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Systematical energy losses of electronic meters

Abstract

The present trend and varying rules of the law have been causing a significant increase of the electric energy electronic meters application; they have simply begun substitute the mechanical ones. Development of technology has made the electronic meters become cheaper and obtain many complex measuring capabilities; their wider and wider use allows to make easier the current analysis of the electric energy parameters and to influence on minimization of the energy losses, which are estimated on the basis of the energy demand forecast. The systematical energy losses, arising (among others) because of any energy meters, are the essential component of the commercial energy losses. In connection with the fact, suitable researches have been realized in order to determine the systematical energy losses caused by the electronic meters.

I. AN ELECTRICITY METER AS A DEVICE BEING THE SOURCE OF THE ENERGY LOSS

The electricity meters are the devices, which consume a little electric energy passing through their internal structures; in the mechanical ones, this energy is being converted mainly into kinetic energy. From this point of view, the mechanical electricity meters operate like the electrical motors. All the energy losses occurring in the electrical rotational machines may be classified [2] as follows:

– losses in windings, caused by the current,
– losses in core plates(hysteresis loss and rotating field loss),
– mechanical losses, resulting of the friction of shaft against bearings and of the friction of rotating parts against air,
– insulation losses, resulting of the variable electrical field (these losses are very small for the low-voltage devices).

Some of the above energy losses arise, per analogy, in the mechanical electricity meters.

In the electronic meters, a part of electric energy is being converted (among others) into light flux of their displays. These meters consume the energy to enable operating of their electronic systems, of their displays, and of their additional input-output elements (optical connection, remote reading of meter).

II. ENERGY LOSS CAUSED BY THE METER STARTING CURRENT

The firms, producing the one-phase induction meters of electricity, place in the catalogues the parameter called “admissible starting current”, which is expressed as the proportional fraction of the meter rated current [1]. The one-phase meters are widely applied to measure electric energy at the municipal consumers being supplied by the low voltage power network. The induction meter starting current is, on the average, equal to 0,5% of its rated current (I_r=0,005I_N). An electric energy consumer may be continuously using up a small portion of electric power that – passing through the one-phase induction meter of the rated current I_N=10 A – will not be measured (will be neglected); the value of this power is being evaluated as follows:

$$P_r = U_N I_r = 230 \cdot 0{,}005 \cdot 10 = 11{,}5W .$$

Assuming that a consumer will be consuming that small power during one-year period, the non-measured electric energy (passing through his induction meter) ΔE_{hs} will reach the value

$$\Delta E_{hs} = P_r T_r = 11{,}5 \cdot 8760 = 100{,}7kWh .$$

This value is relatively high, especially regarding the fact that a common consumer uses up about 3000 kWh/a; the relative non-measured energy $\Delta E_{hs\%}$ amounts to

$$\Delta E_{hs\%} = \frac{\Delta E_{hs} \cdot 100}{E_{pob}} = \frac{100{,}7 \cdot 100}{3000} = 3{,}34\% .$$

Obviously, in the case of applying the electricity meter of the smaller rated current – for example I_N=5 A – this magnitude will obtain respectively the smaller value, and consequently, the greater one in the case of applying the electricity meter of the rated current I_N=20 A. The commercial systematical energy losses will not occur in the consumer’s meter, if the passing current is greater than the starting current. Such a small passage of current occurs mostly during the night while the TV devices work in the stand-by mode; cell phone chargers and other electronic equipment also consume the small currents. Recently, presence of such devices in the households is an ordinary phenomenon, and their quantity may be compared to the entire consumers’ number. Practically, period duration of passage of the current, smaller than the meter starting current, may be assumed in the interval: a few, several hours a day. With the assumption (on the average) 8 hours per day, the monthly non-measured electric energy ΔE_{hsm} being consumed by a common consumer has been evaluated below

$$\Delta E_{hsm} = Pt_m = 11{,}5 \cdot 240 = 2{,}76 kWh \,.$$

In order to decrease ΔE_{hsm}, the producers reduce the starting current of the induction meters; it especially concerns the new produced ones. However, the starting current of the induction meters will never reach the zero value because of the greatest friction while the meter start-up.

The electricity electronic meters are able to measure electric energy corresponding with very small loads; they simply react for the passage of current, which is a few tens times smaller than an analogous one of the induction meters. It could easily create an expression that the commercial systematical energy losses should be significantly lower in the electronic meters than in the induction ones. However, some circuits of the electronic meters ought to be continuously supplied; some meters need also a shunt to measure the current correctly. These make the commercial systematical energy losses increase.

