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Every author is responsible for typographical layout and translation of article.

Covers project: Michał ZASADZIEŃ

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ul. Górnych Wałów 42, 44-100 GLIWICE, POLAND
tel. +4832 400 41 02
fax. +4832 400 41 10

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SPIS TREŚCI

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THE WAY OF PLANNING AND ORGANIZING RESEARCH IN RANGE OF ERGONOMICS ON THE EXAMPLE OF OBSERVATION OF LAPAROSCOPIC SURGERIES

1.1 INTRODUCTION

A work in every field of human activity is, on the one hand, connected with the desire to achieve benefits for society manifested in the broadly defined services and production, on the other hand may result in negative consequences for the working man. These adverse effects could be inter alia fatigue, pain, illnesses, or even fatal accidents. The development of modern civilization shows that a man is the factor within the process of work that deserves the most attention due to its numerous physiological, strength and adaptive limitations. A man should therefore be the special element with respect to which the whole technical, environmental and organizational sphere conditioning the implementation of specific work processes is designed.

A science that deals with the adaptation of such a work environment to human mental and physical capacity, and whose main aim is the work humanization, is ergonomics. The dominant area of activity which places a particular emphasis on research in the field of ergonomics is the industry. This is reflected in the contents of articles that are published in recognized dedicated journals, among which are: Human Factors and Ergonomics in Manufacturing & Service Industries and International Journal of Industrial Ergonomics.

On the ground of multi-annual and extensive studies in the field of industrial ergonomics, a number of papers on the methodology of ergonomic research, including the used for decades and proven methods of ergonomic diagnosis and assessment were developed. These methods are inter alia OWAS [7], RULA [9], REBA [6] as well as the methods based on an energy expenditure tables according to Lehmann [8]. Despite the fact that industrial activity represents the main domain where research in the field of working safety is developed, it is, however, not the only area where ergonomic intervention is absolutely necessary.

Another area of human activity, characterized by the lack of using ergonomic principles and which carries many risks for employees, is the field of health care, and within it the area of laparoscopic surgery.

Surgical procedures are performed in special conditions of working environment. On the one hand, they must ensure patient safety while maintaining the correctness of implementation of medical procedures and specific sanitary regime, on the other hand, the working conditions should ensure the effective performance of surgeries. The observed development of medical methods and techniques is directed to enhancement of the effectiveness of treatment of patients. Along with the development, the degree of the medical equipment complexity increases at the same time. This changes the organization of work in the operating room and the requirements for exploitation of the equipment. The results of these changes are certainly positive for the patient. However, they imply the specific problems for professionals' health. Surgeons perform their operations in awkward body positions causing musculoskeletal disorders [4, 9], and unsuited medical devices handles to the anthropometric characteristics and predispositions of surgeons cause discomfort, fatigue, numbness and paresthesias of hands [2, 10].

Finally, the specificity of work during laparoscopic surgery, which forces on surgeon performing their operations under pressure of effectively and quickly carrying out the surgery, minimizing the cost of the procedure [2], and also the increase of technical equipment variability and a high degree of complexity of how to do even simple procedures, causes the necessity of increased attention over the whole surgery and thus the severity of pain and general fatigue of a surgeon [3, 4, 5].

In addition, the need for more advanced studies in the field of ergonomics in laparoscopic surgery is the result of the survey carried out in the framework of project (implemented in years 2012-2014): Online Vocational Training course on laparoscopy's ergonomics for surgeons and laparoscopic instruments' designers (Lifelong Learning Program: Leonardo da Vinci Multilaternal Projects for Development of Innovation, Agreement number: 2012-3649/001-001, financed by National Agency for Lifelong Learning Programmes Organismo Autónomo Programas Educativos Europeos (OAPEE)), where Silesian University of Technology acts as the project partner. The survey was conducted in six hospitals in the Silesia region of Poland for a population of 56 surgeons performing laparoscopic procedures. One of the issues raised in the survey were the types of ailments that occur most often during or shortly after laparoscopic procedures. Most of the respondents pointed out an overload in the back muscles, shoulders and neck. Among other the identified negative consequences are listed:

- numbness and lack of feeling in the fingers,
- calluses on the fingers,
- musculoskeletal disorders,
- general physical and mental fatigue.

