Accreditation in Croatia: What is the position of testing and calibration laboratories from the science and higher education system?

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Abstract
With the worldwide increasing number of testing and calibration laboratories accredited according to the ISO/IEC 17025 standard to satisfy requirements of customers, the arising question is how much laboratories in the science and higher education system in Croatia use their potentials to respond to these requirements. All accreditations granted in Croatia were reviewed and special attention was given to accreditations granted to testing and calibration laboratories in the science and higher education system. Accreditations granted to testing laboratories alone comprise almost 50 % of all granted accreditations in Croatia, making the ISO/IEC 17025 standard the most used standard for accreditation in Croatia. This is additionally supported by accreditations granted to calibration laboratories, the third accreditation scheme in frequency. However, only a smaller portion (approx. 20 %) of these accreditations is granted to laboratories in the science and higher education system. Low portions of scientific and higher education institutions involved in accreditation lead to a conclusion that the main driving force for accreditation of laboratories in Croatia are laboratories associated to industry rather than scientific laboratories, despite their enormous potential in a form or highly skilled personnel and sophisticated equipment.

Keywords: Commercialization, Laboratory accreditation, ISO/IEC 17025, Quality management system, Science and higher education system

Introduction

The role of universities has recently been a subject of debates. In some opinions, their role is purely academic, i.e. education and research, and in others, it is wider and additionally includes “material improvement of society” as stated by Siegel and Wright [1]. This material improvement of society is achieved through “academic entrepreneurship” or commercialization, which usually refers to patents, start-ups, licensing and collaboration with industry.

This debate can be broadened to include scientific institutions whose primary work is only research, such as scientific institutes. Therefore, it can encompass the whole science and higher education (SHE) system to question their current role and adaptibiliy to changing circumstances. One of these circumstances, which is becoming more and more important, is financing of the SHE system. The state financed share of researches and other costs is

decreasing in time and it is expected from institutions in the SHE system to provide finances themselves. This is where commercialization of knowledge, skills or researches becomes increasingly important for the SHE system. For many laboratories in the system, providing commercial services to public enables them to continue or increase their research [1, 2].

Considering that the success of universities' technology transfer offices (TTO) regarding academic entrepreneurship has been very questionable and that some authors doubt if academic entrepreneurship is even worth pursuing in most universities [1], it would be more advisable to practice simpler types of commercialization, such as providing services. Although it would be a very basic and traditional commercialization, it would also be the most feasible one, especially by various types of laboratories in the SHE system. Laboratories would be rather independent in providing services, which would remove the need for TTOs and simplify the whole commercialization process.

In the light of commercialization of services, accreditation of laboratories according to the ISO/IEC 17025 standard is becoming important as a means of confirmation of laboratory's competency, of gaining better public image and ensuring international recognition of results (i.e. service). International recognition, ensured by International Laboratory Accreditation Cooperation Mutual Recognition Arrangement (ILAC MRA) for testing and calibraton, is especially important because it reduces trade barriers in market exchange. A national accreditation body (NAB) granting accreditations must be a signatory of the ILAC MRA to enable the laboratories to internationally benefit from it. However, even if the NAB is not a signatory of the ILAC MRA, the laboratory can benefit from its accreditation at the national level. It is not mandatory for testing and calibration laboratories (TCLs) to have accreditation, but in some cases it is required, and it definitely gives an advantage in the market. Some customers strictly require accreditation if a laboratory provides them with their services [3]. It may be requested in some specific areas such as environment, health and safety. In that sense, accreditation is a business decision. It requires establishing of the quality management system in the laboratory or at the whole or part of the institution to which the laboratory belongs. In many cases, it also requires change of quality and working cultures. In the last 10 years, number of laboratories accredited according to the ISO/IEC 17025 doubled worldwide [2, 3]. It shows growing market demands for accredited services. It is also a bussiness opportunity for TCLs in the SHE system and the opportunity to contribute to society in forms other than purely academic. Considering that ISO/IEC 17025 was primarily intended for routine, non-research, laboratories, its implementation in research laboratories might be a challenge for them. However, it is possible to conduct both research and routine analyses in the same laboratory, which enables laboratories in the SHE system to respond to growing demands for accredited services.

The intention of this article was to gain insight into state of accreditations in Croatia with special focus on accreditations for TCLs in the SHE system. Whenever accreditation in the SHE system is a subject, it is always remarked that it is still relatively rare and unknown in this system, although it would be expected that laboratories in the SHE system would promote accreditation and commercialization of services. However, how much is accreditation really represented in this system was not quantified yet. Therefore, it was studied and presented in this article.

Methodology

All analysed initial data were collected at the Croatian Accreditation Agency (CAA) [4] and the Ministry of Science and Education of the Republic of Croatia (MSE) internet sites [5, 6]. Considering that the status in the CAA's registry of accredited bodies can be changed on a daily basis, status on 10 October 2018 was taken as a reference. The same reference date was also taken for data collected at the MSE internet site. Regardless of the future changes in the registry of accredited bodies and in the Registries of higher education institutions and scientific organizations, it is not expected that the trends presented in this article will change in the nearest future. Therefore, minor changes in all registries will not influence the actuality of presented results.

All currently valid certificates of accreditation from the CAA's registry of accredited bodies were reviewed. Accreditations granted in the studied period (1999–2018) but which are not valid today due to their suspension or withdrawal, were not included in analysis because they are not found in the registry anymore. Only accreditations granted to conformity assessment bodies (CABs) registered and operating in Croatia were considered.