III. THE COMMERCIAL SYSTEMATICAL ENERGY LOSSES OF THE ELECTRONIC METERS

The commercial systematical energy losses, arising in the electricity meters, have been determined on the basis of the billing system data concerning an urban district. A primary data sample has contained 26048 observations of the type: counter status, corresponding date; observations have concerned both the mechanical and the electronic meters. The primary data sample has been randomly limited to 200 measuring points and subsequently purified. Rules of the data sample purification have been the following ones:

- the readings of each meter should be contained in the period 300-419 days, both for the induction meter before its replacing by the electronic one and for the electronic meter that has replaced the induction one; data that have not belonged to this period, have been rejected,
- the reading period should be equal to the yearly period (or as near, as possible) in order to minimize influence of the energy consumption seasonality on the analysis results; so, only the best completes of data have been qualified to the final sample,
- data, concerning the incorrectly connected meters, have been rejected,
- data, concerning the consumers who have significantly increased power consumption, have been rejected,
- data of the extremely high and low average daily energy consumption have been also rejected.

The Fig. 1 presents the number of days between the particular meters readings. Because of the fact that the G tariff consumers' meters are being read every two months, the annual energy consumption of these consumers could not be precisely determined. It has not yet affected the results because the analysis has taken into consideration exclusively the average daily energy consumptions.

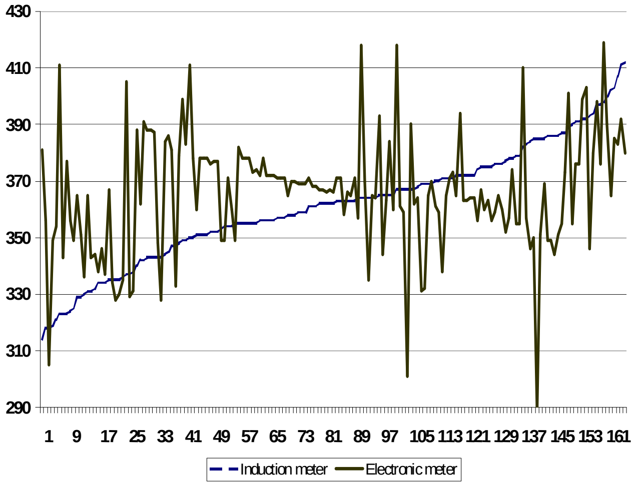

Fig. 1. Number of days between the particular meters readings.

The final data sample has been created according to the following rule: the reading periods for a new electronic meter – which replaces an induction meter – correspond approximately with the reading periods of the one being removed and replaced. In this way, the average daily energy consumptions have been evaluated and compared for both types of the electricity meters at 167 consumers.

IV. INFLUENCE OF AN-INDUCTION-METER-BY-AN-ELECTRONIC-ONE REPLACEMENT ON THE SYSTEMATICAL ENERGY LOSSES

A consumer's electricity induction meter has been measuring the energy during two sequent years; on this basis, his average daily energy consumption has been determined and notified E_{di}. Next, an electronic meter has replaced that one; it has been measuring the energy during the analogous period, and the consumer's average daily energy consumption has been for the second time determined and notified E_{de}. The difference ΔE_d, equal to

$$\Delta E_d = E_{de} - E_{di} \,,$$

either may reach the negative value, or may be the positive one. If the difference ΔE_d is negative, then the electricity seller will suffer the loss; if its value is positive, then electricity seller will gain the profit: the electronic meter of the smaller starting current has measured the greater energy, so its consumer will pay a little more. The obtained results confirm partly the conclusions of the study [1], which has remarked the significant increase of the annual energy consumption measured by the induction meters.

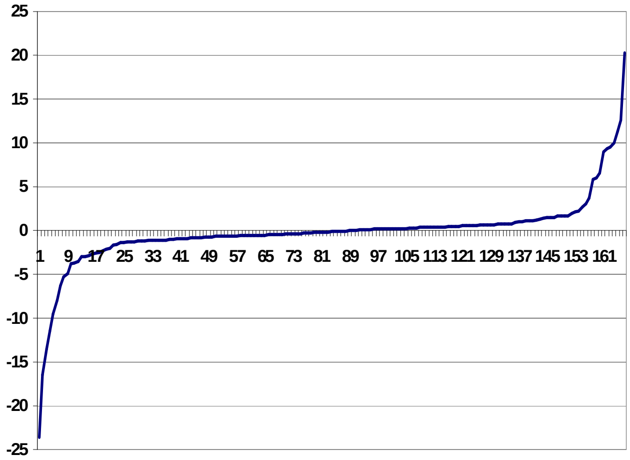

Fig. 2. Difference of the annual energy consumption after replacing an induction meter by an electronic one.