The indicated musculoskeletal disorders as well as the overload of the body are mainly caused by the position at work. According to the respondents the main factors contributing to adoption of a specific body position during surgeries are:

- patient positioning,
- setting the operating table,

- type of laparoscopic surgery,
- monitor setting,
- the need of using pedal of foot activation.

In turn, the factors causing physical loads of operators are mainly:

- duration of the procedure,
- awkward body position,
- monitor setting,
- tools handle design.

The above presented prerequisites for ergonomics research in the field of laparoscopic surgery force on researchers the use of specific ergonomic methods. These methods can be largely taken over from the industrial field. However, the same way of planning and organization of research enabling their use must be adapted to, different from the industrial, specifics of work in the operating room. The differences are here substantial and in general cases relate to the following aspects:

- predictability of events: in industry: a work is based on repetitive patterns of operations (especially in manufacturing); during surgeries there is a high degree of variability of operational activities and there is the need to take different decisions, moreover, a surgeons' activities exhibit a high degree of dynamism and unpredictability in terms of daily duties;
- availability of a research field: for industry: an access to the test objects (people and equipment) is usually open; during surgeries the access to the operational field is limited because of the presence of special zones: "clean" (inaccessible to the researcher) and "dirty" (accessible to the researcher);
- availability of working tools being a subject of ergonomic analysis: in the industry an access to the tools is open, in health care (hospital) an access to surgical tools is limited due to the sterilization procedures;
- distribution of measuring apparatus: in the industry there are usually no restrictions on the distribution of the measuring apparatus, particularly an apparatus placed on the body of a worker; during surgery, there are numerous restrictions on the placement of equipment in the workplace and on the body of a surgeon because of the sanitary regime inside operating room.

1.2 OBJECTIVE AND SUBJECT OF RESEARCH

Taking into account the indicated in Introduction prerequisites for the need of ergonomics research in the field of laparoscopic surgery, and simultaneously the differences in the traditional approach to research in the industrial field forcing the necessity of adjusting the research schemes to the specific environment in health care, the following objective of this article was formulated:

The objective is to present the methodology for the planning and organization of research, based on techniques of observation, conducted in the work environment of laparoscopic surgeons in order to improve ergonomics and conditions of performing

surgical procedures. The aim of the study is first of all the possibility of using ergonomic assessment methods based on observation of work processes, i.e. OWAS, REBA or RULA methods. The methodology was based on the empirical research conducted in District Railway Hospital (DRH) in Katowice, Department of General Surgery with Sub department of Metabolic and Bariatric Surgery.

In particular, the results of the research made it possible to recognize and analyze in details the problem areas on how to video record laparoscopic procedures, as well as perform ergonomic measurements of an operator's position in real and simulated surgeries. The particular objectives of the research are:

O1 Recognition of the limitations and development of guidelines on how to record the course of laparoscopic surgeries;

O2 Definition of the measurement path and development of guidelines for acquisition of data about momentary body poses and volatility of position of the operator's body while performing the surgical procedures,

O3 Development of the concept of processing research material for the ergonomic analysis in range of performing laparoscopic surgeries.

The subject of research is the following type of laparoscopic surgeries:

- removal of the gallbladder (cholecystectomy),
- bariatric surgeries: partly removal of the stomach (sleeve gastrectomy) that is a resection of the greater curvature of the stomach along the stomach bottom; the surgery of gastrointestinal bypass (gastric bypass) that is the preparation of gastric tank and intestinal anastomosis by method Y-en-Roux,
- inguinal hernia surgery involving the preparation of hernia sac and its removal as well as the sewing a synthetic mesh in (hernioplasty TAPP).

The selection of these procedures was intentional and planned. Its purpose was to provide the researchers with a diverse research material in terms of: time of performing surgery, type of surgical instruments, the number of staff, patient positioning, the surgical team work organization and arrangement of laparoscopic instruments.

1.3 MATERIAL AND METHODOLOGY

The manner of realization of main objective and particular objectives was based on the research material, the sources of which were empirical studies conducted by the authors. The ways of data acquisition were following:

- direct observation, the subject of which were:
  - preparatory actions for recording laparoscopic surgeries,
  - the real surgeries;
- the interview with the participants of laparoscopic surgeries.

