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Development of Expert Finding and Opinion from the Field of Electrical Sciences

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Abstract: Electricity theft is a criminal act, which is treated differently in different countries. Starting from the premise that everyone is innocent until proven guilty, it is necessary to give every accused an equal chance for a fair and impartial trial. Considering that it is a professional issue, specifically an electrotechnical area for which the court does not have adequate knowledge, there is a need to hire experts for the purpose of a fair and democratic judicial process. Hiring skilled persons (specifically in the field of electrical engineering) allows the court to work in a relaxed manner without delving into the technical areas itself. In the course of the previous practice in the preparation of expert reports made by fellow experts, differences can be observed, sometimes diametrically, not only in the production methodology, but also in the form of the approach to the problem. This can cause confusion for users of these findings. On the other hand, expertise must be done impartially and professionally, leaving no doubt of bias towards any party. The purpose of this paper is to contribute to the methodology for producing a professional and objective finding and opinion, especially since so far no papers have been produced for such a thing, at least not here in the Republic of North Macedonia. Also, a methodology is offered for the calculation of damage caused by this theft, towards a distribution system operator.

Keywords: Theft, Unauthorized Taking of Electricity, Manipulation of a Measuring Point, Skilled Person, Methodology, Procedure

1. Introduction

Unauthorized taking of electricity (theft) is as old as the registration of consumed electricity. A "competition" between a user and a distribution system operator is like a cat and mouse story. In the beginning, when the first devices for measuring consumption (inductive meters) appeared, the theft methodology was based on 1) disconnection of one or two voltage circuits, 2) acting on the outside of a measuring device with a permanent magnet, 3) with micro hole drilling and mechanical stiffening of the rotating disc. This kind of manipulation of a measuring device was easily determined by on-site inspection. We have completely different situations with the appearance of digital measuring devices. They have a system clock and there are several sensors that detect a violation of the integrity of a measuring device. These disturbances are stored in the device's internal memory under code numbers, the meaning of which is explained through the so-called "OBIS" codes, which will be given later in the paper. Finally, we have "GSM" meters that, with the help of a mobile network, promptly send a certain amount of data to the operation center of the distribution system operator. Here we will mention various SCADA systems as well as other ways of remote control of the measuring device. [1].

2. Definition

Theft of electricity is a common occurrence in our society. The reasons for this are different. Everyone steals electricity. From holders of social assistance, to owners of cafes and other entities, with the aim of obtaining an illegal benefit - payment of consumed electricity. Theft of electricity (professional name - Unauthorized taking of electricity), represents any form of taking of electricity by the User, when there is no proper registration of consumption, partially or completely. Theft of electricity is a criminal act, according to Art. 235-a of the Criminal Law of RNM. For those reasons,

the expertise on this issue is treated as carefully and seriously as possible. A skilled person should first unequivocally establish the existence of the crime. For this purpose, the expert has to determine if the committed act coincides with one of the 7 articles from "Network Rules and Law on Energy, which define cases of theft-unauthorized taking of electricity. Thats all:

1) if a user connected his facility to a distribution network, without a consent decision for connection issued by DSO (Distribution System Operator);
2) after disconnection of a user from the distribution network by the DSO, the user arbitrarily rejoined the distribution network;
3) if a user has manipulated a measuring device, taking an unregistered amount of electricity;
4) if a user receives electricity without measuring equipment;
5) if a user has performed bridging of measuring equipment, taking over unregistered electricity, partially or in full;
6) if the user has installed measuring equipment that is not approved and/or installed by DSO;
7) if a user receives electricity through damaged measuring equipment and/or a protective seal has been removed, which makes it impossible to correctly register the amount of electricity received. [1, 3, 4].

3. Procedure for Determining the Crime

A skilled person determines the existence of the crime by an on-site inspection or from documentation from an on-site inspection, if it was carried out by another authorized person, usually employees of a distribution system operator (DSO). This case is accompanied by a record from the Ministry of the Interior and photographs, which unequivocally show the crime. Taking these data into account, a skilled person determines which of the 7 articles corresponds to the crime committed, as well as how it was committed.