First, all accreditations in Croatia were screened. Then, only accreditations granted to TCLs in Croatia were reviewed and accreditations granted to such laboratories in the SHE system were studied in detail regarding certificates of accreditation and test/calibration methods.

Special attention was given to accreditation granted to Croatian Metrology Institute (CMI). As a legal entity, CMI is not part of the SHE system. However, it was included in the analysis because it comprises designated laboratories belonging to the SHE system. Therefore, CMI was not analysed as a separate, whole institution, but its accreditation and calibration methods were instead assigned to its designated laboratories and their institutions, which were individually analysed as a part of the SHE system.

Accreditation schemes in Croatia

According to registry of accredited bodies, there were 447 valid accreditations granted to CABs in Croatia according to nine accreditation schemes [4]. Their distribution according to types of accreditation schemes is presented in Fig. 1. Taking into account that accreditation is a business decision or a regulatory demand and that the laboratories would most possibly not obtain it if it were not required or necessary, such a large proportion of testing laboratories obviously indicates the need for accredited testing laboratories and their services and states their importance. Their number and areas of work comprised by accreditations are largely governed by the requirements of the market or of the regulator. It should be noted here that the non-accredited laboratories also can be very competent and produce reliable results. Accreditation is a confirmation of already existing laboratory competence and a comparative advantage in the market. One of the reasons of high proportion of testing laboratories in all accreditations could also be found in the fact that the ISO standard for this scheme is one of the oldest ones among the schemes represented in Croatia [7]. Identical or very similar situation was observed in other countries of the region or further in Europe. Accreditations for testing laboratories were the most represented ones in Serbia, Bosnia and Herzegovina,

Montenegro, Hungary, Austria and Italy where they comprised 47.4 %–66.6 % of all accreditations in nine schemes listed in Fig. 1 [8–13].

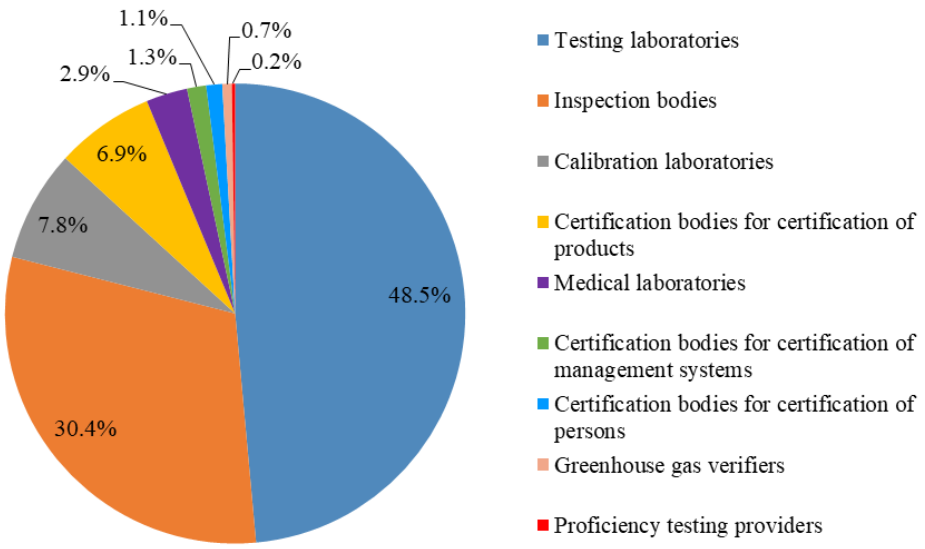


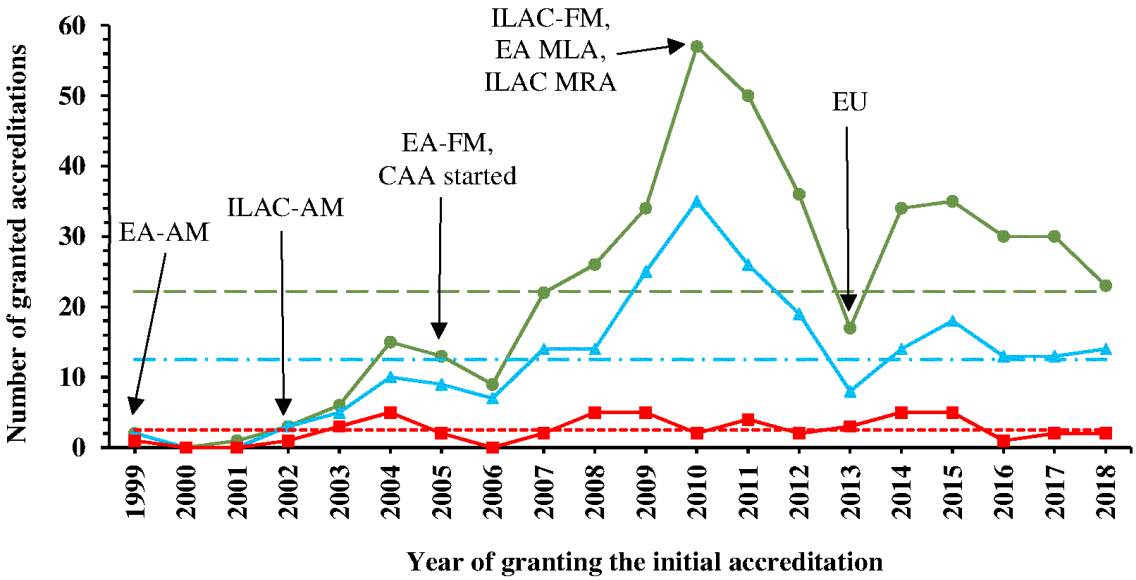
Fig. 1 Distribution of all accreditations according to types of accreditation schemes

This type of accreditation was the second most represented group in Slovenia, with 35.8 % portion [14]. Accreditations of calibration laboratories are significalnty less represented in the total number of accreditations, which is expected due to their role of assuring the traceability to SI units. As a summary, Fig. 1 shows that the ISO/IEC 17025 standard is by far the most used accreditation standard in Croatia.

