GOCE DELCEV UNIVERSITY - STIP
FACULTY OF COMPUTER SCIENCE

ISSN 2545-4803 on line
DOI: 10.46763/BJAMI

BALKAN JOURNAL OF APPLIED MATHEMATICS AND INFORMATICS (BJAMI)

BALKAN JOURNAL
OF APPLIED MATHEMATICS AND INFORMATICS

YEAR 2021

VOLUME IV, Number 1

GOCE DELCEV UNIVERSITY - STIP, REPUBLIC OF NORTH MACEDONIA
FACULTY OF COMPUTER SCIENCE

ISSN 2545-4803 on line

BALKAN JOURNAL OF APPLIED MATHEMATICS AND INFORMATICS

(BJAMI)

YEAR 2021 VOLUME IV, Number 1

AIMS AND SCOPE:
BJAMI publishes original research articles in the areas of applied mathematics and informatics.

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Republic of North Macedonia

BALKAN JOURNAL
OF APPLIED MATHEMATICS AND INFORMATICS (BJAMI), Vol 3

ISSN 2545-4803 on line
Vol. 4, No. 1, Year 2021

EDITORIAL BOARD

CONTENT

DOI: 10.46763/BJAMI2131007ag
UDC: 621.316.1.08:343.148

METHODOLOGY FOR PREPARING EXPERTISE IN THE FIELD OF ELECTRICAL ENGINEERING

Nenad Popovic & Saso Gelev

Abstract. During the current practice in the making of expert witness report made by some of our colleagues, sometimes diametrical differences can be noticed, not only in the methodology of the making, but also in the form of how the problem is approached. This may confuse those for whom these findings are intended. With this paper, the authors try to contribute to the methodology for making a professional and objective finding and opinion, especially since no such work has been done so far, at least not in our country (in RNM). This paper covers the issue of electricity theft and consists of four parts. The first part gives a definition of electricity theft and provides some cases which are considered theft by the laws in RNM. The second part covers the procedure for determining the crime itself, together with administrative evidence. The third part covers the ways of the committed act, from which the existence of the said act can be unequivocally determined. The fourth part covers the manner and methodology of calculating material loss, which was suffered by the distribution system operator (DSO), because during the theft electricity is taken over without it being registered and charged.

Keywords: Theft, electricity, witness expert, methodology, procedure.

1. Definition and classification of the work

Electricity theft is common in our society. The reasons for this are different. Electricity is stolen by different types of groups. From social welfare providers to owners of cafès and other entities, in order to gain illegal benefits - not paying for consumed electricity.

Electricity theft, or otherwise named unauthorized use of electricity, is any form of taking over electricity by the user, when there is no proper registration of consumption, in part or in full. The theft of electricity is a crime, according to Art. 235-a of the Criminal Code of the RNM [1]. For these reasons, the expertise of this issue is treated very carefully and seriously.

A witness expert should first unequivocally establish the existence of the act [3]. To this end, the expert should determine whether the offense complies with one of the seven articles of the "Rules for Distribution of Electricity" [2], which define cases of theft or unauthorized taking of electricity. Those are:

1) if the user has connected his / her facility to a distribution network, without a decision for connection consent issued by the DSO (Distribution System Operator);
2) after disconnection of a user from a distribution network by the DSO, the user voluntarily reconnected to the distribution network;
3) if the user has manipulated a measuring device by taking an unregistered amount of electricity;
4) if the user takes electricity without metering equipment;
5) if the user has bridged the measuring equipment, taking over partially or completely unregistered electricity;
6) if the user has installed measuring equipment that is not approved and / or installed by the DSO;
7) if the user takes electricity through damaged measuring equipment, and / or the protective seal is removed, which prevents proper registration of the taken amount of electricity.

2. Ways of stealing electricity

In case of unauthorized usage of electricity by manipulating a measuring device that violates its integrity, we act as follows. This work is usually determined by a regular or on demand A-test of the measuring device, which is conducted in a certified laboratory for testing measuring equipment. As a result of this examination, the witness expert is not presented with an A-test report which contains the parameters for whether the measuring device is correct or not. If the measuring device is defective, the kind and the type of damage as well as the error of the tested measuring device are stated.

