8th International DAAAM Baltic Conference
"INDUSTRIAL ENGINEERING"
19-21 April 2012, Tallinn, Estonia

THE IMPACT OF METROLOGY IN INDUSTRIAL SECTOR IN ESTONIA.

Simson, K.; Kübarsepp, T.; Uljas, H. ;Leito, I & Karotamm, L.; Karilaid, M.; Metssalu, M.; Parker, M.

Abstract: *The purpose of the survey was to find the impact of metrology on Estonian economy. 450 different enterprises were polled and several interviews were carried out. One of the outcomes was that annual expenditure of 28-40 mln € on metrology produces 2,8 bln € through avoiding unnecessary costs.*

Key words: metrology, industry, measurements, analysis

1. INTRODUCTION

A well functioning metrological infrastructure is essential for sustainable economy. Reliable measurement results are important in industry (e.g. machinery, electronics), consumer care and protection (food production and inspection), emerging technologies (biotechnology and nanotechnology enterprises) etc. A National Measurement System is an instrument in the hands of government to develop and provide measurement services according to needs in society and in economy. For this reason, it is important for decision-makers to study regularly the operation and functioning of metrological infrastructure.

There are some studies about the role of metrology in some countries but no thorough statistical investigation was found which can be exactly applied for Estonian survey.

In the present paper we briefly describe the methods used in the study. The findings, which are based on statistics from period 2005 to 2009 and polls in 2011 are presented. These findings include metrology related costs, technical situation and needs of enterprises mostly in industrial sector.

2. METHODS

The purpose of the study was to find the influence of metrological infrastructure on economy, innovation and sustainability as well to the need for infrastructural development. To achieve the goals, methods were developed for mapping the effectiveness of use of resources and availability of metrological services and its impact on economical growth, quality of life, entrepreneurship and other aspects.

In the study, the use of measurements in several fields was first separately questioned. Mass and related measurements (eg force and torque), dimensional measurements, temperature and humidity, electricity, time, photo- and radiometry, chemical analyses and measurements, water and gas consumption, sound and radioactivity measurements were subject to study. In the next stage, the largest industrial branches were selected based on their annual turnover and exporting capabilities. The aim was to combine the use and future needs for measurements and metrological services in the competitive industrial sector.

The survey based on the data acquired by Statistics Estonia during the years 2005 to 2009 and polls carried out in 2011. The subjects of

survey were selected basing on import and export volumes.

The largest sectors in external trade were:

- Machinery and metal works
- Electrical appliances and electronics
- Chemistry
- Textile
- Foodstuffs
- Furniture
- Power industry
- Plastics
- Wood

Information about sales revenue, value added and trade of sectors was used. In order to exemplify the results of polls, case studies were implemented in different big companies in order to bring out the details and mechanisms between metrology and revenue.

To quantify direct costs on metrology, spending on legal metrology and quality control was used. Additionally, the share of metrology in value added was assessed.

To quantify indirect costs of metrology, the cost of uncertainty was assessed, which is caused by uncertainties of measurement equipment used in trade. In order to assess knowledge about metrology, the development plans of sectors unions were reviewed.

The poll included a pool of 5000 enterprises, from which 450 enterprises were chosen randomly. The multiple-choice questions gathered information about the purpose and significance of the measurements, also needs and volumes of measurements. One of the important aspects was to learn about the relations between measurement accuracy, false measurements and costs through rework, discount and scrapping.

3. COSTS

The direct impact of metrology lies in the costs caused by equipment, facility and employees and in the revenue created by metrology tools, like knowledge and avoidance of scrap or excessive production steps. Average annual spending on metrology according to the answered enterprises is 4398€. The measurements are affecting about 80% of enterprises in a significant manner.

