

## ESTABLISHING METROLOGY INFRASTRUCTURE AND TRACEABILITY OF ELECTRICAL POWER AND ENERGY IN R. MACEDONIA

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**Abstract:** In the paper the current state and the establishment of metrology infrastructure and traceability of the measurements of electrical power and energy, i.e. the creation of conditions for unity of power and energy measurements, international comparability of the results and measurements which insure fair trade and consumers' protection are elaborated. Beside the legal, also other aspects are discussed, like the needs for calibration and verification in the field of electrical power and energy, participants in the chain of measurements and trade with electrical energy, the organization, the infrastructure, the methods and the systems of calibration and verification. An organization and certain documents which will contribute to the establishment of a system in accordance with the international standards and practice, as well as traceability and fair trade, are proposed.

**Keywords:** metrology infrastructure, power and energy measurements, calibrations, standards.

### 1. INTRODUCTION

After gaining the independence of R. Macedonia, the process of creation of a metrological system and infrastructure necessary for establishment of unity of the measurements and metrological traceability has begun. The development has started with the creation of own legislative, institutions, equipment and infrastructure for application of the legal and industrial metrology. For the measurement of electrical energy and power, in the frame of the legal metrology, nothing was inherited from the former Yugoslav system. However, the significance of these measurements because of the large needs and quantity, the large finances connected to the trade of electrical energy, the need of consumers' protection and insurance of conditions of fair trade, impose quick measures to be undertaken. The adequacy of these solutions, the need of their upgrading and improvement, as well as the model which would create conditions for fair trade and electrical energy consumers' protection are further discussed.

### 2. CURRENT STATE OF THE ART

The field of measurements of electrical energy and power is legally regulated by the Law on Metrology from

2002 [1]. Beside this Law a set of Rulebooks [2-4] are adopted. Currently, there is a process of a transposition of the EU documents in the field of metrology, which are connected to certain types of measuring instruments (sector directives), [5].

Through the Law on Metrology [1], as one of the basic objectives in the legal regulation of the measurements of electrical energy, the condition on insurance of fair trade is posed. This fair trade will be insured by exact measurements of the electrical energy, with legally approved instruments in compliance to the Rulebook on Measuring Instruments [3], calibrated and verified, and with measurements traceable to national standard.

The traceability requirement, defined in Article 3 of the Law on Metrology [1], although it is not explicitly stated, should insure measurement traceability to national standard of R. Macedonia, to national standards of other states, international standards etc.

By taking into account that the trade of electrical energy is not only internal, but in a large part it is international, it is necessary to insure traceability and comparability of the results not only at national, but also at international level. The same addresses also to the usage of electricity meters, which should comply with the specifications of the domestic regulation [3] as well as with the European regulation [5]. From the aspect of law regulation, this requirement is fulfilled through transposition of the EU directives and harmonization of the national laws and regulation with the EU directives in the field of metrology.

In respect to the compliance of the electricity meters to the requirements of the regulation, which is declared through posing of the „CE“ mark, and which presumes existence of notified body which will participate in the procedure of approval and marking it is unclear how the domestic producers could address this question, since R. Macedonia is not a member of the EU.

According to the Law on Metrology [1], in order to insure the conditions for fair trade, the electricity meters should be verified, which is done by legal and physical entities selling electrical energy, and formally by the Bureau of Metrology of R. Macedonia. If the requirements of the international standard for bodies performing inspection [6] and the international standard for testing and calibration laboratories [7], are taken into account, this solution, inherited from the former system, is in contradiction to the requirements of these standards in respect to the

independence, impartiality, integrity and confidentiality of the bodies performing verification (control), e.g. calibration. This has become especially obvious after the process of privatization of the distribution of electrical energy in 2006. The control performed by the interested body is in conflict to the requirement for independent, impartial, and confidential control of the electrical energy measurements.

