial disadvantage is an inability to quickly respond to changes in market prices. Also, it cannot manage/deal with imbalances of electricity consumption and production in vertically organised power utility companies.

Active load management is becoming increasingly used in developed countries (3). There are two directions of development: direct control of appliances in households (primarily the appliances related to heat accumulation), and limitation of load during power supply to consumers, throughout the periods of management action.
The advantages of active load management lie in reliable adjustment of load profiles to available power in the electric energy system. A disadvantage is that consumers need to accept the possibility of reduced amenities regarding usage of their appliances. Active load management via direct control also implies changing the consumer's domestic wiring, so that the controlled appliances would be separated from the others. For successful load management by direct control, it would also be necessary for consumers to own such potentially controllable appliances (with thermal accumulation).
Using management techniques based on reducing the load during power supply to the consumer, these shortcomings practically disappear, as it is up to the consumer to decide about the usage of their appliances, within the agreed limited power levels. This technique will therefore be explained in more detail in this paper.

2. LIMITATION OF CONSUMER'S LOAD

The idea of limiting consumer's load is not new. For a couple of decades in the last century, it was used as "buying the right to access the grid" (through main fuses). In this way, distribution companies, amongst others, protected their network from occasional or permanent uncontrolled, unauthorised power consumption exceeding the stipulated load level. Unfortunately, this approach has proven to be technically too rigid and unfit for active management, since the measuring of consumer's load is not accurate (the fuse is not a measuring device!).
There were attempts to broaden the basic purpose of network protection fuses, to label them "limitators" (as they are called in some languages) and use them as a tool for the realisation of a managing command. However, these attempts have failed, mainly due to their insufficiently calibrated measuring capacities.
Nonetheless, the possibility to use real "limitators" as part of a tariff policy has fortunately been kept in Serbia, through a fee. Multifunctional electricity meters (4) for tariff buyers are ideal, certified and officially calibrated measuring devices which can pass the required information to a built in processor or circuit breaker. This information could be the measured power level (at the certain point of time, or during a certain short interval), or the information that the stipulated power level (three-phases or single-phase) has been exceeded.
Based on that information, one can either terminate the overall supply to the consumer, or switch the entire future spent energy to a different, more costly register of the electricity meter during the load management reduction command. Bearing in mind the current social state of consumers, especially in Serbia, the first option would be the recommendation of the authors of this paper.
After reducing the load by "on cold" switching off of excess operational appliances, the electricity supply could be re-established using the reset button.
In the opposite case, the consumer's operational appliances would be left without power supply, as long as the limiting managing command is in force.
A simplified electric scheme for a household switching board with multifunctional electricity meters is shown in Figure 1.

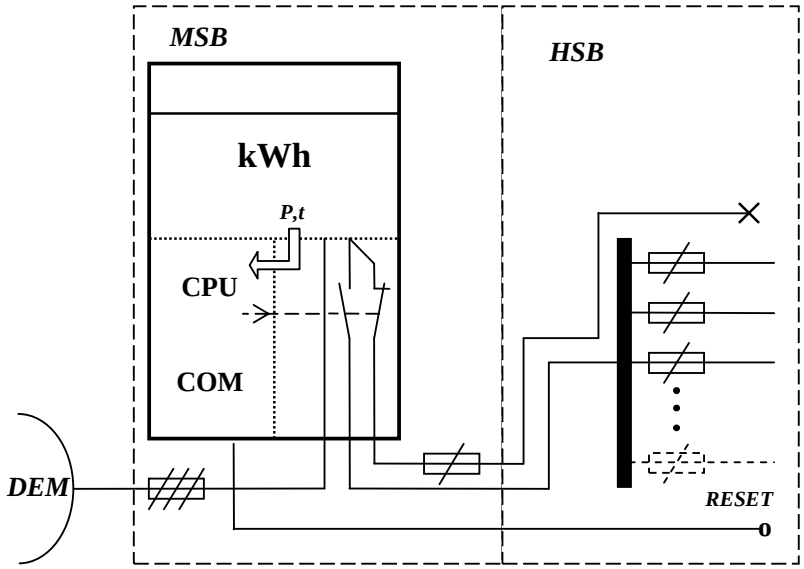

Figure 1. Simplified electric scheme for a household switching board with multifunctional electricity meter

This management method is much more favourable for consumers, as they are allowed to use the available resources according to their own needs. On the other hand, the supplier can be certain that the consumer cannot load the supply grid, nor the entire electric energy system, above the stipulated load level.