Data collection was done using the following recording means:

- 2 digital cameras Sony HDR-XR550 used to recording preparatory actions and laparoscopic procedures (Figure 1.1a),

- the set of the measuring apparatus CAPTIV in the form of wireless sensors (goniometer + torsiometer) recording in continuously way the positions of selected surgeons' body segments during surgery (Figure 1.1b).

a) 

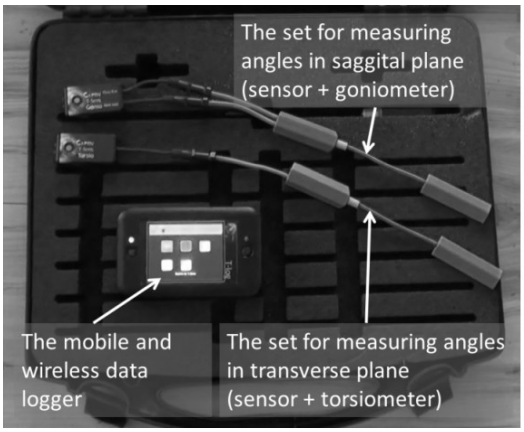
b) 

Fig. 1.1 The recording means
a) digital camera Sony, b) the set for the wireless measuring body position

The studies were conducted in the period from January 2013 to June 2014 in the DRH in Katowice. There were observed (recorded) surgeons in the number of n = 4 possessing experience in performing laparoscopic procedures, who are differentiated in terms of physical characteristics: weight, height and body structure. The group of surgeons was homogeneous in terms of gender, i.e. 100% of them were male. Each of the operators involved in the observation was informed about recordings and consented to it. In addition, the observations of bariatric procedures have been complemented in 2014 by the use of apparatus for wireless measurement of body position.

Table 1.1 shows a quantitative summary of collected source material.

Table 1.1 Quantitative summary of the source material of recorded laparoscopic surgeries

Type of surgery	Video recordings in years	
	2013	2014
Cholecystectomy	2	0
Hernioplasty TAPP)	2	0
Sleeve gastrectomy	1	16
Gastric bypass	0	2
Total	**5**	**18**
	23	

There was used the same medical equipment in all registered medical procedures, composed by: the operating table and laparoscopic column Olympus 3D with the following devices: monitor, light source, laparoscopic camera, fiber optic telescope, insufflators, suction-flushing pump, electrosurgical module, generator for cutting and coagulation of soft tissues.

Table 1.2 Summary of surgical instruments

	Cholecy-stektomy	Hernioplasty TAPP	Sleeve gastrectomy	Gastric bypass
Veress Needle	X	X	X	X
Trocars	X	X	X	X
Safety graspers	X	X	X	X
Retractors				X
Harmonic knife	X	X	X	X
Laparoscopic scissor	X	X	X	X
Clip applier	X	X	X	X
Laparoscopic hook	X	X		
Extractor	X		X	X
Linear endostapler			X	X
Linear and circular stapler				X
Laparoscopic vice		X		X
Surgical hook	X		X	X
Aquapurator	X	X	X	X
Hook probe	X	X		X
Calibration probe			X	X
Bifunctional pedal of foot activation	X	X	X	X

Another group in this category is a group of laparoscopic instruments. For this purpose, before the video recording of surgeries and ahead of time, the photographic registration of laparoscopic instruments used in each of the surgery type was carried out as well as the simulation of bariatric surgery with the use of laparoscopic instruments was made. During the surgeries carried out in real conditions as well as surgery in simulation conditions there were used the instruments from many manufacturers and that are most commonly in the practice of DRH in Katowice.