Initial accreditations in 1999–2018 period and duration of accreditations

Fig. 2 shows trends in the number of annually granted initial accreditations for the 1999–2018 period. The first increase for all CABs in 2004 might reflect only the limited Croatian market and regulator's demands. It is questionable if the adoption of the Accreditation law in 2003 [15] had an important influence on the increase. On the other hand, the beginning of another increase in 2007 could also be associated with the beginning of the CAA's operation in 2005 and with Croatia becoming a full member of the European Co-operation for Accreditation (EA) in the same year [16]. A dealy in this 2007 increase could be explained with the adaptation period of the market and the regulator to new circumstances. A significant maximum in 2010 could be associated with Croatia becoming a full member of ILAC and with the signing of the EA Multilateral Agreement (EA MLA) and ILAC MRA on 29 April 2010 [16], which led to an increased number of accreditation applications and to some kind of saturation in demand. Therefore, from 2010 to 2013, a significant decrease of annually granted initial accreditations for all CABs was recorded. Another possible reason for this decrease might be found in the delayed reaction to the global financial crisis of 2008, whose consequences were clearly visible in Croatia until 2013 [17]. After 2013, an increase was observed again and it could be associated with the improved economic conditions and/or the accession of Croatia to European Union (EU) in 2013. The accession to the EU enabled

better accessibility of Croatian products and services to European market, which may have required additional accreditations. Generally, a long-term trend of increase of annually granted initial accreditations for all CABs has been observed for the 1999–2018 period.



EA-AM: Associate member of EA; ILAC-AM: Associate member of ILAC; EA-FM: Full member of EA; ILAC-FM: Full member of ILAC; EA MLA: EA Multilateral Agreement signed; ILAC MRA: ILAC Mutual Recognition Arrangement signed; EU: Accession to European Union

All conformity assessment bodies

Average number of annually granted accreditations to all conformity assessment bodies

Testing and calibration laboratories

Average number of annually granted accreditations to testing and calibration laboratories

Testing and calibration laboratories in the science and higher education system

Average number of annually granted accreditations to testing and calibration laboratories in the science and higher education system

Fig. 2 Number of annually granted initial accreditations in the 1999–2018 period

The trends related to number of annually granted initial accreditations for TCLs (Fig. 2) are equal to trends observed for all CABs, which is not surprising considering that accreditations for TCLs comprise more than 50 % of all accreditations. Equally, the reasons for the same patterns are probably the same in both cases. A long-term increase of number of annually granted initial accreditations was observed here as well.

Contrary to all initial accreditations for all CABs and to accreditations for all TCLs, number of initial accreditations in the SHE system did not show a significant temporal variability (Fig. 2). The most significant difference between the number of initial accreditations in the SHE system and previously analysed all CABs and all TCLs is that there was no increased number of accreditations in the SHE system in 2010. It can be assumed that the laboratories in the SHE system are not so sensitive to external factors such as market and

regulator's demands, memberships of Croatia in the EA and ILAC, signing of the EA MLA and ILAC MRA, accession of Croatia to EU or the financial crisis. This might be due to the nature of these laboratories, i.e. they are primarily research laboratories and accreditation to satisfy the market requirements is not their priority. Additionally, these laboratories are not primarily financed through the market but through the scientific projects. Fig. 2 might also imply that most of the needs for accredited services are met by the laboratories outside the SHE system.

Most of accreditations in all categories (all CABs, TCLs and TCLs in the SHE system) are between six and 10 years old (Fig. 3). It might be assumed that these laboratories are "mature" laboratories concerning accreditation because they are already in their second accreditation cycle and are experienced in acreditation.