These are abilities that no other implemented systems, such as direct appliance control, possess. The possibility of remote programming and reprogramming of programmable processor chips, via communication modules, allows multifunctional electricity meters to have two programmed functions:

1. Limited electricity consumption permanently set to a certain (stipulated) value over a certain period, such as year;
2. Short-term limitation of consumer's load during reduced power supply (as a measure taken in active load management, activated by the communication module)

A **permanently set limiting value** is agreed upon by both the electricity supplier and the consumer, and as such, is specified over a longer term (one year or more), as a tariff policy measure. The consumer chooses (with professional advice from the supplier) the total maximal three-phase load they want to be supplied with (e.g. 3, 4,... 25 kW). This load is limited by the total load leased as a grid access right, at the moment the consumer is connected to the distribution network. The option of arbitrary, linear choice of total limiting load using multifunctional electricity meters has a significant advantage over the previous necessity of discrete, per-phase limited, load limitation with the main fuses.

Thanks to this, the adaptation of household wiring or switchboards is generally not necessary, nor is it necessary to pay careful attention to the allocation of load to each phase, as the meter will measure the total load of the consumer.

Electricity bills will show the cost of the chosen, stipulated, load value, as well as the cost of energy itself. It is extremely important that in this way, the previously often debatable engaged load, will finally be a matter of mutual agreement, controlled by calibrated measuring devices – electricity meters. After two-three billing periods, consumers will be able to decide the amount of load adequate for them, taking into account both their needs and their ability to pay. The value of the load may be chosen completely arbitrarily, with the possibility of "fine tuning", unlike in the former case of discrete nominal current values of fuses obtained by leasing the grid access rights.

Short-term limitation of load during reduced power supply is an additional option for consumers, who in this way, will become "business partners" of the electricity supplier (in Elektroprivreda Srbije (EPS) the supplier is a distribution company). It would be activated on the command of the electricity supplier, with limited duration. Durations would be limited based on both the realistic requirements of

the supplier, and what is acceptable for the consumer, in such a way that the actions would result in financial benefit.

The previously used daily management method of a two tariff policy, is both from financial and technical points of view, a senseless "drilling" of consumers. The load levels for short term limitation are considerably smaller than the levels for permanent limiting, being in the range of 0.3 to 1 kW. In practice, the choice of this value will be based on the household appliances that the consumer wants to be able to use during the management action periods. As a partner, the consumer shall share the profit made by these actions, as a reward for his acceptance of temporarily giving up on these amenities.

3. SCENARIOS OF LOAD MANAGEMENT WITH MULTIFUNCTIONAL ELECTRICITY METERS IN ELEKTROPRIVREDA SRBIJE

It is obvious that the usage of load management can be recognisably beneficial for everybody involved. More importantly, the cost of installation of hardware for this sort of management system does not involve significant additional investment.
The multifunctional electricity meters, intended for use by EPS as a future standard, with a circuit breaker and the necessary communications port and programmable processor, would allow the upgrading to this kind of load management. It would also require the operational development of load management software, which would then be connected to both the existing electricity payment, and the distribution demand side management software.

Through this type of load management system (permanent and occasional short-term additional limitation of consumers), certain smaller network regions or even "transformer-regions" could overcome and solve middle-term problems of falling behind in the development of the low-voltage network (5). This could also be the way to deal with necessary load reductions during outages in the power system, as well as the continuous imbalance of the demand and supply abilities, caused by insufficient production or unfavourable electricity market offers. In Serbia, this situation was observed not so long ago.