The market of electrical energy in R. Macedonia is not well developed yet. Main participants in the trade of electrical energy are EVN-Macedonia, MEPSO, ELEM, licenced trade houses as well as the large industrial consumers (Mak-Steel Skopje, FENI Industry Kavadarci, Mital Steel-Skopje etc.), light industry and the households. The Bureau of Metrology of R. Macedonia is in charge to insure the unity of the measurements of electrical energy, national standard of electrical energy, type approvals of the electricity meters produced according to the legal requirements, periodical verification/calibration, metrological surveillance of the electricity meters and measurement traceability to the national standard. The Bureau of Metrology of RM, by the help of the EU has formed and partially equipped its laboratories in the last years. However in the laboratory for electrical energy there is no electrical power standard, so the Bureau is not in a position to insure traceability of the electrical energy measurements i.e. is not in a position to calibrate standards and instruments for electrical power.

The legal requirement for verification of the electricity meters is realized through verification (calibration) of electricity meters in EVN-Macedonia laboratory for verification of electricity meters, which has 6 verification systems EMH/MTE on disposal equipped with a power standard, accuracy class 0,05. After the control/verification by the EVN-Macedonia, the Bureau of Metrology on the basis of the control results formally performs the verification and sealing. The Bureau of Metrology performs the metrological surveillance and verification through its Department for verification of electricity meters. However, the methods of surveillance of the verification (metrological control) according to the equipment for control, sampling frequency, number of samples and the application of proper statistical methods according to the standards (IEC 62058-11, [8] и IEC 62058-21, [9], IEC 62058-31, [10]), do not give enough confidence of possible deviations from the requirements of the Rulebook on measuring instruments, [3]. The fee for verification of electricity meters which is paid to the Bureau of Metrology of RM (7 Euro for three-phase electricity meter and 4 Euro for single-phase meter), could be used for significant improvement of the equipment and the other preconditions and resources for confident metrological control as well as for insurance of traceability to the national and international standards, [11], [12].

The electrical energy consumption in R. Macedonia, like in the other countries is connected to the life standard and is in constant increase. According to the State Statistical Office in R. Macedonia 82,6% (2009) and 83,6% (2010), out of 8265 837 MWh (2009), i.e. 8 677 969 MWh (2010), brutto domestic consumption of electrical energy is of domestic production, and around 17 % is imported, [13, 14]. The biggest consumers of electricity in 2010 were the

households with a share of 37.3%, the industrial sectors (energy sector plus industry) with 25.3%, and the other sectors with 17.7% of the gross national electricity consumption. Own consumption (in production, transmission and distribution) of electricity in 2010 was 5%, while distribution losses were 14.7% of the gross national electricity consumption, [14].

All this energy is measured at the level of system interconnections, at the level of large consumers, at the level of industry, at the level of small consumers and households at different voltage levels, different locations, and different types of electricity meters for direct and indirect electrical energy measurements. Currently, in R. Macedonia app. 800000 electricity meters in the households and 7500 meters in the industry are in usage. The electricity meters used in the households of RM were in a large scale three-phase meters, accuracy class 2, produced by ISKRA-Kranj, Slovenia and in smaller scale of domestic production by Video Inzenering-Ohrid (by licence of Siemens) and Energetika-VDS Strumica (own development). The electricity meters used in the industry are mainly for indirect measurements, accuracy class 1 and 0,5, while the electricity meters at the system interconnections are of accuracy class 0,1. Roughly, it can be estimated that these meters are used with app. 30000 instrument transformers of accuracy class 0,5.

According to the Law on Metrology it is foreseen first, periodical and, if necessary, extra verification of the electricity meters to be done. The legal period for periodical verification of the electricity meters is 10 years, which imposes that approximately 80000 meters should be verified annually.

According to the data of the Bureau of Metrology, [15], in the last years the number of electricity meters verifications performed by the BoM is given in Table 1.

**Table 1 Annual verifications of electricity meters performed by BoM**

<b>Year 2007</b>	<b>Year 2008</b>	<b>Year 2009</b>	<b>Year 2010</b>	<b>Year 2011</b>
101 400	99 800	231 900	180 000	120 000

These figures comprise the number of first verifications performed by the meter producers (foreign producers), as well as the number of periodically verified electricity meters by EVN-Macedonia.

The legal period of verification of instrument transformers is 5 years, so the annual number of verified instrument transformers should be 6000.