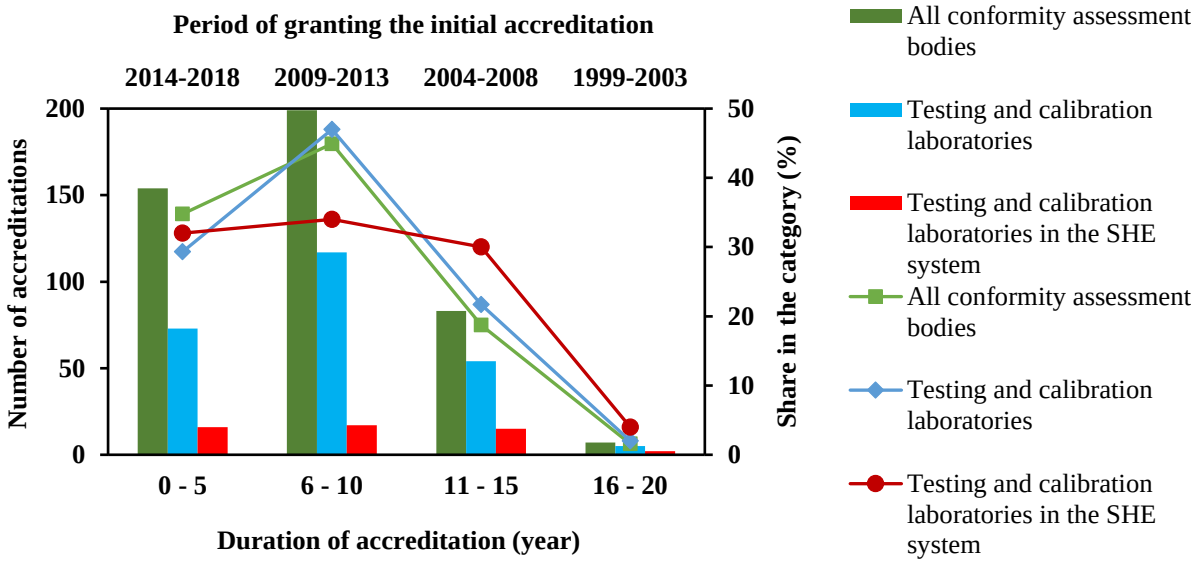


Fig. 3 Frequency of accreditations duration for accreditations granted to all CABs and the selected categories of CABs and their share in each category

It may also be observed that the number of granted initial accreditations for all CABs and TCLs was significantly increasing for 15 years and that more than half of all CABs with granted initial accreditations were TCLs. However, this relationship has changed since 2014, when the number of accreditations for TCLs decreased more rapidly than for all CABs. This shows that other accreditation schemes are becoming more required and that finding its position in the market is becoming more demanding for TCLs. On the other hand, situation with TCLs in the SHE system is different. Although accredited laboratories from the SHE system might not be numerous, they started to accept accreditation as soon as it became available in Croatia. This might especially be applicable to scientific laboratories performing specific tests or calibrations not available in commercial laboratories. Accreditation acceptance was rather limited until 2003, but following the next five years, it became significantly more accepted in scientific laboratories. However, later representation of accreditation in scientific laboratories did not significantly increase, as it was the case with other TCLs. It might be argued that there was no need for that because the market for services

provided by TCLs in the SHE system has stabilised or that the scientific laboratories were not interested in obtaining accreditations.

Accreditation of testing and calibration laboratories in the SHE system

Representation and distribution of accreditations in the SHE system

Table 1 presents basic data on accreditations at institutions in the SHE system. None of the institutions in the SHE system has accreditation for calibration laboratory only. This is expected since the need for testing laboratories is generally higher than for calibration laboratories.

Table 1. Basic information on number and type of granted accreditations at institutions in the SHE system

Parameter	Type of accreditation	
	Testing laboratory	Calibration laboratory
Total number of accreditations in the SHE system	43	7
Number of institutions in the SHE system with granted accreditations	27	5[a]
Minimum number of accreditations per institution	1	0.5[b]
Maximum number of accreditations per institution	6	2.5[b]
Average number of accreditations per institution	1.6	1.4
Mode for number of accreditations per institution	1	1

[a] Five institutions having accreditations for calibration laboratories also have accreditations for testing laboratories, thus making the total number of institutions with any type of accreditation 27; [b] Accreditation granted to Croatian Metrology Institute is assigned to Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb and to Ruđer Bošković Institute in a 50 % : 50 % ratio

All accreditations at institutions in the SHE system make 19.8 % of the total number of accreditations for TCLs. This is a relatively low contribution of the SHE system to the overall number of accreditations, which might leave enough space for some future accreditations in the system, assuming that the need for them will exist. However, comparable contribution of the SHE system accreditations to the total number of accreditations for TCLs was found in some American countries (Canada, Costa Rica, El Salvador, Jamaica, Cuba, Chile, Ecuador, Colombia, Argentina) with 13 %–27 % contribution [3]. This suggests that the SHE system in Croatia responds to the needs for accreditation similarly as the SHE systems in other countries. Mostly one accreditation for testing laboratories per institution in the SHE system may be resulting from the institutions' policies regarding accreditation (all accredited methods on one certificate of accreditation) or from internal organisation of work.

According to Registry of higher education institutions [5] and Registry of scientific organizations of the MSE [6], three large categories of institutions are differentiated in the SHE system: i) Scientific institution and higher education institution (SIHEI); ii) Scientific institution (SIN); and iii) Higher education institution (HEI). There are 17 different types of institutions in the whole SHE system and some of them belong to both science and higher education system. It is important to notice that not all types of institutions need accreditation and are not all eligible to obtain one due to their area of activity (e.g. libraries, student centre).

Table 2 presents distribution of accreditations between two categories of institutions in the SHE system. Institutions that are only HEI have no accreditations. It is observed that approx. two thirds of accreditations for TCLs are found at scientific institutions. The reasons might be numerous: from more available equipment, personnel, methods or time in scientific institutions to their interest in accreditation, the need for methods available in these instistutions or their better collaboration with industry. Institutions from the SHE system with accreditations comprise 14.8 % of all SINs in the Registry of scientific organizations and 8.7 % of HEIs in the Registry of higher education institutions.

Table 2. Basic data on distribution of granted accreditations between two categories of institutions in the SHE system

Institution category	Number of institutions in the SHE system with accreditations	Number of accreditations for testing laboratories	Number of accreditations for calibration laboratories
Scientific institution	14	27	4.5
Scientific institution and higher education institution	13	16	2.5

Representation of different types of institutions from the SHE system among SHE institutions with accreditations shows that faculties are the most numerous institutions with accreditations (Fig. 4).

