ESPM 2018

Engineering sciences
&
Production management

Workshop proceedings

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Foreword

Industrialisation and the associated scientific and technological progress have been geared mainly toward ever-increasing consumption by a growing population and the production induced therefrom. The 1970s saw major world industrial and economic clusters to start to shift toward concepts and models for cleaner and safer consumption and production, sparked by their relationship to environmental sources and pollution of elements in the environment.

With the turn of the 21st century, the global community has come to acknowledge and accept that any further economic development and assuring the world's growing population a quality of life would be unsustainable unless policies, principles and objectives of green growth and the green economy are accepted.

Engineering sciences and production management needs to respond to the new situation by promoting and creating an innovative knowledge base. The priority in the face of global challenges and sustainable development agreements is to move today from raising awareness to more intensive action by all countries, organisations and individuals. Meeting the current ambitious goals set in European socioeconomic development strategies (EUROPE 2020, HORIZON 2020) would be unrealistic unless there are innovative, intelligent changes in both management methodology and practice.

The current role the **engineering sciences and production management** are playing in this context is the creation and expansion of the supportive knowledge base in order to implement smart Industry 4.0 elements, namely increased automation, robotisation, digitalisation and environmentalisation in production. The innovative potential of a modernised economy lies in new, smarter production models, in the development and application of best available technologies (BAT) in intelligent production logistics and both for circular and green resource-based economies.

Smart growth involves the creation of a knowledge-based, innovative economy which is resource-efficient, low-carbon, environmentally and socio-economically balanced and "intelligently" managed. Intelligent production management (IPM) is based on the use of more exact preventive instruments and global standards in an integrated system of managing technical, economic, environmental and safety risks. An organisation's innovative management system needs to integrate comprehensive quality, competiveness and sustainable production together with green growth and a green economy within its planning, organisational, control and improvement activities.

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Milan Majerník, prof. h. c., prof. Ing. PhD.
chairman of the scientific committee of ESPM 2018

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RISK MANAGEMENT IN SMALL AND MEDIUM ENTERPRISES WITH A FOCUS ON MONITORING OF RISK AND SELECTED CONTROL SYSTEMS

Katarína Buganová [1], Mária Hudáková[2]

Abstract: *Every company operating in the current dynamic environment should concentrate on increasing the security of its activities and processes. The reason is not only its primary effort to achieve positive economic results but especially responsibility which the management bears in connection with all interested parties. The employees, customers, shareholders, regions, state and many other subjects profit from the results of the entrepreneurial activities of the large companies or SMEs. The extension of awareness about the possibilities and approaches to the risk management in the entrepreneurial activity supports the successfulness of the realised entrepreneurial activities of the SMEs, the development of the regions and last but not least of the state. The paper deals with the issue of risk management in small and medium enterprises with a focus on monitoring of risk and selected control systems.*

Keywords: risk, risk management, small and medium enterprises, monitoring, control.

1 INTRODUCTION

The companies create inspection systems whose aim is to identify the changes before they become transparent in the financial area. However, the current inspection systems are not built only on the outputs from accounting. They are able to work also with soft signals and their scope has extended from the present days to the future.

The risk management system itself is an object or regular monitoring. The functionality and reliability of the risk management system can be checked either internally or externally. The input inspection carries out revisions and the external inspection is realised e.g. in the form of an external audit.

The risk monitoring in the risk management system can take place in various forms utilising several methods and tools. The company can build the early warning system for the needs of monitoring. However, it is not necessary for the company to utilise several parallel inspection systems but to use the implemented ones as effectively as possible.

2 IMPLEMENTATION OF RISK MANAGEMENT IN THE SMES IN SLOVAKIA

In 2017 the investigators of the project VEGA - Risk Management of Small and Medium Sized Enterprises in Slovakia as Prevention of Company Crises – in the framework of the support of the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic, realised an empirical research aimed at identifying the entrepreneurial risks of the SMEs in Slovakia. Its task was to detect the state of the risk management in the enterprises. Altogether 487 SMEs participated in this research in Slovakia. From the point of view of the lines of business the SMEs were working in the structure was as follows: industry 16 %, trade 24 %, agriculture 1 %, building industry 12 %, transport, information 6 %, accommodation and boarding 9 %, trade services 7 %, remaining services 22 %, other services 3 %. The structure from the point of view of their size [1]:

- 64 % - micro-companies,
- 24 % - small enterprises,
- 12 % - medium-sized enterprises.

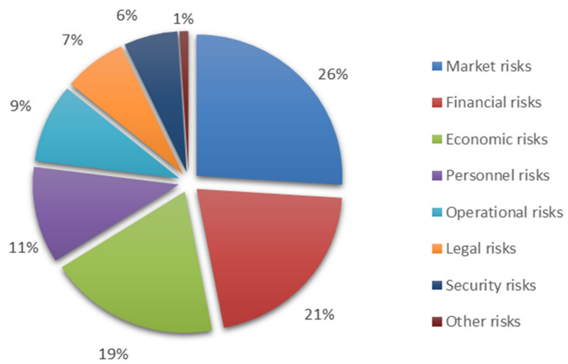

Fig. 1 Percentage of the identified entrepreneurial risks of SMEs in Slovakia [1]

The addressed SME owners and managers in Slovakia were to determine maximally three risks (there were seven options) that they consider being the key ones for their business. The overall number of 487 addressed SMEs identified the sequence of the most serious risks in the Slovak SMEs as follows: 26 % - the market risks, 21 % - the financial risks, 19 % - the economic risks, 11 % - the HR risks, 9 % - the operational risks, 7 % - the legal risks, 6 % - the security risks and 1 % - other risks (see the figure 1).

The market risks were identified as the most serious ones for the SMEs. The research results show that a SME is most vulnerable by the market environment. This can be also proved by other results which point out the biggest intensity of the market risk sources for SMEs as follows – the loss of customers, strong competition in the line of business, market stagnation and unreliability of the suppliers.

The financial risks were identified as the second most serious ones for the SMEs. Currently the financial risk management has the same importance both in a small or a medium-sized enterprise. The most serious sources of the financial risks for the SMEs were detected – the insufficient company profit, unpaid receivables, inability to pay the obligations (insolvency) and company indebtedness.

The economic risks also affect the business of the SMEs. They were identified as the third most important ones for the SMEs in the research framework. The most intensive sources of the SME economic risks were detected – development of the tax and insurance burden, growth of process of all types of energy, insufficient availability of the financial resources and development of the interest rates.

The personnel risks are frequently underestimated in the current entrepreneurial environment. This fact is also confirmed by the research results – the personnel risks were identified as the fourth most serious ones. This can be proved by the detected sources of the personnel risks – the insufficient employees´ qualification, high fluctuation rate, decline of working morale and discipline and the employees´ errors.

The operational risks were identified as the next risks; they are connected with the production process and services. The main sources of the operational risks were detected – low rate of innovations, obsolete production equipment, increasing the amount of claims and insufficient utilisation of the production capacities.

The legal risks occupy the sixth position. They are connected with the economic and legislative government policy. The legal standards in Slovakia show still larger dynamics and are permanently changed. From the point of view of the legal risks the SME owners and managers perceive especially the long periods of solving the litigations, low enforcement of laws, frequent changes of the legal standards and insufficient independence of the courts.

The last in the sequence are the security risks. The reason can be that currently especially the processes and information are preferentially secured. From the point of view of the security risk sources the SME owners and managers perceive the accidents, external threats, property criminal offences and abuse of information as the most frequent security risks.

After assessing the identified sources of the entrepreneurial risks the following areas were identified as the most serious ones for the SMEs in Slovakia:

- the development of the tax and insurance burden,
- the loss of customers,
- the long period of solving litigations.

3 DESIGN OF METHODOLOGY FOR IMPLEMENTING RISK MANAGEMENT IN THE SLOVAK COMPANIES

Based on the results of the empirical research, on the current state analysis in both the theoretical and practical level and other results from individual projects of the scientific and research activity at the Faculty of Security Engineering of University of Žilina we can design a methodology for implementing the risk management in the companies. The basis of this methodology is the international standard ISO 31 000 Risk Management – Principles and Guidelines adapted into a form for an easier and more concrete instruction for implementing the risk management in the Slovak companies.

The designed methodology can be used in various types of enterprises, but especially in the SMEs. It assumes a rational adaptation of the risk management implementation to the concrete company conditions.

The methodology of implementing the risk management in a company is created by the following nine steps [2]:

a. Stating the strategy, principles and responsibility for the risk management.
b. Analysing the environment and stating the risk criteria.
c. Identifying the risks and risk sources.
d. Analysing the risks and determining their priorities.
e. Assessing the risks and creating the catalogue of risks.
f. Working out and realising a plan of preventive measures.
g. Assessing the effectiveness of the preventive measures.
h. Ensuring the monitoring of the environment and the risks.
i. Taking a positive attitude to the risks.

The most important thing for enforcing the risk management in the enterprise is to have sufficient support of the top management. The company management should be oriented on prevention. The prevention implemented through the risk management should be part of the company management, approaches that orient on analyses of the failures, accidents and are to stop their repeated occurrence.

The next step is to work out the risk management strategy that will become part of the company strategic planning. The risk management strategy should solve the allocation of the resources, tools and tasks in the risk management area. It is the basic material for making decisions in the risk management and significantly affects the state and assumed development of the company economic environment.

The managers should define the adequate risk management policy that supports the selected strategy with a positive impact on fulfilling the company goals in dependence on a particular situation, financial strength of the company and the amount of estimated potential losses.

It is necessary to define the responsibility for the risks to the top management and responsible managers of the company key processes.

Second step of methodology is to work out an analysis of the external and internal environment of the company for the managers to be able to define the strategic and organisation linkages with the risk management. It is also inevitable to assess the company abilities in connection with the stated goals and risk management strategy (management policy). The company top management should define the current key risks the enterprise faces minimally once a year and to take into account the overall environment the company operates in.

Furthermore, the managers should define the risk criteria by which the individual risks will be assessed. The criteria represent boundaries for assessing the importance and seriousness of the risks. The companies should define the threshold of the biggest loss the company is able to survive (the risk capacity) and state the risk level which is acceptable for the enterprise and which can be borne by it (the risk appetite), i.e. state the tolerance limits.

In the third step of the methodology is necessary to identify the risks, to recognise and describe them. The managers should ensure a regular and continual monitoring process of all external and internal events under way which affect the fulfilment of the objectives. In the framework of these events it is necessary to differentiate the positive influence (opportunities) or the negative influence (risks).

Then it is necessary to work out the identification of all risk sources (causes), events and their potential effects which influence the company and provide the input assumptions for the risk analysis. It is based on the conclusion of the previous stage where all negatives, weaknesses and threats can be a risk source. It is very useful to carry out the causal analyses of the sequence of the events that provide a possibility to make the development of an undesirable event through various methodological procedures more visible.

In the fourth step of the methodology we have to work out the analysis of the identified risks by two criteria – the probability and the effect. The mutual Cartesian product of the criteria represents the resulting point evaluation, i.e. the risk level. The risk level determines the priority of the risks, i.e. in what extent the risks can affect the goals of the processes, the company.

The companies should define their own probability rate and risk effects on the basis of their needs. In the case of determining the effects we differentiate individual types of effects (the financial, non-financial – e.g. damage of health, environment, good reputation of the company, etc.). The effects can be defined differently, e.g. large, medium or small or we can choose five assessment levels.

Fifth step of methodology compares the probability of occurrence and effects with the defined criteria from the first step. The responsible managers should decide which risks are to be reduced, which are the priorities for work with the risks and which activities are to be carried out. To make the risk assessment easier, the managers can use:

- Creating a risk assessment matrix.
- Stating the priorities of the risks and determining the acceptable and unacceptable risk.
- Creating the catalogue of the risks.

The risk assessment matrix is one tool the managers can evaluate the risks with. It is considered the most frequent form of assessment. The risk matrix can have various arrangements, e.g. 3x3 or 5x5 and others. Its task is to state the importance of the risk, e.g. low, medium or high based on the determined risk rate which is given by the Cartesian product of the probability assessment and effects. The utilisation of the matrix is connected especially with lack of information for the quantitative risk assessment or with situations where it is necessary to make use of the experts´ knowledge fur to the complicatedness of the problem being solved.

From the point of view of the graphical transparency it is possible to use the map of the risks for the risk assessment. The recording of the risks by the map of the risks can be used especially for the primary adjustment of the management and inspection tools at the level of the key processes (divisions) in the company.

In the sixth step of methodology it is necessary to design preventive measures for reducing the risk. It is the coping with the unacceptable risks through intended tactics. The managers should move the unacceptable risks to the group of the acceptable ones. The acceptable risks should be monitored due to the possible future change of the level of the identified risks but of their characteristics.

The managers can choose and implement various tactics (measures) for reducing the given risk. The determined tactics are various processes and procedures which are based on an active influence of the risks, i.e. reducing the potential impacts and probability of their development though the measures taken. It is necessary to state the characteristic and realisation deadline for each measure. The measures are to be implemented in compliance with the policy, strategy of the company and its financial possibilities. The company preventive measures should be included in the company plans.

In the seventh step of methodology it is necessary to investigate the risk management process on condition that the communication, consultancy and reporting are effective. The managers should ensure the inspection of:

- the designed measures for reducing the unacceptable risks, investigating their effectiveness and efficiency,
- the risk management system and the fulfilment of its plan from the point of view of the continual improvement.

Great emphasis should be placed on eight steps of methodology on continuous monitoring and risk control, what we will discuss in the next section.

The last step of implementing the risk management in the company is the requirement on the top management to create values in the framework of the corporate culture that will lead the managers to a positive attitude to the risks and their prevention in the company.

4 RISK MANAGEMENT AND SELECTED CONTROL SYSTEMS

The inspection of the risks should be based on record keeping of the risks, i.e. each assessed risk should be registered and information about it should be handed over to the competent managers. For record keeping of the risks the managers can utilise e.g. the updated catalogue of the risks or also the card of the risk which involves a file of standardly monitored data. The report of the risk can be also a suitable tool for keeping records; it is worked out by a responsible manager.

An important point in the area of the risk management implementation is to monitor and check the effectiveness and efficiency of the designed preventive measures for reducing the risks but also the overall system of the risk management. The results of the assessment and improvement of effectiveness of implementing the risk management in the company can be carried out by the internal audit.

From the point of view of reporting about the company risks it is important for the responsible process managers and managers at corresponding levels of the company management to gather, classify, create and provide information about the assessed risks to the top management. For the purposes of the horizontal level the summary report about the risks is used as a suitable tool for informing about the risks.

Especially the overview of the company process, the monitoring period, overview of the reported risks, the overview of the measures for reducing the unacceptable risks, verbal comments to the reported facts (deviations from the previous accounting period, etc.), and solution proposals should be parts of this report.

The early warning system is a tool of the risk management. Its task, differentiation and integration to the system and process of management should be adapted to the needs of every organisation. The factors that can affect the probability of the risk occurrence and the size of consequences can change, as well as the factors which influence the suitability of measures for the risk management and the costs of the risks connected with them. Therefore the monitored data is to be updated continually and in regular intervals.

The task of the early warning system is to identify the potential or real strategically relevant changes of the internal and external environment which do not comply with the planned activities and threaten the company in time. The essence is to monitor important strategic signals and to identify the unexpected events (opportunities, threats) already in the initial phase. The early warning system is to provide a platform for ensuring the existence and development of the potential for further successes of the enterprise. [3]

The objective of the early warning system is to analyse and assess the actual values of the evaluated processes through suitably chosen indicators and to identify the possible risks and future threats for the organisation in time.

The creation of the early warning system assumes [4, 5]:

a. Creating a structure of the company early warning system – based on the outputs from realisation of the assessment and management of the risks which can be in the form of a risk catalogue it is necessary to define the areas (the risk categories) which will be monitored.
b. Creating a file of indicators of early warning – the selected areas will be monitored through indicators of early warning and they will monitor changes indicating their negative development, e.g. reducing the production volume, increasing the amount of scrap, increasing the number of industrial injuries, frequent failures of the chosen machines, etc.
c. Defining the boundaries of indicators´ acceptability – these values are stated in compliance with the level of the risk tolerance that the company has with regard to the stated company goals. It is necessary to select the right moment for realising the reaction.
d. Stating the tasks, responsibilities and competencies – for the departments but also individual managers. The receipt and processing of the warning signals as well as the adequate reactions for managing the threats identified through creating an information database.

The standard ISO 31000 contains an investigating phase aimed at monitoring the operation of individual risk management phases. The information about the realised procedures and methods improve the effectiveness, functionality and transparency of the risk management process and provide data for the risk monitoring and thus also for the early warning system. [6]

The early warning system can be understood also as part of the management information systems including the methods and tools which help the organisations prepare for the future development and foresee the changes in their environment. They are the systems for an early detection of significant changes threatening the organisation existence for the enterprise to take preventive measures and to make use of the opportunity.

In this way the organisation will gain time for an adequate reaction and this will enable it to improve its market position and finally it positively affects the development of the organisation´s total value as well as increasing the value for shareholders and other interested groups.

The purpose of the audit is to increase the process effectiveness, looking for stimuli for improvements and increase of the value added. As the companies utilise the inspection tools in connection with the risk management most frequently, we will deal with those that are most frequently used in relation to the risk management.

For small and medium-sized enterprises is advantageous to use internal control. The control can be defined as the systematic gathering of information about the course of processes leading to the set objectives. Based on the detection of deviations characterizing the difference between the plan and the actual outcome, control allows and justifies the adoption of measures to regulate the controlled process.

Internal control is an integral part of business management (planning, organizing, management, controlling) and represents the total control of the enterprise. The internal control system is a set of methods and procedures that are applied within the control of management. Managers at all levels of management are responsible for its implementation, whose responsibility is, in case of deficiencies, to inform immediately the competent workers. [7]

The main objective of internal control in the enterprise is to ensure compliance of generally valid regulations and internal standards, effective use of enterprise sources, information systems, protection of property and achieving defined objectives of the enterprise.

The task of internal control in the early warning system is early and effective detection of deviations, which can be positive or negative. Based on their further analysis there is taken the adoption of conclusions for elimination of the causes of negative deviations and their applications. Control activity usually takes place in a structured certain steps or phases, (Fig. 2). [8]

Internal control ensures that the objectives of all institutions are achieved economically, efficiently and effectively, and then it ensures that their assets are properly protected and transactions are legal, right and verifiable.

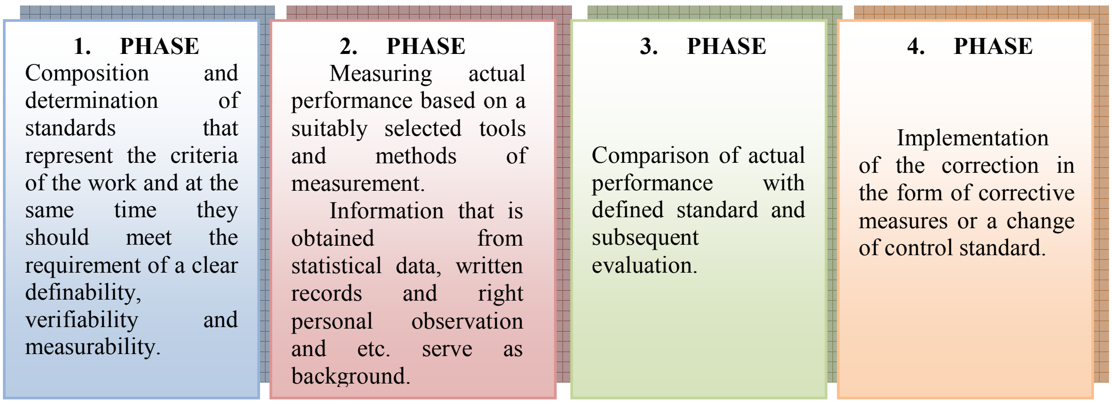

Fig. 2 Basic phases of control [8]

5 CONCLUSION

The corporate culture has a big influence on the managers´ attitude to the risk management and the risks themselves. The effort of the top management should be a permanent increase of the risks management prestige in the whole enterprise. The most suitable way how to implement the risk management to the corporate culture is to create an effective and clear policy of the risk management which includes the philosophy and responsibilities for the risk management in the whole company. The risk management philosophy in the enterprise should ensure that the risk management involves all types of the risk and is in compliance with the overall company strategy.

The adjusted values for correct motivation, mutual collaboration (team management), consultancy regarding to the risks for all company managers should be part of the corporate culture. The risk management area is very extensive and to cope with it requires a big effort which consists especially in training and education of the managers who want to deal with the risks as well as the key process managers and the top management. In the framework of the corporate culture it is important to adjust the communication about the risks involving important information for the interested parties but also for the company employees.

This communication about the risks is important and it has to ensure that those who are responsible for realising the risk management in the enterprise as well as responsible managers of individual processes will be aware of the need and importance of the particular measures. The effective communication helps create awareness about the risks with the goal to involve all employees to the company risk management.

To take a positive attitude to the risks is forming a positive relation to the environment and processes in the company. It respects the intelligence of the individuals and provides a feedback about his/her stances and behaviour. Therefore it is important for the top management to create a positive relation to the risk and prevention in the way of thinking of the managers for them to be prepared for development of a crisis situation and being aware they will cope with it.

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AUTHORS ADDRESSES

[1] Doc. Ing. Katarína Buganová, PhD.
University of Zilina, Faculty of Security Engineering,
1. mája 32, 010 26 Žilina
Slovak Republic

Email: katarina.buganova@fbi.uniza.sk

[2] Doc. Ing. Mária Hudáková, PhD.
University of Zilina, Faculty of Security Engineering,
1. mája 32, 010 26 Žilina
Slovak Republic

Email: maria.hudakova@fbi.uniza.sk

BUSINESS PERFORMANCE MANAGEMENT IMPLEMENTATION IN A SMALL AND MEDIUM-SEIZED ENTERPRISES

Jozef Klučka [1] Stanislava Strelcová [2] Alexander Kelíšek [3]

Abstract: *Business performance management in small and medium-sized enterprises (SMEs) reflects queries of top management and owners and also financial constraints and limits in know-how, what is linked also with the lack of qualified employees. The reason for implementation is also requirement to know performance of enterprises key processes and also to maintain long term sustainability and competitive position of an enterprise. When characterizing SMEs it is often cited its orientation to technical and technological aspects of production and a product and to suppression of other managerial aspects - financial and marketing. [1] Despite the fact that managerial activities in SMEs are extremely differentiated it can be stated that also because of objective reasons, the performance management system - agenda is underestimated in many SMEs and it is not paid attention (mainly due to lack of personnel capacities or for financial reasons). At the same time, however, under Slovak conditions (and confirmed by our statistical survey), there are many SMEs that apply business performance system in their managerial activities. [2] In this paper will be applied the terms of business performance management as complex to business measurement.*

Keywords: Small and Medium-Sized Enterprises (SMEs), Key Performance Indicators (KPIs), Performance Management System (PMS), Business Performance (BP), Implementation of Processes

1 INTRODUCTION

Business measurement deals with quantification of identified process – key process. [3] Key process is a process that is in relation to enterprise strategy. Business measurement is associated with key performance indicators – KPI. [4] These indicators, therefore, refer to the achievement of the processes' objectives and thus to the achievement of the corporate objectives set out in the company strategy.

In addition to the KPI issue, the performance evaluation also addresses the issue of responsibility for the business objectives achieved as well as the competencies and responsibilities of the relevant staff accountable for taking measures and implementing them. Business measurement is thus a condition for the application of business management system in an enterprise. The measures resulting from the analysis of the achieved indicators represent a quantitative basis for applied managerial measures.

2 INFORMATION RESOURCES AND PROBLEM DESCRIPTION

Business performance system has relations to the following issues:

- creating a system of indicators for key business processes; a performance measurement; performance measurement can be performed with IT support (specialized software) as well as non-computing - without IT support; both approaches are supposed to secure data sources and their processing,
- establishing a business performance system that incorporates achieved results, measuring into an enterprise's management system; to enter tasks and monitor their performance, an internal system (project, agenda) is expected - with or without IT support,

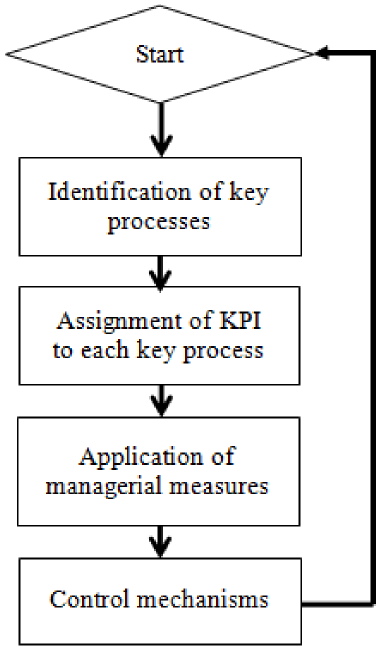

Fig. 1 Implementation and running processes within business performance system [4]

Identification of key processes means clearly define processes associated to core business and also to strategic objectives of an enterprise. [5] In SMEs practice it is often reflected complete misconception on the part of managers. [6] In some applications [7], [8], [9] there were as the key processes identified those that were in relations to responsible field (-s) in managerial activities; there was no clear link to the strategic objectives. Assignment of KPI is explained above.

At the same time, consideration should be given to the availability of data and the need for the transfer of these data to the responsible employee for the agenda. Application of managerial measures is in fact about KPIs transformation and their interpretation to specific steps assign to responsible employees within an enterprise. The objective of a control is to verify validity of measures and at the same time the correctness of the company's direction with regard to sustainability and competitive position.

Based on the results of the statistical survey and the personal communication of authors with entrepreneurs it can be stated that [2]:

- in a vast majority of SMEs it is not elaborated the business plan; entrepreneurs/ responsible persons were not able to formulate key processes in an enterprise,
- business performance management is mainly focused on measurement of some performance parameters; these ones reflects owners'/CEO' professional preferences,
- decision to business performance system implementation (often associated with the purchase of specialized software) is isolated decision of a member top management member; no managerial framework is developed that would integrate measured results into managerial activities and communication within an enterprise; in practice it means that business measurement is limited – there can be hardly proved results, positive benefits to balance costs derived in business performance system,
- the performance measurement is reduced to selected employees, the information flow in the enterprise is not modified, and the competencies and tasks resulting from the performance measurement are not explicitly defined; in connection with a steady increase in the agenda for a limited number of staff, puts pressure on the rejection of the importance of this agenda; in enterprises dealing with quality management, however, the business performance agenda is up to date.

3 IMPLEMENTATION FRAMEWORK

Based on the results of the statistical survey as well as personal interviews with entrepreneurs, problems were identified [2]:

- lack of qualified employees,
- lack of managerial communication systems within the results and objectives communicated,
- lack of time and doubts about the benefits of measuring and evaluating performance,
- the content of the agenda is facultative therefore a lot of executive employees this agenda consider to be irrelevant / insignificant (in contrast to binding agendas, usually associated with legal standards).

With the objective to minimize assumptions of failure in implementation of business performance system in SMEs it is further in the paper proposed the procedure that can help SMEs in successful implementation and operation of business performance system in an enterprise. Hence the concept of project management will be applied in implementation and operation of business performance system in SMEs in the Slovak republic.

In this part, besides the general characteristics of the project management phases, the specificities that are relevant to the implementation and operation of the business performance system in the enterprise will be given.

Project consists of following phases:

Initial phase of the project – in this phase requirements are specified and documents are proposed that will serve for interior communication in solving project; scope and quantity of documentation is determined by the seize of an enterprise and participants' willingness to communicate; a working meeting is recommended at this stage where the project manager (the person responsible for the implementation of the system in the company) informs the participants about the project, requirements and risks of the project; the initiation phase is conditional upon the approval/support of the project by the top management of the company.