The average daily energy consumption has been evaluated on the final sample basis and presented in the Fig. 3; this sample has been suitably prepared in order to keep proportional share of the particular tariff consumers on the same level as in the District of the Distribution Company.

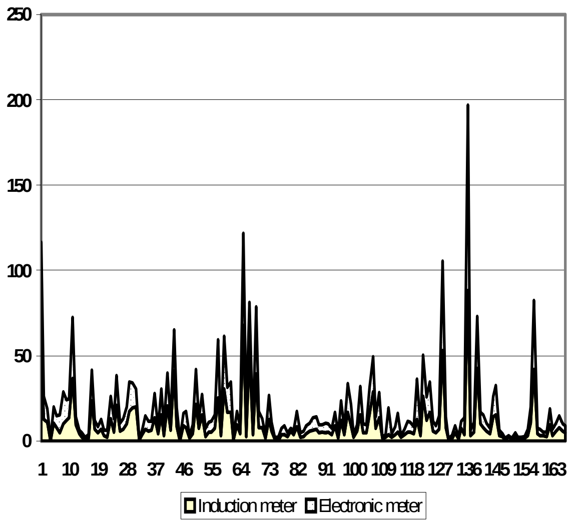

Fig. 3. Average daily energy consumption for the final sample of meters (167).

V. ANALYSIS OF THE RESULTS

The average daily energy consumption – for different data samples – has been placed in the Table 1. The consumption concerns only these consumers, at which an induction meter has been replaced by an electronic one.

Table 1. The average daily energy consumption (ADEC)

Sample peculiarity	1	2	3	4	5	6	7
	piece	[kWh/consumer]				[kWh/a]	
Contains the data for 300-419 days long period of measuring	167	9,79	9,64	9,72	-0,16	3546	-57
Records, concerning the consumers of increased power consumption and of the incorrectly connected meters	5	29,94	37,24	33,59	7,30	12259	2665
Contains the data after rejecting the records of second row	162	9,77	9,41	9,59	-0,36	3501	-131
Records of the extremely high and low average daily energy consumption	16	24,01	19,60	21,80	-4,41	7958	-1610
Contains the data after rejecting the records of fourth row	146	8,52	8,48	8,50	-0,04	3102	-14
Records of the low size of the definite type meters	18	8,63	10,22	9,42	1,59	3440	566
Final representative data sample	128	7,96	7,71	7,84	-0,25	2861	-91

Columns in this table mean (respectively):

1. Sample size,
2. Average daily energy consumption (ADEC) by an induction meter,
3. ADEC by an electronic meter,
4. ADEC by a meter,
5. Average daily balance,
6. Average annual energy consumption,
7. Annual balance.

It results from Table 1 that the average annual energy consumptions are inconvergent; the average annual energy consumption is equal to 3546 kWh and it corresponds with the analogous average for the District of Distribution Company. The obtained data show simultaneously either an increase, or a decrease of the consumed energy in the case of replacing an induction meter by an electronic one. Randomness of the analyzed sample concerning the considered district proves that – in spite of its relatively small size – this sample is representative. The average daily balance is equal to 0,16 kWh; it means the difference of the energy consumption in the case of replacing the meter. Additionally, during two-year period of the analysis, the average annual energy consumption has increased by 0,4%.

The analysis of the energy balance has not taken into consideration the energy being used up by the electronic meters to ensure their operating; an additional study, very expensive and long lasting, should be realized to regard these losses.

The difference between the average daily energy consumptions of the one-phase meters: mechanical and electronic is positive; this difference indicates that they have been working in the accuracy class upper range. The same difference, but concerning the three-phase meters of both types, has turned out to be the negative one; it is probably caused by occurrence of miscellaneous loads like pumps, ventilators, and air-conditioning devices.

The insignificant difference between the average daily energy consumptions, in the case of replacing an induction meter by an electronic one, implies similarity of the systematical energy loss level for the meters being considered.

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