Evidence is not always offered sufficient to establish the crime unequivocally. Sometimes it is necessary to carry out an additional on-site inspection. These include unfinished probate proceedings, renting of business or residential space to other persons, etc. In that case, a skilled person, determining the time of the committed act, asks the involved parties for additional documentation, such as title deeds, sales contracts, or rental contracts. There are cases when the parties are abroad, and their houses are guarded by relatives or friends, so at that time thefts are detected. Answers to these questions can be easily obtained by looking at the indicated documents. [7, 8].

Let us mention that during the on-site inspection to establish the facts, or if a skilled person receives documents with minutes from other persons, there should be at least three photographs. One of the measuring place or the object itself, another of the way the act was performed and the serial number of the meter. This data is necessary so that a skilled person can "associate" the user with the work. In doing so, the skilled person should also request from the DSO other data, such as the number of the measuring point, the number of the user or other data, if there is a need for it, in order to unambiguously determine the connection of the user with the crime. Often times, the building where the theft of electricity was determined was leased, with a probate procedure not carried out or ownership rights not transferred in the cadastre. In those cases, it is necessary to request documents or other acts that would establish the identity of the user at the time of the crime. [9].

4. Ways of Stealing Electricity

In case of unauthorized taking over of electricity, with manipulation of a measuring device and its integrity is violated, we proceed as follows. This work is, by right, determined by a regular or extraordinary a-test of a measuring device, which is carried out in a certified laboratory for testing measuring equipment. As a result of this examination, a non-skilled person is presented with an a-test Report, which contains the parameters of whether the measuring device is correct or not. If the measuring device is defective, the type and type of damage as well as the error of the tested measuring device are indicated. The most common case is the manipulation of measuring voltage circuits (one or two), with which the device has an error of -33% or -66%, respectively. If any of the parties expresses doubts about the accuracy of this examination, a skilled person can schedule an inspection of the laboratory for examination in the presence of interested parties. The inspection is carried out in the presence of two members from the laboratory and an authorized person from the State Metrology Institute, because the state seal is destroyed when opening a measuring device. Imaging of the actual state of determined manipulation is performed, which confirms the results of the a-test.

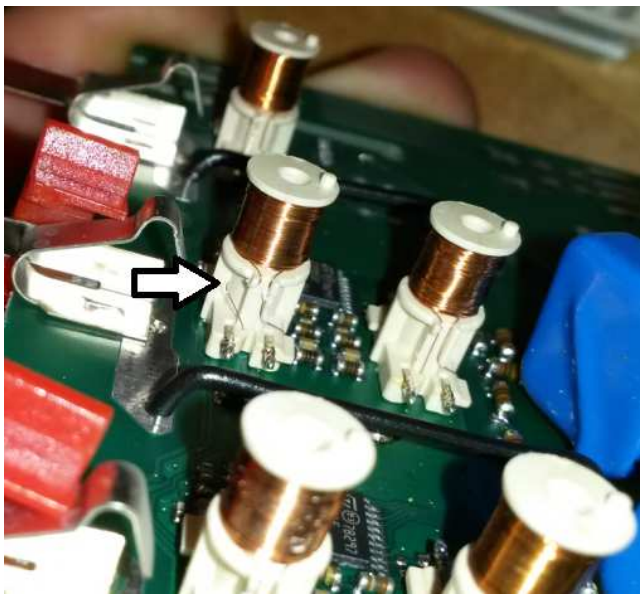

Figure 1. *Damaged voltage circuits due to which the meter registers with an error.*

Unlike the old induction meters, the new electronic meters are equipped with an internal memory and an internal clock. With their help, the memorization and timing of a whole series of data from the operation of a measuring device is enabled. These data are standardized with so-called "OBIS" codes. OBIS codes identify various data in the device in accordance with the "OBIS" standard (IEC 62056-61). A complete analysis of data obtained with the help of OBIS codes is beyond the scope of this paper, but we will refer only to some important ones, which contribute to the creation of the expertise. During an a-test of a meter, several listings with data important for making a skilled finding and opinion can be obtained from it. One such is "Tabular data readout". The document represents a set of data in chronological order in terms of consumption, as well as situations with violation of the integrity of the meter with dates and time. The second document that we can get from the meter's memory is the so-called "Book of events" (Tabular log book). The document provides chronological events related to the meter from the moment of installation until its dismantling from the measuring point at the user's place. The third document, called "Report" (ReportReadout), represents a document that is obtained with each reading of a meter with an optical probe. From it, the state of the integrity of the meter can be determined, between two consecutive readings, which allows a skilled person unobstructed insight into a change in the meter's parameters. For practical reasons, these reports (listings) are attached to this paper. [5, 6].