Project planning – within this phase are defined responsibilities of team members, their objectives, proposed time table for tasks. Allocation of financial resources depends on the size of the team and the explicit goals related to the project.

Project performance and monitoring – within this phase is important the quality of the product (the measured results should be delivered to responsible employees), meeting the timetable, common agreement to quality of outputs and communication, achievement of common agreement to quality of outputs and communication related to implementation of measures that are based on assessment of key processes outputs.

The list of risks faced by enterprises in implementation of projects is as follows [10]:

- lack of support by tom management and incompetent work of the project leader,
- missing justification of the project,
- changing conditions of the project,
- lack of resources for development, implementation and routine operation (human, financial, information, etc.).

On the basis of the statistical survey and discussions with SME managers, the most common risks to entrepreneurs in implementing and routine operations were the following identified:

- lack of support for top management and responsible staff,
- unclear and changing expectations,
- due to the project's readiness, implementation and routine operation have not been associated with expected benefits,
- negative enterprise culture and attitude of employees during implementation and operation of business performance management,

- results were not communicated to top-management and the results did not draw conclusions about the practical activities of the company, its employees,
- there was not formally appointed project manager (due to the size of an enterprise it is also possible to talk about informal delegation); it was rather a voluntary initiative of an employee (member of top management) of an enterprise,
- lacking communication relationships necessary for the implementation and operation of the business performance management system; the responsible employee may have not data, competencies or know-how.

As the most important factor was the fact that the company implements the quality management system (usually required by customers). These enterprises have a greater affinity for project management (in general) and have understood the link between quality management and business performance. Therefore, their position to implementation and business performance operation was stated as an unnecessary and burdensome - non-contributory additional benefit for the enterprise.

4 RESEARCH

In [11] identified list of problems related to performance management systems implementation. The authors based on analysed information resources identified problems that will be discussed with experts. The problems were organized in hierarchy, analysed and compared. [12] The list of the problems was defined as follows:

(1) Management puts low priority on the implementation
(2) The implementation requires more time and effort than expected
(3) There are insufficient resources and capacity available for implementation
(4) The organization is in an unstable phase
(5) The PMS implementation does not have a clear goal
(6) Lack of management commitment
(7) Period of attention from management for the implementation of the PMS is not long enough
(8) Organizational members lack a positive attitude towards the PMS
(9) Insufficient commitment from middle management and staff for PMS implementation and use
(10) The current ICT system does not support the PMS adequately
(11) Organizational members are not adopting the right management style
(12) The organization does not have a clear and understandable strategy
(13) I tis difficult to define relevant CSFs
(14) There is not enough focus on internal management and control
(15) It is too difficult to decompose goals for lower levels in the organization
(16) There is lack of knowledge and skills in regard to the PMS
(17) The KPIs are not linked to departmental, team and individual responsibilities
(18) It is difficult to define relevant KPIs
(19) There are too many KPIs defined
(20) The organization measures the wrong KPIs
(21) There is too much focus on the results of the implementation, while the change process of the organization is ignored
(22) There is resistance from organizational members towards the new PMS
(23) There is an insufficient link between the PMS and the reward system
(24) The PMS lacks cause and effect relations or is over-complex due to too many causal relation
(25) The organization does not have a performance management culture
(26) The PMS is not used for daily management of the organization
(27) The PMS is not regularly updated and maintained after implementation
(28) There is no organizational member appointed to take ownership of the PMS
(29) There are difficulties in getting the data to calculate the performance indicators
(30) The PMS gets a low priority or its use is abandoned after a change of management
(31) The organization does not see (enough) benefit from the PMS

Further we will assign the problems to three phases related to BP implementation phases [13]:

A) initiation and planning,
B) implementation and
C) control.

Tab. 1 Problems and their assignment to BP implementation phases

Phase	Figure of Problem	Cumulative Number of Problems
A) Initiation and Planning	(4), (6), (8), (12), (13)	5
A) & B)	(15), (17), (18), (19), (30), (31)	5
B) Implementation	(1), (2), (3),(5), (7), (9), (22), (28), (29)	9
B) & C)	(10), (11), (20), (21), (23), (25), (26), (27)	8
C) Controlling	(14), (24)	2
A) & B) & C)	(16)	1

Although the assignment of problems to phases is not straightforward listed Tab. 1 provides results from our analysis.

The Table above proves that the highest problem related to agenda PM in an organization is the phase implementation. The cumulative number of problems related to phases A) and B) proves the importance and also difficulties in organizations in planning and implementation. Both are related to corporate culture and willingness of top management and employees to improve effectiveness and efficiency in an organization. [14]

In order to compare the situation in Slovakia with findings cited above there were created questionnaires with ambition to:

a) identify reasons why an organization has not BP implemented but it plan do so in the short term
b) identify reasons why an organization has not BP implemented yet
c) identify reasons and results in an organization that has implemented and operates BP
d) identify reasons why an organization that implemented BP has cancelled it (has finished it).

The research is focused on SMEs and will be performed during February – May 2019 in Slovakia (mainly from region of North Slovakia).

The results will be summarized and if possible (availability of data) compared with Austria.

5 CONCLUSION

The paper deals with implementation and operation of business performance system in SMEs. Statistical surveys and discussions with SME management in Slovakia show that there are a number of reasons why SMEs do not implement business performance or why they consider it as a non-prospective or relatively in short period of time they cancelled the project due to not delivering the benefits.

It is crucial that the project meets the goals of the owners and the executive management. Focusing on key processes and therefore business objectives is crucial. Also, the implementation approach is significant - if the implementation decision is isolated by the top management decisions without a competent dialogue, this fact may cause aversion to the implementation of the system; the consensus of all concerned is therefore inevitable - whether in the position of top management or employees to whom the agenda will be assigned.

Therefore, the position of the Project Leader is recommended, and he (she) is guided by the leadership and competence of the whole process in communicating with other responsible persons. Performance ratings may not be reduced to performance measurement; KPIs represent a quantitative expression of the observed key processes indicators. Performance measurement is a subset of the performance management - performance appraisal is focused on applying management measures to strengthen the competitive position and sustainability of the business.

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AUTHORS ADDRESSES

[1] doc. Ing. Jozef Klučka, PhD.
University of Žilina, Faculty of Security Engineering, Slovak Republic

Email: Jozef.Klucka@fbi.uniza.sk

[2] doc. Ing. Stanislava Strelcová, PhD.
University of Žilina, Faculty of Security Engineering, Slovak Republic

Email: Stanislava.Strelcova@fbi.uniza.sk

[3] Ing. Alexander Kelíšek, PhD.
University of Žilina, Faculty of Security Engineering, Slovak Republic

Email: Alexander.Kelisek@fbi.uniza.sk

PRODUCTION SYSTEMS SUPPORTED BY DESIGN USING VIRTUAL REALITY

Juraj Kováč [1]

Abstract: *The article deals with the design of manufacturing systems using virtual reality. It describes the virtual reality and its use in designing. The individual chapters of the article show the procedure for creating 3D models. The article describes the necessary software security for modeling, introduces the creation of a database of production machines and the subsequent project activity using the created virtual 3D models.*

Keywords: Production systems, Virtual reality, 3D model

1 INTRODUCTION

Nowadays, it is necessary to analyze parts of production processes or whole processes in three spatial dimensions. A suitable technical tool in this case is a spatial model, that is, a reduced symbolic image of a production machine or device or the entire manufacturing system. It can be a single device model or a whole model. The advantage of these models is in particular their unambiguous expression. Their use is suitable wherever spatial relationships cannot be represented by drawing solutions, or they are represented in a very complex way. At the same time, routine drawing activity is eliminated, while the designer's intellectual creative work is rationalized. They can get to know each other in time, eliminating errors in the design solution. Nowadays, the most modern innovation trend is virtual reality models. A virtual reality (VR) is a computer-generated environment that allows the user, through his senses, to perceive the environment as real and interact with it. This in turn allows you to work in this environment and with this environment as real:

2 VIRTUAL MODELING OF REALITY

To accelerate and streamline a designer's work, a variety of tools in the classic design of production systems have already been designed and manufactured for processing especially the last stage of technological design – an image of spatial layout. Currently, the most widely used method of technology design imaging is a two-dimensional (2D) or three-dimensional (3D) model. With 2D imaging, the individual production machines, handling, transport, storage and other devices are shown in the selected model scale based on actual ground dimensions. An important parameter is the range, the range of motion of the moving parts of the machinery, and appropriate labelling. Graphic design of production technology in three-dimensional space is made in a plane, front elevation, and side elevation. In classic design this is a "labor intensive" activity. The front elevation always shows only one cross-section. When showing multiple cross-sections, a problem with displaying the respective relations arises. Recently, an analysis of production processes or entire processes in three spatial dimensions have become required. An appropriate technical aid in this case is a spatial model, i.e. a reduced symbolic image of the production machine or the whole production system. It can be a model of an individual device or a model of the whole in the form of an illustration, installation, construction, teaching or architectural model. The advantage of these models is their clarity. Using 3D models is appropriate if the drawings clearly cannot define and illustrate the design section of the proposal. At Intelligent industrial engineering - Innovation potential 185 the same time, the routine part of design drawings is eliminated and the creative aspect of the designer's work is unleashed. The 3D model of a workstation can detect collision circumstances in the primary stage of the solution that would otherwise overload the total solution due to optimizing deviations from the original state after the implementation of the selected solutions have been made and such deviations have been discovered. Today, the state-of-the-art innovation trends are models of virtual reality. The aim of the virtual reality (VR) systems is to provide users or a group of users collaborating together with an illusion that they are in an artificial environment, called virtual world, virtual scene or virtual environment. The basis for virtual reality are procedures creating spatial models and scenes where those models can be toyed with, moved
in three-dimensional space and displayed in real time. Using special peripherals to deliver video, audio and tactile interactions, virtual reality brings extraordinary experiences and brings about new and unexpected possibilities to computer technology applications. Virtual reality applications have the following characteristics:

- Actions occur in real time.
- Scenes and objects are three-dimensional or create an illusion of being so.
- The user can enter the scene and move through it.
- The scene is not static, the user can interact with its objects.

Virtual Reality enhances the distribution of imaging techniques in computer graphics in two ways. The first aim is rapid creation of an image and the second objective is to create a realistically looking object. Modeling and 3D imaging is an irreplaceable area of design dealing with the creation of production systems and with their implementation into nowadays largely utilized CAD systems. The computer graphics is the basis for virtual reality processes, namely for creation of spatial models and scenes, interacting with them, moving in three-dimensional space, detecting collisions and realIntelligent industrial engineering - Innovation potential 186 time display. These methods are enhanced by the use of peripherals that provide video, audio and tactile interaction. In particular, these are the helmets with built-in screens, stereoscopic projection screens, position sensors in space, tactile devices, simulation cabins, etc. Virtual reality models allow to:

- Replace physical prototypes with virtual ones.
- Simulate various stages of development in virtual
- environment.
- Improve and accelerate the product development
- and other processes, etc.

The purpose of virtual reality is that the virtual environment can be shared by many users at once, and allows them to interact with each other. In this way, several people can work together to solve problems.

3 SOFTWARE MODULE FOR CREATING VIRTUAL PRODUCTION APPLICATIONS

Currently, production companies face global competition caused by more demanding customers. Therefore, companies seek to make their activities more efficient in the so-called supply chain environment. They join the production structure network, which means that suppliers and customers become part of those production structures. Such systems need not only to be managed but also to optimize their activity based on appropriate criteria. Development of new information technology enables the use of network (computer) communication structures for the transfer and management of information flows, the management of material and financial flows, and for finding optimal conditions for a company's production based on customer requirements. Program modules of advanced graphic systems rely on significant support from information databases that contain either elementary 3D objects for technical execution modeling in their structure or reliable models created in advance. Modes of technical means of implementation or other technical facilities in terms of unfinished procedures use the method of volume elements, from which complex objects are Intelligent industrial engineering - Innovation potential
created by synthesis. From an initial source of information, i.e. leaflets, catalogs, etc., a set of graphic-focused information of technical means of implementation is formed, with recorders in the so-called information sheet. Thus created files of builders of means of production in production systems reported in an appropriate structure (data bank) allow to create and use 2 or 3-dimensional models of the means of production (shown in different views) in automated design activity. The corresponding software modules allow to perform sets of general interactive graphic functions as well as specialized design procedures. After its installation, the proposed module is integrated into the graphic system of user interface of the Inventor, using the user programming interface API (Application Programming Interface) designed to run programs and interactions. The "Communication language" between the module and the API interface is the application of the Visual Basic Editor, which is also a part of the installation and serves as a tool for creating independent software components in the Inventor environment. By its application a new toolbar with added function keys, or references to the macro, has been designed, based on modifications, size of icons may be allocated, etc. Modified custom menu can be implemented in the standard Inventor menu. The structure of the model is created by:

Graphic database of three-dimensional models of production technology (*.ipt file types).

- Information database containing the main technicaland dimensional data of the individual productionequipment (* .idw, * .doc).
- Program system, including variants of access algorithms for work with the above-mentioned database (Autodesk Inventor, Design Data Manager).
- Production system module transforming model *.iam created by Inventor in a format suitable for virtual reality * .wrl.
- Module for Internet browser Cortona VRML client.

4 PRODUCTION TECHNOLOGY DATABASE

Three-dimensional models were created in the environment of the Autodesk Inventor graphic system. The primary source of information were drawings, brochures and catalogs of manufacturing technology. Application program systems using advanced computer graphics are strongly supported by information databases. These may include elementary geometric 2D or 3D objects in their structures, from which individual facilities of manufacturing technology are modelled, or contain reliable, previously created models of these facilities. For trustworthy records of the models, basic methods derived from principles of computer graphics were used. Each model is a 3D model of a production facility at 1:1 scale. A file of graphical information about devices is recorded in the so-called information sheet.

Fig. 1 Examples of information sheet extracted from the database of manufacturing technical models

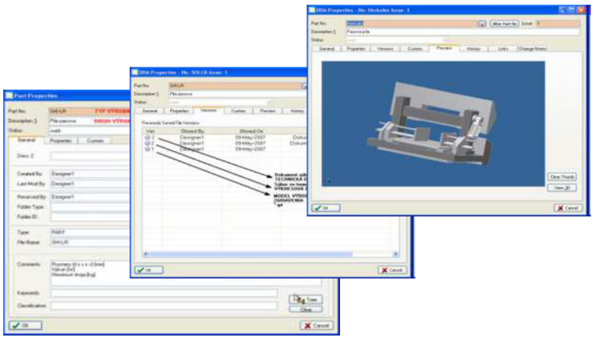

Fig. 2 Example of 3-dimensional model of production equipment created in a CAD system

Following the successful introduction of 3D model of a production facility into a database, it is possible to search and select appropriate equipment for the production system design. The user will search for the required model by defining the parameter as a specified criterion or by selecting it from the list of models (Module database is marked "PDM integrator") that the databas includes.

5 DATABASE APPLICATION IN DEVELOPING MANUFACTURING CLUSTERS:

Methodology for designing a new production cluster using this module starts with the choice of the design area. Models of production equipment are selected from the database and situated on the selected design area that was created as a *ipt component and stored in the database. Models of manufacturing clusters are created by the user – designer, using information from the production facilities database in the desired output format in 3 dimensional or 2-dimensional space (assembly *.iam).

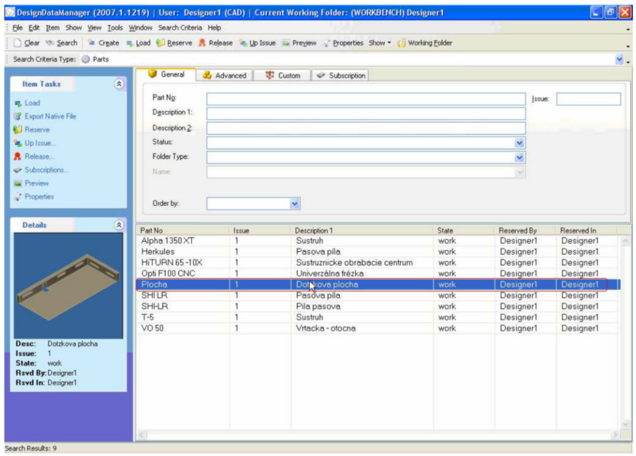

Fig. 3 Method for selecting an area for designing manufacturing equipment

Individual models inserted in the configuration will be connected (command "joining”) in the final alignment and, depending on the proposal, their deployment will be adjusted to achieve the desired position, which determines the final alignment of the production system model.

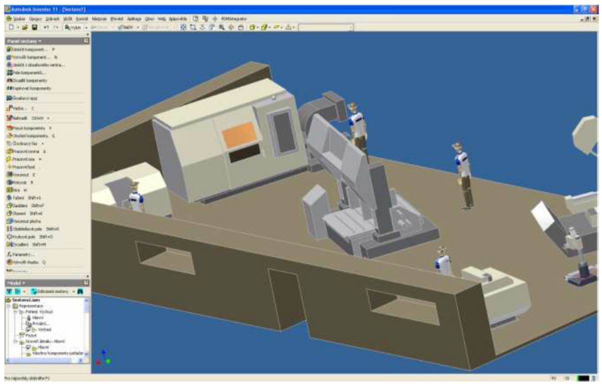

Fig. 4 The final alignment of a production cluster

Figure 4 shows the model of a production system from a different point of view. Using the resources of virtual reality, realistic scenes can be created in 3D environment, to be used for practical purposes in further product development and testing and even in training of workers and maintenance personnel who will manufacture the product and operate the equipment in the future.

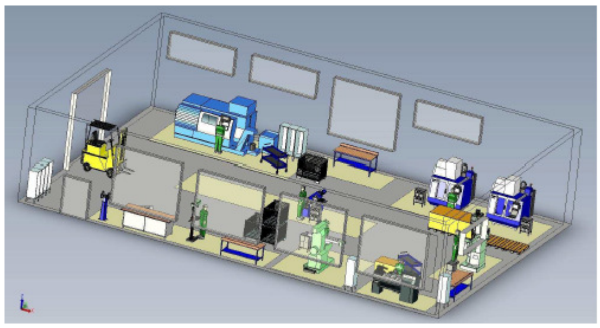

Fig. 5 Production system model

6 CONCLUSION

The system of knowledge and methodologies aimed at designing production systems needs to be built open for further development in terms of evolution and inclusion of new knowledge. Software, information and communication technology applications should be considered a significant trend in the area under investigation. It is necessary to introduce new design methodologies based on variant, interactive, innovative and virtual solutions into project practice.

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AUTHORS ADDRESSES

[1] Ing. Juraj Kováč, PhD.

Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial Engineering and Digital Park Komenského 9

Email: juraj.jkovac@tuke.sk

APPLICATION OF MODULAR PRINCIPLES FOR DESIGNING PRODUCTION SYSTEM STRUCTURES

Albert Mareš [1]

Abstract: *Production structures can be various and every variant has own specifics. These specifics require different access to design production systems. In every production systems it is possible to find workstations. They can be manual, partially automated or fully automated. When workstations are designed some of them are intended only for specific tasks, but others can be intended as a universal for many different tasks. Nowadays due to high competitive, producers must quickly reacts on customers' demands change. Sometimes it is necessary to adapt production structures to product new product. It can be helpful to use modular architecture to easy adapt production to product new product. The paper shortly describes workstations and application of modular architecture for production system design.*

Keywords: Manufacturing, Workstation, Assembly, Modular architecture

1 INTRODUCTION

Workstations are production and organizational units, defined by a certain space, equipped with the necessary means of production according to the character of the activities performed, in which complete and closed partial technological, handling, control or other operations take place. The resulting function of the production process (execution of production tasks) is the unification of partial functions, which are done at the physical elements (workstations). Using means of production, the manufacturing process determined by the production program of production system is carried out. Other subsystems (handling and control) are needed to make the production or the technological subsystem to perform the functions specified as efficiently as possible.

2 MANUFACTURING WORKSTATION SPECIFICATIONS

In terms of meeting production targets, workstations integrated in the production system do not have the same structural shape and roles. The production or technological workstations are basic, conditions for their activity are created elsewhere. Types and the number of necessary workstations are determined by the technology used and the organization of the material flows. The production process is divided into operations that are subdivided into individual production and time-related parts, which are assigned to the workstations as separate tasks. Each workstation is designed to perform a certain range of operations.

Since automation in the production process shifts human activities to technical elements, in the field of technology, handling and management, the position of a man in the production process changes. Depending on the character of the operator's activity, the following types of workstations are distinguished:

- Conventional.
- With NC machines.
- Automated.
- Without an operator.

Conventional workstations are those where the worker handles products, semi-finished products or other material objects directly or through handling equipment and by his direct or indirect action, workplace preparation and technological or other processes are carried out.

In the NC machine workstations, the worker handles the semi-products or products directly or indirectly by means of handling equipment. Technological or other processes are done automatically, whereby the operator ensures only the start and controls the execution. The sequence of the workplace is set by designated worker.

Automated workstations are those where the worker only sets the sequence of the operation and controls the process execution. Handling is performed automatically by handling equipment (e.g. a rotary table where technological pallets are used during the machining of cupboard components) or by an industrial robot or handling equipment (e.g. when using the pallet system in the machining of rotary components).

Workstations without operator are those where the worker only sets the sequence of the workplace. All activities in the workplace are performed automatically. The goal of workstations without operator is independent labour of the workstation without human supervision (e.g. in the 2nd and 3rd shift) for at least 4 to 8 hours.

With regard to the management of the production process in the production system and the interchange ability of individual workstations, the following are distinguished:

- Completely interchangeable workstations; they have the same working ability (identical ranges of possible production tasks).
- Partly interchangeable workstations; Interchange ability applies only to a certain class of operations (overlapping spectrum of possible production tasks) and is judged according to the ability to perform a particular operation (e.g. drilling holes from a certain interval).

- Mutually not interchangeable workstations (disjoint spectra of possible production tasks).

According to technological operations or processes performed, it is common to characterize workstations as machining, forming, welding, spraying, assembly workstations and the like. Depending on the object breakdown based on the production system breakdown, the following are distinguished: technological, non-technological, handling, transport, storage, controlling, etc. workstations. In breakdown by flow: flow of semi-finished products and unfinished products, flow of production aids, flow of waste, pallets, energy, information.

Workstations are considered to be relatively closed (isolated) systems. Workstations have their surroundings and their border elements. Through the border elements, the surroundings affect the workstations materially, energetically and informatively. Similarly, workstations affect the surroundings by means of material and information. Similarly, a system defined at the workstation level can be broken down to subsystems just like the production system. When designing a particular workstation, its architecture (physical element structure), functions can cumulate in one element, or several interdependent elements are used for one function only. Some functions of a workplace do not have to be implemented by means of a technical element due to the influence of a certain level of automation (the function is done by an operator), organization of the material flow and the production system, technology used, and so on. If the workstation needs to be put to use under different conditions, it (the entire manufacturing system) needs to have a modular structure and to be assembled from modules purposely chosen from the construction kit. The requirement for modular construction based on the modular system also applies to the level of individual technical elements in order to allow for their simple adaptability to changing the production program by replacing the modules of elements (for example automatic exchange of a drilling unit for grinding machine etc.). Other types of workstations are just conditionally indispensable depending on the organization of material flow and technological requirements of the production process. The entire class of these workstations is known as auxiliary workstations. Auxiliary workstations are designed to perform all activities related to the preparation of work operations, production aids, means of transport, etc. prior to performing technological or control processes and also after their completion. An example of their functional capacity are the following activities:

- Preparation of assembly or welding components (palletization, single-pallet or multiple-pallet loading).
- Preparation of work operations (basic technological preparation - clamping surfaces of semi-finished-products, clamping, switching and disconnecting products on technological pallets, dimensioning and measuring the correctness of clamping on technological pallets, cleaning of technological pallets with clamped products, if the purifier is not a part of the technological workplace, storage and selection of products in system pallets).
- Preparing the means of transport (assembly of fasteners, specialization and final specialization of technological and system pallets, pallet cleaning).
- Preparation of manufacturing aids (inspection of manufacturing aids, rebalancing, sorting, assembly and dismantling of tools, assembly of manufacturing aid kits for individual machines, cleaning and temporary storage of manufacturing aids, temporary archiving and release of production documentation and NC programs or transport of manufacturing aids to workstations and their sorting).
- In a particular production system solution, all functions are not affected. The number of auxiliary workstations is different due to possibility of cumulating or division of the functions among more workstations, depending on calculation of the capacity and other factors.

The means of transport are a significant element in the workstation's surroundings where the workstations are interconnected indirectly, and other workstations are integrated with the material flow in a direct connection. From the information point of view, this is the production system's management subsystem. The variation and diversity of workstation inputs and outputs depend on the character of the process performed in the workstation.

The structure of material flows at the entry / exit points of workstations includes consumables and auxiliary materials, semi-finished products, processed products, tools, preparations, manufacturing aids, waste. The efficiency and reliability of non-automated production workstations is influenced in particular by the following factors:

- Technical and technological level of means of production and their production capabilities,
- Mutual adaptability of the man and the means of production as elements of one system.

In designing non-automated production workstations, the tasks related to the solution of their ergonomic characteristics are particularly important. A set of ergonomic criteria must be taken into account in the design of non-automated production workstations (dimensions, lighting, temperature, dust, vibrations, noise, colour solution etc.).

3 APPLICATION OF MODULAR PRINCIPLES TO PRODUCTION SYSTEM DESIGN

Using the principles of modularity for configuring the means of production is one of the paths to development of the manufacturing technique of the future. These principles touch on the following aspects:

1. Design:
    - Aiming to optimize the construction of the means of production.

- Enabling computer optimization of variants.
- Unifying methodological procedures during construction.

2. Feasibility:
   - Aiming to minimize implementation costs.
   - Enabling optimization of their economic efficiency.

3. Operational – service:
   - Leading to increased reliability.
   - Reducing operating costs.

Modular manufacturing systems result in increased production efficiency by quick adaptation to changing market demands. Modular production system implementation is reflected in the organization of work, maintenance, storage and technical preparation of production. These systems are ideal for building manufacturing applications based on the principles of lean production. Their application in new production designs is one of the most progressive directions of development and modernization of engineering productions.

Elements and components of modular systems enable creation of new, atypical solutions for manufacturing assemblies, assembly and dismantling workstations, shelves, conveyor systems, and expansion, completion and modification of the existing ones, and so on. Advantages of their application:

- Highly modifiable structure system based on modular architecture - variability due to the integrity and compatibility of building elements.
- Simple and fixed mounting connections... screw mounting technology.
- Reduced design time - a wide range of supportive computer CAD systems and the existence of exemplary standards reduce the execution time and cost.
- Simple dismantling of structures and reuse of components.
- Optimal stiffness and strength of the structure combined with light weight - a wide range of basic building elements and kit complements, the use of high quality materials.
- Recyclability and high level of ergonomics.
- Attractive design, aesthetic appearance - easy to use and maintain Al structures, the profiles are corrosion-resistant, surface treatment is not required unlike in steel structures.
- A specific method of individual parts and components manufacturing.
- Installation of machinery and equipment directly at the customer's site.
- Enable to create manipulation and other peripheral means.
- Capable to be purposely incorporated into higher production clusters.