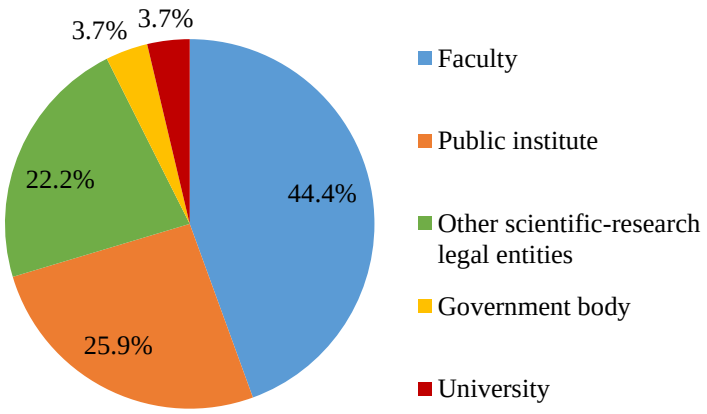


Fig. 4 Distribution of institutions in the SHE system with granted accreditations according to types of institutions in the SHE system

However, when quantity of certificates of accreditation per type of accreditation and institution is examined, other scientific-research legal entities have the largest share of accreditations, both for testing and calibration laboratories (Fig. 5). It is interesting that public institutes are moderately or relatively weakly represented in both cases. This implies that there is still some space for them to be involved in accreditation, especially concerning their higly educated personnel and available equipment.

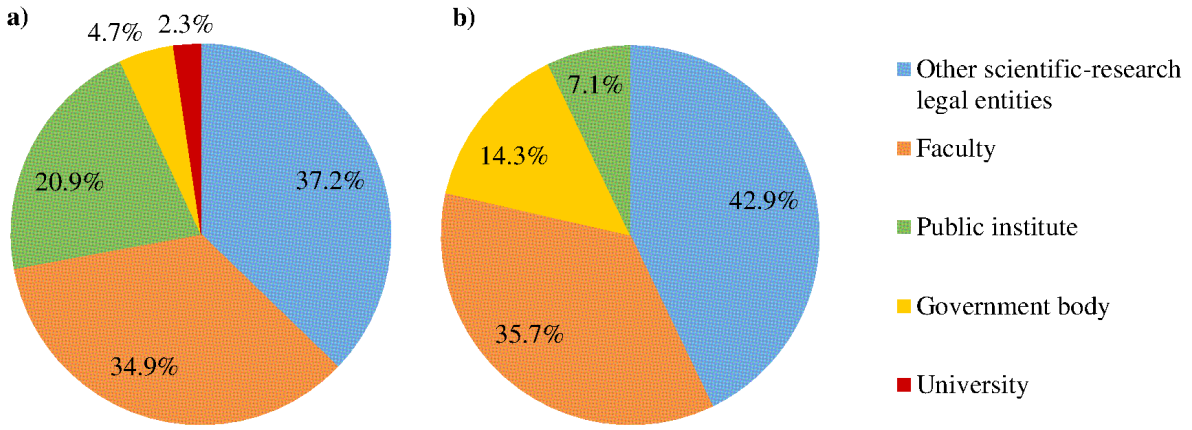


Fig. 5 Distribution of accreditations according to types of institutions in the SHE system: **a)** Testing laboratories; **b)** Calibration laboratories

Representation and distribution of methods in the SHE system

Basic data on number and type of accredited methods at institutions in the SHE system are given in Table 3.

Table 3. Basic data on number and type of accredited methods at institutions in the SHE system

Parameter	Test method	Calibration method
Total number of methods	2110	131
Minimum number of methods per institution	1	4
Maximum number of methods per institution	699	72
Average number of methods per institution	78	26
Mode for number of methods per institution	5	-
Median for number of methods per institution	14	17

The majority of institutions in the SHE system has 1–10 test methods per institution (Fig. 6). Among them, two institutions have only one accredited method, which is unusual and it might seem disadvantageous to implement a management system just for one method.

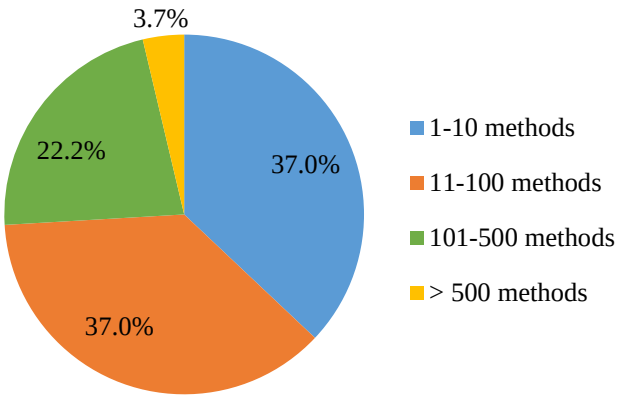


Fig. 6 Distribution of institutions in the SHE system according to number of test methods per institution

However, there are justifiable reasons why this would not be disadvantageous in these two specific cases. One of these two institutions is the Croatian Institute for Transfusion Medicine (CITM), from Zagreb, and its scope of accreditation is sterility testing of pharmaceutical solutions for parenteral use [4]. CITM is one of the most important centres for transfusion medicine in Croatia and it provides its services to other centres and hospitals. Therefore, high customer demand justifies obtaining accreditation even if it was just for one method. The other institution with only one accredited test method is the Faculty of Electrical Engineering, Computer Science and Information Technology (FERIT), from Osijek, whose accredited laboratory works in the area of electromagnetic compatibility with the scope of accreditation for testing of low frequency electric and magnetic fields [4]. Accredited services provided by FERIT are also provided by other institutions in Croatia. However, FERIT's specific location justifies its need for accreditation. It is located in the east Croatia, while other institutions are located in central Croatia. This makes FERIT regionally important in Croatia and improves the availability of service in east Croatia. Institutions having the most methods per institution (more than 100) work in the areas of forestry, petroleum industry, public health, animal health, and energy and transportation [4]. Only one institution has more than 500 methods (Fig. 6, Table 3) and it operates in the civil engineering area [4].