The most common case is the manipulation of measuring voltage circuits (one or two), so that the device has an error of -33% or 66%, respectively. If any of the parties expresses doubts about the accuracy of this examination, the expert may schedule an inspection in the examination laboratory in the presence of the interested parties. The inspection is performed in the presence of two members of the laboratory and, because the state seal is destroyed when opening the measuring device, the presence of an authorized person from the State Metrology Office is necessary. The actual condition of the determined manipulation is photographed, which confirms the results of the A-test.

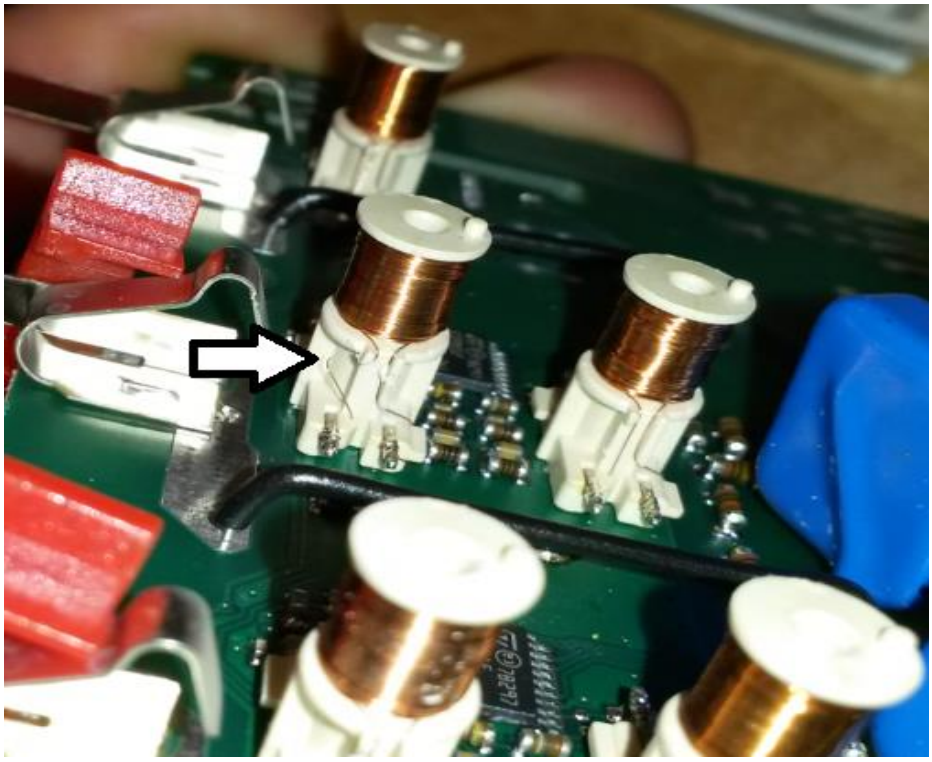

Figure 1. *Damaged voltage circuits due to which the meter registers with an error*

Unlike the old induction meters, the new electronic meters are equipped with an internal memory and an internal clock [4]. With their help it is possible to memorize and determine the time of a whole series of data from the operation of the measuring device. These data are standardized with the so-called OBIS codes. OBIS codes identify different data in the device in accordance with the OBIS standard (IEC 62056-61) [5]. The complete analysis of data obtained with the help of OBIS codes goes beyond this paper, but we will focus only on some of the important data, which contribute to the preparation of the expertise.

During the A-testing of the meter, several reports can be obtained with important data for making a witness expert finding and opinion. One such report is the Tabular data readout, a document that is a

set of data in chronological order in terms of consumption, as well as a condition of violation of the integrity of the meter with date and time.

The second document that we can get from the memory of the meter is the so-called Tabular logbook. The document gives chronological events related to the meter from the moment of installation until its dismantling from the measuring point at the user.

The third document, called ReportReadout, is a document that is obtained from each reading of an optical probe meter. It can be used to determine the state of integrity of the meter between two consecutive readings, which allows the witness expert to see the change in the parameters of the meter. For practical reasons, these reports are attached to this paper.