Table 1.2 shows a summary of surgical instruments with division into individual laparoscopic procedures. Figure 1.2 shows an example of two sets of surgical instruments: for cholecystectomy (Figure 1.2a) and sleeve gastrectomy (Figure 1.2b).

a) **b)**

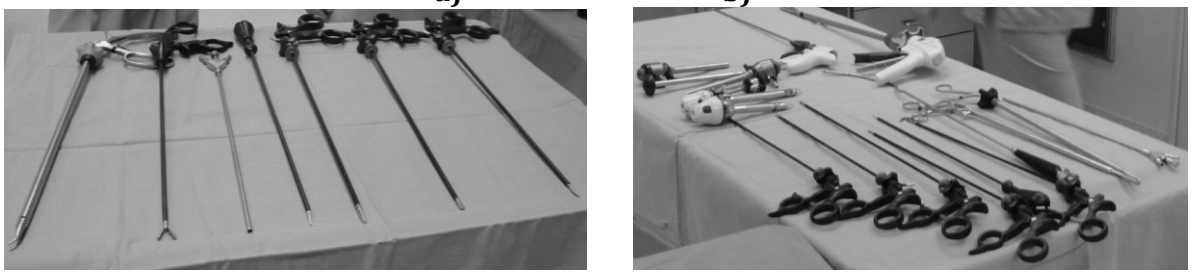


Fig. 1.2 The examples of sets of laparoscopic instruments for a) cholecystectomy b) sleeve gastrectomy

The surgical instruments used in the surgeries, which were a subject of observation, can be classified into two categories. The first category concerns the division of reusable and disposable instruments. Disposable tools were used by the surgeons in bariatric procedures, and an example a disposable tool is endostapler. The second division includes a division of instruments that have universal character and were used in each of the recorded surgeries and instruments that are specialized and assigned to the certain type of surgery.

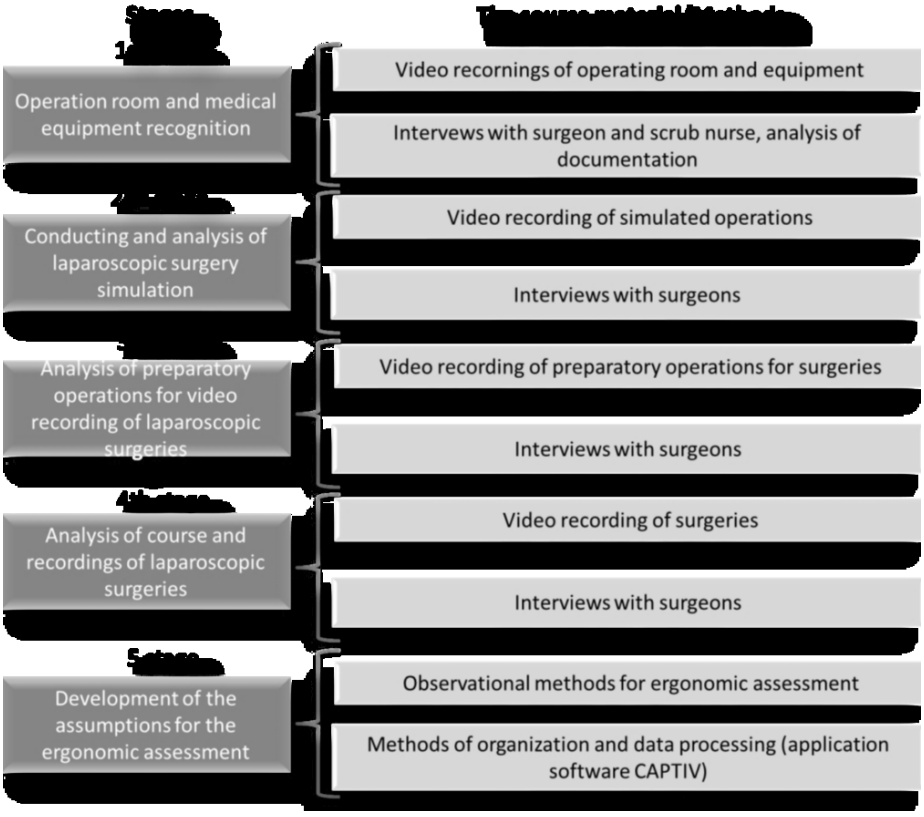


Fig. 1.3 The stages of planning and organization of research concerning ergonomics of laparoscopic surgeries

The collected empirical material became the basis for the development of a standardized method of planning and organization of research in the field of ergonomics in laparoscopic procedures, the stages of which are shown schematically in Figure 1.3.