Distribution of calibration methods between institutions in the SHE system is simpler than distribution of test methods and it is also uneven (Table 3). These institutions operate in the areas of ionizing radiation protection, mechanical engineering, energy and transportation, civil engineering, and hydrology and meteorology [4]. It is observed that the fields of energy and transportation and civil engineering are significantly represented in both testing and calibration methods. This can be explained by the nature of these industries. Their products or products related to their services are widely present in everyday life and are often associated with high risks for lives and property, which may cause high internal and/or external demand for accredited methods. They can provide their services of testing or calibration to internal or external customers.

Table 4 shows that the majority of test methods are accredited at SINs, while the majority of calibration methods are accredited at SIHEIs.

Table 4. Basic data on distribution of accredited methods between two categories of institutions in the SHE system

Institution category	Number of test methods	Number of calibration methods
Scientific institution	1812	59
Scientific institution and higher education institution	298	72

More detailed distribution of test methods according to types of institutions in the SHE system is presented in Fig. 7.a). Other scientific-research legal entities are particularly represented among institutions with test methods. Studying only this group of institutions, it was found that the methods are extremely unhomogeneously distributed between institutions. This is primarily due to institutions that work in the area of civil engineering (both research and market oriented), which express significant need for accredited services. One third of all accredited test methods was found in this area of work. Other areas of work of this group of

institutions are energy and transportation, public health, petroleum industry and health care, in a descending number of accredited test methods. Fig. 7.b) shows distribution of calibration methods according to types of institutions in the SHE system. Unlike testing methods, accredited calibration methods are primarily present at faculties, i.e. at the FMENA, which is the only faculty with accredited calibration methods. However, such a situation has been of a relatively recent date, since 2013. This is related to CMI's designated laboratories that are partly financed by the state, which might have been one of the motivating reasons for obtaining accreditations. On the other hand, other scientific-research legal entities were not state financed, but they were first to obtain accreditations for calibration methods, starting in 2004. This shows that the state financing may significantly stimulate obtaining accreditations, but that it is not equally important for all institutions.

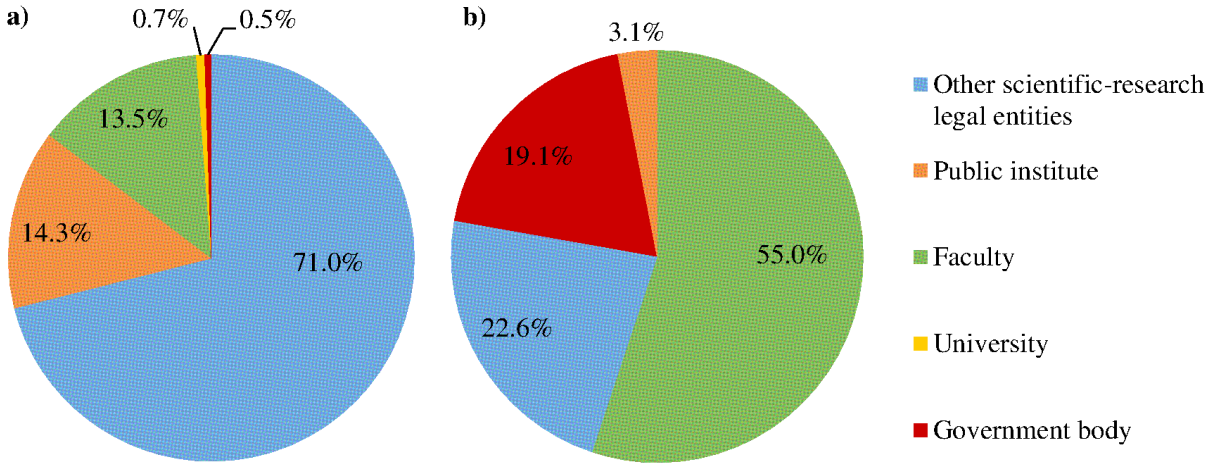


Fig. 7 Distribution of methods according to types of institutions in the SHE system: **a)** Test methods; **b)** Calibration methods

As a summary, testing laboratories cover wide fields of work such as: agriculture, hydrology and meteorology, electrical engineering and computing, transport, traffc, mechanical, geotechnical and civil engineering, forestry, veterinary medicine, public health, health care, petroleum industry, ionizing radiation protection, radioactivity, sediment testing, oceanography and fishery, energy, medicine, biotechnology, and mining and geology [4]. The most represented areas of testing are: petroleum and related products and materials, electrical equipment, electromagnetic fields, food, animal feeding stuff, wine, objects of common use, waters, microbiological cleanliness of facilities, waste, soil, ambient air, construction products, acoustics and veterinary medicine tests.