Table 1. *Reports*

Code	Value	Comment
51.7.0	0.0 A	presence of current in phase 2
71.7.0	0.5 A	presence of current in phase 3
32.7.0	229 V	presence of current in phase 1
52.7.0	229 V	presence of current in phase 2
72.7.0	230 V	presence of current in phase 3
C.51.1	0011	number of socket cover openings
C.51.2	1110618122558	time of the last opening of the socket cover
C.51.3	0001	number of openings on the main meter cover
C.51.4	0091213174452	last time the main meter cover was opened
C.51.5	0000	number of manipulations (impacts) with a permanent magnet
C.51.6	0000101000000	time of the last impact with a permanent magnet
C.51.7	0000	number of energy leaks in the reverse direction through the meter
C.51.8	0000101000000	time of the last case of reverse energy flow
C.2.0	0000	Number of parameterizations
C.2.1	0000101000000	Date of the last parameter
C.6.0	53060	Batter hour counter
0.2.0	V1.11	Version number
0.2.1	07131622	Time switch program checksum

Example of what a report looks like (Tabular data readout). We are most interested in data under code C.51.1.

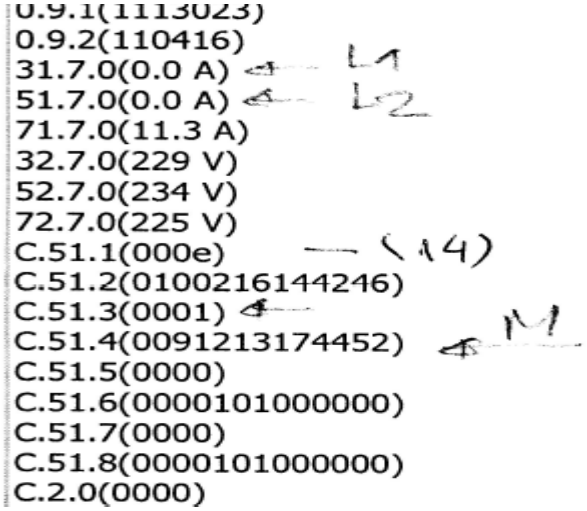

Figure 2. *Increase in the opening of the socket*

Figure 2 shows an increase in the opening of the socket. It is given in the hexadecimal system C.51.1 (000e = 14 opening), as well as the date of the last opening (C.51.2). Such a report is received every month, making it easy to track openings between two readings.

Other ways of electricity stealing:

- Manipulation at the measuring point
- switching on the meter
- switching behind the meter
- switching of the ceiling-parallel installation

When manipulating a measuring point, it is mainly determined how the crime was committed. For example, when switching to a meter socket, it is determined on the spot and documented with photographs (Figure 3). This violates the integrity of the meter (opens the socket cover), which is also documented in the "Tabular logout" under the codes: C.51.1, total number of socket openings and C.51.2, date of the last socket opening).

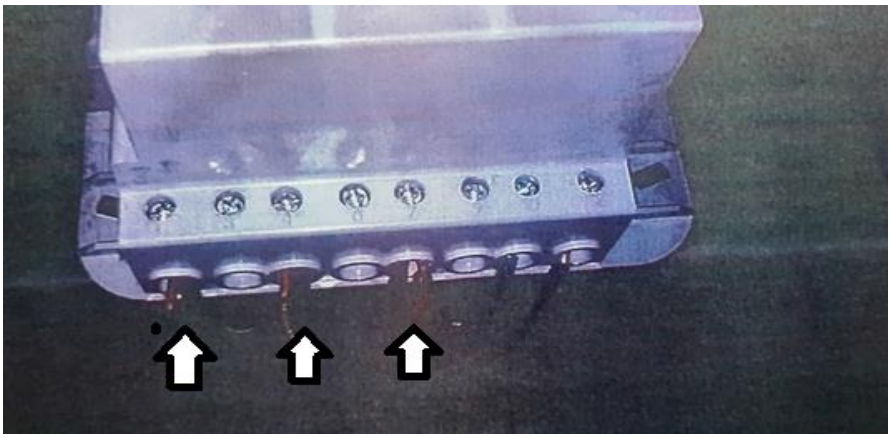

Figure 3. *Manipulation of the measuring point by switching the measuring device in the socket*