Table 1. *ReportReadout Data - certain parameters obtained during each optical probe reading.*

Code	Value	Comment
51.7.0	0.0 A	Presence of phase 2 current
71.7.0	0.5 A	Presence of phase 3 current
32.7.0	229 V	Presence of phase 1 voltage
52.7.0	230 V	Presence of phase 2 voltage
72.7.0	230 V	Presence of phase 3 voltage
C 51.1	0011	Socket cover opening number
C 51.2	1110618122558	Time of last opening of socket cover
C 51.3	0001	Number of opening head cover of the meter
C 51.4	0091213174452	Time of the last opening of the head cover of the meter
C 51.5	0000	Number of manipulations (impacts) with a permanent magnet
C 51.6	0000101000000	Time of last manipulations (impacts) with a permanent magnet
C 51.7	0000	Number of reverse energy flows through the meter
C 51.8	0000101000000	Time of last flow of energy in the reverse direction through the meter
C 2.0	0000	Nr of parameterisation
C.2.1	0000101000000	Date of last param.
C.6.0	54060	Battery hour counter
O.2.0	V1.11	Version number
O.2.2	07131622	Time switch program checksum

An example of what a listing looks like (Tabular data readout). We are mostly not interested in data under code C 51.2.

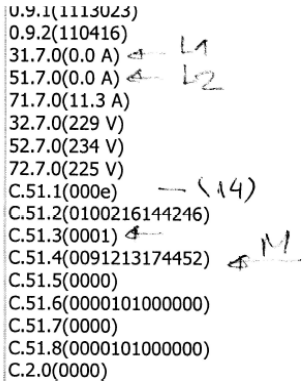

Figure 2. *Part of the data from ReportReadout, essential for determining the date of the theft.*

The image shows an enlarged port opening. It is given in hexadecimal system C51.1 (000e = 14 opening), as well as the date of the last opening (C 51.2). This listing is received every month, so it is easy to send an opening between two readings. Other ways of theft: Manipulation of a metering point:

a. Interconnection in meter.
b. Connection behind the meter.
c. Ceiling connection-parallel installation.

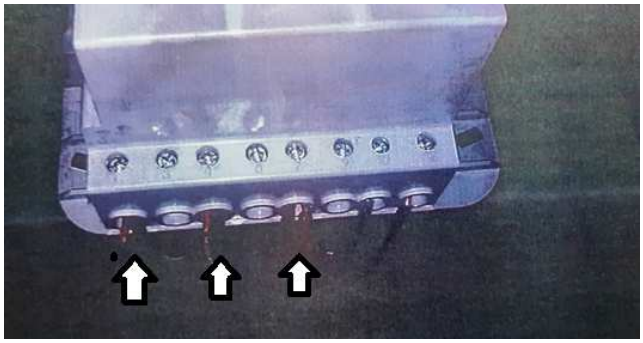

Figure 3 *Manipulation of a measuring point by connecting a measuring device in a socket.*