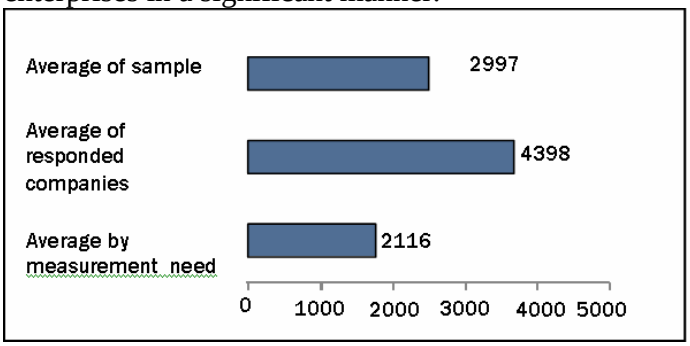

Illustration 1. Annual spending on measurements, €

Over half of enterprises (54%) expressed that failure in measurement or false measurement result affects the ability to sell product or services. The most dependent on measurements are machinery and metal work sectors, furniture production, production of non-metal minerals and agriculture.

About one third (33%) of the respondents said, that they could not sell their product, when it is out of specification. The fraction of 17% of answerers said, that they should do 5-20% discount but only 8% stated, that they do not need to make a discount to sell the product. To summarize, it can be said, that measurements affect at least 79% of the whole revenue produced in Estonia.

Most of the enterprises use measurements for end-product quality control. Very important is the use of metrological tools in process control, raw material control and work environment monitoring.

Especially sensitive to the quality of measurements in Estionia are processes and products in machinery and metal production

sector, furniture production food, printing sector and non-metal mineral production. Also, these sectors can be found in the top of the most exporting industrial sectors in Estonia. The sectors, which produce most of sales revenue and depend highly on metrology, are power production (1,3 bln €), food industry (1 bln €), metal and machinery production (0,85 bln €) and wood industry (0,8 bln €).

The total metrology related expenditure of the enterprises, which took part of the poll, was 1,34 mln €. The most of it, 21%, is spent on chemical analyses, 20% on mass, 19% on temperature, 14% on dimensional and 26% on other types of measurements.

A part of chemical analyses is done for environmental monitoring purposes. It must be brought out, that most of the environment taxes are based on measuring the extent of impact on environment. This includes greenhouse gas, fuel, pollution and many other measurements. The results are the base for applying certain taxes or regulatory obligations on the company.

A good example is the measurement of sulfur levels in ship fuel and its direct impact on transportation cost. This cost causes indirect costs also to the other industrial sectors and operators. The quality of the measurement is therefore very important because of the risk involved.

4. TECHNICAL SITUATION

Metrology is used mainly for quality control purposes including checking of final products as well control of raw materials and process management. In all of the surveyed sectors the most of measurements are conducted for purpose of control of final products. Only 2,7% of the enterprises were not able to specify the purpose of the measurements, which shows, that the knowledge about the role of measurements and metrology in business processes is well established. In electrical appliances and electronics industry the measurements are conducted moderately in quality control of end products. This shows the diversity of sectors and the difference of needs for metrology.

For products and processes in metal and machinery, furniture, food and print industry accuracy of measurement is essential. These sectors are the most important contributors to foreign trade. For that reason, it is very important to ensure the fulfillment of their needs to not harm the continuity of quality control in those sectors.

Legal metrology affects industry through the measurements taking place in trade and in customs. Mostly the measurements are conducted in the fields of mass, volume, length and different concentration. The direct impact can be expressed to alternative cost which is caused by measurement uncertainty. In that sense measurement uncertainty is used to estimate the possibility of giving or receiving more or less goods, than stated. It could be described as following equation:

Uncertainty (%) x cost (€) = alternative cost of uncertainty (€)

Equation 1

Therefore it is very important to set the optimal legal maximum permissible error limits by the state, so that the risks related to alternative cost of uncertainty for all sides of trade would be as low as possible and in mean time be economically feasible. These regulatory limits set also obligations and additional cost for traders.

Other tools in industrial metrology are mostly aimed to protect the customers from unacceptable quality products. Well established control system helps enterprises to avoid unnecessary costs coming from ill-production, logistics of out-of specification products and warranty costs.