The benefits of modular principles applied to configuration of the means of production can be summarized as follows:

- Purpose and time generation of the specific means of production is coupled with optimal technical and economic parameters that meet specific, current production conditions of use.
- New configurations of the means of production are modified by purposeful integration of suitable elementary elements and modules.
- Simple, fast and flexible modifiability of project tasks when production conditions change.
- Greater economic efficiency compared to systems generated on the basis of universal technical units.
- Use of already developed and proven building modules of the means of production.
- Increased production system reliability through module application verified in practice.
- Reduced cost of production, maintenance and service of the means of production due to decreasing overall nomenclature of modules and elements.

The conditions for introducing a modular principle in the implementation of new means of production include:

- Application of uniform structural and technical principles.
- Application of type and size ranges.
- Application of normalized and standardized building elements.
- Independence of building elements and units.
- Integrity of elements and units.
- High level of technology.
- High level of ergonomics.
- Economic efficiency.

The following principles are recommended for designing functional modules for the means of production:

- Consistency of technical and structural procedures and the characteristics of the functional modules intended to execute the same type of activity.
- Creation of functional modules in a range of type-specific dimensions.
- Maximum independence of the functional modules from the type of energy and the way of controlling the operation of the means of production.
- Mutual compatibility and interconnection of functional modules with possibility of flexible modification.
- High internal unification of a functional module.

It is obvious from the possible approaches to how the means of production can be modernized that the development direction is highly attractive and also considerably effective, since it allows for different manners of elimination of activities related to both technical preparation and development, but also to the actual implementation of designs.

At present, modular systems of various manufacturers, especially foreign ones, offering their own patented building elements and accessories, are available on the market. In addition to the basic structural, load-bearing profiles and connecting elements, the modular systems of leading manufacturers and suppliers are developed to offer various types of auxiliary positioning, transport, technological and other units. They consist of normalized and standardized components. The use of modular modules in designs of production configuration further supports:

- Modification of highly productive, flexible production clusters.
- Reduction of labour intensity of designing.
- The possibility of functional verification of the modular means of production.
- To increase the reliability of modular means of production as a whole at the expense of the lifetime of the structure of modules.
- To reduce the cost of modules by serial production.
- Increase in the share of unified building elements.
- Construction of systems with a high level of technological equipment and a high degree of automation.
- Many other benefits related to the possibility of designing fast-modifiable single-purpose machines and automated lines and more.
- The possibility of creating variant technical solutions based on combinations of basic building elements.
- Variability of equipment by technical means according to the type of contract.
- Variability of deployment of the working personnel.
- Permanent customization.
- Varied simulation of the system's functional and performance characteristics.
- Interchange ability of building elements due to high degree of standardization and normalization.
- Flexibility in extending the system by its technical peripheral elements.

Hence the advantages of such modifiable systems lie in: Advantages and disadvantages of modular system application are:

- Perfectly redesigned application modular series of structure, by area of use.
- Simple installation of such systems,
- Existence of a wide range of peripheral elements.
- Simple mounting conditions.
- Short delivery times.
- Easier interchange ability of elements and easy service.
- Minimization of structural deficiencies, etc.,
- Specialized... contain building elements and units of a closed nature.
- Universal - non-modular elements and units are also included.
- Structurally and technologically limited in terms of the structure stiffness.
- Relatively high investment costs.

With promising applicability in the future, the principle of modular construction and modular systems is the innovation trend thanks to such systems' simplicity, expediency, complexity, price and other factors. In addition to decreased size of the manufacturing system structures and their modular architecture, which in essence resembles LEGO, they also include standardized and normalized building elements complemented by technological, handling, control and other modules. By using the elements, units, and modules of the building kit, it is possible to create manufacturing workstation variants, their various modifications and layouts.

The modules are considered to be autonomous, functionally independent parts of production systems from which they can be taken apart. Via standardized interfaces, the modules are easily interchangeable and integrate with other modules.

Modularity enables creation of autonomous manufacturing workstations that can be connected to larger systems as needed, depending on the object and the volume of production. The number of workstations linked to a larger production complex is variable, it can be supplemented or reduced. An important condition for designing the architecture of non-automated workstations and their elements at the site of their implementation is ergonomics. The structural design must fully meet the requirements of modularity of all elements, maximum functionality and performance, as well as the ergonomic parameters. Modular construction procedure, based on the use of modular systems, requires the following tasks to be solved:

1. Multiple analyses of existing and available solutions.
2. Breaking the solutions down to generally valid functions.
3. Creating a general model for the problem to be solved.
4. Analysis of the general model and specification of its functions by type.
5. Creating type-specific modules.
6. Creating a modular system containing a set of type-specific modules.
7. Generation of modular system custom variants.

When deciding on module functions, it is necessary to take into account:

- The variability need. The variability in the implementation of functions varies; where high variability is assumed, it is advantageous to create a larger number of small modules (from the functional point of view), with the assumption of low variability, it is advantageous to create modules with a greater functional power.
- The usefulness of aggregation of elements whose participation in the module operation is necessary, or those that still have sequential links.
- Functional capacity of the module. The greater the functional capacity of the module, the lesser the labour intensity of the system, but its flexibility is diminished and potentially the usability of the

module elements decreases, and vice versa, the smaller the functional capacity of the modules, the greater the labour intensity of the system, and also its size.

- The expediency of element utilization from modules already formed, or of the whole modules during another module formation (the hierarchical structure of the module).
- The possibility of using the module even for diametrically different functions, with regard to the fact that the module ensures the function assigned to it via the identical transformation process of the input / output transformations.

By applying the modular principles to establishing production systems based thereon, a wide range of applications with a relatively small number of modules and their appropriate combination can be achieved. Substantially greater labour intensity in generating a general model and a general modular system is compensated by rapid and cost-effective establishment of new production systems.

New types of modular systems based on aluminium (Al) profiles are currently applied to numerous designs of the means of production, as to production system applications and modernization solutions. These building kit types are of a complex character and allow for solving a considerable number of innovative tasks, which focus on modernization of building elements as well as production systems.

By using modular components during modernization, the following advantages, improving the production system properties utilization, are achieved:

- Flexible structural system based on modular architecture,
- Simple fixed screw connections -screw connection technology of assembly is energy-preserving, compared to, e.g., welding.
- Reduced time for planning, designing -through computer supported CAD systems and assembly - pattern-based standards reduce the time and cost of execution.
- Simple assembly and dismantling of structures, reuse of components by simple dismantling, installation of assemblies and facilities on site,
- High strength of structure combined with light weight, low recyclability.
- High level of ergonomic and attractive design, aesthetic appearance.
- Customization and optimization of parameters for specific application conditions, i.e. made-to-measure.
- Simple operation and advantageous maintenance of Al structures, profiles are corrosion resistant -no surface treatment and paint coat is required, unlike the steel structure cases.
- Wide range of basic building elements and accessories from the kit, use of high quality materials.
- The variability of structures due to integrity and compatibility of building elements, possibility to assemble handling and technological equipment in the construction of peripheral mobile and stationary workstations in case of production system expansion.
- The possibility of distributing power lines in profile cavities.

All modular components made of Al profiles enable creation of a large number of node combinations and are adaptable to any user conditions and operating situations, they enable the workstations to be equipped with taste while assuring maximum functionality.

Modular workstations can be purposely integrated into the structures of higher production clusters, whose elemental composition depends on their designation, the degree of their technical equipment, their modularity, the structural and the organizational perfection; they enable the application of product ability increasing units to full extend, and they optimize material and energy flows. The main benefits of Al structures - modular components are expressed via the following factors:

- Surface treatment is not necessary in the finishing phase because the Al profiles have a durable smooth and glossy surface, there is no corrosion of the surface layer and no future interference and correction is required by applying a paint coat.
- They do not have to be ground or polished after possible later dismantling, there are no signs of damage that would prevent later reuse.
- No welding or other energy-intensive assembly technology is required because all the components are screwed together by the connecting elements, and after dismantling, the profiles and the modular elements can be used again.

A wide range of connecting elements, as well as various adapters, enable to create a variety of structures from Al profiles fit for manufacturing and assembly workstations as well as the means of conveyance and storage. Besides higher financial demands, presented tendency represents at present and for the future a major venue for innovation possibilities.

Complete processing of profiles for assembly and a wide range of components from the kit ensures rapid implementation of modernization projects. Since all joints are made by screw driving technology, the assembly time and demanding finishing work such as, for example, grinding and varnishing of welded structures, is not necessary at all. Whenever it is possible to make changes or to complete a structure, there is no problem to do so and all the components can be used again after the structure is rearranged.

Diversity of offers from numerous building kits manufacturers, with different types of profiles, connecting elements and assembly principles, translates into different structural construction and construction architecture of production workstations proposed herein. The number of modular system manufacturers, developing their own patented building elements and accessories, and completing the existing assortment of new components, increases mainly abroad.

In addition to basic structural, load-bearing profiles and connecting elements, modular systems are developed to offer various types of auxiliary positioning, transport, technological, control and other units. The assortment of elements and comprehensive modular units is constantly expanding and changing, therefore, the building elements represent an important source of inspiration for development of innovations and for modernization of the production system workstations, with a considerable potential of use in the future as well.

The methodical procedure of modular system component synthesis into larger units presented herein is based on the following assumptions:

- The use of a database (catalogues) of available modular elements. The production system can be established from type-specific elements or modules. The available elements are obtained through selection of fuzzy decision making nature.
- The production system design is based on the integration of partial functions of the catalogue elements, respecting the conditions of common interfaces, taking into account the capacity requirements, the time sequence etc.
- Aggregates are created by integration of partial elements and units. It is important to respect the behaviour of the system as that of the target organization number one and to verify the coordination of parts of the system with respect to global tasks.

4 CONCLUSION

Application of modular principles allows standardization of workstation design process. It also allows make adaptation for new product and extends production structure easier and faster.

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AUTHORS ADDRESSES

[1] Ing. Albert Mareš, PhD.

Technical University of Košice, Faculty of Mechanical Engineering, Department of Automobile Production, Mäsiarska 74, 040 01 Košice
Slovak Republic

Email: albert.mares@tuke.sk

IMPACT OF NEW ELECTRONIC COMMUNICATIONS ON INFORMATION SOCIETY DEVELOPMENT

Katarína Repková Štofková[1]

Abstract: *Informatization of society is not just a technological issue – due to its range and consequences, it becomes an economic, legislative, regulatory, social, political and ethical issue. If the process of informatization of society happens inconsistently, or with a delay, it can have political, economic, social and ethical consequences in polarizing the society (i.e. a creation of two categories of citizens – digitally literate and digitally illiterate) and polarizing whole countries. Electronic communications, which allow citizens and businesses to use modern electronic services of a developed government have significant influence on the development of information society. Fostering industrial competitiveness in accordance with sustainable development has been recently one of key objectives of the 21 century. Globalisation further convolutes the running process of changes. As a consequence of the globalisation processes the environmental, economic and political conditions are changing. Therefore, the main goal of manufacturing industry is finding effective methods, tactics and measures, which would enable it`s adaptation to these changes. At the same time manufacturing industry has to adjust to an effective resource exploitation mode.*

Keywords: History of science and technology**,** History of Hungary/Slovakia, Industrial revolution, Industrialisation

1 INTRODUCTION

Electronic communication currently fulfil a crucial role in many aspects of life, whether they be in private or public sectors. Electronic communications fulfil said crucial role by allowing objectives of modern information society to be met, which were set by the Lisbon strategy where an important priority was building higher competitiveness of countries based on the so-called knowledge economy.

Fast development of electronic communication and information and communication technologies, information has become a commodity, but also a tool and a catalyst for societal development. Development of electronic communications and the beginning of society transformation into information society has opened new questions on society perception. Informatization of society is dependent not only on development of global electronic communication infrastructure, but also on systematic direction of the information society, which is the core of informatization programs in all developed countries. Informatization of society has not only become a technological issue, but due to its extent and consequences, also economic, legislative, regulatory, social, political and ethical issue.

Initial steps for process improvement in an industrial enterprise are to have a strategy, the main purpose towards which the business will be directed, and to set up processes in a way that best fits this purpose. The necessary step is to automatically collect data, analyse them thoroughly and secure their flow in the company environment and beyond. Every industrial enterprise must find its own way to apply the Industry 4.0 concept.

Industry 4.0 reflects societal changes caused by connecting the physical, virtual and social worlds. It is a society-wide change impacting industries, technical standards, security, education, legislation, research, relations and social systems, job markets and requirements on employees, their education and specialization.

2 THE KNOWLEDGE SOCIETY

Knowledge and innovation have transformed society, economy, production, and human status. At present, knowledge and innovation are the basic conditions for producing knowledge, i.e. they are a powerful force and means of achieving economic and social goals. The post-industrial society can not change without one fundamental element - radically changing the meaning of knowledge. Peter F. Drucker states that knowledge is used in the knowledge society to produce new knowledge, to find better ways to use available information, to find new solutions, to determine and evaluate what new knowledge is needed, whether the acquisition of such knowledge is meaningful and what needs to be done in order to ensure the efficiency of their use. [1]

The retreat of man from his narcissistic tendencies is also to contribute to the development of the knowledge society. Reasonable and qualified co-operation, professional and scientific partnerships, well-grounded communication of knowledge and information at the global level will also lead to further development of the knowledge society. Science, technology and progress without borders characterize today's knowledge-based society, which is built on knowledge workers, their cooperation and creative communication.

The quality of the knowledge-based society requires not only the production of new knowledge but also the constantly improving technologies, which means that the country's political strategies focus on the development of human resources. [1]

3 INFORMATION SOCIETY

The development of the information society is determined by the possibilities of new information and communication technologies. They allow rapid production and transfer of information and scientific knowledge into technological and social processes to an extraordinary extent. There is a change in the way each person lives. These changes affect all human activities, which means changes in trade, services, production, but especially the management of enterprises and entire states. Time and distance barriers are gradually being removed by networks for the transmission of information (e.g. telephone, satellite, cable), basic services for the use of networks (e.g. e-mail, the Internet) and new options (e.g. distance learning, e-Government). The development of the information society is no longer a technical problem but an economic, social, political, regulatory, legislative and ethical issue. [2]

The information society uses information to stimulate economic growth. Most information is needed to develop the tertiary sphere (trade and services), which is most important for the economies of the developed countries. Information is used to facilitate and improve the lives of citizens. Citizens can use public information systems to improve access, for example to education, culture and healthcare information. Access to information on the activities of the authorities, the government and on their citizens' rights is improved. The information industry, which becomes transnational, even global, is being developed. The information industry consists of three segments: 1. generating information, 2. providing their transmission and transmission to users (telecommunications, media), and 3. is represented by the manufacturer of hardware and software for information processing. [2]

Informatization of society represents a gradual move to the maximum use of information and communication technologies in all areas of social, political and economic life. From the viewpoint of the state, informatization of society is a conceptually governed process targeting electronization of services provided by public administration institutions, i.e. eGovernment, development of high-quality digital content and expanding the penetration of broadband internet. It is also one of the key tasks of government programs in developed countries of the world. [3]

As time went by, several partial topics for information society were introduced: education (eLearning), healthcare (eHealth), culture (eCulture), transport (eTransport), public administration (eGovernment), privacy protection (ePrivacy), justice (eJustice), tourism (eTourist), active inclusion of marginalized citizens into social life (eInclusion), etc. [4]

The aim of the information society policy is to increase quality, simplify the way of life for the society as a whole and make it more user friendly and in terms of business – make business activities through modern information and communication technologies faster and more effective. The development of modern technologies has impacted all areas of society (state - business sector – citizens) independently of whether it concerts everyday or occasional needs and in the entire spectrum of some activities, such as work, business, trade, education, research and innovation or gathering new experience – travel or fun. In the EU, the information society policy has become its integral part since March 2000 and an important priority for a great future process – building higher competitiveness of countries based on the so-called knowledge economy. [5]

4 ELECTRONIC COMMUNICATION

Electronic communications ensure exchange or transfer of information between a finite number of users; they take place in electronic communication networks. Electronic communications do not include information transferred as a part of TV or radio broadcast for public using electronic communication networks apart from information, which are related to identifiable user who receives the information.

The term electronic communications mean the setup, operation and providing of devices for electronic communication, electronic communication networks and electronic communication services. [6]

Differences in economic performance between developed countries can be explained by the level of investment into information and communication technologies, their research and use as well as the competitiveness of information society and the media sector. Services, abilities, media and content in the field of information and communication technologies have become ever greater and more conditional part of economy and society.

Over the last few years, information and communication technologies have been developing with increasing speed and they're currently entering the mass market in the field of information society and the media, which is only made possible thanks to faster and more available communication connections between various devices. Traditional content (e.g. films, video, music) is currently available in digital form and new services are being created which are digital from their onset, such as interactive software. Digital convergence of an information society and media services, networks and devices is finally becoming an everyday reality.

Information and communication technologies are becoming ever more intelligent, smaller, more secure, faster, always connected to networks, easier to use and more often offer three-dimensional multimedia content.

To manage this significant technological change, a pre-emptive policy is needed. Digital convergence requires political convergence and readiness to adjust, if necessary, the regulatory framework in such a way, that it corresponds to the newly-minted digital economy.

Apart from the 'economic' regulation, the objective of the framework is consumer protection through setting legal commitments in the areas of personal information protection, universal services and user rights. Regulatory framework is not related to content services, which are regulated by other directives within the EU. The task of the new regulatory framework is to strengthen the consumers' interests. This aim is mostly achieved by strengthening of economic competition in order to provide a selection of innovative services. Apart from this, the framework contains individual protections for consumers, including the obligation of any universal service to ensure the fulfilment of consumers' needs.

5 ELECTRONIC COMMUNICATION AND INFORMATION SOCIETY

The solution of the questions for information society belongs to the areas where the chasm between Slovakia and the EU countries is most pronounced. Current potential of economic growth must be built on knowledge, information, people and their ability to use information effectively. Informatization of society is a way to develop this potential. [7]

Informatization of society is dependent on the development of global electronic communication infrastructure, which is the core of all informatization programs in all developed countries. Creation of such society is dependent on the access to a world-wide information network – the Internet. Connection of citizens, businesses, public administration to the Internet then becomes another factor that decides the development of any given region. The main advantages of this technology includes decrease of costs for transactions; from this stem other phenomena such as modernization of individual branches that add to creation of new job positions especially in the area of gathering, evaluating and providing information, removing of geographical barriers between regions.

The development caused by information-communication technologies, especially the Internet, creates pressure for invention in society and increases the importance of intangible estate as a source of prosperity. This in turn causes larger emphasis on effective work with information. Within this process, the transition of data into information, their consolidation and placing them within a context as well as their subsequent use is very important for the good of the entire society on a regional, national and international levels. It requires ensuring a consistent, complex solution for information systems of related subjects from all sides – such as technical, network, application, security and organizational sides.

The aim is to ensure a sufficiently universal environment which would allow for cooperation with information-communication technologies used by individual subjects as well as transfer of information in voice and data form. [8]

ICTs are currently not only a tool, but rather a stimulus for economic and social development and allow for:

- more effective business processes through decreasing costs of business transactions,
- opening of new business avenues on world markets even for small and medium businesses through wide and cheap access to information,
- fast innovation of all types of products made and services rendered as well as increase in production of goods with high added value,
- rationalization of production processes and saving resources and energy,
- strengthening regional development through wide availability of information and new forms of work, which significantly increases competitiveness of economy and employment.

The changes brought about by the increasing significance of information and ICTs aren't only technological in character and don't influence only the economy. No less important of a factor is their diffusion into the life of the society and citizens. A result of accelerating influence of ICTs in a qualitative change of society's character – from industrial into information society.

Electronic communications, which allow citizens and businesses to use modern electronic services of a developed government have significant influence on the development of information society.

However, the influence of electronic communication development on the information society development must be seen as a two-way influence on electronic communication networks and services which create the right conditions for the information society development, where the aims of development of information society create sort of a feedback influence on development and targets of the electronic communication development. [3]

Mutual influence between electronic communication and information society means also a system of legislative, regulatory directions and mutual influences of the areas of interest. The legislative part of both areas leads to maximum use of the electronic communication systems' capacities with regards to the aims of the information society.

6 ELECTRONIC COMMUNICATION AND INFORMATION SOCIETY

The basis for Industry 4.0 is direct communication and cooperation of people, machines, devices, products, entire logistical systems, all the while collecting ungathered and unprocessed information for faster and better decision-making, e.g. about the production processes.

The Industry 4.0 concept concerns itself with optimization of the entire value chain within the life-cycles of products. The cycle is based on increasing individual requirements of customers. It begins with an idea followed by work, development, production and delivery to the customer and ends with recycling including all related services. The basis is availability of all relevant information in real time. [9]

A point of significance is the construction of a Smart Factory, that is considered the main advantage of Industry 4.0. It helps machines and people with performing tasks. The results are smart products which fulfil the individual needs of customers at a favourable price. In real-time, we can monitor the status of the device based on information gathered online. From a technological standpoint, the smart factory concept is very much formed through objects and tools [10,11,12]

- Internet of Things is a network formed by physical, uniquely identifiable objects, that have in-built electronics, software, sensors and connection to network CPS. The aim is to increase effectiveness and precision.
- Big data serve for the company to store, process and make available all data necessary for effective functioning, decision-making, lowering risks and providing services to customers.
- Cloud – means shared resources (HW, SW), characterized by high scalability. Resources are made available to the used based on their needs from wherever and at any time through the Internet and the customer only pays for the resources he's using etc.

Industry 4.0 should be seen as an evolutionary nation-centered process that seeks to innovate and transform the industry into an interconnected, information-driven environment that allows for optimization of the enterprise's own production processes as well as the entire value chain. [13]

Process optimization is geared towards increasing productivity, innovation activity, and customer care quality. The Industry 4.0 concept philosophy is focused on research and development, standardization and creation of shared infrastructure for expanding intelligent manufacturing technologies based on advanced data analysis from intelligent sensors.

7 KNOWLEDGE SOCIETY AND E-GOVERNMENT

Informatization of society represents a gradual move to the maximum use of information and communication technologies in all areas of social, political and economic life. From the viewpoint of the state, informatization of society is a conceptually governed process targeting electronization of services provided by public administration institutions, i.e. e-Government, development of high-quality digital content and expanding the penetration of broadband internet. It is also one of the key tasks of government programs in developed countries of the world.

In today's age of communication, we must consider what must be done for successful implementation of information-communication technologies and solutions for public administration so that the prerequisites for knowledge economy, based on optimal and rational state apparatus with effective use of resources of electronic communication, are as fulfilled as possible.

The state play an important coordination role in the process of society informatization – it provides financing from EU resources as well as resources of its own, also deal with new legislation and sets up new programs to support the development of information society.

The intersection of information society policies and improvements of electronic communication is in their aims – improving and simplifying the way of life for society as a whole and creating a highly competitive and stable economy. To meet these goals, development of modern technologies is necessary as well as their accessibility. This development then impacts all segments of society (state – business sector – citizens) independent of whether its related to everyday or occasional needs.

E-Government, through the use of information and communication technologies, together with organizational change and new knowledge, brings better, faster and more efficient public administration services. It improves the creation and implementation of public policies and helps the public sector to cope with conflicting requirements to provide more high quality services while using less resources. [14]

The term e-Government describes the efficient and low-cost electronic provision of public services provided by public administrations using information and communication technologies in administrative and democratic processes.

The way government perceive e-Government is based largely on its definition in government strategies and is often limited to the use of information and communication technology. However, the goal of e-Government is an overall change of the established paradigm, i.e. this process is not just about digitizing existing bureaucratic processes. It is about transforming the public sector by applying electronic business models, taking into account the conditions in which governments and public institutions operate. This new way enables interactive access 24/7 via web portals.

The electronisation of public administration presents progress in the providing of public administration services. Both citizens and businessmen had to visit the various institutions repeatedly to solve their problems, or they had to appear personally, which made the process of providing public administration services time consuming. E-Government is an attempt to move people from the queues in from of government offices to an online environment with unlimited availability. [15,16]

E-Government services are intended for all entities that are authorized to communicate electronically with the public administration. The services vary according to individual user groups, and this diversity has led to the emergence of different types of e-Government. Based on on-line communication from individual parties, we distinguish several forms of e-Government.

Government to Business (G2B) - online communication between PA and business entities. Services provided within G2B have a significant impact on the development of SMEs, as online transactions reduce bureaucracy and simplify regulatory processes to help businesses become more competitive. G2B offers, for example, electronic public procurement, development of an electronic market for government purchases, disclosure of conditions for obtaining grants and entry into business registers. Delivering integrated public services creates opportunities for both businesses and governments to collaborate and offer hybrid public and commercial services under one roof.

The most frequent situations covered by the public administration services in which the company comes into contact with public administration are shown in Figure 1.

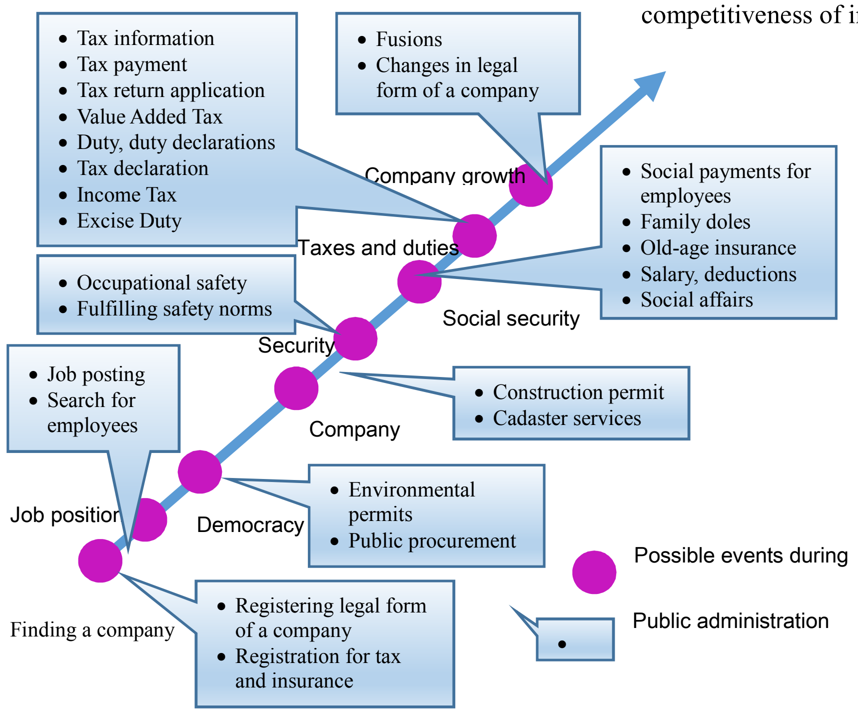

Fig. 2 View of public services as “life-cycle of a company” [Source: own processing]

The term digital literacy has been in existence since the late 1990s. In connection with the rapid onset of information technology, it has established itself among the common skills immediately and is required by any modern company. The age of electronization and computerization often limits its meaning to only computer literacy, which is just one of many areas. [17]The issues of security, communication, creative and critical practices, work with digital technologies, as well as social and cultural awareness are considered digital literacy.

Generally speaking, we can talk about the ability to correctly understand the information presented from different sources and technologies and their subsequent transformation using modern ICT for the purpose of their further use. [18, 19]

8 CONCLUSION

Due to the explosive growth of scientific knowledge and fast development of the information-communication technologies (ICT), the world economy is going through far-reaching global changes, the most significant changes since the industrial revolution. New perspectives are being open with new economy with great potential for growth, increase in production and employment. ICTs are a significant phenomenon of current economy because they erase geographical boundaries and support the process of economic globalization and international cooperation.

The aim of the convergence process of information society and telecommunication and information technologies is “the creation of inclusive information society as a tool for development of highly performative knowledge economy”, which will aid in achieving the target of the strategic priority (Knowledge economy), which is “development of resources for long-term sustainable economic growth and increase in competitiveness of industry and services”.