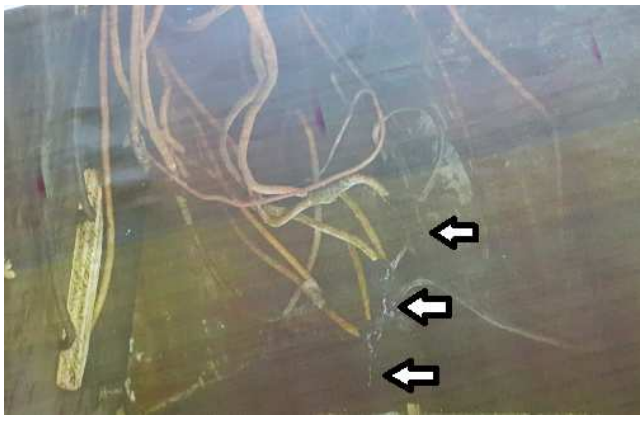

Figure 4. *Connection of a meter behind a carrier board made of fiber.*

I will cite an interesting example of theft, which is less common. Namely, during the construction of the building, the owner made a parallel installation, connecting to a supply cable from a pole (roof connector), directly in front of a

measuring device. At the same time, he received an orderly connection with a meter which, in this case, did not register the total consumption. The case was discovered during technical control-replacement of the meter. Since the owner died in the meantime, and he did not inform his wife about this parallel installation (so that she would know how to behave in this situation), when the meter was dismantled, there was still electricity in part of the house. With a detailed inspection, another distribution cabinet hidden in the kitchen was found.

Finally, when talking about electricity, when a user is connected directly to an electrical network, without a measuring device, a skilled person is a relatively easy task. With an on-site inspection, or if the inspection is done by other persons, the most important thing is to establish the fact that there is a place where the user connected to the electrical network. Sometimes it is the place of the nearest pole, and sometimes the user connects to a completely different place, in relation to his location, up to 200 meters away or more. The crime is proven by photographs of the place of the connected cable and the absence of a measuring device. [10, 15].

5. Method of Determining Consumed and Unregistered Electricity in Case of Theft

Often, a skilled person is asked to determine the (approximate) amount of consumed and unregistered electricity, which occurred as a result of unauthorized taking of electricity. In this case, two methods are available to a skilled person to determine it.

The first way is to use the list of reported consumption immediately before or after determining the crime, to determine the approximate consumption, and to consider it as consumed and not registered. this uses a comparative method of comparing consumption in a period when we have proper registration of consumption and which we assume is close to the period when the theft was committed. An example of what a meter reading by DSO looks like.

R	19669,2	28.02.2018
O	19952,4	27.03.2018
M	20314,1	30.04.2018
O	20314,1	31.05.2018
O	20314,1	27.06.2018
O	20334,7	24.07.2018
E	20356,9	27.08.2018
O	20510,3	26.09.2018
R	20527,8	30.09.2018
O	20694,9	29.10.2018
R	20709,5	31.10.2018
O	20971,2	27.11.2018
R	21008	30.11.2018
O	21523,4	26.12.2018
R	21633,4	31.12.2018
O	22143,6	28.01.2019
R	22184,1	31.01.2019
O	22483,7	22.02.2019
W	22543	25.02.2019

Figure 5. *Typical appearance of a single meter reading.*

O - reading from a reader
R - reset states
K - user reading
V - manually entered state by operator
I - extraordinary reading
E - manual assessment of reported conditions
M - machine-assessed condition
W - reading when replacing the meter.

From these data, the consumption for the period in question is determined, and thus the damage caused to the DSO. In this way, the following table is obtained (from another user). [2].

Table 2. *An overview of the client's consumption for one year.*

Month	Date	HT Old	HT New	Difference	LT old	LT New	Difference	Total
1	January	10899,0	12075,0	1176,0	14005,0	15119,0	1114,0	2290,0
2	February	12075,0	12717,0	642,0	15119,0	15878,0	759,0	1401,0
3	March	12717,0	13104,0	387,0	15878,0	16319,0	441,0	828,0
4	April	13104,0	13438,0	334,0	16319,0	16782,0	463,0	797,0
5	May	13438,0	13588,0	150,0	16782,0	16941,0	159,0	309,0
6	June	13588,0	13755,0	167,0	16941,0	17088,0	147,0	314,0
7	July	13755,0	13846,0	91,0	17088,0	17204,0	116,0	207,0
8	August	13846,0	14048,0	202,0	17204,0	17376,0	172,0	374,0
9	September	14048,0	14210,0	162,0	17376,0	17516,0	140,0	302,0
10	October	14210,0	14327,0	117,0	17516,0	17710,0	194,0	311,0
11	November	14327,0	14523,0	196,0	17710,0	18054,0	344,0	540,0
12	December	14523,0	14766,0	243,0	18054,0	18630,0	576,0	819,0
				Total for 2017 y. KWh				8492,0

Legend: HT High Tarife; LT Low Tarife.