To find out the impact of industrial metrology a magnitude of a mistake in measurements was

estimated which could be acceptable in production, so that the products must not be scrapped. The results of poll showed, that it is allowed to make up to 4% of measurement mistakes. This number must be considered with caution, because every sector has specific features. In addition, some of work-environment measurements, which might have a quite large measurement uncertainty, can affect the aforementioned average estimate significantly.

If the companies' mistake making rate is over 4%, then 33% of the respondents must totally scrap their production. This is a very large amount of products. Additionally, there are quite high costs for rework. Finally, only 9% of answerers said, that it might be possible to sell their products without making any reductions or additional costs.

Another important technological issue of measurement is the time aspect. Measuring of products takes certain amount of time, which can be converted to costs in some more or less direct way. When the metrological tools used in quality control, are in irregular calibration or in verification and, therefore, cannot be used at the moment, the production stops or running of the production possesses a higher risk of producing inadequate products.

Therefore it is important to establish a well functioning metrological infrastructure to minimize the time, during which the measuring and control equipment is out of use. Until now, most of the metrological infrastructure is meeting the needs of industry. The quality of calibration facilities is up to needs- most of the measurement ranges and uncertainty ranges are covered, but in some measurements, eg dimensional, mass, electrical quantities as well chemical analyses, the responsiveness of calibration service is somewhat problematic. This can be due to several reasons: measurement range, uncertainty and time for service, which can even set higher demands in future.

5. NEEDS

The needs for measurements in industry were studied for the next 3 to 5 years future. In general, the most important was to improve the measurement accuracy and the timeliness of measurements.

The need for achieving more accurate results shows different trends. The companies' tasks are two-fold: fulfill legal requirements and, in order to stay competitive, tighten quality control measures.

The importance of working environment monitoring is constantly growing. In 2007 a survey about chemical analyses was carried out, which showed, that only 11% of enterprises were using measurements for work environment monitoring. In 2011 already 47% of enterprises were measuring working environment parameters. The importance of this marker is much higher, taking into consideration, that in 2007 only medical and food industries were studied, as these are some of the sectors, where environment monitoring regulation requirements are very high.

Needed accuracy of measurements is different in different measurement categories. This is causing some problems of investment planning of metrological infrastructure. Therefore it is very important role of metrological facilities to listen to their customers to be informed about the movements of economy. Rapid changes in economical environment are also causing rapid changes in the needs for measuring capabilities, which can somewhat problematic.

In Estonia, there have been made some significant investments to different R&D enterprises and projects during last years. In such a small country as Estonia, it is important to follow, that the infrastructure is not duplicated and out of work. On the other hand, it is important to provide R&D breakthroughs access to needed measurement equipment at a reasonable cost.

The employees of 64% answered companies and institutions were qualified for current work. On the other hand, 35% enterprises need workers with a better qualification or they need additional training. In addition to industry, also medical and R&D companies expressed a growing need for college-degree specialists, who have a good understanding of measurements in applicable field.

5 SUMMARY AND CONCLUSIONS

The costs on metrology reflect the use of investments very well, although the measuring of the effectiveness is quite difficult. The simplest way to express the effectiveness is trough alternative cost. This shows also the undeveloped method for estimation of the effectiveness of metrology- nobody notices metrological infrastructure, when it is well functioning and, therefore normally, it is rather difficult to justify the investments basing on macroeconomics. However, if the infrastructure is performing poorly, it affects dramatically all parties of industry, life quality and sustainability.

This survey is mainly based on polls and statistical information gathered by Statistics Estonia. The objectivity of the reflection of the situation was affected by the scope of 450 answerers. In some branches the subject group was too small to make generalizations of the situation.

The survey showed that metrology affects most of the branches significantly, because measurements are used in quality control mechanisms. As the quality control becomes gradually more important for the enterprises, the importance of measurements is growing. The most metrology-intensive branches are machine and metal industry, furniture production and food industry in Estonia.