The development of information society and knowledge economy play an important role within a national economy. Rapid development of electronic communications and the subsequent liberalization of the market in this sector brought on a new view on development and direction of society.

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AUTHOR ADDRESS

[1] Doc. Ing. Katarína Repková Štofková, PhD.
University of Žilina, Slovak Republic
Email: katarina.stofkova@fpedas.uniza.sk

DESIGNING MANUFACTURING SYSTEMS OF THE FUTURE

Vladimír Rudy[1]

Abstract: *Engineering production design requires a system solution for a set of structural, technological, spatial and organizational factors resulting in the design of an optimal manufacturing configuration. The goal is the functional integration of people, information, production technology, materials and energy to prevent wasting these resources and to achieve high productivity. The efficiency of operation depends on the level of mutual synchronization, the ability to predict and eliminate adverse effects of these factors on the production characteristics of the production system. Greater requirements for design activity need significant computer support, i.e. information and computer technologies, without which the high quality of design, greater variety of solutions, innovative flexibility as well as other attributes, are difficult to achieve.*

Keywords: reconfiguration systems, building new innovative productions, designing production systems

INTRODUCTION

So the role of design activity is to design and, in the form of design documentation, to process the production configuration that can be executed under optimal financial conditions in the required space and time, capable to meet time-limited market demands. The final design, taking into account the mutual synergy of these factors and guaranteeing the consistency of designed ideas with the achieved results, leads in practice to the complexity and variability of possible solutions. Capability of reconfiguration or building new innovative productions is, therefore, one of the most complex tasks in the company life cycle. It requires the application of adequate computer, information and software support for modern CAx systems capable to apply standardized design procedures and to modify configurations from "proven" designs.

1 PHILOSOPHICAL ASPECTS OF PRODUCTION STRUCTURE DESIGNS

Innovations in project activities require special knowledge and appropriate methods, procedures and tools. An important role is played by theoretical sciences. The development of engineering work is supported by several engineering disciplines. Design Science (Design Theory, Design Philosophy) is important because it contains a set of logically clustered knowledge about solutions generated by engineering activities. Designing is a complex area of theories, methods and information, including a broad field of engineering activity. The knowledge base of design team members can be divided into:

- General and special knowledge of technical systems and processes, including the manner of their expression, characteristics and quality, structures and principles of their development.
- General and special knowledge of engineering design, its structure, features, characteristics and management.
- Special, detailed, design-necessary knowledge of the technical, technological, economic, organizational and control nature of the aspect of design.
- Managerial skills in the field of design management and teamwork.

Designing today's manufacturing systems requires a comprehensive analysis of their activities in real space and time. Only this approach is a guarantee of identification, optimization, or elimination of design deficiencies before their future physical implementation. It is necessary to take into account the philosophical aspects of technological innovations, modeling, examples and studies of successful reference solutions, financial support and material provision for innovative changes, multipurpose and purpose-oriented designs for the synthesis of technological innovations, etc. The frame methodology of application designated for the assembly of the production structure model is illustrated in Fig.1.

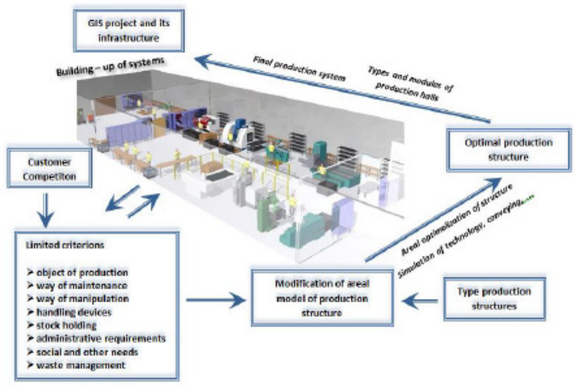

Fig.1 Design procedure characteristics of new production structure

It takes place in four stages:

1. Creation of knowledge base and its analysis (in accordance with customer requirements).
2. 2D/3D variant modeling - spatial optimization of the system's structure.
3. optimal production structure –functional simulation of the virtual production model.
4. production of design documentation, GIS modification of the production model and its implementation.

Concepts of new production systems are currently designed as the systems of new generation. The aim of such solutions is to increase productivity without losing flexibility, shortening production time, increasing the quality and the value of products and services, and so on. They are modified as social and economic systems and place high demands on design, implementation and operation. The numerous papers in professional literature deal with their development.

Combination of software applications with hardware of 3D type beamers, cameras, 3D scanners, digitizers, etc., enables the future real image of the production system to be interpreted in virtual reality and by that:

- It reveals critical deficiencies before the real system implementation.
- Simulates the functional activity of system elements, i.e. verifies dynamic properties of static objects (e.g. the course of technological processes, movement of workers, flow of material).

Simulation of the processes of the proposed manufacturing assemblies means:

- A thorough analysis of CAE variants of generated structures and the complexity of their assessment as a result of a multidisciplinary solution.
- Application of prototype and the already existing knowledge databases enabling reuse of the data.
- Verification of the use of already approved analysis procedures, etc.
- Data management and effective handling of large data amounts related to simulation including solution parametersand results.
- Correction of functional visualization of the means of production of the real production model.
- High consistency of the design with the real production model (objectivity of the virtual reality model), on-line back-up design correction, etc.

2 NEW APPROACHES TO DESIGNING CUSTOMER-ORIENTED PRODUCTIONS

Design of today's complex structure of diverse manufacturing systems requires a comprehensive analysis of the activities involved in three spatial dimensions and in time. Only this approach is a guarantee of identification, optimization, or elimination of design deficiencies before they are physically implemented in the future.

Greater requirements for design activity need significant computer support, i.e. information and computer technologies, without which the high quality of design, greater variety of solutions, innovative flexibility as well as other attributes, are difficult to achieve. The combination of software applications with

hardware tools such as 3D beamers, cameras, 3D scanners, digitizers, etc., enables the future real image of the production system to be interpreted in virtual reality and by that:

- To identify critical deficiencies before starting to build a real system.
- Simulation of the functional activity of system elements, i.e. verification of dynamic properties of static objects (e.g. the course of technological processes, movement of workers, flow of material).

The current market offers application software systems that support manufacturing system design in different application areas. The use of such systems allows to design the entire production system, to purposely situate the means of production in the production area, to design traffic paths, storage areas, to make their simulation, to display and describe them from any views, etc.

Current development enables these different approaches to be included in a single integrated system. Synchronous work in real and virtual environments brings a number of effects. Integrated procedures ensure that all actions applied to real physical models are transferred to parallel work with computer models that are subsequently presented in virtual environment.

An important innovative method of designing production systems is simulation and its methods, techniques and tools. Managing simulation means:

- A thorough analysis of CAE variants of generated structures and the complexity of their assessment as a result of a multidisciplinary solution.
- Searching and application of prototype, already existing knowledge databases enabling data re-use.
- In combination with supportive process algorithm procedures, it enables the verification of the use of already approved analysis procedures, etc.
- Visualization of simulation results of the time cycle of simulated action in a specific environment.
- The reliability and confidence of the reality of the results obtained and the possibility of online feedback on the development, or design status.

In the past, the concepts of creating production system configuration rested on the creation of two model types. The models were not integrated with one another or used together. The overview (selection) of the virtual reality technical means and technologies is shown in Fig.2.

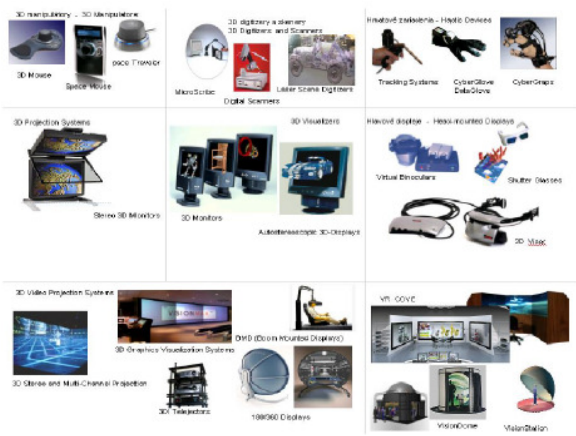

Fig.2 Technologies for viewing virtual scenes

An example of creating a project using a multi-touch projection table is illustrated in fig.3.

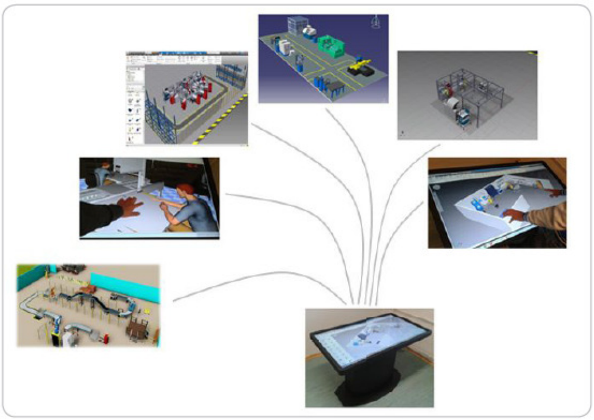

Fig.3 An example of creating a project using a multi-touch projection table (Multi-touch pro)

Models of virtual reality enable:

- replacement of physical prototypes with virtual ones,
- improvement and acceleration of the product development processes,
- simulation of different development stages in virtual environment.

In virtual environment there are applied in engineering production:

- Process planning (production layout, time analyses, technological preparation of production, product evaluation, cost analyses, etc.).
- Replacing physical prototypes with virtual ones,
- Improving and accelerating the product development processes,
- Simulating different development stages in virtual environment
- Processing details and validation (production and maintenance, welding, assembly procedures, cell and factory layouts, manufacturing operations, employee performance, etc.).
- Modeling and resource simulation (material flow simulation, robotic cell type pre-specification, NC machining, virtual reality scenarios, ergonomic analyses, etc.).
- Automation and Control (Control Logic, Programming, Robots,)

The company's digital configuration is conceptually formed by integrating three basic building elements - product with its static and dynamic properties, production planning and the production itself with the possibility of using planning data to increase process efficiency. (Digital Factory) is mainly used in engineering, automotive, aviation, electrotechnical and shipbuilding industry and in the manufacture of industrial goods. The digital enterprise serves the purpose of planning, analyzing, simulating and optimizing the complex product manufacturing.

The approaches used in the environment of digital enterprise cover the four most important areas:

• Process planning (production layout, time analyses, technological preparation of production, product evaluation, cost analyses, etc.).
• Process detail and validation (production and maintenance, welding, assembly procedures, cell and plant layouts, manufacturing operations, employee performance, etc.).
• Modeling and resource simulation (material flow simulation, robotic cell type pre-specification, NC machining, virtual reality scenarios, ergonomic analyses, etc.).
• Automation and control (control logic, programming of production technology..).

The concept of digital enterprise introduces the following benefits:
• It reduces business risk associated with introduction of new production.
• It enables to pay a virtual visit to the production halls.
• It verifies the proposed production concept.
• It optimizes the situation of production equipment.
• It verifies the pre-production process.
• It reduces the area required and enables equipment modification.
• It reveals weaknesses and conflicts.
• It allows for better use of available resources.
• It allows for programming of the machines and lines off-line.
• It limits the need for prototypes and reduces the needs for repair.

Hardware resources for virtual object manipulation (virtual Oculus Rift, Samsung Gear VR, nReal Light, Olympus EyeTrek Insight EI-10 ...) are illustrated in Figure 4.

Figure 4 Means for virtual reality perception - "headset"

The use of digital enterprise should improve economic and production indicators, namely by reducing the respective costs. Any small savings that will be gained during the planning stage will be multiplied in serial production, significantly increasing the return on investment into the system of digital enterprise. The digital enterprise model allows for designing manufacturing procedures as well as technologies, including the insertion of a different degree of automation. It allows for running tests in virtual practice in which the physical properties of materials and specific production activities are programmed, as well as the assembly procedures in a particular workstation - including the preparation of tools in accordance with the worker's ergonomic requirements.

The designer is able to assemble the entire production hall in the software, to try the machine deployment, and to test the processes of in-house logistics, too. According to hitherto published analyses, all this results in cost savings, better resource utilization and material flow optimization, or spatial optimization of an adequate number of machines in the area. The core of the digital enterprise virtual environment is represented by various modeling systems, including, e.g. CAD systems, computing and simulation systems as well as administrative applications. Contact with the outside world is maintained through three systems: the communication and information system and the data management system.

3 INNOVATIVE PROCESS DESIGN IN MECHANICAL PRODUCTION

Development and designing of new production systems is nowadays influenced by the global economic situation. The world markets have recently developed as:

- Globally open and developments therein are
- Dynamic with a large scale of products manufactured and with a demand to shorten the production cycle of products as well as to change the price strategies.
- Markets with the most important assumption of a successful innovative action lying in meeting the demand to shorten the production cycle as well as to continuously improve the quality of basic production resources.
- Areas with intense competition, progressive depletion of natural resources etc., which call for the use of new approaches and thoughts in order to develop innovative activities.
- Systems of production flexibility, as they are able to produce a wider range of finished products with the minimum loss of time.
- Areas of flexibility and competitiveness in the technical preparation of production.
- Areas of project creation, searching, collecting and processing of information with the help of modern information technologies, which must support and develop the creativity of individuals and teams.
- Areas for the application of 3D modeling techniques making it possibly to simulate and eliminate the risks associated with new incoming designs and new production systems.

From the basic approaches to development of engineering design point of view, design methodologies are developed as knowledge based engineering. This taking over by knowledge based engineering is manifested in expert systems and differences from the classic program systems in more than one feature.

In a competitive environment with the production volume changing dynamically having a permanent implementation of new production variants and technologies could translate into a high level of automation economically just as effective as is the case when the manual performance, required for the market indicated reconfiguration of the productive systems, is reduced to minimum.

The solution for the "production of tomorrow", Figure 3 are innovative applications enabling flexible production and assembly systems, combining the advantages of production techniques based on automation and robotization with the advantages of maximum adaptability. I.e., designed production structure enables efficient production of individual products and helps decrease the sale turbulences of the market and eliminate production dilemmas of the managers. The customer-oriented production systems of today make their headway thank to high flexibility, based on their highfunctional adaptability. These "self-optimizing systems" are able to conceive new system targets based on continuous observation of the state of the current system and to allow simultaneous adaptation of systems behavior in synergy with new targets. They could be characterized by the following activities:

- "In-time" analysis of the functions the system performed.
- Decision about new system targets.
- Adaptation of the system to new environmental conditions.

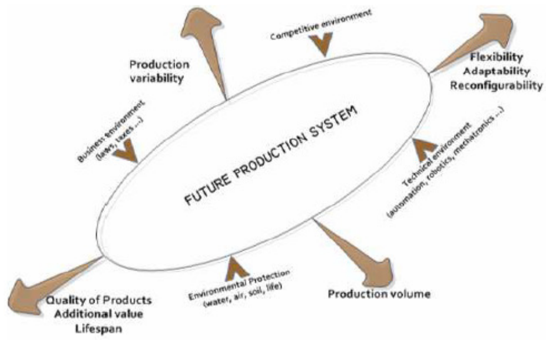

Figure 3 The concept of adaptive modification of the production structure of the future

The changes in the production environment could be triggered by different factors (products, components, process attributes, user interaction, etc.). In the system, these factors are requalified and other (new) system targets are defined based on the comparative analysis. The evaluation is based on the selection of the most relevant targets from a predefined list or based on the adaptation of present targets to the current situation. The adaptation is achieved with the change of system parameters, configuration and behavior of the system in accordance with the newly defined targets.

The behavior of these production systems is considered to be intelligent, which means they possess the ability to interact autonomously and flexibly with the environmental demand, as well as with the external users / systems or their dynamic behavior. These systems are usually able to learn from their own experiences and are able to remember past events which could be helpful in forecasting new events and in optimizing their behavior under several conditions in the future based on this.

The basic pillars of creating a highly flexible system are as follows (Figure 4) :

1. Flexibility and permanent ability to provide the basis of system adaptation to dynamic factors affecting the various external stimuli resulted from environment. Flexibility could be understood as a connection between the individual parts of the system, which are predicted and defined during their planning stage. When the predicted flexibility is not sufficient for the systems feasibility under the required condition, its diversity could help reconfigure the organizational and technical parameters of the individual connections with the aim to maintain correctness and integrity.

2. *Operation autonomy allows* for proactive reactions to changes in the market environment. It independently guides the system to the required and safe condition during long term operation of the same without any intervention from external operators. The higher the level of automation, the greater the likelihood of breach process. With the aim to control such breach autonomously, the integration between the components and the modules of the system, as well as the resistance to failures, must be ensured.

3. Recognition, evaluation and decision making thanks to the ability to sense the external environment. It evaluates relevant information, collects it, learns from its previous own experience to make intelligent decisions based on such information resources and to act in a safe and direct way.

The decision, learning and thinking processes must be based on statistical calculations, probability analyses, available information, as well as the complex artificial intelligence tools.

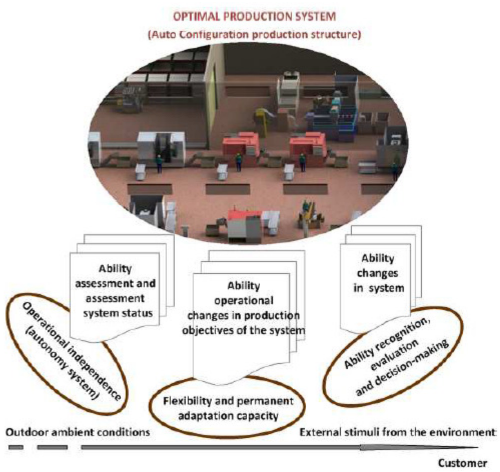

Figure 4 Pillars of customer orientid production systems of the future

The construction of production systems based on the pillars of "flexibility / diversity, autonomy, recognition ability" is possible with the help of technologies that could be synergistically functional, mutually combined. Such technology is the modularity of production technology, robotic technology with exchangeable tools and sensors, multi-sensor integration, data fusion, etc. The robotic technology, together with the standardization elements, plays the key role.

4 CONCLUSION

Requirements that are placed on modern machinery production are oriented on eco-innovations, high productivity and flexibility of small-series produced assortment, shortening of continues production time and effective usage of machines to increase quality of production and its outputs (articles), reduction of goods stock, minimalization of production costs and others, that everyone is commonly familiar with. Nowadays, during world's recession of machinery production, market floods of low-cost Asian good, etc., dominant requirement and key factor of success and future of company are beside continues improvement of article functionality is ability to react dynamically on customer demands and transformation of those requirements into future properties of the articles in very short time period. Fulfilment of requests, quoting for shortening of overall production cycle from its proposal to end-customer dispatching with lowest possible production costs is the most important pre-requisite for successful company.

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AUTHORS ADDRESSES

[1] doc.Ing. Vladimir Rudy, PhD.
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial Engineering and Digital Park Komenského 9

Email: vladimir.rudy@tuke.sk

ENERGY CONSUMPTION AND ECONOMIC GROWTH NEXUS IN THE DANUBE REGION COUNTRIES

Jana Chovancová [1]

Abstract: *The emergence of resource and energy efficiency as well as the low-carbon economy as European policy priorities is grounded in a recognition that the prevailing model of economic development — based on steadily growing energy and material consumption is not sustainable from the long term point of view. In order to increase green growth and strengthen cooperation at a macro-regional level, the European Union established the Danube Region Strategy with eleven priority areas, among them one focusing on energy. The Danube Region is characterized by a divergent group of 11 countries (9 of them are EU member states, 5 are non-EU countries) concerning the process of integration and the preconditions in geographic, economic, cultural and socio-demographic terms. The aim of the paper is to perform quantitative evaluation on the relationship between economic development and energy consumption based on decoupling model theory. The paper focuses on the case of the Danube region countries in the period of 1994 – 2014. Throughout 20 year period examined, the countries spread out into different forms of decoupling. The results of analysis suggest that in most observed partial variables occurs the absolute or relative decoupling of economic growth and energy consumption, what can be considered as positive trend. Though decoupling index convey a positive message, the Danube region countries will need to accelerate their implementation of new policies, while restructuring the ways how they meet their demand for energy. The findings of this research can provide useful information to energy policy decision makers.*

Keywords: Energy consumption, Gross Domestic Product, Decoupling theory, Danube region countries

1 INTRODUCTION

Energy production and consumption is fundamental to modern lifestyles and living standards and with growing quality of life grows also demand for energy. But in the same hand, increased demand for energy is causing many negative effects such as climate change and global temperature rise caused by increased carbon dioxide emissions into the atmosphere. In addition, high levels of energy use results in greater depletion of fossil fuels, oil or natural gas. That is the reason why these issues have emerged as central themes in global discussions on the transition to a green economy (OECD, 2014; UNEP, 2014b). The fundamental importance of these issues to future prosperity is likewise reflected in Europe's medium- and long-term planning. For example, one of the priority objectives of the 7th Environment Action Programme emphasizes the need to „turn the Union into a resource-efficient, green, and competitive low-carbon economy“ (EU, 2013).

At the strategic level, EU policy sets out a broad framework for resource efficiency and climate change policy, including a variety of long-term (non-binding) objectives. For example, the Roadmap to a Resource Efficient Europe (EC, 2011) includes a vision for 2050, wherein 'the EU's economy has grown in a way that respects resource constraints and planetary boundaries, thus contributing to global economic transformation. These are complemented by policies addressing specific pressures and sectors. The EU's 2020 targets on greenhouse gas emissions and energy consumption (EC, 2010) are prominent examples.

The Danube region is comprised of 9 EU (Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Romania, Slovakia and Slovenia) and 5 non-EU countries (Bosnia and Herzegovina, Moldova, Montenegro, Serbia and Ukraine).

In terms of the Danube Region we can highlight some interesting characteristics:

- It spreads on an area of about 800.000 km2 which in huge parts is some sort of ‘hinterland’ of the river.
- There live about 115 million citizens – a population strongly characterized by different identities in terms of language, traditions and religion.
- It consists of 14 countries (not all of them neighboring the river), which are participating in the initiative. These countries experienced different processes in political, economic and socio-demographic terms and show different statuses of integration to the EU.
- Countries within this region are meeting new challenges like an increasing competitive situation through the EU-isation of national policy and through the process of globalization (Hamilton, et al., 2005).
- They create very heterogeneous group in terms of of geographic, economic, cultural and socio-demographic characteristics (Giffinger and Suitner, 2010).

The region connects countries that are not only highly heterogeneous in terms of their economic performance, but also countries with ultimately different energy sectors. Energy prices are high in the Danube Region compared to other parts of Europe. Primary energy is mainly imported, its transport is costly, the markets are fragmented and energy infrastructures are not well interconnected. In addition, the Danube Region is specifically vulnerable regarding security of supply, as it was demonstrated in January 2009 when gas supplies were cut. Energy production and consumption are also significant sources of pollution. A greater diversity of supply at national level through interconnections and the establishment of a genuine regional market may significantly increase energy security.

The Danube Region strategy presents a platform to ensure security of supply, to create a functioning energy market and to realise economies of scale on investments. Regarding energy efficiency and renewable energy, there is a significant potential still untapped. Reducing energy needs and increasing the share of energy produced at local level (including small scale energy production) would be beneficial for all consumers in the region.

Concerning energy infrastructure, the aim is to coordinate the long-term energy policies as well as the national investment strategies to create win-win situations for all countries. In achieving sustainable development on EU level requires the careful use of resources, technology, fostering initiatives and strategic management at regional and national levels. It also requires to monitor the impact of selected policy and strategy to see whether it is furthering sustainable development or if it should be modified. It is essential to be able to measure a country's or region's state of development and to monitor progress towards achieved goals of sustainability (Siksnelyte, 2019). When striving for such ambitious goals it is inevitable to monitor situation in all Danube region countries.

2 MATERIAL AND METHOD

Historical data witness a strong correlation between energy production and consumption and economic and social development. Energy is a basic input in the generation of wealth (Constanza, 1980; Cleveland et al., 1984; Nathwani et al. 1992), so the power sector has a crucial role. Any measures adopted on that area should be compatible with the basic principles of sustainable development. The European Union as one of the mayor international actors seeks for energy sustainability. One of the five goals set by the EU in 2011, to be achieved by 2020, is fulfilment of several objectives concerning energy and climate change. One of the pillars of the European growth strategy is meeting those green objectives. (Fernández Gonzáles, 2014). The interactions between environmental, social and economic phenomena are clearly stated. Therefore, development of proper indicators capable of collecting those interactions becomes of great interest in order to design energy and environmental policies. Among indicators related to energy sector we can include energy productivity, CO_2 productivity, energy intensity in different sectors of the economy, share of energy from renewable sources in gross final energy consumption etc.

In this regard, we will focus our attention on decoupling analysis, as a set of methods that enable quantitative assessment of determinant factors influencing changes over time in main energy and environmental aggregates.

The dilemma of expanding economic activities while attempting to stabilize the rate of resource use and reduce environmental impacts poses an unprecedented opportunity and challenge to society. Since most of the world's economies are striving towards economic growth, ways to achieve it with less environmental harm are being sought for. There have been several concepts proposed for this. These include increased eco-efficiency, de-materialisation, immaterialisation, de-linking, decomposition and decoupling. The drawback in these approaches is to get more from less, which means using resources more efficiently to produce the same value with less material. The environmental impact remains the same, but only the economy grows faster (e.g. Saunders, 1992, Ayres and Warr, 2005, Binswanger, 2001).

Within environmental research these approaches has been applied to several areas, e.g. de Bruyn and Opschoor (1997), Heiskanen and Jalas (2000) or Vehmas, Luukkanen and Kaivo-oja (2007) referred to "dematerialization" as de-linking of economic activity from its material base. "Decarbonization" refers to a decreasing energy intensity of economic activities, determined by CO_2 emissions per GDP unit (Tapio, 2005). Decoupling concepts vary also in sectoral base and were applied e.g. for decoupling of GDP from traffic volume and CO_2 emissions from transport (Tapio, 2005), decoupling of carbon dioxide emissions per capita from income per capita in developed countries (Marzio, 2003), decoupling of GHG emissions and economic growth (Vavrek and Chovancová, 2016), etc.

The decoupling of economic growth and environmental impacts caused by this growth has rich tradition within the sustainable development literature. Basically, the literature records four paradigms that may be used in order to decompose the change of particular indicator. These are (a) econometric analysis, (b) analysis based on aggregate data, (c) index decomposition analysis and (d) Structural decomposition analysis. Out of this group, the simplest technique is decomposition analysis, since it considers aggregate variables and does not require specific information (e. g. Kaya Identity by Kaya, 1990). By contrast, Structural Decomposition Analysis (SDA) and Index Decomposition Analysis (IDA) enable use of data from sectoral disaggregation. For assessing the energy sector of the Danube region countries, the IDA method was selected, as it allows both additive and multiplicative decompositions, enables decomposition for any kind of aggregates (absolute variation, ratio, elasticity) and requires less initial information (Fernandéz Gonzáles, 2014), so it is appropriate technique in multi-country studies. IDA has wide application in environmental studies, especially in assessment of environmental pressures of energy sector (Ang, 1994; Ang, 1995b; Gardner and Elkhafif (1998); Sun, 1998; Ang and Liu, 2001; Ang and Zhang, 2000; Sun and Ang, 2000; Wang et al. (2005); Xu and Ang 2013, Chovancová and Vavrek, 2019).