All the meters used for billing the electrical energy, must have a type approval and verification. The type approval means compliance of the meter type to the technical standards and the legal regulation. In the procedure of type approval app. 30 different tests, including testing of the electrical and metrological characteristics, isolation tests, mechanical tests as well as some newer tests: software validation, life cycle and confidence are performed.

Practically, it is impossible to test each meter, therefore samples of the newly developed meters are taken, and if all the tests are satisfying, the type approval is issued. The meters identical to the approved are considered to comply to the standards.

According to the Law, each electricity meter used for billing of electrical energy must be verified. For verification of the meters and instrument transformers a limited set of tests is required, which is mainly testing of the meter error at different working conditions.

### 3. ESTABLISHING OF LEGAL REQUIREMENTS, TRACEABILITY AND CONFIDENCE OF ELECTRICAL POWER MEASUREMENTS

The current legislation which regulates the measurements of electrical energy in R. Macedonia is discussed and referred in Section 2. If this regulation is compared with the regulation for measurement of electrical energy used in the EU countries, it can be noticed that a transposition of the MID directive, [5] is done, but for full coverage of the field of measurements of electrical energy and power, it is necessary to apply the European standards EN 50470-1, [16] and EN 50470-3, [17] for classes A, B, C (classes A, B and C correspond to accuracy classes 2, 1, 0,5, respectively). The standards IEC 62052-11, [18], IEC 62053-21, [19] and IEC 62053-22, [20], for classes 2, 1, 0,5, 0,5S and 0,2S should be applied too.

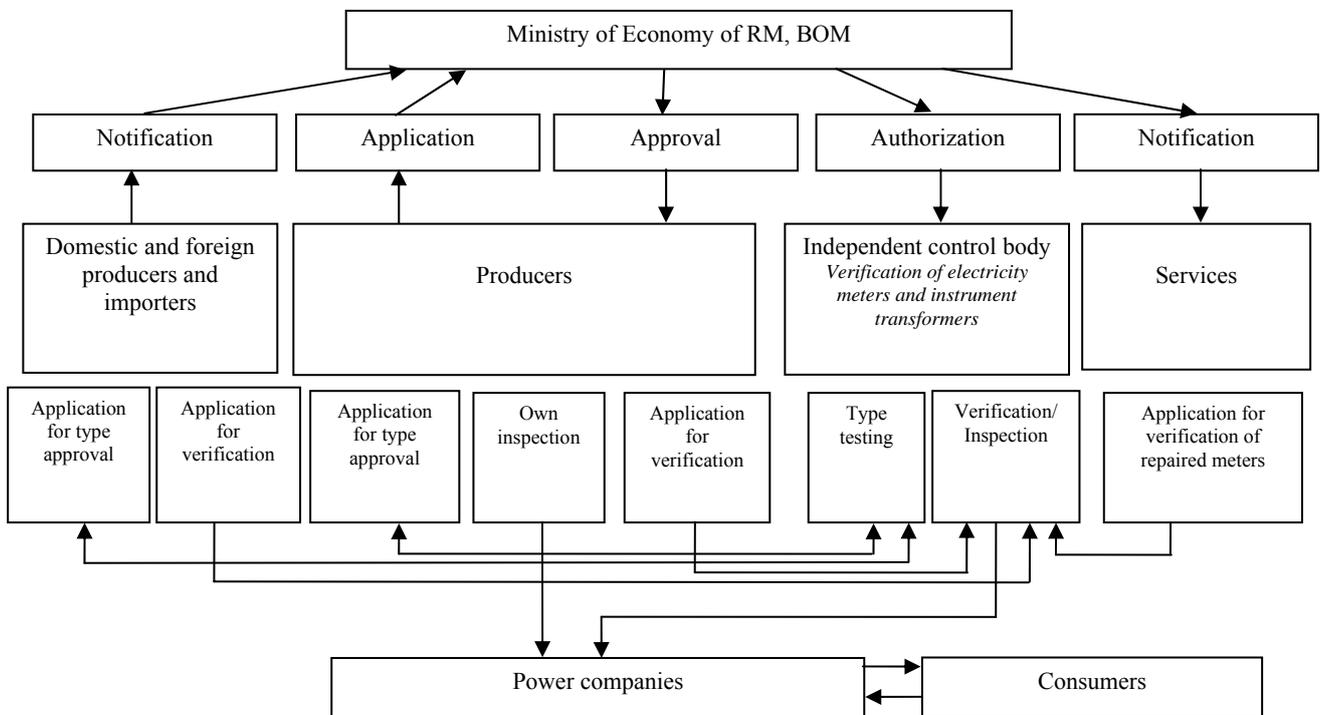
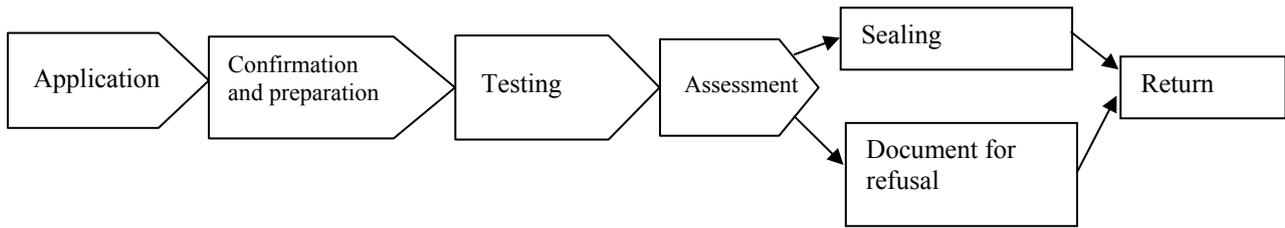