The second way of calculation is by performing an on-site inspection, in the user's facility, which determines the number and type of consumers that the user has. By applying empirical formulas for the average use of individual consumers, an approximate value is obtained for consumed and unregistered electricity for the period for which the calculation is performed. Let's mention that the transition period for calculation for unauthorized taking of electricity can be a maximum of 365 days, counting backwards, from the day of determination of the crime. (Art. 142 paragraph 1) of the Network Rules). The period can be shorter if there is data about it in the records of the DSO (Article 142 paragraph 2). The obtained data are

processed with the following tables.

Table 3. *Assumed daily consumption of the client in summer.*

No.	Consumers	No of same consumers	Installed power of one consumer (KW)	Coefficient of simultaneous	Simultaneous power (KW)	Average daily use (h)	Average daily consumption (KWh)
1	Electric stove	1,00	4,50	0,33	1,49	2,00	2,97
2	Refrigerator	1,00	0,25	1,00	0,25	6,00	1,50
3	Water heater	1,00	2,00	1,00	2,00	2,00	4,00
4	Lamps	6,00	0,01	0,50	0,03	4,00	0,12
5	Tv, radio	1,00	0,50	1,00	0,50	4,00	2,00
6	Washing machine	1,00	2,20	1,00	2,20	0,42	0,92
7	Heater	1,00	2,00	1,00	2,00	0,00	0,00
	Total daily consumption Summer KWh						11,51

Table 4. *Assumed daily consumption of the customer in winter.*

No.	Consumers	No of same consumers	Installed power of one consumer (KW)	Coefficient of simultaneous	Simultaneous power (KW)	Average daily use (h)	Average daily consumption (KWh)
1	Electric stove	1,00	4,50	0,33	1,49	2,00	2,97
2	Refrigerator	1,00	0,25	1,00	0,25	4,00	1,00
3	Water heater	1,00	2,00	1,00	2,00	2,00	4,00
4	Lamps	6,00	0,01	0,50	0,03	8,00	0,24
5	Tv, radio	1,00	0,50	1,00	0,50	4,00	2,00
6	Washing machine	1,00	2,20	1,00	2,20	0,50	1,10
7	Heater	1,00	2,00	1,00	2,00	7,00	14,00
	Total daily consumption Winter KWh						25,31

Table 5. *User consumption for the period in question.*

No	Period	Number of days	Total consumption daily KWh	Total consumption for 11 months
1	Winter	(four months) 120 days	25,31	3.037,00
2	Summer	(seven months) 214 days	11,51	2.463,00
3	Total consumption for period 11 months (KWh)			5.500,00

In this case, the theft was established over a period of 11 months. Total consumed electricity for a period of 11 months (KWh) 5,500.00 Financial calculation: In the calculation for the price of one KWh, the average price for one tariff is taken.

Table 6. *Financial calculation.*

Accounting period	11 months
Amount of reg. energy in KWh	5.500,13
Unit price per KWh. In den.	4,16
Total	22.880,00
Tax basis	22.880,00
Tax 18%	4.118,00
Total denari	26.998,00

This is how a typical calculation looks like for the user, where the calculation is made according to the type and type of devices. [11, 12]

6. Conclusion

Electricity theft is relatively easy to determine and prove in modern conditions. In most cases, it was done by socially vulnerable categories for financial reasons. Experience shows that theft also occurs in mini-businesses, local powerhouses and the like. In recent times, it has gained more momentum due to the generation of crypto currencies.

Calculation of damage caused to a distribution system operator is always approximate, because during manipulation of a metering point, the metering device is partially or completely unable to register accurate consumption. Various methods presented in the paper give results with greater or lesser accuracy. Our goal is to choose the method with the least error. For those reasons, when calculating the damage, it is said that it is about "approximately consumed and unregistered electricity". [13, 14]

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