The concept of decoupling environmental pressure from economic development is the crucial form of putting the concept of sustainable development into operation. This conception refers to breaking the links between two variables, often referred to as the driving force, particularly economic growth usually expressed in terms of GDP, and the environmental pressures, such as the use of natural resources and the generation of waste/pollutants. (OECD, 2002).

The Decoupling Index (DI) refers to the ratio of (1) change in the rate of consumption of a given resource (e.g. water), or in the rate of production of a given pollutant emission (e.g. SO_2); to (2) change in the rate of economic growth (GDP) within a certain time period (typically one year). For example, if we define

a) change in the rate of resources consumption (e.g. total energy consumption) between year t and year t-1 as:

$$\Delta P_t = \frac{(P_t - P_{t-1})}{P_{t-1}} \qquad (1)$$

b) change in the rate of economic growth as

$$\Delta Y_t = \frac{(Y_t - Y_{t-1})}{Y_{t-1}} \qquad (2)$$

then the Decoupling Index in year t,

$$DI_t = \frac{\Delta P_t}{\Delta Y_t} \qquad (3)$$

Decoupling of economic growth of the Danube region countries and environmental pressures of energy consumption can be calculated as the ratio of percentage units of changes in environmental indicators (energy use) and percentage units of changes in economic indicator (GDP) in the analysed period. The result will be decoupling elasticity e:

$$e = \frac{\%\Delta P_t}{\%\Delta Y_t} \qquad (4)$$

In the case of continued economic growth, namely ΔY_t>0, the Decoupling Index (DI) may imply one of three following scenarios:

When DI>1, it means the increasing rate of resource consumption or pollutant emissions keeps pace with or is higher than economic growth (see Case A in Figure 1 and Figure 2). In this case, no decoupling is taking place. In other words, as the economy grows, resource consumption and environmental degradation increase rapidly. This is the first half of the Kuznets Curve, or 'climbing stage'. When DI equals 1, it is the turning point between absolute coupling and relative decoupling. In the stage of absolute coupling, a higher DI value means higher dependence on resources by economic growth, lower resource efficiency and heavier environmental pollution.

When 0<DI<1, it means the rate of growth in resource consumption or pollutant emissions falls short of that of economic growth. In this case, relative decoupling is taking place (Case B in Figure 1 and Figure 2). When DI ranges from 0 to 1, lower DI means higher resource efficiency and lower dependence on resources.

When DI=0, it means the economy is growing while resource consumption remains constant. In other words, when the economy grows continuously, the amount of pollutants does not increase. When resource consumption or pollutant emissions/discharge decreases while the economy keeps growing, then DI<0 (Case C in Figure 1 and Figure 2). Here the relationship between environment and economy can be described as the 'declining stage' of the Kuznets curve, namely, absolute decoupling.

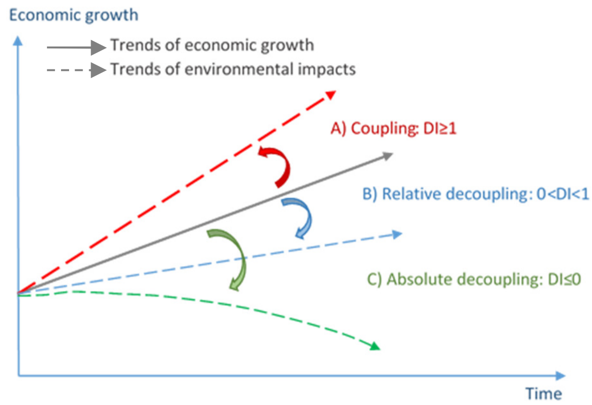

Figure 1 Scenarios for economic growth and environmental pressure nexus (modified from OECD, 2002)

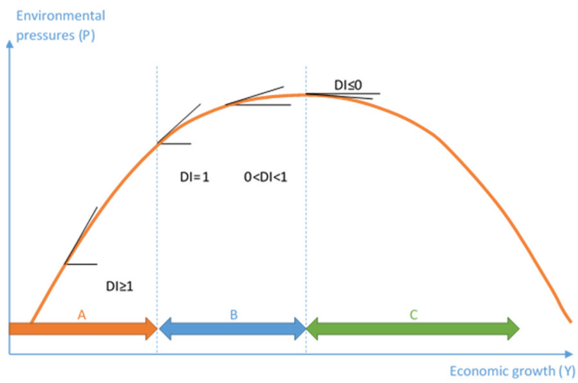

Figure 2 Three stages of environmental pressure and economic growth based on Environmental Kuznets curve

The aim of this paper is to quantitatively assess the relationship between economic growth and energy consumption in the Danube region countries using decoupling method. The ratio between energy consumption and the gross domestic product (GDP) can be referred as energy intensity. This indicator measures the energy consumption of an economy and its overall energy efficiency.

The used data we obtained from the databases of the World Bank: GDP, PPP (current international $) and Energy use (kg of oil equivalent per capita).

PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

3 RESULTS AND DISCUSSION

In this study, the relationship between Gross Domestic Production (GDP) and Energy use (EnU) of Danube region countries (Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Romania, Slovakia, Slovenia, Bosnia and Herzegovina, Moldova, Montenegro, Serbia and Ukraine) is assessed. The analyzed period is divided into four sections, where S1 refers to 1994-1999; S2 refers to 1999-2004; S3 refers to 2004-2009 and S4 refers to 2009-2014. Values ΔGDP and ΔEnU were calculated using data from available databases of the World Bank using the equation (1) and (2). Subsequently the value of decoupling index DI was calculated using the equation (3).

Based on the partial calculations we performed decoupling analysis. Results of the analysis are summarised in table 1. According to decoupling analysis of Danube region countries during four time periods we can distinguish following sub-categories:

Absolute decoupling: in this sub-category the GDP increases and energy use decreases. Thus the decoupling index is below 0. This is the best case for both the economy and the environment. This sub-category is in our survey the most frequent – it occurs in total of 27 observed cases (55%), which can be considered as a positive fact.

Relative decoupling: is the case when the rate of growth in energy use falls short of that of economic growth. In this case DI ranges from 0 to 1, lower DI means higher energy efficiency and lower energy dependence. Decoupling occurs to some extent, because energy use grows more slowly than the GDP, but it is weak, since the absolute amount of used energy nevertheless continues to grow. This situation occurs totally in 21 analysed cases (42%).

Absolute coupling means that the increasing rate of energy use keeps pace with or is higher than economic growth. In this case, no decoupling is taking place. In other words, as the economy grows, energy consumption increase rapidly. In the stage of absolute coupling, a higher DI value means higher dependence on energy resources by economic growth, lower energy efficiency and heavier environmental pollution. In this sub-category we have only one case of absolute coupling – Bosnia and Herzegovina in period 2009-2014.

In seven cases the data was not accessible, therefore the calculation was not able to be performed.

Decoupling analysis of the Danube Region countries revealed some interesting findings, e. g.:

- The period 1999-2004 was characteristic as relative decoupling in all the Danube region countries.
- The period 2004-2014 was mostly characterized by absolute decoupling in most of the Danube region countries.
- Absolute coupling occurred only in one case – Bosnia and Herzegovina in period 2009-2014.

Table 1: Decoupling index of the Danube region countries in period 1994-2014

Country	ΔGDP				ΔEnU				DI			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Austria	0,19	0,20	0,19	0,18	0,10	0,10	-0,06	-0,01	0,53	0,52	-0,29	-0,05
Bosnia and Herzegovina	0,76	0,32	0,31	0,15	0,59	0,31	0,23	0,24	0,77	0,95	0,76	1,60
Bulgaria	0,10	0,33	0,33	0,17	-0,13	0,09	-0,04	0,05	-1,29	0,26	-0,11	0,30
Croatia	NA	0,29	0,28	0,08	0,15	0,12	-0,01	-0,13	NA	0,40	-0,03	-1,67
Czech Republic	0,17	0,26	0,26	0,15	-0,05	0,15	-0,11	-0,03	-0,28	0,59	-0,40	-0,20
Germany	0,14	0,17	0,15	0,20	0,00	0,01	-0,09	0,00	-0,02	0,05	-0,59	-0,01
Hungary	0,18	0,32	0,21	0,18	0,03	0,03	-0,04	-0,07	0,19	0,11	-0,20	-0,40
Moldova	NA	0,33	0,24	0,29	-0,61	0,09	-0,05	0,04	NA	0,27	-0,21	0,14
Montenegro	NA	NA	0,40	0,16	NA	NA	NA	-0,07	NA	NA	NA	-0,45
Romania	0,11	0,35	0,42	0,18	-0,17	0,11	-0,05	-0,08	-1,62	0,30	-0,13	-0,42
Serbia	NA	0,35	0,31	0,12	0,07	0,30	-0,17	-0,11	NA	0,87	-0,56	-0,96
Slovak Republic	0,26	0,29	0,34	0,21	0,00	0,04	-0,10	-0,06	0,01	0,14	-0,29	-0,27
Slovenia	NA	0,26	0,19	0,12	0,13	0,09	-0,02	-0,08	NA	0,36	-0,11	-0,67
Ukraine	-0,23	0,40	0,14	0,10	-0,17	0,10	-0,22	-0,07	0,76	0,26	-1,55	-0,63

Legend:

Absolute decoupling | Relative decoupling | Absolute coupling | Data not available

- The strongest absolute decoupling occurred in case of Ukraine in period 2004-2009.

Throughout 20 year examined period, countries spread out into different forms of decoupling. The largest group of examined periods falls under the subcategory of absolute decoupling, which can be seen as a very positive. But as with all studies, this study has limitations. First, the decoupling index does not reveal the environment's capacity to sustain, absorb or resist pressures of various kinds. DI values cannot convey the message of whether the economic growth is sufficiently decoupled from negative environmental impacts. Constant environmental impacts or decreased environmental impacts over time do not guarantee that human economic activity is within the physical limits of biosphere. Even if strong decoupling could be achieved, this would not necessarily ameliorate the environmental impacts of economic growth.

We also have to state that even absolute decoupling at the individual country level, may not indicate that energy use is actually decreasing with increasing GDP. It may just indicate that more energy intensive operations has been off-shored (Wiedmann, 2013). Developed nations experience an increase in imports of semifinished and finished products and a change in economic structure toward service economies, which add high value to the GDP. These trends make developed countries look more resource-efficient, but they actually remain deeply anchored to a material foundation underneath.

Though using this method can bring a lot of advantages. The quantification of the extent of decoupling makes it possible to assess if implemented decoupling strategies are sufficient to reach the goals of sustainable development. We can track the trends; compare the extent of decoupling among countries and set future decoupling targets. Results of decoupling analysis can facilitate environmental policy making processes.

4 CONCLUSION

The issue of reduction of energy use directly affects all European Union member states, whose vision is to reduce energy consumption by 20% relative to business-as-usual projections. In this study, we focused on the Danube region countries which create very heterogeneous group in terms of geographic, economic, cultural and socio-demographic characteristics. Despite of these differences, they have great potential to improve in many areas including energy sector, where they can increase their energy efficiency, improve energy infrastructure and foster the use of renewable energy sources.

Using the method of decoupling, we determined the decoupling index, thus de-linking economic growth and energy use in the individual Danube region countries within the monitored periods. On the basis of the performed analysis can be concluded prevailing absolute decoupling, which means that the economies of these countries grow, energy consumption is declining.

Ensuring a cost-efficient transformation of the energy system of Danube region countries necessitates a diverse mixture of actions addressing both supply and demand side. On the supply side, breaking the continuing dominance of fossil fuels will require a strong commitment to improving energy efficiency, deploying renewable energy, and continuous climate and environment proofing of energy projects. Substantial investments and regulatory change will be needed to integrate networks and facilitate the growth of renewables. On the demand side, there is a need for fundamental changes in society's energy use. Smart meters, appropriate market incentives, access to finance for households, energy saving appliances, and high performance standards for buildings can all contribute.

Findings of the paper are relevant for government, state and public institutions as well as stakeholders in general who play important role in preparation of programs, projects and initiatives to make energy appliances, buildings, transport and energy generation more efficient, and introduces stringent new energy efficiency standards and financing mechanisms to support more energy efficient products.

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AUTHORS ADDRESSES

[1] Ing. Jana Chovancová, PhD.
University of Prešov in Prešov, Faculty of Management,
Department of Environmental Management,
Konštantínova 16, 08001 Prešov
Slovak Republic
Email: jana.chovancova@unipo.sk

ENVIRONMENTAL BURDENS AND THE IMPLEMENTATION OF ENVIRONMENTAL POLICIES OF DEVELOPMENT SUSTAINABILITY IN EUROPE AND SLOVAKIA

Gabriela Sančiová [1], Milan Majerník [1], Vojtech Ferencz [2]

Abstract: *Fulfilling the ambitious objectives of the European socio-economic development strategies is unrealistic today without innovative and smarter approaches to old environmental burdens. A serious environmental and security threat is the closure of the troscopo-blended power sludge basins, which have been closed and currently unused. Within this paper, the results of our multiannual research and development of a fundamentally new remediation-reclamation technology based on the use of structured layers of solidified stabilizer (waste product from desulphurization technology) ensuring the water and soil permeability for biomass cultivation, sustainable technical and economic and environmental a well-balanced integrated model. Variables in the optimization function of a sustainable remediation model are safety, environmental and socio-economic aspects and risks, their management and verification at a specific tailing pond in an environmentally protected area.*

Keywords: environmental burdens, troscopola mixture sludge pit, remediation-reclamation technologies, sustainable development, risk management, process modeling

1 INTRODUCTION

Improving the quality of life from the point of view of health and safety of the population is currently also subject to improving the environmental profile of the area. All development goals and strategies are today, whether viewed from a global or regional or local point of view, in a coordinated way in relation to environmental damage and fulfillment of socio-economic parameters (EIA/SEA/HIA process) of development. However, the old environmental burdens caused by environmentally inappropriate consumption and production in the past that are transferred to the present and the sustainable socio-economic development as environmental debt remain a problem in the EU and in the regions of Slovakia.

2 IMPLEMENTATION OF DEVELOPMENT ENVIRONMENTAL POLICIES

Within the framework of its development strategies, the EU is focusing on the achievement of a sustainable state of the environment with an emphasis on its protection. Fig. 1 presents an overview of EU policies devoted to the environmental field. It can be said that the number of binding environmental policy objectives is significantly higher than the number of non-binding objectives. For example, in 2013, environmental policy objectives were exactly in the opposite ratio. Non-binding environmental objectives with a total of 68 were prevailing compared to binding environmental policy objectives of 63, with most of the targets set to 2015.

A frequent trend in the implementation of environmental policies in the European area is breach of obligations. There are time spans between policy adoption and implementation, such as 5-10 years, which results in the costs from non-compliance with environmental policy. These costs are estimated at up to approximately EUR 50 billion over a one-year period. [2]

Strategies need to be formulated in such a way that they are feasible and at the same time aimed at maintaining the minimum costs of eliminating negative environmental impacts. [3] A more detailed overview of the objectives of environmental and climate policies overlaid with a time axis is shown in Fig. 2.

In relation to the worked-out strategies and visions centered on achieving a sustainable state in Europe, the state of the environment is monitored and evaluated through several instruments. One of them includes the environmental report, which is produced by the European Environment Agency over a five-year period.

It can be said, that the trend of increasing environmental pollution persists and ecosystems are reaching the level of critical pollution. Globalization is a trend that is closely linked to the change in consumer and production patterns in countries and increases the pressure on the environment. From the point of view of European production, pressure is particularly prevalent on the use of resources, the amount of emissions and their ensuing consequences for the environment.

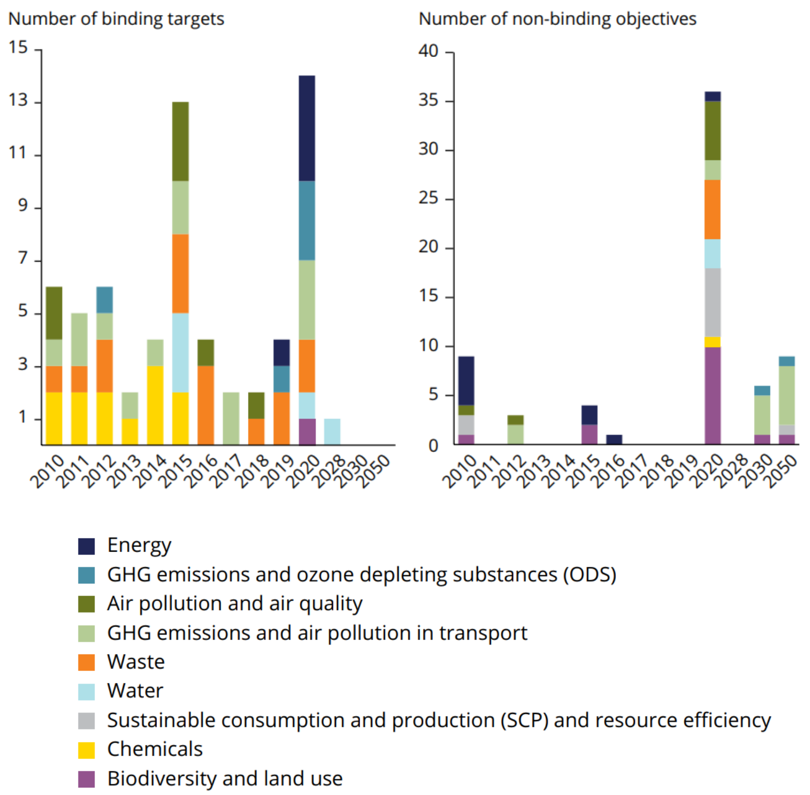

Fig. 1 Overview of objectives within the different EU environmental policy areas

Source: EEA, SOER, 2015

Fig. 2 Timeline of Environmental Policy Objectives

Source: EEA, SOER, 2015

3 MANAGEMENT OF CONTAMINATED TERRITORIES IN EUROPE

According to the EEA estimates, there are about 2.5 million sites in Europe, specifically in 39 European countries (EEA members) with potentially contaminated soil.

In part of the sites, about 342,000 sites, soil contamination was identified, with 15% of them already being remediated.

Estimates of the amount of contaminated sites and potentially contaminated sites per 1,000 inhabitants in selected European countries are shown in Fig. 3.

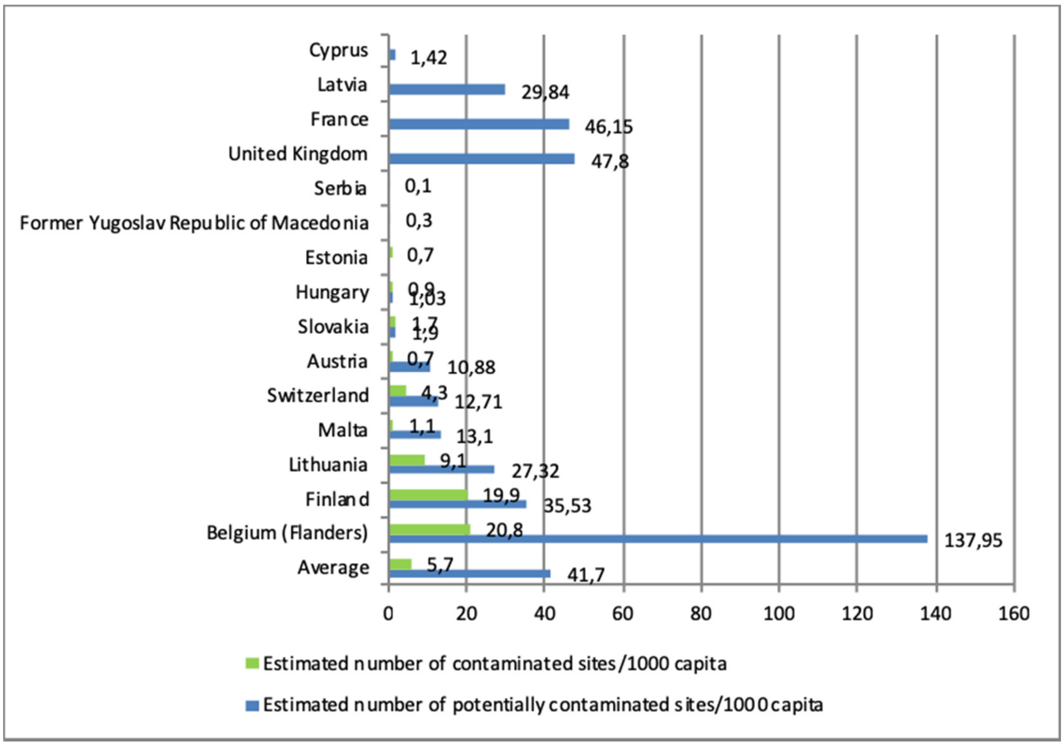

Fig. 3 Estimates of potentially contaminated sites and old environmental burdens

Source: EEA, 2015

The number per 1,000 inhabitants is on average 41.7 potentially contaminated sites and 5.7 contaminated sites. Estimates show that there are up to two and a half million of potential environmental burdens in Europe, of which 14% are those that are dangerous, requiring implementation of remedial measures.

The procedure for managing and controlling contaminated sites consists of four consecutive steps:

- identification of contaminated sites,
- the preliminary investigation,
- the main investigation,
- implementation of specific risk elimination measures, pollution removal.

The considerable expenditure of European countries spent on the management and administration of contaminated sites is shown in Fig. 4.

The unauthorized and dangerous handling of waste and hazardous substances has a dominant position within contamination. The percentage of individual sources of contamination on the total amount of identified sources, Fig. 5.

According to the latest available data for 2011, published by the European Environment Agency, the largest share of sources of soil contamination is mainly waste and industrial and commercial activities, reaching a 38.1% share for waste disposal and management and a 34% share for industrial and commercial activities. The data obtained represents 22 countries in Europe.

The percentage of soil pollutants defined in the identified European countries is represented by Fig. 6.

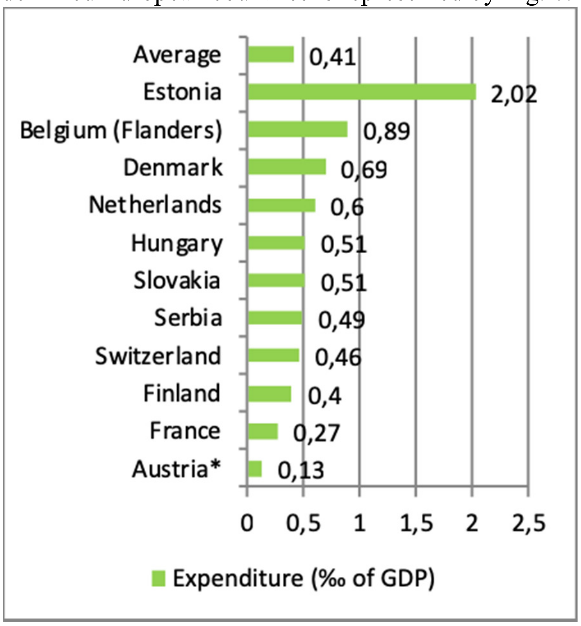

Fig. 4 Annual national expenses for the management of contaminated sites in mil. EUR (expenditure ‰ GDP)

Source: EEA, 2015

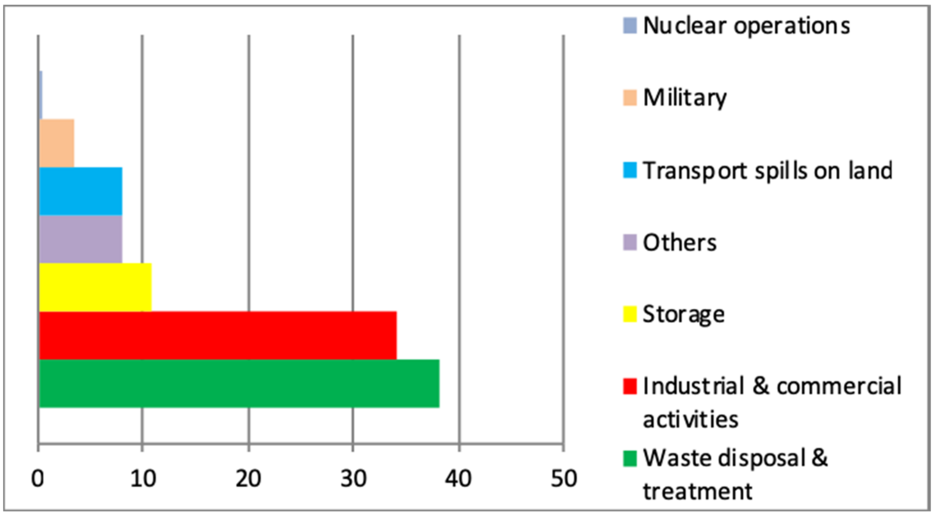

Fig. 5 The main sources of soil contamination (average based on 22 countries / regions)
Source: EEA, 2015

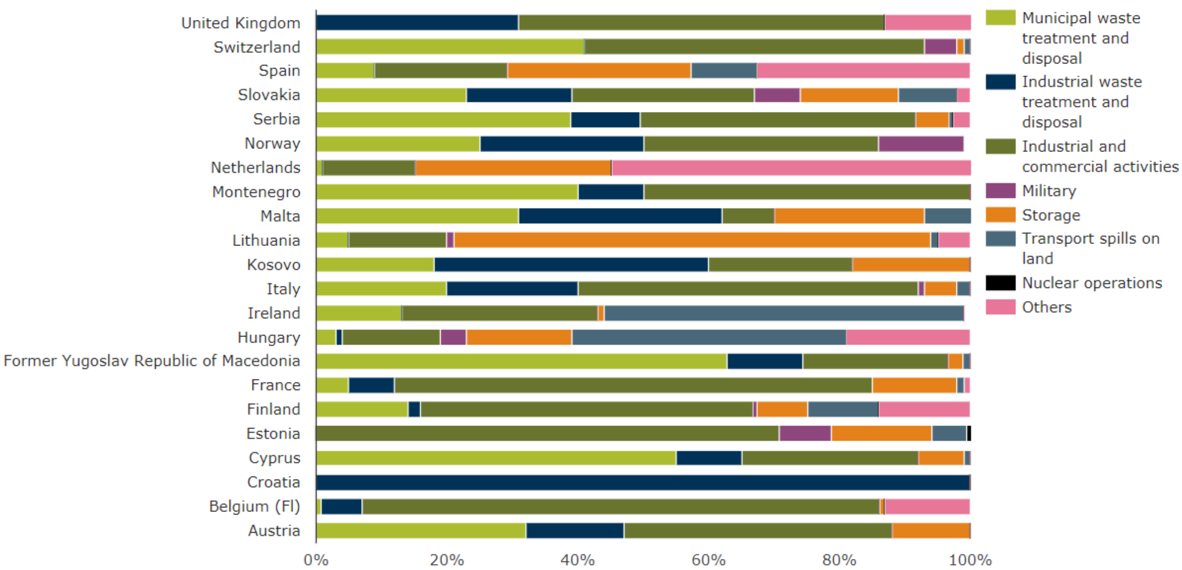

Fig. 6 Activities causing soil contamination in selected countries
Source: EEA, 2015

4 THE OVERALL CHARACTER OF INDUSTRIALIZATION BEFORE CZECHO-SLOVAKIA

In the future, increasing remediation costs will require the creation of new models and procedures on how to remove these environmental burdens. Fig. 7 provides an overview of the most common remedial methods, or techniques that can be found in European countries. In the case of contaminated groundwater, the most frequent (37%) of ex-situ techniques are applied either physically or chemically.

On average, 42% of public spending and 58% of private sector spending cover the financing of EU environmental burdens. The most public expenditure on environmental burdens is used by Estonia (92%), while the least finances of the public sector are used by Belgium (only 25%).