On the other hand, due to small number of accreditations for calibration laboratories and a small number of related institutions, there are significantly less fields of work covered by them. These are: mechanical engineering, hydrology and meteorology, civil engineering, energy and transportation, and ionizing radiation protection [4]. The areas of accreditation are associated with temperature, pressure, relative humidity, ambient air, torque, length and temperature gauges, force measuring, vibration tables, non-automatic weighing instruments, electrical measuring systems, and high voltage measuring systems.

International context and comparison with gross domestic product (GDP)

Hexsel Grochau, Schwengber ten Caten and de Camargo Forte [3] found strong positive correlation between the total number of laboratories with accreditations according to the ISO/IEC 17025 standard and the GDP of the country. Almost identical relationship was found between the number of institutions and GDP by studying the available data.

Number of accreditations according to the ISO/IEC 17025 standard in Croatia was compared with accreditations in Hungary and Latvia based on similar real GDPs per capita and relatively similar population sizes (Table 5). Number of accreditations in Croatia is twice lower than the number of accreditations in Hungary and is approx. 1.8 times higher than the one in Latvia.

Table 5. Real gross domestic product (GDP) per capita (for 2017) [18], population [19] and approximate number of accreditations according to the ISO/IEC 17025 [4, 11, 20] per country

Country	Real GDP per capita (EUR)	Population (million)	Approximate number of accreditations
Croatia	11 500	4.23	250
Hungary	11 800	9.86	500
Latvia	11 600	1.99	140

This might be partly associated with the population size, considering that Croatia has more than twice less population than Hungary and approx. twice more than Latvia. It might be concluded that the situation in Croatia regarding the number of accreditations per population is comparable to representation of accreditation in Hungary and Latvia. However, this in not the case when accreditations vs. real GDP per capita are considered because all three countries have almost the same GDPs but very different numbers of accreditations.

Comparing Croatia with North, Central and South American countries regarding the total number of institutions with accreditations according to the ISO/IEC 17025 and the GDP, it is seen that Croatia is comparable to Chile and Colombia, which have 209 and 222 such institutions, respectively [3], while Croatia has approx. 200 [4]. However, with its GDP of 53×10^9 US$ or 45×10^9 EUR for 2015 [21], Croatian GDP is 4.9 times lower than Chile's (258×10^9 US$ for 2014) and 7.1 times lower than Colombia's (377×10^9 US$ for 2014) [3]. This shows that Croatia has significantly more institutions with accreditations according to the ISO/IEC 17025 than would be expected based on its GDP. Similar pattern was observed for Mexico, Colombia, Chile, Ecuador and Costa Rica [3]. Such analysis was not performed for individual institutions in the SHE system due to data unavailability.

National regulations requiring accreditation are present in some sectors in Croatia. It is required that the laboratory testing the quality of liquid oil fuels is accredited according to the ISO/IEC 17025 standard [22]. It was also required that entities performing testing in the area of urban planning and construction are accredited as a testing laboratory [23]. However, the respective article of the regulation was only in use for a little bit less than 3.5 years (between July 2015 and December 2018) because it showed non-feasible in practice, especially for small laboratories. In the environment sector concerning environmental radioactivity, accreditation according to the ISO/IEC 17025 standard is given as an option for radon measurement in environment and buildings [24]. Regulations concerning ^{134}Cs and ^{137}Cs in

food and foodstuff for animals originating or delivered from Japan after incident in the nuclear power plant in Fukushima are applied to import of goods [25]. It is required that the tests concerning radioactivity are performed in accredited laboratory in one of the state members of EU.

Other countries also apply national regulations that include obligation of accreditation. In Chile, laboratories performing material testing in the urban planning and construction sector must be accredited [3]. In Columbia, accreditation is mandatory for laboratories that issue product certifications [3]. In Slovenia, laboratories involved in environmental radioactivity monitoring must be accredited according to the ISO/IEC 17025 standard [26]. This applies to Croatian laboratories as well and serves as a motivation for accreditation. It may be observed that accreditation found its way in national regulations in many countries worldwide, where it stimulates obtaining of accreditation. Regulations may differ among the countries, but their effect is very similar and comparable. It increases number of accredited methods.

Conclusions

Accreditations for testing laboratories are the most represented accreditations in Croatia and together with accreditations for calibration laboratories comprise more than half of all granted accreditations. This makes the ISO/IEC 17025 the most used accreditation standard in Croatia. Regardless of temporal variations, long-term trend of increase of the number of granted accreditations in time is generally observed. It is unrewarding to predict future trends because they depend on market conditions, requierments of customers and legislation, acceptance of accreditation etc. However, if an increase of number of accreditations will not be expected in the future, it can at least be assumed that significant decrease, compared with the current state, will not occur in the next ten years. Majority of CABs have accreditation between six and 10 years and only some longer than 15 years. Relationships between the total number of institutions with accreditations according to the ISO/IEC 17025 and GDP and between the real GDP per capita and number of accreditations for TCLs show that representation of accreditation in Croatia is average in comparison with comparable European countries and above average when compared with comparable Central and South American countries.