This management method allows the temporary solution of problems caused by an underdeveloped network. The solution consists of allowing new consumers temporary access to the network, under somewhat reduced access conditions (e.g. a couple of kW), so that they would be able to use it for essential needs, but not for cooking or heating. This practice, with 3 kW limitation, exists e.g. in some parts of Italy.

We shall present the premises of some elements, i.e. scenarios for future tariff systems, without going into evaluations of their effects, which can be the topic of some future paper.

Technological requirements regarding the measuring and billing systems for consumers, would impose the existence of the following options, based on groups of consumers using different types of electricity meters, envisaged by the future tariff policy manual:

1. Consumers for whom active load management is not possible

1.1. For consumers with single and two-tariff Ferraris and electronic electricity meters, all features of the existing tariff manual should be kept (up to the moment when most of the existing electricity meters would be replaced by new, multifunctional ones). The engaged load for these consumers could be calculated on the basis of amount of spent electricity, or on the basis of sum nominal load (current) values of main fuses.
The lower price tariff would be in force in the period between midnight and dawn.

1.2. Consumers with the so-called DUT-tariff (with separate electricity meters for supplier-commanded appliances with thermo accumulation), would have unchanged supply conditions, until the moment when their measurement group is replaced by multifunctional electricity meters.
Before this happens, if there is a need for load reduction in the system, these groups could be managed by switching off appliances with thermo accumulation.

2. Consumers for whom active load management is possible

The consumers who have new multifunctional electricity meters will have two options:

2.1. Permanently set limiting value of load (3 – 25 kW) – which will be the stipulated measure of tariff policy (engaged load item in electricity bills) for a specified period, less of equal to the total load leased as a grid access right.

2.2. Additional short term limitation of load level (0.3 – 1 kW), where the consumer would accept reductions during the periods of management activities. Reduction periods – periods of active management - would be announced in advance, through the media.
This type of consumer would become a so-called partner. The total load reduction would last for 200 – 300 hours per year, and would normally only exceed 5 hours per day, up to not more than 10 hours a day, during the few days with the most severe outages in electric power system. The consumer will in return gain the right to have lower prices for the load item on their electricity bill. The consumers who did not go for the 2.2. option, and have not become partners, would not have right to be compensated in accordance with the yearly agreed load level.

2.3. In the case of outages, all consumers (under options 2.1. or both 2.1. and 2.2.) would be limited to the level of e.g. 0.3 kW. Consumers for whom none of the types of load management during outages is possible, would be cut off from the system!
The main objective of this approach is not only to eliminate the possibility of consumers being cut off, but also to reduce their load in the long run. A key advantage of the proposed management method is that the consumers, the partners of the supplier, would not be left without the minimal supply necessary for short-term socially bearable living during power reductions.

In time, with higher standards, limitations of consumption through cut-off measures for those who exceed it, would be applied only in cases of non-payment. The cut-offs, since multifunctional electricity meters have this ability, would be recorded and translated into power spent during the management actions, charged at a significantly higher price. Global experience shows that the desired result can be achieved with prices at least 10-20 times higher than the current regular supply price (2). For all consumers, more expensive day and cheaper night tariffs would still be applied.

4. CONCLUSION

The paper presents the load management system based on multifunctional electricity meters with a built in circuit breaker. This device presents a sophisticated alternative to “limitators”.
At the moment, EPS has a huge number of electricity meters whose life times expired long ago. Since the replacement of these meters with multifunctional electricity meters is currently on-going, this opportunity should be used, to at the same time, and with no significant extra cost, realise an additional, extremely useful, technically sophisticated tool for load management in the electric energy system. This system will without doubt enable financial benefit for all involved, and significantly improve the supplier-customer relationship.

5. REFERENCES

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