National average annual reimbursement costs for individual countries are as high as 81%. National expenditure for on-site investigations is 15% on average per year. Relatively often, the funds spent on aftercare are not reported separately in individual countries, with the exception of Denmark, Sweden and Austria. The share for sanitation measures in Sweden is 13%. Denmark and Austria spend less on subsequent remediation measures, with the percentage standing at 7-8%.

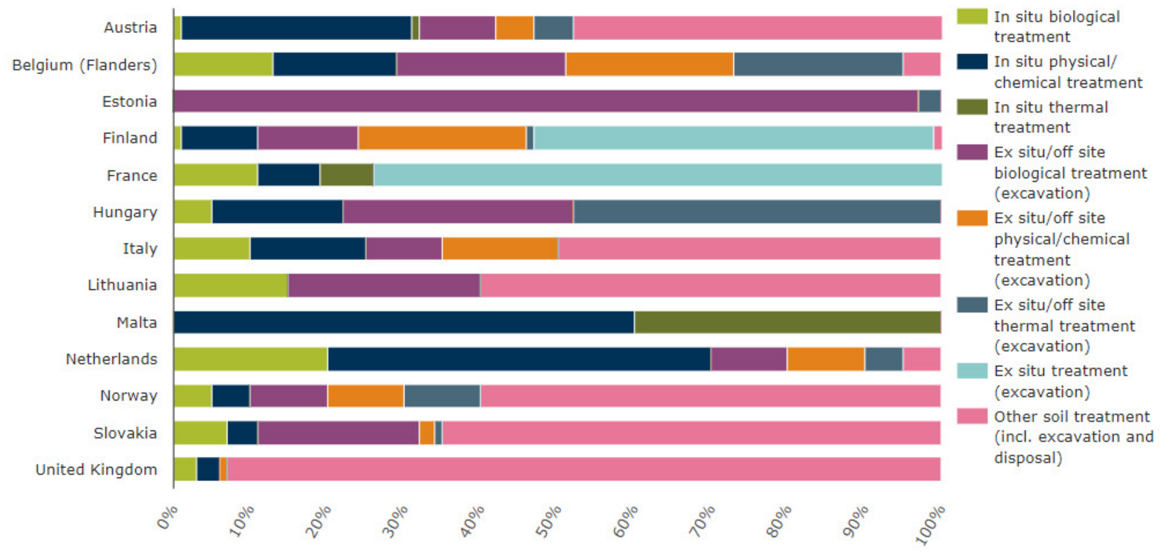

Fig. 7 Most commonly applied soil remediation techniques
Source: EEA, 2015

In 60% of the cases reported, the costs of the on-site investigations amount to between EUR 5,000 and EUR 50,000. Increasingly expensive cases of on-site investigations were found in Italy and Switzerland where they climbed up to EUR 5,000,000. Such costly cases account for only 8% of all cases found. Perhaps the lowest costs for this activity were recorded in the Netherlands, where a value not exceeding EUR 500 was paid in around 10% of cases of on-site investigations.

Governmental institutions of the EU Member States have focused their attention within environmental protection mainly on activities in areas such as waste management, biodiversity protection and waste water treatment. [4]

5 THE STATE OF ENVIRONMENTAL BURDENS IN THE CONDITIONS OF THE SLOVAK REPUBLIC

The overview and classification of identified sites for 2008 is shown in Fig. 8. [5]

The identified sites (within the survey) showed signs of long-term and uncontrollable leakage of hazardous substances that have a negative impact on the environment. In part of the identified sites, the enterprises still showed active production, some of them have finished production and implemented remediation with subsequent monitoring of the site.

The designation "likely environmental burden" or "potential environmental burden" is used for sites where no sufficient evidence has been obtained confirming the presence of contamination. In Fig. 9, the location of all types of environmental burdens in the Slovak Republic is identified by the Slovak Environment Agency.

Fig. 10 shows the areas identified in category B (confirmed environmental burdens) in eastern Slovakia, including the Vojany settling pond examined by us, on the map marked with a flag. The environmental burdens registered in the Register were discovered and identified on the basis of exploratory work.

At present, 2,035 items are available through the environmental portal within the environmental burden information system registered "online". Records of environmental burdens – expressly settling ponds of energetics – include 28 settling ponds characterized as environmental burdens. From the total number of 28 settling ponds, 5 of them are in group A, 9 of them are part of group B and the largest group C is formed by the remaining 14 settling ponds.

Costs of remediation methods of environmental burdens

There are several types of remediation methods and procedures. Each organization, considering the specific conditions and extent of pollution, decides on the implementation of the most appropriate solution, of course using the lowest cost. At the same time, organizations are not interested in sharing their remediation practices in a competitive environment, but it is in the interest of the state to obtain such data and have a more comprehensive overview of the remediation methods used.

Creating a uniform procedure for assessing site remediation can be described as very demanding. All remediation work is linked to specific conditions. The suitability of the use of the remediation method of the polluted site are determined by the nature of the pollution, the natural conditions, the operation itself and, last but not least, the remediation limits. [7]

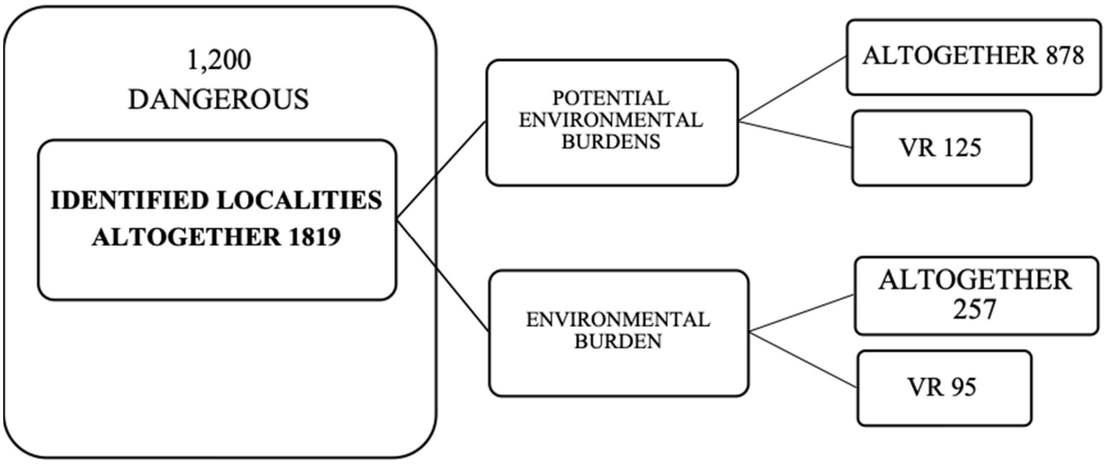

Fig. 8 Identified sites of the SR environmental burden (2008)
Source: Frankovská et al., 2010

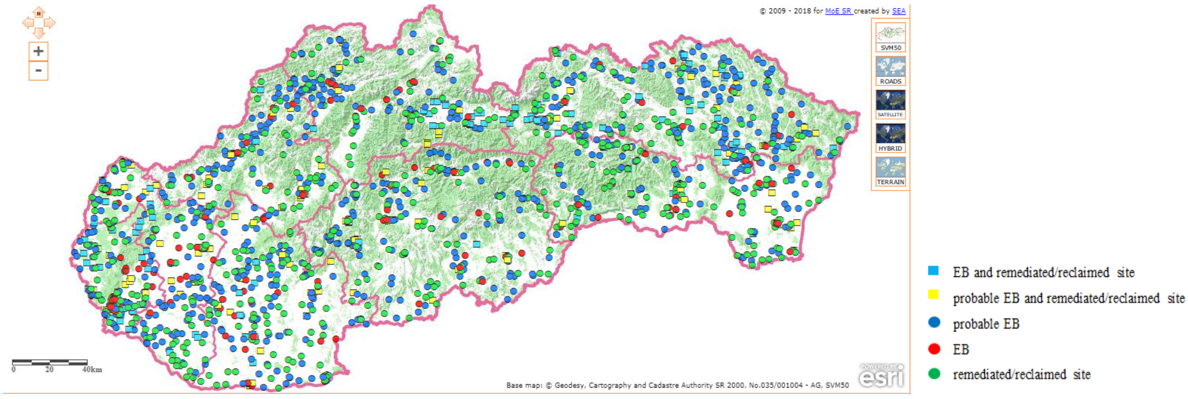

Fig. 9 Visualization of the location of the EB detected on the SR territory
Source: Enviroportál, 2018

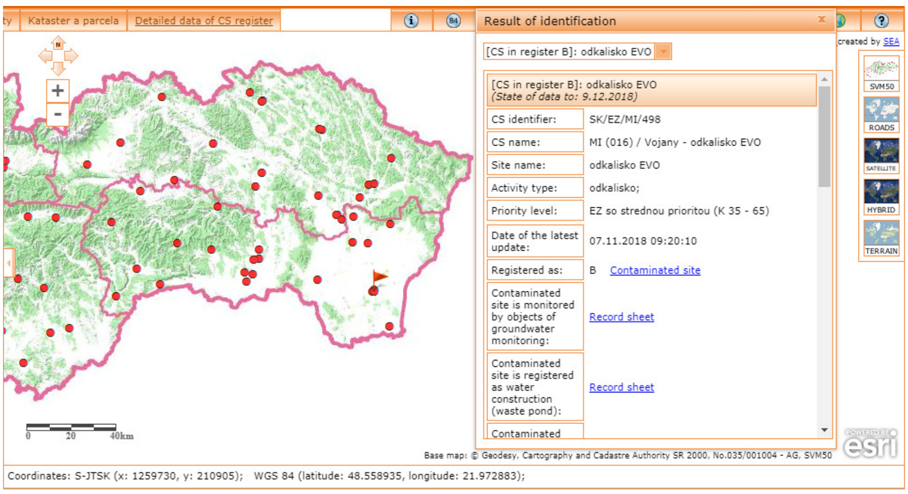

Fig. 10 Visualization of the location of EVO Vojany EB in SR – identified category B
Source: Enviroportál, 2018

For the processing of data on the economic cost of remediation, information available from specific cases of already implemented remediation can be used. However, even in this case, there are problems. Within the carrying out of remediation, there is indeed information available about the cost of remediation, but only as overall cost. The cost of the sub-items in these cases is not available.

Creating a flexible model example could help to better predict the cost of remediation and to better compare costs of the remediation of environmental burdens. A sample example of a site for subsequent remediation should include at least information on the standard area along with the specification of hydrogeological ratios.

Within the created sample site, it is possible to estimate the costs necessary to perform the remediation on the basis of the specified parameters, but in practice there is an overestimation or understatement of these costs, which may differ significantly from the forecasts. [8]

Within phytotechnologies (used for reclamation or remediation) it is extremely difficult to determine their specific benefits and costs. From an economic point of view, experts argue that these are new low-cost remediation techniques. [9] Research into phytotechnologies has so far been centered on addressing scientific and technical issues. However, as reported by Newman et al. (2004) and Van Nevel et al. (2007), increased attention should be paid to price developments, modeling and monitoring systems to provide a better basis for phytoremediation implementation in practice.

6 CONCEPT OF AN INTEGRATED MODEL OF REMEDIATION OF OLD ENVIRONMENTAL BURDENS

From the analysis of the theoretical and methodological aspects of the remediation and reclamation of power plant settling ponds and the study of EU strategic development documents transferred to the conditions of practice in Slovakia, it is clear that environmental and security risks are a priority in solving the problem. These could be met in connection with the further existence, operation and safe closure of a power plant settling pond as a water management structure. From more accurate analyses of the identified significant risks, it is obvious that they are very closely interrelated, mutually connected and demonstrably interrelated in relation to the effectiveness of the solution and developmental sustainability. There is no approach in scientific literature or in other regulations and outputs of scientific research that would include all areas (safety, environment, economy) and relevant risks as an integrated management system for the remediation of old environmental burdens within optimization.

With regard to the methodology for the elimination of environmental burdens, priority is given to acquiring data identifying environmental risks. These are subsequently analysed to be evaluated and preventively minimized. The identified environmental (in the form of EMS according to ISO 14001) and energy (in the form of EnMS according to ISO 50001) safety risks (via authorized security supervision), are addressed separately in remediation technologies. The economic aspects of remediation and reclamation have been and are more in the level of estimates than more precise specifications, both in relation to the fulfillment of the environmental and safety objectives of remediation, as well as the basic principle of development sustainability. Sustainable development is understood today and will be understood in the future as a "balanced socio-economic and environmental-safe development ensuring a comprehensive quality of life". Consequently, the concept of an integrated model for the risk management of remediation technologies and reclamation procedures of power plant settling pond ash-slag mixture should, in the sense referred to, methodically include aspects of safety, environment and economy and their interrelationship (Fig. 11).

The concept for a Sustainable model of power plant settling ponds remediation can be presented in the form of:

$$U_S = f(B_R, E_T, E_P) \qquad (1)$$

where:

US - Sustainable model of power plant settling pond remediation

BR - Elimination of security risks

ET - Economic aspects of BAT technology remediation

EP - Improving the environmental profile (environmental effectiveness)

Calculation of the overall effectiveness of the implemented environmental measures [12] :

$$E_c = \frac{\sum_{i=1}^{n}(U_c - N_d)_i}{\sum_{i=1}^{n} JN_i} \cdot 100\% \qquad (2)$$

where:

Ec – the overall effectiveness of the implemented environmental measures

Uc – the resulting economic effect (extent of the damage avoided to the environmental compartments) of the implemented measure

Nd – overall additional costs of the implemented corrective actions in the area of creation and protection of the environment

JN – one-off costs of damaging the environment

i – the number of measures taken to prevent environmental damage

Source: Information system for the prevention and

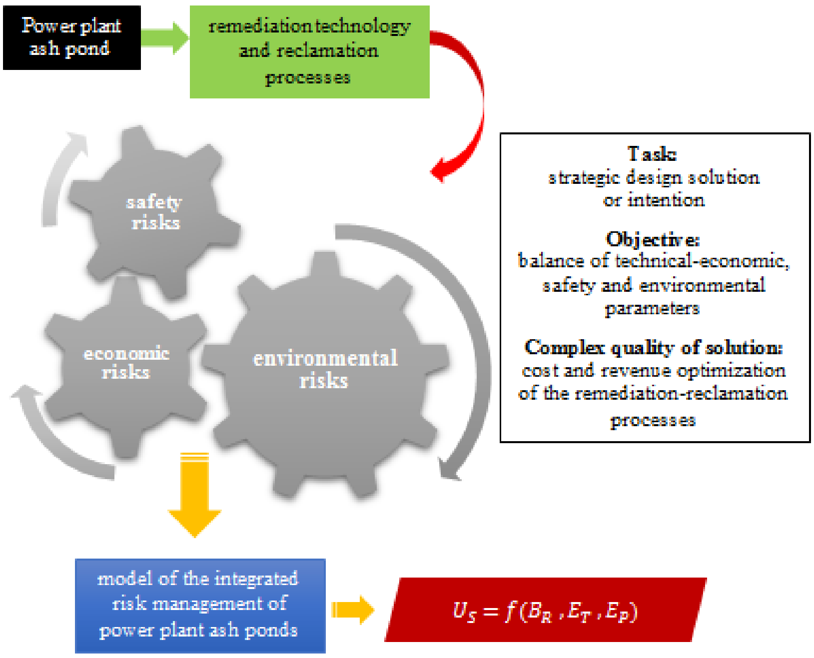

Fig. 11 Concept for integrated risk management of power plant settling ponds
Source: Own processing

7 RISK MANAGEMENT OF EXPOSED ENVIRONMENTAL BURDEN

From the point of view of the location of the power plant ash settling pond and of the indicated natural resources and protected areas located in the vicinity of this environmental burden, it is necessary to assess the environmental risks of potential adverse impacts of the power plant settling pond.

As shown in Fig. 12, near the settling pond, there is a Protected Bird Area (Medzibodrožie), Laborec River, which is a water conservation area, an important water catchment area and a waterworks watercourse, and even significant sources of ordinary underground water that pass under the entire body of the settling pond. There are also areas of European significance and within 20 km the protected area of Latorica.

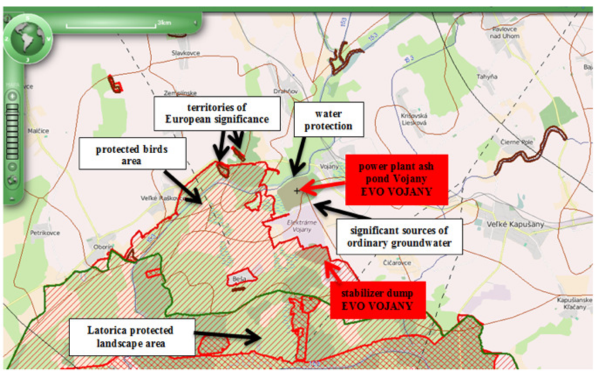

Figure 12 Natural resources and protected areas near the EVO Vojany power plant ash settling pond

remedy of environmental damage

A threat to the safety of the settling pond can cause significant environmental damage, which in turn causes high costs on its disposal and the fees and fines for the pollution of the surrounding municipalities. Research has identified potential risks in each of these areas (safety, economy, environment) on the example of an EVO power plant settling pond.

8 DISCUSSION

The current global approaches and progressive European trends in the management of old environmental remediation management in the sense of our analysis and research are unambiguous. Environmental burdens and the resulting safety risks are an ongoing problem not only from the past but also in the future. It is necessary to deal with them in an economically effective and environmentally acceptable manner, in the interest of safety and the principles of sustainability. Developmental sustainability strategies are emerging at the level of major global communities, but sooner or later they must be implemented within the framework of the legislative and international standards applicable in specific countries and regions. Within the regulated sphere in globalized markets, they are committed to working in these communities, so they must also provide conditions for organizations operating on their territory and on the international market.

These analyzes have confirmed that the main problem facing environmental burdens is an environmental safety problem. The cause of environmental burdens, additional traffic with these burdens, and efforts to eliminate them, include a combination of safety, environmental, health, social, technical, technological and economic aspects. It is not possible to look at the issue without omitting any of these aspects, or preferring one over another. An integrated and balanced, thus sustainable solution has good prospects for the future.

It is in the interest of all stakeholders to invest in research activities that would contribute to the elimination or complete disposal of environmental damage and environmental burdens. It is significant that many countries [1], including the SR [5] are now struggling with the problem of soil, water or air contamination, also due to the effects of old environmental burdens. Contaminated site management and waste management, in which considerable funds [1] from the ESF are being invested in, are not far behind.

There are many remediation technologies and practices [7], but their implementation in specific regional practical conditions is not always clear, especially when it comes to cost and revenue items of implementation [8], [9], [10], [11]. In this context, we are also currently working on concepts such as circulate or non-waste economy, green growth, green economy, and so on.

Systematic results of laboratory and small-scale experiments by PHF EUBA workers [13] have shown that the stabilizer produced as a waste product (desulphurization) in power plants can be used as a waterproof solidified layer in remediation technologies and land reclamation processes. However, the use of this material will require a sufficient amount of moisture to obtain the desired properties. Otherwise, unpaved sites could be created that release dangerous substances out of the area of the settling pond body or allow the seepage of precipitation into the settling pond body, which can ultimately cause a disaster in the form of the overflow of the settling pond or breakage of its dyke.

The cultivation of the researched verified energy crop of the genus salix has been proven in the case when hydropholes have not been used and in the case of irrigation. Therefore, it is advisable to consider other energy crops [14], [15], [16], [19], [20], [21], which ensure a high yield on their plantations even during the dry season, taking into account the undemanding conditions (e.g. various grass mixers).

Regardless of the storage status, resp. non-disposal of the waste product in the settling pond area, the costs of the settling pond will "forever" accompany the EVO power plant settling pond. It follows from the current European legislation, when it is necessary to ensure the monitoring of the power plant settling pond for at least 30 years (Decree No. 372/2015 Coll.), the practice being that, it will be necessary to ensure monitoring as long as this environmental burden exists. Cost differences will depend on the periodicity and amount of monitoring work carried out, but it can be predicted that they will never enter zero values. This would be the case if new, better, more innovative technology on BAT principles were put in place by research to ensure complete removal of the environmental burden (e.g. encapsulation).

SE a.s. still operates as a state-owned organization and without any support from the EU Structural Funds. Current legislation does not allow such financing either. Therefore, the financial reserves are guaranteed by EVO. The state co-ownership of the organization excludes the use of funds.

The problem in many countries in the context of growing energy crops is in particular the seizing of agricultural land for energy purposes. Legislation in individual countries seeks to protect agricultural production in terms of the conservation of agricultural land. The use of reclaimed settling pond areas in this context would be appropriate for such purposes to be used, together with the soils that are legally defined for the cultivation of RRD, namely land in floodplains, wet or subjected to wind erosion.

As far as the pollution fees are concerned, the “polluter pays” principle is still legislatively applied and, as stated above, it will apply even more (new bill on fees, tightened criteria in the world, failure to respect European development strategies, etc.).

9 CONCLUSION

The technology of remediation and bio-reclamation of power plant settling ponds as a multidisciplinary problem involves many aspects, impacts and risks. Its realization requires awareness of a wide range of knowledge, legislative provisions and standards. Their synthesis into a single integrated system also requires the development of risk management, which is the basis for system evaluation and optimization. From the results of our research (VEGA 1/0936/15, ENEL 4600005494), it is important to take into account the safety, technological, health, environmental and economic (social) risks that affect each other as a single system ensuring development sustainability. That is why we have developed a draft concept of integrated assessment of the identified risks of remediation and reclamation technologies and the processes of power plant settling pond ash-slag mixtures. The introduction of the best available innovative BAT technology lies in the implementation of stabilization into the overlay layers of power plant settling ponds, replacing other water-permeable economically more demanding layers – a waterproofing membrane with a drainage system.

The design concept of the model was dimensioned in its decomposition based on the real parameters and variables of the settling pond ash-slag mixture in EVO Vojany. The model in relation to the economic and environmental efficiency of remediation and bio-reclamation of power plant settling ponds is based on the confrontation of cost and yield requirements of implementation. In this context, it is important to note that the return of one-off investment funds for environmental protection projects (compared to technical projects) is more long-term, but from the point of view of competitiveness and development sustainability, it is highly efficient. In general, prevention is more cost-effective than damage repairing.

A key problem for the practical implementation of innovative environmentally safe and economically viable technologies for the remediation of settling ponds is, in particular, the current (3-4 years) legislative restrictions (EC Regulations and their Legislative Application in Slovakia, Waste Act, Old Environmental Burden Act, Environmental Damage Act, EIA/HIA/SEA assessment of development plans and strategies, relevant EN and STN).

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AUTHORS ADDRESSES

[1] Mgr. Gabriela Sančiová

University of Economics in Bratislava, Faculty of Business Economy with seat in Košice,
Slovak Republic

Email: gabriela.sanciova@gmail.com

prof. h. c. prof. Ing. Milan Majerník, PhD.

University of Economics in Bratislava, Faculty of Business Economy with seat in Košice,
Slovak Republic

Email: milan.majernik@euke.sk

doc. Ing. Vojtech Ferencz, PhD.

Technical University of Košice, Faculty of Mining, Ecology, Process Control and Geotechnologies,
Slovak Republic

Email: vojtech.ferencz@gmail.com

ANALYSIS OF OPPORTUNITIES FOR INCREASING DURABILITY MATRIXING MATERIALS THROUGH APPLICATION OF TiAlN COATING

Dominika Siwiec[a)] - Andrzej Pacana[b)]

Abstract: *The aim was to analyze the increase the trimming matrixes life by used the TiAlN coating, showed the achievements more exploitation possibilities with used the tool with TiAlN coating, and propose to use the Ishikawa diagram to analyze of factors, thanks which is possible to increase the accuracy of the conducted tests. The material which was analyzed is the high-speed steel HSS, from which was made the matrix subjected to analysis. The process of covering the matrixes the TiAlN coating was analyzed and the average thickness of the obtained coating was specified. The chemical composition, structure and adhesion for the TiAlN coating on the matrixes were analyzed. The results form exploitation the for four matrixes were compared, where the number of work cycle for the matrixes witout TiAlN cover were compared with the number of work cycle for the matrixes with TiAlN cover. In addition, the factors which can be the effect on the efficient research with the Ishikawa diagram were analyzed. It was concluded, that in temperature 500 °C and time about 100 minutes it is possible to get the average thickness of TiAlN coating on the trimming matrix equal 2,93 μm, and with the TiAlN coating on the trimming matrixes(average thickness equal 2,93 μm) allowed fourfold increase their life. The analyze and the results can be base to used the TiAlN coating on the tools used in industry in the aim to increase their life, and the Ishikawa diagram which was proposed can be useful to find the factors which let to make efficient researches.*

K e y w o r d s: mechanical engineering; matrix; quality management; TiAlN; eksploation; Ishiakwa diagram

1 INTRODUCTION

The life research of the product has important meaning in case of the products using in industry, where the key is to select the tool to long-lasting and efficient work. The coating type TiAlN have been used to increase the durability of different types of tools and machines parts. The increased life the tools with TiAlN coating is achieved because of their structure or oxidation processes at elevated temperature. For example, the previous researches from the area TiAlN coating and the PVD methods for the high-speed steel concerned among others: to obtain the optimal state of the TiAlN coating on a high-speed steel fabric, with high microhardness and optimal coating thickness [1], non-destructive and non-contact TWIN measurement system for coated high speed steels and oxidation steels including TiAlN were applied to determine the thermophysical properties of PVD coatings [2]. Dry drilling analyzes were carried out, which showed that the TiAlN / TiAlZrN multilayer coatings with a nanometric scale were characterized by a better drilling performance compared to single-layer coatings (TiN, TiAlN) [3]. After testing two gears made of high-speed powder-hardened PVD (PV-HSS) steel, coated with TiAlN (nano layer) and TiN (mono layer), it was concluded that the TiAlN coated cutter worked better than the TiN coated cutter [4]. The use of coated tools for machining is common because many coated tools show better performance compared to uncoated tools [5], [6]. It was concluded, that important is make analyze to increase trimming matrixes life by used TiAlN coating, and demonstration of the achievement of greater exploitation possibilities using tools coated with TiAlN coating. The research has shown that it is possible to achieve four times longer durability of trimming matrixes at an average coating thickness of 2.93 μm.

2 MATERIALS AND METHODS

The material was the high-speed steel HSS, from which was made the analyzed trimming matrixes. The high-speed steel is the tool steel characterized by good durability and cutting properties, high ductility, impact resistance and abrasion resistance. It has application in tools production to metalworking, for example, matrixes, drills, cutters, molds for plastics [7-9]. The chemical composition of HSS is shown in Table 1.

C	Mn	Si	P	S	Cr
0,82 – 0,92	max 0,4	max 0,5	max 0,03	max 0,03	3,5 – 4,5
Ni	**Mo**	**W**	**V**	**Co**	**Cu**
max 0,4	4,5 – 5,5	6 -7	1,7 – 2,1	max 0,5	max 0,3

Table 1. The chemical composition [%] of HSS [10].

The subject of the research was the trimming matrix coated with TiAlN coating. The trimming matrix was after exploitation (screwes production) in which made about 150000 cycles (Figure 1).