Figure 1 Scheme-proposal on legal metrology of measurements of electrical energy

One of the possible problems in the legal harmonization would be the insurance of independence, impartiality, integrity and confidence of the bodies performing type testings, calibration and verification. Therefore changes in the Law on Metrology [1] and in the Rulebook [4] are necessary. The goal of these changes is

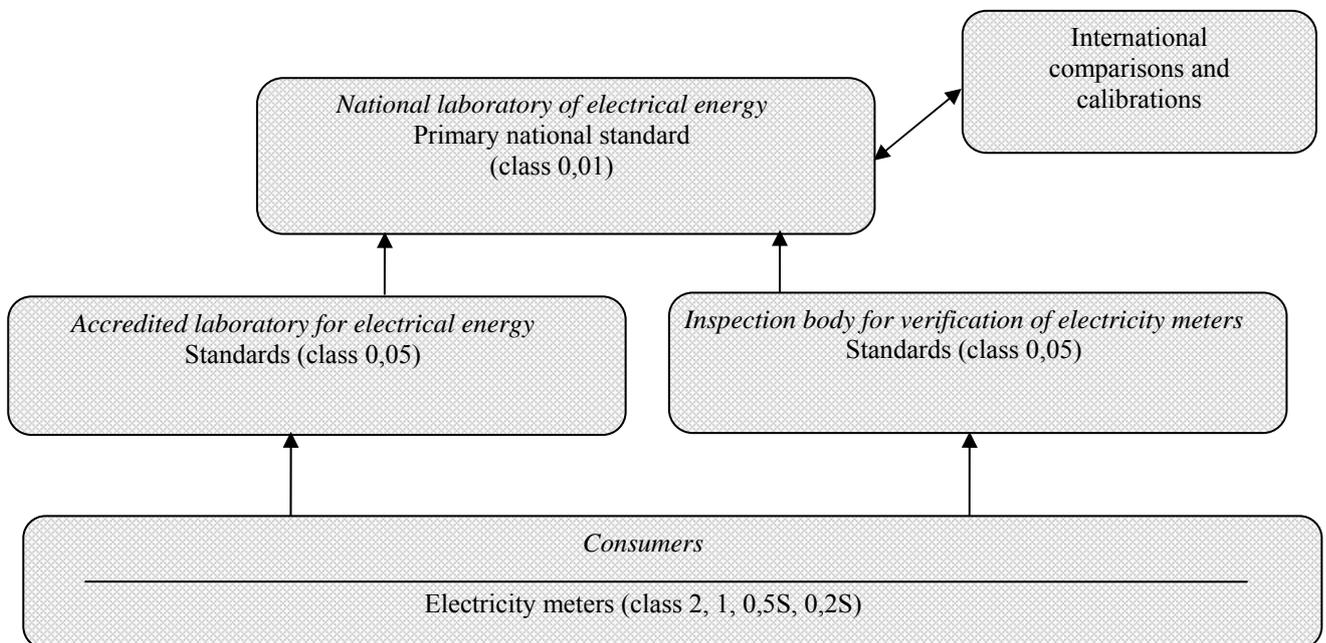
to enable the activity of independent accredited and authorized bodies for control of electricity meters, independent accredited calibration laboratories and independent services for electricity meters. One of the possible options of organization of the legal metrology for electricity meters is given in Figure 1.