It was found, that chemical analyses are the most important measurement type in the production sector, followed by mass and related measurements. force, torque and weight measurements.

Legal metrology affects industry mostly through trade and environmental taxes. The most important types of measurements in legal metrology are mass and volume measurements and chemical analyses.

The companies stated, that in the next 3-5 years measurement accuracy and timeliness will be more and more important. The importance of accreditation is steady, because it is becoming self-evident. The importance of timeliness shows, that Estonian industry enterprises pursue effectiveness by trying to minimize the downtime caused by maintenance and control.

The working environment measurements are getting more and more important. The difference between 2007 and 2011 is showing dramatically growing interest in acoustics, temperature and other directly working environment related measurements as it is also verified by interviews.

It was found that metrology has the most substantial impact on main industry branches in manufacturing cost optimization. The availability of reliable measurement services is essential for a well-functioning company, industry and whole economy. The annual expenditures on metrology are approximately 28-40 million € facilitating companies to avoid unnecessary additional costs of manufacturing estimated in total 2,8 billion € per year in Estonia. The survey is to be repeated in the future in order to see trends over the years.

The survey indicated that reliable measurements are needed for Estonian industry for quality control, process control and other purposes. The costs carried out by industry are significant and they would grow dramatically, if there would be problems with current service providers. Therefore there is a growing need for a well established metrological infrastructure providing diversity related services.

7. REFERENCES

- „Measuring the Impacts of Science: Beyond the economic Dimension", Benoit Godin and Christian Dore, http://www.csiic.ca/PDF/Godin_Dore_Impacts.pdf
- The Impact of Metrology in the economy, industrial companies and quality of life" http://cim2010.com/CIM/comunicac/ACruz_IPQ_The%20Impact%20of%20Metrology.pdf
- „Economic Impact Report Metrology Investment: Impact on Innovation and Productivity" http://www.bis.gov.uk/assets/bispartners/nmo/docs/nms/economic-reviews-august-2010-updates/economic-impact.pdf
- Keemiliste analüüside ja mõõtmiste hetke- ja arendamisvajadused Eestis. Ivo Leito, Ivari, Kaljurand, Reet Tallo, Kristina Virro. Tartu Ülikool, Bradley Dunbar Associates Estonia OÜ, Tartu, Tallinn 2007.
- Eesti Statistikaamet www.stat.ee

8. ADDITIONAL DATA ABOUT AUTHORS

1) Author: Kaarel Simson, R&D specialist, Metrosert AS

2) Title of manuscript "Metroloogia infrastruktuuri, metroloogia mõjude ning mõõteteenuste hetke- ja arendusvajaduste uuring"

3) Kaarel Simson, R&D specialist, Metrosert AS, Aru 10, Tallinn, Estonia, tel +372 5836 0825, Kaarel.Simson@metrosert.ee

2) Co-authors:
Toomas Kübarsepp, R&D director, Metrosert AS, Aru 10/Tallinn University of Technology, Department of Mechatronics, Ehitajate tee 5, Tallinn, Estonia, tel. +372 681 4815, tkubarsepp@metrosert.ee

Ivo Leito, Head of Chair of Analtical Chemistry, University of Tartu, Ravila 14a, Tartu, Estonia, tel. +372 518 4176, ivo.leito@ut.ee

Marikai Karilaid, Partner, BDA Consult OÜ, tel. +372 627 4414, info@bda.ee

Harli Uljas, Partner, BDA Consult OÜ, Tatari 64, Tallinn, Estonia, tel. +372 627 4414, harli@bda.ee

Liina Karotamm, Project consultant, BDA Consult OÜ, Tatari 64, Tallinn, Estonia, tel. +372 627 4414, liina@bda.ee

Märt Parker, BDA Consult OÜ, Tatari 64, Tallinn, Estonia, tel. +372 627 4414, mart@bda.ee

Margus Metssalu, tel. +372 627 4414, margus@asiconsult.ee