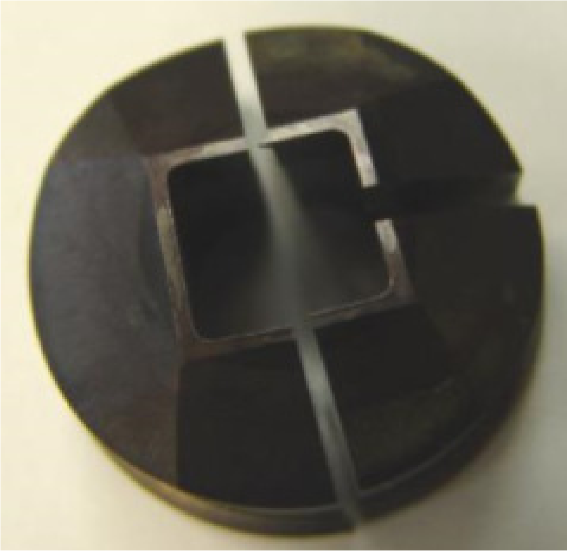

Figure 1. The example of worn-out trimming matrix.

The previously conducted research of the trimming matrixes made it possible to choose the right type of PVD coating. To the research, the TiAlN coating was chosen in the aim to increase matrixes life, which work in heavy load. The TiAlN coating is characterized by high durability so protect by erosion and abrasive wear [11-14]. Choosing the right relationship between the hardness and the residual compressive stress of the TiAlN coating allows for increasing the stability of the cutting tool's edge. The basis properties the TiAlN coating are shown in Table 2.

Microhardness HV 0,025	3000 - 3500
Thickness μm	1 – 7
Coefficient of friction μ	0,35
Temperature of the coating process °C	do 600
The working temperature of the coating max °C	900
Color	fioletowy

Table 2. The basis properties the TiAlN coating [15].

The process of preparing the trimming matrixes for coating with the TiAlN coating was started with machining, and then the matrixes were subjected to thermo-chemical treatment. The process in which the matrixes were coated with TiAlN was started by washing the matrixes on the Vetter cleaning line. The washing process was supported by ultrasound and pendular motion, samples were washed for about 180 seconds at a temperature of about 53 ° C in a chemical substance Galvex 17.30, intended for cleaning in the ultrasonic process. The samples were rinsed for approximately 18 seconds with deionized water in a reciprocating process, subsequently dried with compressed air. Then, in the ultrasound-assisted process, samples were washed for about 180 seconds at about 43 ° C with slightly basic GP 17.40 powder, for surface disinfection in ultrasonic processes. It was again rinsed for approximately 18 seconds with deionized water in the reciprocating process and dried with compressed air. At about 110 °C, the samples were dried with a stream of heated air. The samples prepared in this way were mounted on a planetary gear and placed in the chamber of the "DOMINO L" device from Oerlikon Balzers intended for applying the coatings. Coatings were prepared from sources of metal ions TiAl (50/50%) as well as nitrogen with a purity of 99.999%. The steps of applying the TiAlN coating to the material began by creating a high vacuum that lasted about 1 hour, subsequently heating the chamber of the device to about 450 °C. The surface was cleaned by argon ion digestion, where the argon treatment time was about 67 minutes, and the 300 V voltage was applied at about 500 ° C and about 100 minutes to the HSS steel material TiAlN coating according to the planned program. They were cooled in the chamber for about 180 minutes.

The research the thickness of TiAlN coating on the trimming matrixes was made with using the Kulzer tester by Sulzer Metaplast. The thickness of the TiAlN coating of the two areas of the sample was measured five times. The average thickness in the two areas was calculated by summing five measurements for each area and dividing by the number of measurements. The chemical analysis of the TiAlN coating for three areas of the sample was analyzed by emission spectrometry. Shell structure analyzes were performed using the Hitachi S-3400N scanning electron microscope. Subsequently, the adhesion of the sample attached to the batch was measured by measuring the hardness with a stationary Rockwell 600A hardness tester manufactured by INNOVATEST. In the last stage of the analysis, the results from the exploitation of four trimming matrices were compared, where the number of work cycles for matrixes coated with TiAlN coating and for matrixes not covered with the TiAlN coating was examined. The Ishikawa diagram, called the fish bone diagram, was used to analyze factors that could affect the accuracy of the analyzes. Among the basic factors (ie 5M + E), factors such as man, machine, method, measurement and environment were analyzed, because these factors were considered to have a significant impact on the effectiveness of the conducted tests and correctness of the results [16-17].

3 ANALYSIS

The graph of the parameters important for the process of applying the TiAlN coating is shown in Figure 2.

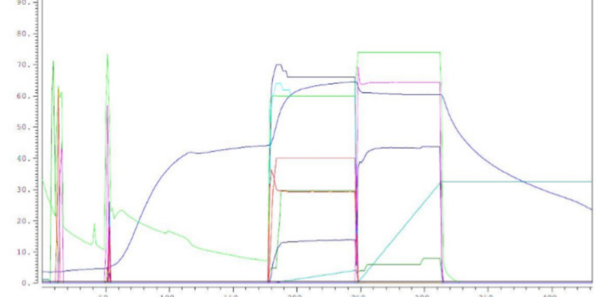

Figure 2. The graph of the parameters important for the process of applying the TiAlN coating

The results from the TiAlN coating thickness measurement for two sample areas made of the trimming matrix are shown in Table 3 and Figure 3.

The number of coating thickness measurement [µm]					Average thickness from areas [µm]
1	2	3	4	5	
2,28	3,51	3,07	3,16	3,16	3,04
3,16	3,16	2,90	2,02	2,81	2,81
Average thickness from all areas [µm]					2,93

Table 3. The results of TiAlN coating thickness measurement

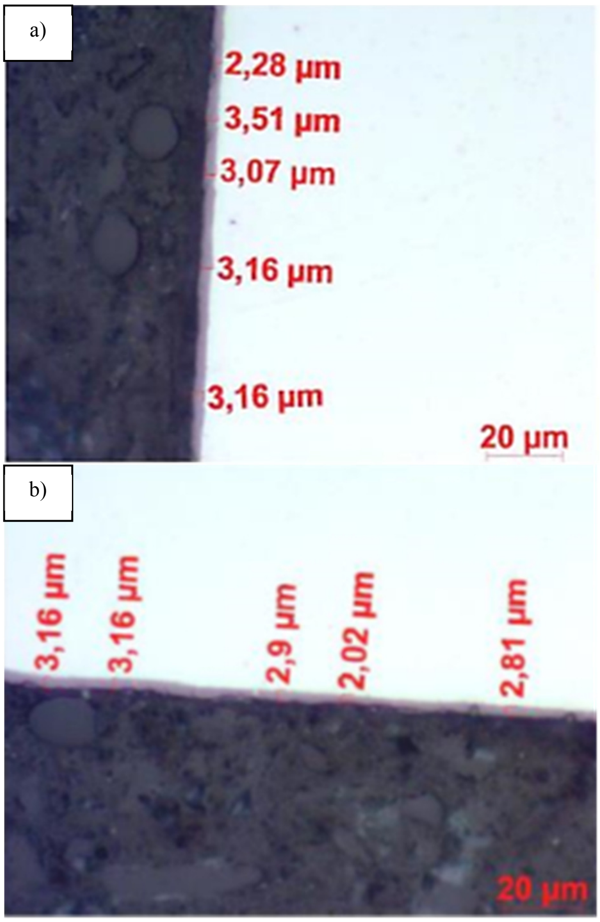

Figure 3. The results from the TiAlN coating thickness measurement. Observation under the light microscope at 20 µm magnification, transverse section: (a) area 1; (b) area 2.

The average thickness of the coating resulting from the thickness measurements of the TiAlN coating of the trimming matrix was 2.93 µm.

The results from the analysis of the chemical composition of the TiAlN coating for tree areas of the trimming matrix is presented in Table 4, and the results from the analysis performed on an SEM scanning electron microscope for the presence of given elements in the TiAlN coating are shown in Figure 4.

Area	C	N	Al	Ti	Cr	Fe	Mo	W
1	3,93	24,48	19,38	31,55	1,01	17,60	0,92	1,11
2	4,60	23,22	19,64	30,64	1,08	20,16	-	0,65
3	2,97	24,21	20,28	31,92	1,06	17,64	-	1,42

Table 4. The results from the analysis of the chemical composition of the TiAlN coating

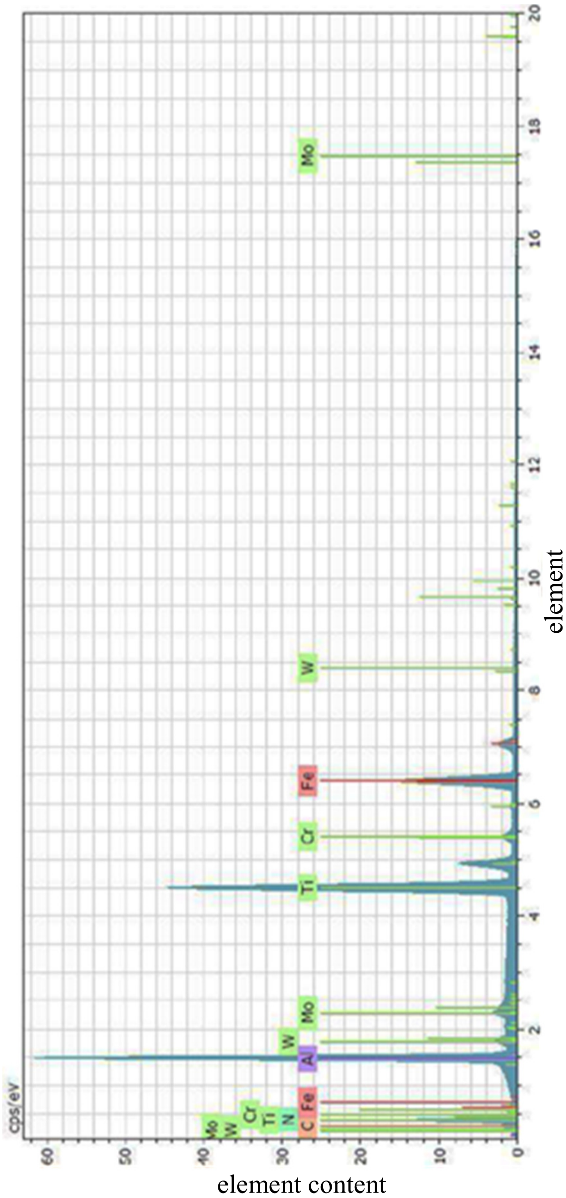

Figure 4. The results from the analysis performed on an SEM scanning electron microscope for the presence of given elements in the TiAlN coating.

The average content of given elements in the surface layer from the TiAlN coating: C – 3,83 %, N – 24,14 %, Al – 19,77%, Ti – 31, 37 %, Cr – 1,05%, Fe – 18, 47 %, Mo – 0,92 %, W – 1,06%. In the case of elements' content, i.e .: Fe, Mo, W, Cr and C in the surface layer, their content may result from the measurement method, because these elements from the native material do not occur in the TiAlN layer.

Examples from the analysis of the TiAlN coating structure and deformation of the adhesion measurement sample are shown in Figure 5.

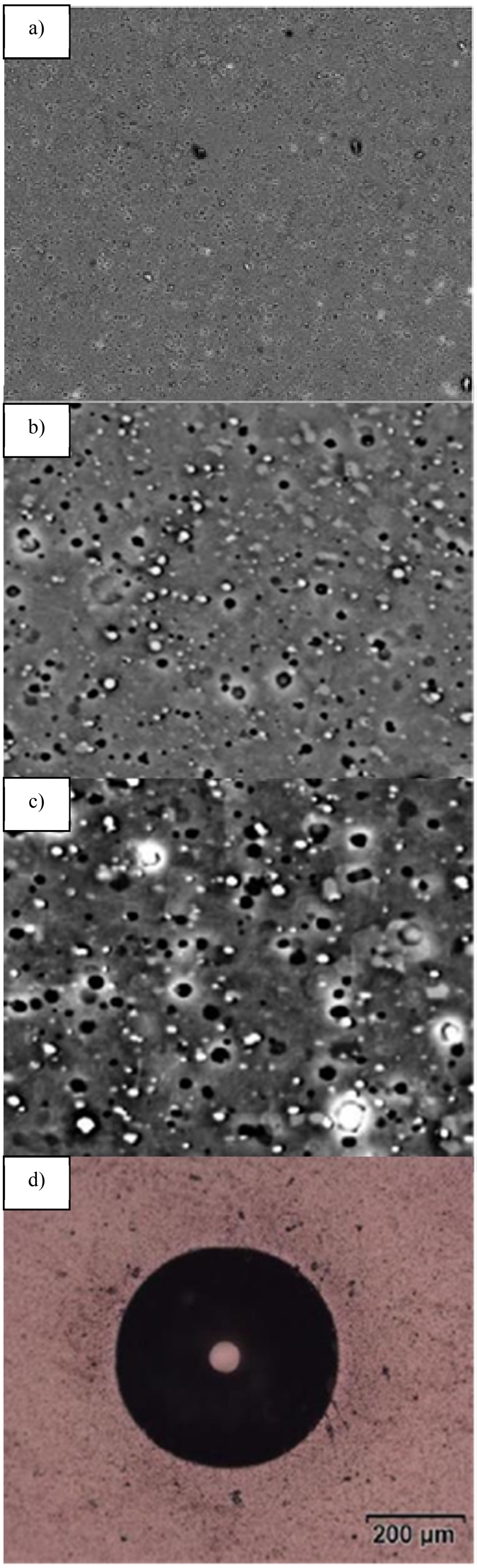

Figure 5. The structure of the TiAlN coating: (a) 1000x; (b) 5000x; (c) 7000x; (d) deformation of the adhesion measurement specimen.

No nonconformities were identified after analyzing the structure of the TiAlN coating at a magnification of 1000x, 5000x and 7000x respectively. There were no cracks or delamination on the surface of the sample, which proved good adhesion of the coating with the substrate.

An analysis was carried out comparing the results from the exploitation of four trimming matrixes, where the number of work cycles for coated TiAlN coatings and for non-TiAlN coated matrixes were examined. The results from the analysis are shown in Figure 6.

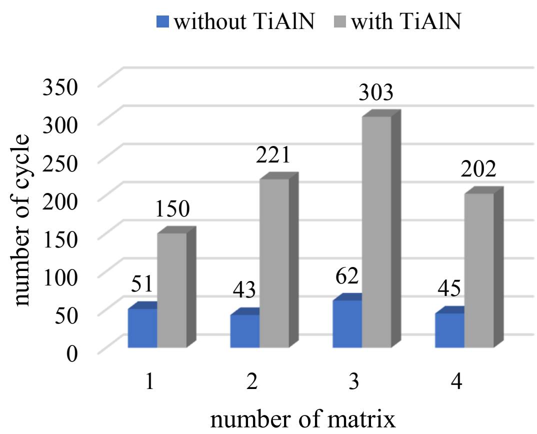

Figure 6. Results from the analysis of four trimming matrixes coated with TiAlN coating and without TiAlN coating in terms of the number of cycles in the operation process.

The results of the analysis showed that the matrixes with the TiAlN coatings have higer life than the matrixes without the TiAlN coating.

On the result of the analysis may influence other factors which should be noted during further research on the service life of TiAlN coatings. These factors are presented in the Ishikawa diagram in Figure 7. During the next research of the measurement of matrixes' life may be useful to consider the factors which could cause the variability of results. It should note on the way workers work both during preparing the samples to research and during the use of samples on the machine. It is important the method and the systematic measurements and also the work according to the standards. The important factors are the machine, used tools and material, on which influence the indirect factors, i.e.: type of material, parameters, efficiency, TPM, load, the way of processing and time of exploitation. It would be necessary to observe the environment of work, for example, lighting and order in work positions, which sometimes neglected can influence on the results of measurement.

4 CONCLUSION

After the research, it was concluded that in temperature 500 °C and time about 100 minute is possible to achieve the average thickness of TiAlN coating equal 2,93 µm. The analyze let to stated no incompatibility on the TiAlN coating on trimming matrix and absence of cracks and delamination on the surface of the sample, which proved good adhesion of the coating with the substrate.

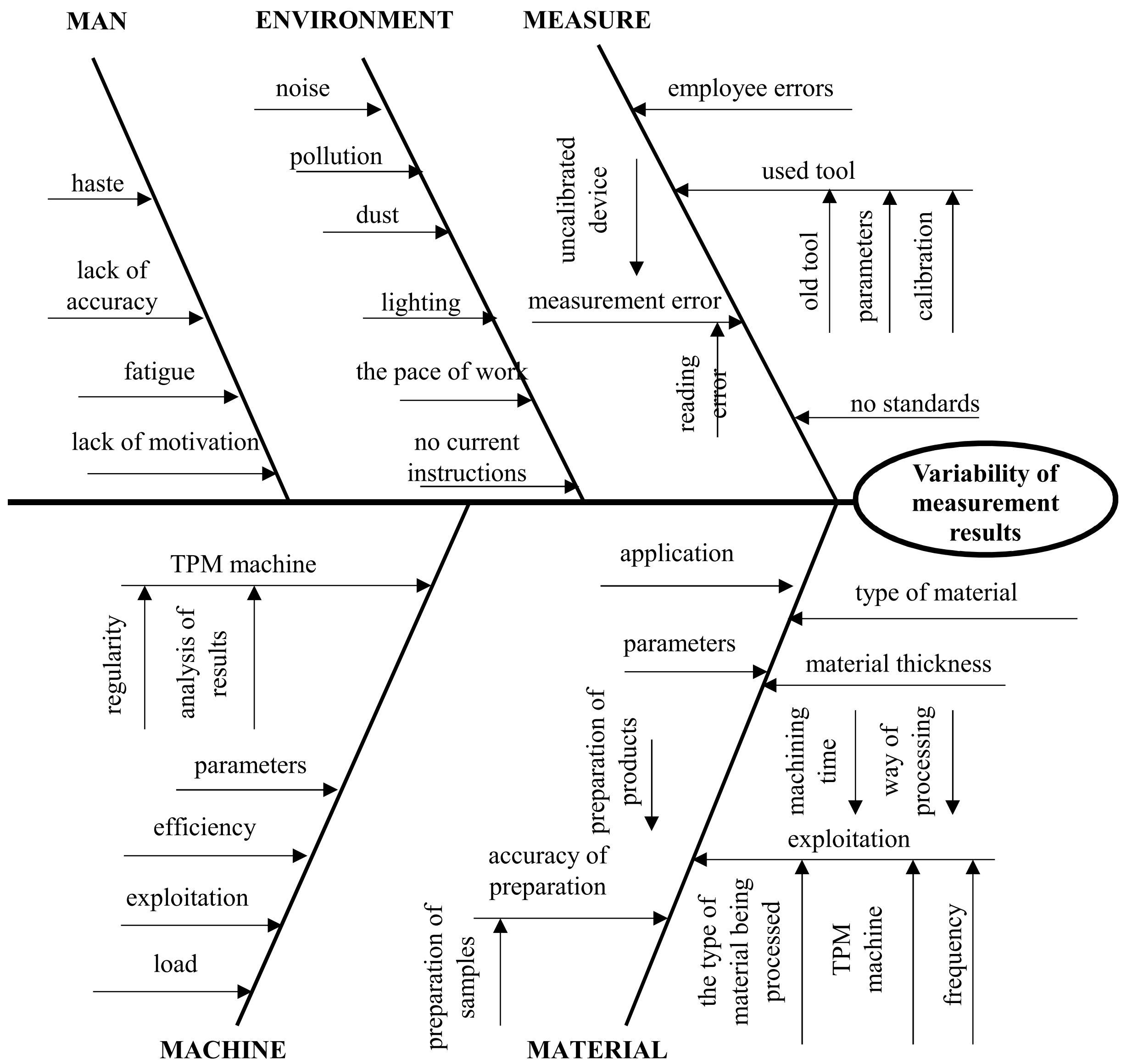

Figure 7. The Ishikawa diagram with the factors influence on measurement results.

The analyze of the possibility of increasing the life of the trimming matrixes by TiAlN coating showed that the trimming matrixes with TiAlN coating (thickness 2,93 μm) were characterized about four times longer life, which indicates their better performance.

It was concluded that the trimming matrixes with TiAlN coating:

- made several times more cycles than the matrixes without TiAlN coating,
- were quality good,
- did not require additional regeneration during operation, which significantly affected the economic effects associated with production.

It was showed that the TiAlN coating is useful to increase the tools life used in industry (in these of example - production of screwsIt seems purposeful to make next research in which will be analyzed the influence the coating thickness on the increasing matrixes life. The analyze and the results can be base to used the TiAlN coating on the tools used in industry in the aim to increase their life, and the Ishikawa diagram which was proposed can be useful to find the factors which let to make efficient researches.

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AUTHORS ADDRESSES

a. mgr inż. Dominika Siwiec
Rzeszow University of Technology,
Faculty of Mechanical Engineering and Aeronautics,
al. Powstancow Warszawy 8
35-959 Rzeszow
Poland
E-mail: d.siwiec@prz.edu.pl

b. dr hab. inż. Andrzej Pacana, prof. PRz
Rzeszow University of Technology,
Faculty of Mechanical Engineering and Aeronautics,
al. Powstancow Warszawy 8
35-959 Rzeszow
Poland
E-mail: app@prz.edu.pl

POTENTIAL OF USING RENEWABLE ENERGY SOURCES FOR THE ELECTRICITY PRODUCTION IN VOJANY THERMAL POWER PLANT

Michal Stričík [1] – Jaroslav Dugas [2] – Vojtech Ferencz[3] – Gabriel Szabó[4]

Abstract: *Slovak as well as world economy is dependent on security of energy sources. Addressing this problem can also be in the use of renewable energy sources, which include biomass and energy recovery. In this context, we focus on the analysis of the use of biomass and waste co-incineration together with black coal in Vojany Thermal Power Plant belonging to Slovenské elektrárne, a.s. The achieved results point to positive facts related to the better price for 1 MWh of electricity produced, the possibility of deduction of CO_2 emissions as well as a positive impact on Slovakia's trade balance. These effects can be achieved if the analysed power plant is changed to a waste recovery facility and the use of these energy sources.*

Keywords: energy recovery, sewage sludge, biomass, waste incineration, power plant, alternative fuel, renewable energy.

1 INTRODUCTION

The European Union (EU) depends on more than 50 % of imports of primary energy sources, often from politically or economically not very stable regions. The EU Energy Strategy therefore focuses mainly on energy efficiency and the use of RES (Renewable Energy Sources), whose potential for individual member countries is not negligible. The energy principles and targets by 2020 are based on the "Europe 2020" strategy and are further elaborated in the "Energy 2020 Communication: A strategy for competitive, sustainable and secure energy". In one of its five headline targets, "Europe 2020" targets the "Climate Change and Energy Sustainability" area, where it foresees:

- to reduce greenhouse gas emissions by up to 20 % (or up to 30 % under a wider global agreement) compared to 1990 levels,
- to obtain 20 % of energy from renewable sources,
- to achieve 20 % increase in efficiency of energy use.

The energy policy of the Slovak Republic is significantly influenced by the EU targets, which are to reduce the greenhouse gas emissions by 20 %, to increase the energy efficiency by 20 % and to use the RES to 20 % by 2020. The objectives and priorities of the Slovak Republic's energy policy are also set to meet the targets set at EU level. [1]

The strategic objectives are based on three pillars: energy security, competitiveness and sustainability. The use of domestic RES, in particular biomass, hydro-energetic potential and secondary energy sources, increases energy security by reducing dependence on imports.

The Slovak Republic has the obligation to increase the use of RES in gross final energy consumption from 6.7 % in 2005 to 14 % in 2020. The basic document in relation to the achievement of the 14 % target is the National Renewable Energy Action Plan, which was approved by the Government of the Slovak Republic on 6 October 2010 by Government Resolution No. 677/2010. This document envisages a 15.3 % use of RES in relation to the gross final energy consumption in 2020.

In connection with consideration of waste incineration we must also take into account the new Waste Act [2] which came into force on 1 January 2016 and its set of concepts and the definition of basic competences, from which we select at least the following:

Article 5 Waste management equipment

(2) Waste recovery equipment is an installation intended to perform at least one of the activities listed in Annex. 1 (Waste Act), which consists of a technical unit with a set of machinery and equipment operated according to the documentation thereon, the activities of which are related to each other and have a technical continuity; if such a device is rigidly connected to the structure due to its design, the waste management equipment is also considered to be the space in which the device is located. (e.g. R - 1 use as a fuel or to obtain energy in another way)

Article 18 Waste incineration

(1) The incineration of municipal waste in municipal waste incineration plants is considered as recovery of waste by the activity R1 according to Annex No. 1 (Waste Act) if energy in the form of heat or electricity is produced for commercial purposes and if the energy efficiency of such equipment is equal to or higher than

a) 0.60 if it is an installation that has been licensed to operate until 31 December 2008 in accordance with generally binding legal regulations; or

b) 0.65 for an installation that has been licensed to operate after 31 December 2008.

(2) Incineration of other than municipal waste at waste incineration plants is considered as an energy recovery of waste by the activity R1 according to Annex No. 1 (Waste Act) if the following conditions are met:

a) it is the activity mentioned in Article 3 par. 13,

b) the purpose of waste incineration is energy production,

c) the energy generated by this waste incineration is greater than the energy consumed during the incineration process,

d) during waste incineration most of the waste must be consumed; and

e) most of the energy obtained during the incineration of waste has to be recovered and actually used, the use being either instantaneous in the form of heat produced by incineration or after processing in the form of electricity.

Emissions trading also has a major impact on electricity generation.

The Emissions Trading Scheme (EU ETS) is the cornerstone of the EU climate change policy and a key tool to reduce greenhouse gas emissions in a cost-effective way. The system works under the "Ceiling and Trade" principle. A ceiling is set for the total amount of greenhouse gases that can be emitted by the devices that the system covers. The ceiling lowers over time to reduce total emissions. Under this ceiling, companies receive or buy emission allowances that they can trade with each other as needed. They can also buy a limited amount of international credits from saving projects around the world. If a company reduces its emissions, it can leave free quotas to cover its future needs or sell them to another company that does not have enough allowances. [3]

In the Slovak Republic, ICZ Slovakia PLC has been performing the function of the national emission allowance manager since January 01, 2013. The function is performed under the Contract No. 62/2012-8.2, concluded between the Ministry of the Environment of the Slovak Republic and ICZ Slovakia, PLC. This administrator establishes and keeps a holding account of the operator in the Union registry for each operation that has a permit to emit greenhouse gas emissions into the air issued by the district authority. [4]

The prices of CO_2 emissions are subject to market changes, and their development can be seen in the following graph.

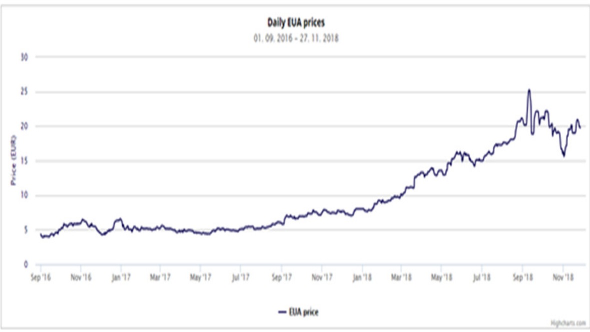

Fig. 1 Developments in CO_2 prices between 9/2016 and 11/2018

Source: https://virtusegroup.com/

In the monitored period, the price started at € 4.38/t CO_2 on September 01, 2016, with the highest price of € 25.23/t reached on September 10, 2018. At the end of November 2018, the value dropped to € 19.29/t. In our calculations, the average value for the years 2016 and 2017 will be used, with the higher CO_2 price that could be achieved on the market in the future will have a beneficial impact on the incineration of biomass and biomass waste in relation to the saved CO_2 when incinerated.