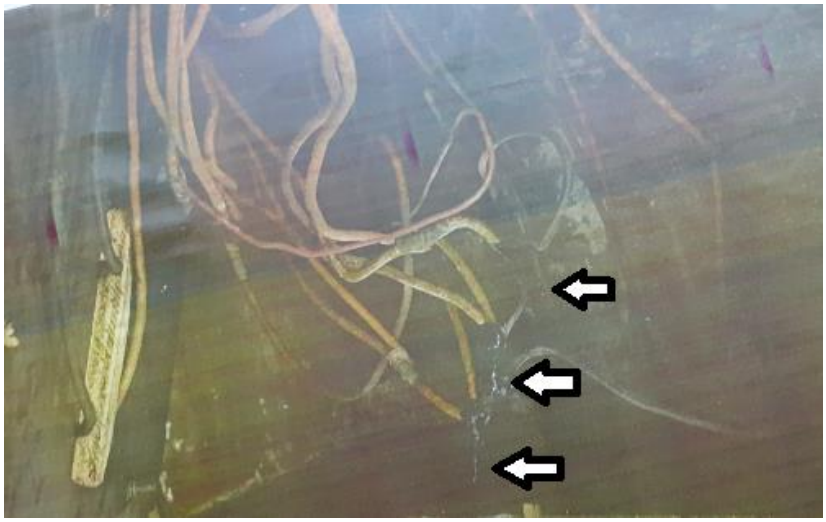

Figure 4. *Switching the meter behind a fiberglass support board*

An interesting and less common example of theft:

During the construction of the building, the owner made a parallel installation, connecting to a supply cable from a stand (roof connection) directly in front of the measuring device. At the same time, he received a proper connection with a meter which in this case did not register the entire consumption. The case was discovered during a technical control, i.e., replacement of the meter. The owner died in the meantime, and he did not inform his wife about this parallel installation; there was still electricity during the dismantled meter in a part of the house. With a detailed control, another distribution cabinet hidden in the kitchen was identified.

In the case of a power theft, when the user is connected directly to the main electrical supply without a measuring device, the expert has a relatively easy task. On-site inspection or if the inspection is made by other persons - the most important thing is to determine the fact that there is a place where the user has connected to the electricity network. Sometimes it is a place on the nearest pole, and sometimes the user connects to a completely different place in relation to his or her location more than 200 meters away. The crime is proved by photographs of the place where the cable is connected, as well as the absence of the measuring device.

3. Procedure for determining the crime

Each witness expert determines the existence of an act by on-site inspection or from documentation from the on-site inspection, if it is performed by another authorized person, most often by the employees of a distribution system operator (DSO). This case is accompanied by a report from the Ministry of Interior and photographs, which unequivocally depict the crime. Having in mind this information, the witness expert determines which of the seven articles or acts named above correlates with the committed act, as well as the way it was committed.

Sufficient evidence is not always offered for an unequivocal determination of the crime. Sometimes an additional on-site inspection is required. These include unfinished bequest procedures, renting business or residential space to other persons etc. In that case, the witness expert, determining the time of the act, requests additional documentation from the involved parties, such as property deeds, purchase agreements, or lease agreements. There are cases when thefts are found while the parties are abroad,

and their houses are guarded by relatives or friends. The answer to these questions is easily obtained by inspecting the indicated documents.

Note that during the on-site inspection to establish the facts, or when the witness expert receives relevant documents from other experts or third parties, it is necessary to have at least three photographs. One from the measuring point or the object, another showing the way the crime was performed, and the third with the serial number of the meter. This information is necessary for the witness expert to make a connection between the user and the crime. In such a situation, if there is a need for unequivocal determination of the connection of the user with the crime, the witness expert should ask the DSO for other data such as: number of measuring points, number of the user or other data. Often, the building where the theft of electricity was determined is leased with no proper hereditary procedure or no transferred property rights in the cadaster. In those cases, it is necessary to request documents or other acts that would determine the identity of the user at the time of the crime.