**Figure 2 Verification process**

The verification of the electricity meters and the instrument transformers in authorized inspection body would be realized according to the sequence in Figure 2.

The traceability of the electrical energy measurements to national and international standards could be realized through three-scale hierarchy chain shown in Figure 3.



**Figure 3 Traceability chain of the electrical energy measurements**

For the realization of the traceability chain it is necessary to create a national laboratory which will be equipped with a national primary standard for electrical energy. This laboratory should fulfil the requirements of the standards ISO 17025, [7], as well as to participate at international comparisons with other national laboratories i.e. to calibrate its standard at national laboratories of other states with standards of higher accuracy class. This national laboratory and the national standard could be in the frame of the Bureau of Metrology of R. Macedonia, but also other solutions are possible. The laboratory can be created where staff, equipment and space for such a laboratory already exist.

According to the practice in most of the countries, the calibration laboratories for electricity meters would serve the industry and other owners of instruments for electrical energy and power for calibration and type testing, and should be independent laboratories which fulfil the requirements of the standard ISO 17025, [7].

One of the important conditions for insurance of fair trade of electrical energy is the creation of independent and confident control/inspection body for verification of electricity meters. According to the international standard for control bodies ISO 17020, [6], such bodies of Type A should fulfil the following requirements:

1. The inspection body and its staff shall be independent to the parties involved, i.e. shall not be the designer, manufacturer, supplier, installer, and

purchaser, owner, user or maintainer of the items which are inspected, nor authorized, representative of any of these parties.

2. The inspection body and its staff shall not be engaged in any activities that may conflict with their independence of judgment and integrity in relation to their inspection activities. In particular they shall not become directly involved in the design, manufacture, supply, installation, use or maintenance of the items inspected or similar competitive items.
3. All interested parties shall have access to the services of the inspection body. There shall not be undue financial or other conditions. The procedures under which the body operates shall be administered in a non-discriminatory manner.

Beside the organizational, management and documentation requirements, the inspection body must be equipped with competent and responsible staff, which will respect the inspection procedures, criteria and ethics as well as proper equipment which must be calibrated with traceability to the national electrical energy standard. The inspection body should have on disposal proper procedures and protocols of testing and procedures for processing of the results, as well as statistical indicators for the pool of verified meters. For the activities of this inspection body, beside the standard ISO 17020 and the national legislation, there are more international standards and international guides.

#### 4. CONCLUSION

The current state and the importance of the measurements of electrical energy for billing and other purposes requires quick measures for harmonization and upgrading of the Macedonian system of legal and industrial metrology for electrical energy. It is necessary to establish national standard of electrical energy and national laboratory for electrical energy, as well as traceability of the electrical energy measurements to them. It is necessary also to create independent competent calibration and testing laboratories, i.e. independent, impartial and confident inspection bodies for control/verification of electricity meters in compliance to the international standards ISO 17025 and ISO 17020, the standards for electricity meters and the practice in the other countries in Europe and the world. The proposed schemes for practicing the legal metrology and insurance of the traceability chain in the measurements of electrical energy are possible options which should be further elaborated by taking into account all the aspects: legal, current state, staff, technical requirements, as well as the economic aspects.

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