2 WORK OBJECTIVE AND METHODOLOGY

The aim of our contribution is to evaluate the possibility of using renewable energy sources from biomass in the form of wood chips or waste biomass in the form of sewage sludge and municipal waste for electricity production in Slovenské elektrárne, a.s. – Thermal Power Plant Vojany (SE, a.s. – EVO).

The data for writing the paper were obtained from available data from the (SE, a.s. – EVO), professional literature, and valid legislation.

SE, a.s. – EVO is located in the Michalovce district in the south-east of Slovakia, figure 2.

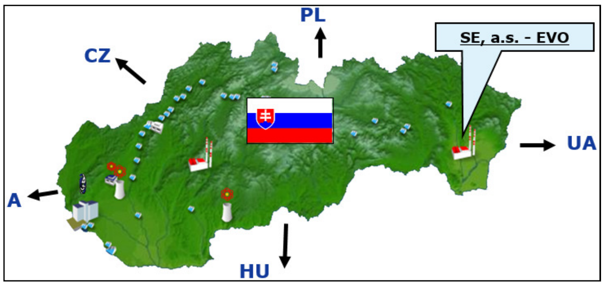

Fig. 2 SE, a.s. – EVO location

Source: Own processing based on SE, a.s. – EVO

At present, two modernized units of the original twelve units are in operation at the power plant. The total installed power of these two units is 220 MW (2 x 110 MW). The most important aspects of the decision to build a thermal power plant were the advantageous position near the Ukrainian border, the maximum shortening of the wide-gauge track, after which the semi-anthracite coal is imported from the Donbasko-Kuzbecki mining area, and the possibility of cooling water from the Laborec River.

The main mission of the power plant is to provide support services for the transmission and power system of the Slovak Republic in the highest quality, safety and reliability, with the lowest impact on the environment. Co-incineration of biomass contributes to meeting the goal of operating the power plant in a cleaner, environmentally-friendlier way. An important contribution of the power plant for Slovakia's electricity grid is a wide range of control power of 40 - 110 MW for Units No. 5 and 6 of the *SE, a.s. – EVO* which is presented on figure 3. [5]

In these units, black semi-anthracite coal is used for their fluid boilers with a heating value of 25 - 27 MJ/kg. It contains about 6 - 8 % of water, has an ash content of 15 - 17 % and a sulphur content of 0.2 - 0.3 %. To the carbon, the biomass is added in the form of wood chips as an additional component. The wood chips are added for both Units 5 and 6 in different calorific ratios. The heat of the wood chips is 8 - 10 MJ/kg, the water content is 40 – 45 % and the ash content is 1 - 2

%. In incineration, natural gas is used as the supporting fuel with the heating power of 34.25 MJ/m^3. The gas is used specifically for the ignition process and for the stabilization of incineration in boilers.

Fig. 3 SE, a.s. – EVO

Source: Own processing based on SE, a.s. – EVO

In the years 1997 - 2001, the reconstruction of Units 5 and 6 was carried out. The reason for the reconstruction was to improve the economic, technical and environmental conditions. The restoration consisted of the exchange of the steam boiler, steam turbine, separators, generator, control system and electrical equipment. After the reconstruction, the units use the incineration technology in the fluidized bed circulation. Thanks to the technology, the adverse impact of the operation on the environment has been reduced. With the new technology it is possible to incinerate charcoal with a higher quality range.

Unit 5:

Thanks to technological modifications, the power plant can incinerate biomass in the form of wood chips in calorific volume of up to 22 %.

An experimental introduction of biomass incineration started in 2007 and commercial co-incineration of biomass in the calorific volume of 4 % was launched in 2009, which is about 65 t/day, 1,450 t/month. The shift took place in 2012, when a special transport line from one of the two trays of the disused 4th Unit was built during the reconstruction. The calorific share was increased to 20 % due to the direct input of biomass to the boiler, which is approximately 320 t/day, 4,400 t/month. Since 2014, it has been 22 %, approximately 350 t/day, 6,500 t/month with the ability to regulate fluctuations from 4 to 22 % in order to maintain boiler dynamics (support services).

The dosing power is controlled in the range of 20 - 100% and controlled depending on the amount of charging of coal into the incineration chamber (boiler). This enables the operator to choose and change the incineration ratio of coal and biomass.

Unit 6:

Unit 6 co-incinerates 6 % of the calorific biomass ration. This is less compared to Unit 5 because Unit 6 has no separate biomass transport line into the boiler. For Unit 6, the biomass is pumped directly onto the conveyor with black coal. The situation of Unit 6 can be solved by building a separate biomass transport line. The calorific share of biomass would then be equal to Unit 5. Funding for the reconstruction could be possible, for example, through state support, support from the European Union or investment by the power plant owners. Co-incineration began on Unit 6 as well as Unit 5 in 2007 by testing biomass incineration. In 2009, commercial co-incineration in a calorific volume of 4 %, about 65 t/day, 1,450 t/month was also launched with Unit 5. By covering the landfill in 2010, the quality of the fuel (wood chips) increased, resulting in an increase of the incinerated biomass to 5 %, which is about 80 t/day, 1,780 t/month. In 2014, this calorific share increased to about 90 t/day, 2,000 t/month.

In 2017, the wood pellets co-incineration tests were carried out in Unit 6. The investment objective was to optimize gas consumption at start-up and to reduce the daily reserved gas capacity.

The essence of the project implementation is to separately feed the pellets into the boiler, replace the part of the hot gas with pellets and ultimately reduce the daily reserved gas capacity with the positive economic impact of the project.

Based on the savings predicted by the project, the 2018 investment was approved and implemented with the expected savings in optimizing daily reserved capacity (reduction from 50,000 m^3 to 40,000 m^3) and one-off expected savings of € 12,000.

In addition to wood chips, sewage sludge can be used as alternative fuels in electricity generation.

Sewage sludge. "These are complex heterogeneous suspensions of inorganic and organic matter separated from waste water or generated by technological processes of wastewater treatment." [6]

Sludge from urban waste water treatment plants (WWTPs) on average contains 0.5 - 7 % of dry matter. It consists of 60 - 70 % of organic matter and 30 - 40 % of inorganic substances. The solid sludge phase contains approximately 80 % of the suspended particles with the size of above 0.1 mm and about 20 % of the 0.1 mm particle size. In WWTPs sludge is deposited in two forms. In the form of primary sludge which separates from water by sedimentation in sedimentation tanks, and in the form of secondary (activated) sludge. This occurs in the biological stage of waste water treatment and separates from the purified water in the settling tanks. The two types of sludge are combined and concentrated together or separately before further processing. Such bonded sludge is called raw sludge.

“The basic condition of the positive energy balance of the energy use of sewage sludge is the energy-efficient reduction of their moisture. This can be achieved actually only in two ways of drying the sewage sludge:

1. Drying by waste heat.
2. Bio-drying, i.e. by partial composting”.

Drying by waste heat: The most common case of waste heat utilization. This is a reduction in the moisture content of the fuel by means of heat supply when moisture is removed by evaporation.

Partial composting: This is the decomposition of organic waste by microorganisms in the presence of air. This process produces carbon dioxide, water, ammonia, heat, and more stable organic material (compost). In order to save primary raw materials, the compostable waste is returned to the production process for the production of the socially desirable product (in this case the compost). [7]

3 RESULTS OF WORK

This section describes the experiment that was carried out in August 2015. The experiment consisted of electricity production in a fluidized bed boiler with the addition of alternative fuel (AF) to the main fuel (black coal). The AF was created by mixing the wood chips with the sewage sludge in a precisely determined ratio. Each day the AF had a different composition. The difference between experiments was mainly due to the different ratio between the alternative fuel composed of wood chips and sewage sludge on one hand, and black coal on the other hand.

The expertise was intended to theoretically analyse the usability of the sludge energy potential, analyse various options for reducing the sewage sludge humidity, preparing sludge with lower humidity, and verifying the impact of the addition of sewage sludge to the incineration process in the fluidized bed boiler on the basis of experiments.

"The tests were carried out during the normal operation of the unit without the provision of support services. Power regulation was controlled by the operator manually assigning the requested power according to an agreed timetable. Minor power corrections in control tests were needed to stabilize the unit according to the actual boiler status." [8]

Experiments at the power plant have proved effective the co-incinerating process of AF with coal in a proportion of up to 61 % of weight, which is a ratio of sewage sludge with wood chips and coal with a share of up to 22 % of the total fuel weight, but the BAT reference document for large combustion plants expects calorific ratio only slightly above 10 %.

Fig. 4 Import of sewage sludge to SE, a.s. – EVO

Source: Own processing based on SE, a.s. – EVO

Co-incineration of the AF has also had a positive impact on sulphur production. Sulphur (SO_2) achieved in Tests No. 1 and No. 2 average decrease to 300 mg/Nm^3. As a result, the average consumption of limestone also dropped to an average of 1 t/h, while without the AF it is 2.5 t/h at SO_2 volume of 350 mg/Nm^3.

The results of the experiments show that the feasibility of co-incineration processes of sewage sludge and wood with coal in the fluidized bed boiler was clearly confirmed. The process of partial composting can be further optimized, for example by using a higher proportion of sludge to wood. It is also possible to mix around 10 % of the AF in calorific input. [7]

The tests showed the ability to:

Create a homogeneous biodegradable waste blend of sludge and wood chips, transport it to the fuel tank and burn it in the boiler. Adherence to emission limits has also been demonstrated for the following substances: NO_x, SO_2, Dust, CO. In this respect, the boiler efficiency was maintained above the guaranteed value of 92.25 %, as well as the capacity of the unit to operate at a maximum output of 100 MWh and the provision of support services at a trend of 1.5 MW/min. [8]

During the tests, the following facts were found:

- to achieve the homogeneous mixture, strenuous manipulation using bulldozers and a wheel loader was necessary,
- the equipment used for sorting and dosing of biomass at the biomass landfill was operated at a maximum output of 80 – 100 t/h,
- due to the different specific weights of biodegradable waste and black coal, a non-homogeneous mixture is produced when removing fuel from a crude fuel tank,
- non-homogeneous mixture results in fluctuation of boiler parameters.

For long-term burning of biodegradable waste, we recommend the following measures:

- to build a roofed landfill to control the fermentation of biodegradable waste,
- to buy a compost shovelling device for easier blending of raw materials,
- increase the capacity of the biomass line at external coalification,
- to solve the separation of biodegradable waste from black coal in crude fuel storage tanks,
- adjust boiler control software settings,
- to certify biodegradable waste co-incineration support services,
- lobbying to improve the legislative conditions for, SE, a.s. – EVO
- to solve transport logistics and biodegradable waste storage. [8]

Coal combustion economy of alternative fuels co-incineration

In this part of the article we will evaluate the economic possibilities of biomass combustion in SE, a.s. – EVO.

I. For better orientation, the following tables show volumes, average prices, fuel parameters, ash and CO_2 emissions resulting from activities of SE, a.s. – EVO and other organizations whose activities are related to the production inputs that SE, a.s. – EVO buys or would buy if necessary.

Input fuel	Price €/t	Moisture %	Calorific value in delivered condition GJ/t	Ash content %
Black energy coal (BEC)	79.97	8	25.18	17
Wood chips	43.83	33	12.17	2
Sludge (ENERGOKAL)	-8 / 0 / 8	60	4	67
Biodegradable waste	32	45	7.5	10
Biodegradable municipal waste	10	45	7.5	4
Certified ENERGOKOMPOST quality A	29.5	41	8.7	21.5
Certified ENERGOKOMPOST quality B	20.9	46.5	7.4	34.5

Table 1 Input data for cost calculation

Source: Own processing based on SE, a.s. – EVO

The presented calculations do not show the price for the treatment and storage of ash in the conditioned fly ash landfill, which includes a fee to the municipalities in the cadastral area of which the disposal site is located.

In the case of sludge (called ENERGOKAL), there are 3 prices due to the assumption of several possibilities of agreement with the companies that would supply the sludge. The water company would pay for the disposal of the sludge, the second alternative – the company would not pay, and the third possibility counts on the payment by the power plant for the sludge purchase.

In this section we describe the co-incineration of input fuels according to several alternatives. According to the power plant data and the regulation of the Regulatory Office for Network Industries (RONI), we report on the sales price for fuel alternatives that could be incinerated in the power plant.

Planned data	Value	Unit
Price of power electricity without surcharges (valid for the power plant)	40.95	€/MWh
Average price of CO_2 emission allowances	5.77	€/t
Cost for processing and depositing ash in the conditioned fly ash landfill	3.80	€/t

Table 2 Other input data for cost calculation

Source: Own processing based on SE, a.s. – EVO

The average selling price of base electricity for 2017 produced from black coal and wood chips was € 40.95/MWh.

For sludge, which has been modified to a certified product with the working name ENERGOKAL, we also calculate the price of € 40.95/MWh.

Sludge in the form of stabilized waste. This sludge is found in the Waste Catalog under the designation 19 08 05 - Sludge from municipal waste water treatment. It is a sludge that can be used to produce a fermented mixture by aerobic fermentation of biodegradable waste. Support for the production of electricity from this sludge is regulated in the RONI Decree No. 18/2017 Coll., Article 10 (1) (g) No. 8 = € 78.42/MWh.

Biodegradable waste - In the Waste Catalog it is designated as 19 05 01 – Non-composted components of municipal waste and similar waste. As an example of this waste we can mention, for example, waste biomass taken from general parks, gardens and landscaping, but it is unsuitable for the production of compost. The promotion of the production of electricity from this waste is regulated by the RONI Decree No. 18/2017 Coll., Article 10 (1) (g) No. 8 = € 78.42/MWh.

Biodegradable municipal waste - according to the Waste Catalog, this is a waste from Group 20. The waste that is biodegradable and cannot be materially evaluated is usable for our purposes. The promotion of the production of electricity from this waste is regulated by the RONI Decree No. 18/2017 Coll., Article 10 (1) (f) = € 74.83/MWh.

In the following case, the biodegradable municipal waste called ENERGOKOMPOST (hereinafter referred to as EKOMP) has two different qualities. EKOMP quality A and EKOMP quality B. Both fuels are a mixture of wood chips and sewage stabilized sludge that would be fermented in the power plant. The power plant anticipates that the mixture has passed a certification. For EKOMP Quality A, the company calculates with a weight ratio of wood chips = 70 : sludge = 30. For EKOMP quality B with a weight ratio of wood chips = 50 : sludge = 50. The support for the production of electricity from this fermented EKOMP is regulated by the ÚRSO Decree 18/2017 Coll., Article 10 (1) (g) = € 78.42/MWh.

For our calculations, purchase prices of fuels, sales price of electricity according to the fuel used, as well as calorific values are required. Next, we will calculate the amount of fuel needed to produce 1MWh of electric power and the cost in € per 1MWh of the electricity produced. In the case of alternatives where CO_2 taxes are not levied by the state and the legislation of the Slovak Republic, we also add these costs. This is basically just the case of black energy coal.

Calculations of the cost of electricity production according to alternatives

The following calculations determine the amount of fuel needed to produce 1 MWh of electricity. The result is determined by dividing the HR (heat rate = the amount of GJ bound in the fuel required to produce 1 MWh with the technology used in the power plant at Units 5 and 6) and Q (the amount of GJ bound in the fuel). The result is V (fuel quantity) that is multiplied by C (fuel costs). From this calculation we get the CE (cost of 1 MWh of fuel), which indicates how many euros is needed to produce 1MWh. It is still necessary to add to these costs the price of the produced CO_2 emission, but only in the case of fuels which exempt from the fees and charges by the state and the legislation of the Slovak Republic. For this calculation, we need to reduce the C_{CO2} (cost per tonne of CO_2) by M_{CO2} (the tonnage of CO_2 per MWh that the power plant would produce if it replaced the biomass with coal). The input data for the calculation are shown in Table 1 and Table 2.

1. **Fuel: Black coal**

$V_{BEC} = HR / Q_{BEC} = 12.3 / 25.18 = 0.488$ t/MWh = for the production of 1MWh of electricity (with the given heating value of BEC) 0.488 tonnes of BEC is necessary.

$CE_{BEC} = V_{BEC} * C_{BEC} = 0.488 * 79.97 = 39.03$ €/MWh = Cost of production of 1MWh by incineration of BEC is € 39.03.

$CV_{CO2} = C_{CO2} * M_{CO2} = 5.77 * 1.033 = 5.96$ €/MWh = The amount added to the costs as the CO_2 emission cost as this is CO_2 production by incineration of fossil fuels exempt from the charges.

The total cost of 1 MWh, when we add the emission price per 1MWh, is:

$CE_{BEC} + CV_{CO2} = CE_{BEC} + CV_{CO2} = 39.03 + 5.96 = 44.99$ €/MWh

2. **Fuel: Wood chips**

$V_{WCH} = HR / Q_{WCH} = 12.3 / 12.17 = 1.011$ t/MWh = for the production of 1MWh of electricity (with the given heating value of wood chips) 1.14 tonnes of wood chips is necessary.

$CE_{WCH} = V_{WCH} * C_{WCH} = 1.011 * 43.83 = 44.31$ €/MWh = Cost of production of 1MWh by incineration of wood chips is € 44.31.

$M_{CO2} = 1.033$ t/MWh = The amount of carbon dioxide emissions saved, due to the fact that wood chip is exempt from the charges as this is a closed cycle of CO_2 circulation that plants have captured during their lifetime during photosynthesis. This is a so-called zero circulation. That is why their value is not added to the total cost of producing 1MWh of electricity from wood chips.

3. **Fuel: Sludge**

$V_{SLUDGE} = HR / Q_{SLUDGE} = 12.3 / 4 = 3.075$ t/MWh = for the production of 1MWh of electricity (with the given heating value of sludge) 3.075 tonnes of sludge is necessary.

$CE_{SLUDGE} = V_{SLUDGE} * C_{SLUDGE} = 3.075 * (-8) = -24{,}6$ €/MWh = Burning the amount of sludge required to produce 1MWh, Power Plant Vojany will earn € 24.6. This is only the case for an alternative if there is an agreement between Power Plant Vojany and the sludge supplier, where the supplier will be obliged to pay € 8 per 1t of sludge and the sludge will be transported to Power Plant Vojany at their own expense. This alternative is due to the fact that sludge producers have to pay for the disposal of sludge produced by their activities. The cost of transport would be at the supplier's expense.

$CE_{SLUDGE} = V_{SLUDGE} * C_{SLUDGE} = 3.075 * 0 = 0$ €/MWh = In this case, there would be no revenue or production costs of 1 MWh. In the case of this alternative, we anticipate an agreement where the Power Plant Vojany would not pay for the fuel (sludge), but at the same time they would not charge for its disposal. The cost of transport would be at the supplier's expense.

$CE_{SLUDGE} = V_{SLUDGE} * C_{SLUDGE} = 3.075 * 8 = 24.6$ €/MWh = This alternative would arise if an agreement was reached that the power plant would pay for the imported sludge. The cost would already include the transport costs.

$M_{CO2} = 1.033$ t/MWh = Amount of CO_2 emission saved.

4. **Fuel: biodegradable waste (BW)**

$V_{BW} = HR / Q_{BW} = 12.3 / 7.5 = 1.64$ t/MWh = for the production of 1 MWh of electricity (with the given heating value of BW) 1.64 tonnes of BW is necessary.

$CE_{BW} = V_{BW} * C_{BW} = 1.64 * 32.00 = 52.48$ €/MWh = Cost of production of 1MWh by incineration of BW is € 52.48.

$M_{CO2} = 1{,}033$ t/MWh = Amount of CO_2 emission saved.

5. **Fuel: Biodegradable municipal waste (BMW)**

At municipal waste landfills, where waste is separated and subsequently sorted, waste ceases to meet the qualitative parameters for material recovery. It is a pity that such waste ends in waste dumps. In the event of incineration of such waste, its high energy value could be used.

$V_{BMW} = HR / Q_{BMW} = 12.3 / 7.5 = 1.64$ t/MWh = for the production of 1 MWh of electricity (with the given heating value of BMW) 1.64 tonnes of BMW is necessary.

$CE_{BMW} = V_{BMW} * C_{BMW} = 1.64 * 10.00 = 16.4$ €/MWh = Cost of production of 1MWh by incineration of BMW is € 16.4.

$M_{CO2} = 1{,}033$ t/MWh = Amount of CO_2 emission saved.

6. **Fuel: Mixed fuel - wood chips and sludge after fermentation, quality A (EA)**

$V_{EA} = HR / Q_{EA} = 12.3 / 8.7 = 1.41$ t/MWh = for the production of 1 MWh of electricity (with the given heating value of EKOMP A) 1.41 tonnes of EKOMP A is necessary.

$CE_{EA} = V_{EA} * C_{EA} = 1.41 * 29.50 = 41.60$ €/MWh

= Cost of production of 1MWh by incineration of EKOMP A is € 41.60.

7. **Fuel: Mixed fuel - wood chips and sludge after fermentation, quality B (EB)**

V_{EB} = HR / Q_{EB} = 12.3 / 7.4 = 1.66 t/MWh = for the production of 1 MWh of electricity (with the given heating value of EKOMP B) 1.66 tonnes of EKOMP B is necessary.

CE_{EB} = V_{EB} * C_{EB} = 1,66 * 20,90 = 34,69 €MWh = Cost of production of 1MWh by incineration of EKOMP B is € 34.69.

M_{CO2} = 1,033 t/MWh = Amount of CO_2 emission saved.

Revenue:

If electricity was to be produced from sludge, the use of 30,000 tonnes of sludge imported from eastern Slovakia would be envisaged. The same volume of BW would be counted with. In the case of BMW, a volume of 1,000 tonnes is calculated.

In 2017, 607,077 MWh of electricity was generated in the power plant. Of these, 20,994 MWh was produced from wood chips.

Sludge (Mixed fuel): Because of a higher sale price it is better to consider the sludge in calculations as stabilized sludge for its higher sales price. That is why we did not calculate its revenue difference compared to the BEC.

The amount of electricity produced from the BEC and the wood chips is determined by the internal Power Plant Vojany source. This cannot be accurately determined on the basis of the fuel supply and the amount of fuel required for 1 MWh, as this figure is calculated on the basis of the average heating value of the fuel fluctuating during the year.

BEC and wood chips: In 2017, Power Plant Vojany achieved revenues from the incineration of the BEC and the wood chips in the amount of € 24,859,803.15. Costs amounted to € 27,298,118.31. All in all, the production loss of € 2,438,315.16 was achieved.

In the case of stabilized sludge, the amount of revenue is the same in each alternative, as for each alternative, the same purchase price applies as well as the same amount of MWh produced. The difference is, however, when we deduct the fuel costs from sales. Each alternative has its own purchase price that would have a significant effect on the economic performance of the power plant.

- Stabilized sludge 19 08 05 – Alternative 1: If the sludge accounted for under the first alternative would be incinerated in the expected amount, the revenue would amount to € 765,065.52. As the plans counts with incinerating of 30,000 tonnes of sludge and the power plant would receive € 8 for each tonne that it would have disposed of, the revenue of € 240,000 has to be added. Profit from sludge incineration according to Alternative 1 would be € 1,005,065.52, which would be a significant asset for the power plant.
- Stabilized sludge 19 08 05 – Alternative 2: Based on this alternative, the power plant would have the same revenue as in Alternative 1 - € 765,065.52. With this alternative, however, the power plant does not receive a surplus for sludge disposal but still has no fuel costs. Profit is therefore equal to the revenues - € 765,065.52.
- Stabilized sludge 19 08 05 – Alternative 3: With this alternative, the revenue would also be € 765,065.52. But there are also fuel costs. This would be a case if the sludge was bought, for example, from a company that uses sludge for material recovery and sells sludge as a product. The costs would therefore be € 239,997.6. Nevertheless, the power plant would have a profit of € 525,067.92 resulting from the positive difference.
- Biodegradable waste – Municipal waste 19 05 01: In this case, we calculate the same quantity of 30,000 tonnes as for sludge. Revenues would be € 1,434,537.06. This is due to the fact that less fuel is needed to produce 1MWh due to higher calorific value of biodegradable waste. The cost would be € 960,016.64. The profit would therefore be € 474,520.42. In this case, it would be advantageous, but the problem would occur in winter when there is a lack of this waste.
- Biodegradable municipal waste 20...: In the case of this fuel, only 1,000 tonnes are calculated. By incinerating this amount of fuel the sales would be € 45,646.3. The cost of producing electricity from it would be € 10,000. Even here the expected profit of € 35,642.3 would be achieved.

In these calculations, we only counted on the fuels that are essential for electricity production in the power plant, or which could help with their legislative advantage in achieving better economic results. We did not count on gas which is used only for auxiliary purposes at start-up. We also do not count with the cost of storing ash and limestone used in the boilers to capture hazardous substances generated by fuel incineration.

4 CONCLUSION

The aim of the paper was to evaluate the possibility of using renewable energy sources from biomass in the form of wood chips or waste biomass in the form of sewage sludge and municipal waste for electricity production in Slovenské elektrárne, a.s. – Thermal Power Plant.

This is based on the Energy Policy of the Slovak Republic, which is strongly affected by the EU's objectives.

The objectives of the European Union are:

- reducing greenhouse gas emissions by 20 %,
- increasing energy efficiency by 20 %,
- using RES to 20% by 2020.

The goals and priorities of the Energy Policy of the Slovak Republic are set to meet the priorities and targets set at EU level in the energy field by 2020. They are based on the “Europe 2020” strategy. The strategy was elaborated in more detail in the Communication "Energy 2020: A Strategy for a Competitive, Sustainable and Secure Energy".

For the fuel mix of wood chips and stabilized sludge at its fermentation, the cost of electricity produced from the "Energokompost A" was calculated at € 41.60/MWh, from "Energokompost B" it was € 34.69/MWh.

In connection with the economy of the electricity production, the selling price of electricity produced is estimated to be significant for the year 2018 at the level of € 40.95 per MWh produced.

If technology in the Power Plant Vojany meets the conditions of the waste recovery facility, then it will be possible, in accordance with valid legislation and possible legislative changes, to obtain through the "Regulatory Office for Network Industries" advantageous selling prices for the co-incineration of waste or of fermented waste mixture.

On the basis of an analysis of each alternative, we have shown that a profit would be obtained when incinerating new alternative fuels in the form of a mixture of fermented waste. This revenue would be used to cover the loss of black energy coal incineration.

The steadily rising trend in CO_2 emissions prices gives the assumptions for the power plant to pursue this idea.

The Slovak Republic is committed to reducing the amount of landfilled waste and CO_2 production. Applying our proposals will contribute to these goals. In case of appropriate legislative changes in favour of waste recovery, the economy of electricity generation in the analysed enterprise will improve.

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AUTHORS ADDRESSES

[1]doc. Ing. Michal Stričík, PhD.
University of Economics in Bratislava,
Faculty of Business Economy with seat in Košice
Department of Economy
Tajovského 13, 041 30 Košice
Slovak Republic
tel.: +0421(0)55 / 722 31 11
e-mail: michal.stricik@euke.sk

[2]Ing. Jaroslav Dugas, PhD.
University of Economics in Bratislava,
Faculty of Business Economy with seat in Košice
Department of Information and Language Communication
Tajovského 13, 041 30 Košice
Slovak Republic
tel.: +0421(0)55 / 722 31 11
e-mail: jaroslav.dugas@euke.sk

[3]doc. Ing. Vojtech Ferencz, PhD.
Technical University of Košice
Faculty BERG
Park Komenského 19, 043 84 Košice
e-mail: vojtech.ferencz@gmail.com

[4]Ing. Gabriel Szabó
Technical University of Košice
Faculty BERG
Park Komenského 19, 043 84 Košice
e-mail: gabriel.szabo@slovnaft.sk

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