4. Manner of determining the consumed unregistered electricity during theft

The witness expert is often required to determine the approximate amount of electricity consumed and unregistered, resulting from an unauthorized electrical usage. In this case, two methods are available to the expert to determine the perpetrator of the crime of unauthorized taking of electricity.

The first way is with the help of the report from the read consumption, immediately before or after the determination of the crime, to determine the approximate spent or unregistered consumption. This uses a comparative method of comparing consumption in a period when we have a proper registration of consumption and which we assume is approximate, with the period when the theft was committed.

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. *An example of what a read meter by the DSO looks like*

O – Reading of the reader
R – Reset states
K – Reading from the user
V – Manually entered state from the operator
I – Irregular reading
E – Manual assessment of the read conditions
M – State assessed mechanically
W – Reading when replacing a meter

From these data, the consumption for a certain period of the given case is determined and thus the damage done to the DSO. With the data above, the following table is obtained (from another user).

Table 2. *Consumption for a certain period*

Mon -th	Date	High Tariff old	High Tariff new	Diffe-rence	Low Tariff old	Low Tariff new	Diffe-rence	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 KW/h		**8492,0**

The second way of calculation is by performing an on-site inspection, i.e., in the facility of the user, which determines the number and type of consumers that the user has. By applying empirical formulas for average consumption of individual consumers, the approximate value for consumed and not registered electricity for the period for which the calculation is performed is obtained. Note that the calculation period for unauthorized usage of electricity can be a maximum of 365 days, counting down from the date of determination of the offense (Article 142 paragraph 1 of the Grid Code). The period may be shorter if there are data for that in the records of the DSO (Article 142 paragraph 2). The obtained data are processed with the following tables.

Table 3. *Total daily consumption during summer (KW/h)*

No.	Consumption	No. of the same consumers	Installed power on one consumer (KW)	Coefficient of simultaneity	Simultaneous power (KW)	Average daily usage in summer (h)	Average daily consumption in summer (KW/h)
1	Electrical oven	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	Electrical boiler	1,00	2,00	1,00	2,00	2,00	4,00
4	Lights	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 during summer (KW/h)						**11,51**

Table 4. *Total daily consumption during winter (KW/h)*

No.	Consumption	No. of the same consumers	Installed power on one consumer (KW)	Coefficient of simultaneity	Simultaneous power (KW)	Average daily usage in winter(h)	Average daily consumption in winter (KW/h)
1	Electrical oven	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	Electrical boiler	1,00	2,00	1,00	2,00	2,00	4,00
4	Lights	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 during winter (KW/h)						**25,31**

When inspecting such cases, the witness expert perceives the social structure of the family, enabling a realistic perception of the time usage of certain devices. Of course, all the data from the place are supported by appropriate photos.

In this case (Table 4), theft was established for a period of 11 months.

Table 5. *Total electricity spent for a period of 11 months*

No.	Period	Number of days	Total consumption by day in KW/h	Total consumption for 11 months
1	Winter	120 days	25,31	3.037,00
2	Summer	214 days	11,51	2.463,00
3	**Total electricity spent for period of 11 months (KW/h)**			**5.500,00**

Financial calculation: The average price for one tariff is taken in the calculation for the price of one KW/h.

Table 6. *Financial calculation*

Accounting period	11 months
Amount of unregistered in consumed but unregistered electricity KW/h	5.500,13
Single price of KW/h in denars	4,16
Total	22.880,00
Tax base	22.880,00
VAT 18%	4.118,00
TOTAL in denars	**26.998,00**

Typical user calculation where the calculation is done according to the kind and type of devices. (Table 5)

5. Conclusion

In this paper we have elaborated on the research methodology applied by a witness expert in a situation where there is a suspicion of electricity theft. This issue in RNM is insufficiently addressed.

In the first part we explained what electricity theft is and how the cases of electricity theft are defined according to the criminal law of RNM. In the second part, we elaborated the procedure for determining the crime itself. The third part explains the ways in which the crime was committed, from which the existence of the crime can be unequivocally determined. The fourth part describes the methodology for calculating the material losses suffered by the distribution system operator (DSO).

We hope that this paper will help and assist in the work of witness experts in situations where there is a court case for theft of electricity.

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