Accreditations from the SHE system are represented with approx. 20 % in the total number of accreditations for TCLs. Institutions in the SHE system with more than two accreditations per institution are rare. Large majority have only one accreditation per institution. There are very few institutions with accreditations for calibration methods and they comprise less than 4 % of SINs and SIHEIs. Share of institutions in the SHE system with accreditations in the total number of SINs and HEIs shows that only approx. 15 % of SINs and approx. 9 % of HEIs are involved in accreditation. Only three types of institutions were found to be significantly important for the number of granted accreditations and test and calibration methods in the SHE system. These are other scientific-research legal entities, faculties and public institutes. Other scientific-research legal entities whose work is associated with industry always stand out more or less in all studied categories. It points to significant stimulation for accreditation from industry. Therefore, it can be concluded that accreditation

in the SHE system is not unknown, but that it surely is not well known and common. In addition, scientific laboratories are not the ones primarily advocating for accreditation, but they are the ones to be encouraged. This is not unusual, since scientific laboratories are focused on non-routine work, while accreditation requires routine methods and analyses. There is a great space for more active involvement of scientific laboratories in current world trends regarding commercialization of their services and accreditation.

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References

[1] Siegel DS, Wright M (2015) Academic Entrepreneurship: Time for a Rethink?. Brit J Manage 26:582-595

[2] Hexsel Grochau I, Schwengber ten Caten C, de Camargo Forte MM (2018) Motivations, benefits and challenges on ISO/IEC 17025 accreditation of higher education institution laboratories, Accred Qual Assur 23:183-188

[3] Hexsel Grochau I, Schwengber ten Caten C, de Camargo Forte MM (2017) Current American landscape in laboratory accreditation according to ISO/IEC 17025. Accred Qual Assur 22:57-62

[4] Croatian Accreditation Agency (2018) Registry of accredited bodies. http://www.akreditacija.hr/registry. Accessed 10 Oct 2018

[5] Ministry of Science and Education of the Republic of Croatia (2018) Ustanove iz sustava visokog obrazovanja. http://mzos.hr/dbApp/search.aspx?appName=ustanove_VU. Accessed 10 Oct 2018

[6] Ministry of Science and Education of the Republic of Croatia (2018) Ustanove iz sustava znanosti. http://mzos.hr/dbApp/pregled.aspx?appName=ustanove_Z. Accessed 10 Oct 2018

[7] International Organization for Standardization (2019) Advanced search for stanadrds. https://www.iso.org/advanced-search/x/. Accessed 10 Jul 2019

[8] Accreditation body of Serbia (2019) Registar TOU. http://www.registar.ats.rs/. Accessed 9 Jul 2019

[9] Institute for accreditation of B&H (2019) PDF List of accredited conformity assessment bodies as of 17 May 2019. http://www.bata.gov.ba/Akreditirana_tijela/default.aspx?id=18&langTag=hr-HR. Accessed 9 Jul 2019

[10] Accreditation body of Montenegro (2019) Registar akreditovanih organizacija. http://www.akreditacija.me/reg.php#. Accessed 9 Jul 2019

[11] National accreditation authority (2019) Accredited organisations. https://www.nah.gov.hu/en/categories. Accessed 9 Jul 2019

[12] Akkreditierung Austria (2019) Listen der akkreditierten Konformitätsbewertungsstellen. https://www.bmdw.gv.at/Nationale%20Marktstrategien/Akkreditierung/Seiten/AkkreditiertePIZ-Stellen.aspx. Accessed 9 Jul 2019
[13] Accredia (2019) Organismi accreditati e riconosciuti. https://services.accredia.it/ppsearch/accredia_orgmask.jsp?ID_LINK=1733&area=310. Accessed 9 Jul 2019
[14] Slovenian Accreditation (2019) Seznam akreditiranih organov. http://www.slo-akreditacija.si/?s=&post_type=lpacreditation&status%5B%5D=70. Accessed 9 Jul 2019
[15] Narodne novine (2003) Zakon o akreditaciji. NN 158/03
[16] Croatian Accreditation Agency (2019) International Cooperation. http://www.akreditacija.hr/international_cooperation. Accessed 10 Jul 2019
[17] Croatian National Bank (2015) Mikroekonomski aspekti utjecaja globalne krize na rast nefinancijskih poduzeća u RH. Croatian National Bank, Zagreb
[18] Eurostat (2019) Real GDP per capita. https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=sdg_08_10. Accessed 22 Jul 2019
[19] European Union (2019) Living in the EU. https://europa.eu/european-union/about-eu/figures/living_en. Accessed 22 Jul 2019
[20] Latvian National Accreditation Bureau (2019) Accredited bodies. https://www.latak.gov.lv/index.php?option=com_institucijas&view=institucijas&type=K&Itemid=465&lang=en. Accessed 22 Jul 2019
[21] Croatian Bureau of Statistics (2018) Spatial level: State - National accounts – Gross domestic product – In EUR – 2015. https://geostat.dzs.hr/?lang=en. Accessed 30 Nov 2018
[22] Narodne novine (2017) Uredba o kvaliteti tekućih naftnih goriva i načinu praćenja i izvješćivanja te metodologiji izračuna emisija stakleničkih plinova u životnom vijeku isporučenih goriva i energije. NN 57/2017
[23] Narodne novine (2015, 2018) Zakon o poslovima i djelatnostima prostornog uređenja i gradnje. NN 78/2015, NN 118/2018
[24] Narodne novine (2018) Pravilnik o praćenju stanja radioaktivnosti u okolišu. NN 40/2018
[25] Narodne novine (2012) Pravilnik o posebnim uvjetima za uvoz hrane i hrane za životinje podrijetlom ili isporučene iz Japana nakon incidenta u nuklearnoj elektrani Fukushima. NN 88/2012
[26] Uradni list Republike Slovenije (2018) Pravilnik o monitoringu radioaktivnosti. št. 27/18