Stages 1st and 2nd have planning nature and concern mainly the recognition the assumptions and possible ways to implement research, in turn, stages 3rd to 5th have organizational nature and focus on grouping activities and resources, a result of which the specific research goals will be achieved.

1.4 PRESENTATION OF RESEARCH RESULTS AND DISCUSSION

There is presented the results of certain stages of work, as a documented track of implementation of the main and particular objectives of the research (see p. Objective and subject of research).

Operating room and medical equipment recognition

The aim of the stage was to identify the technical and organizational constraints related to the planned observations of laparoscopic surgeries. Figure 1.4 shows the diagram of an operating room including the location of people and equipment, as well as the areas: "clean" and "dirty".

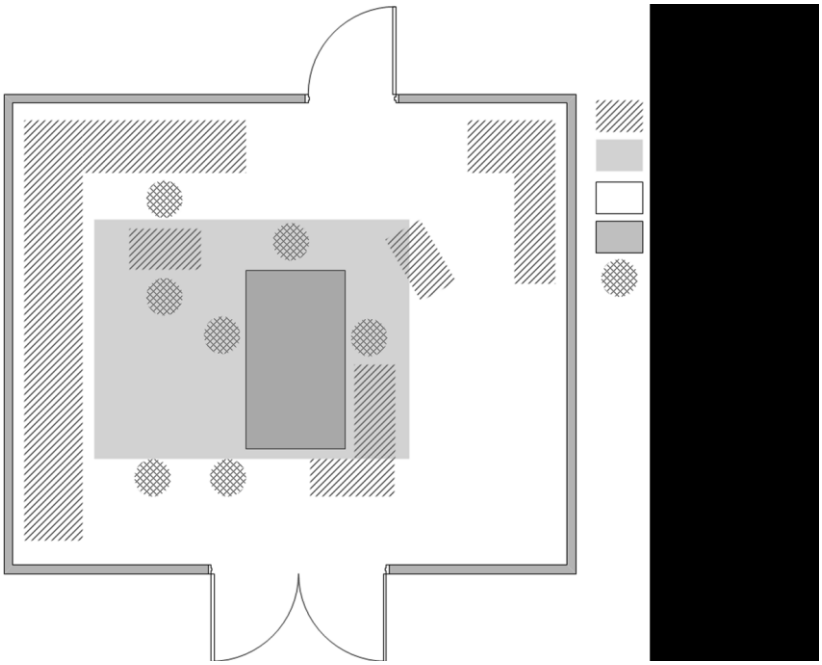


Fig. 1.4 The scheme of layout in operating room

Depending on the type of surgery and the conditions of its implementation the number of medical personnel generally ranges between 3 to 4, and the number of nursing staff is usually 3. There were identified the following limitations associated with video recording of surgeons' operations during surgery which are the result of examination of the operating room, as well as the analysis of interview with the surgeon and the scrub nurse:

- a camera operator can move only in the "dirty" zone;
- the recommend at least two directions of video recording (front and side) of surgeon's operations may not be able to meet because of the barriers in the form of equipment and people involved in the surgery;
- the initial location of the camera operator (or operators) may vary due to the dynamics of the surgical procedure, such as changing the surgeon's position or location of the surgical team members.

Taking into account the specified constraints, it is recommended to use the small hand-held cameras without using tripods because of a relatively high frequency of moving the camera operator during the surgical procedure. Because of possible obstacles during video recording, it is proposed the additional manual registration of the surgeons' body position in a function of time based on the coding method of body position

according to methods OWAS, REBA, RULA or the use of wireless sensors for capturing the surgeons' body position during laparoscopic procedures.

Conducting and analysis of laparoscopic surgery simulation

In addition to the studies on recognizing limitations in the range of recording laparoscopic procedures there was organized and conducted the simulation of sample bariatric surgery. In particular, the aim of the simulation was to determine the condition of real-time acquisition of measurement data on body position of surgeons, which their adopt during surgery. The simulation of surgery took place in a real operating room with the participation of:

- surgeon operator,
- the dummy representing the patient,
- instruments needed to perform the bariatric surgery,
- measuring apparatus (see Figure 1.1 b).

Figure 1.5 shows an example of simulated operations during surgery involving the surgeon with the measuring apparatus installed on the right hand.

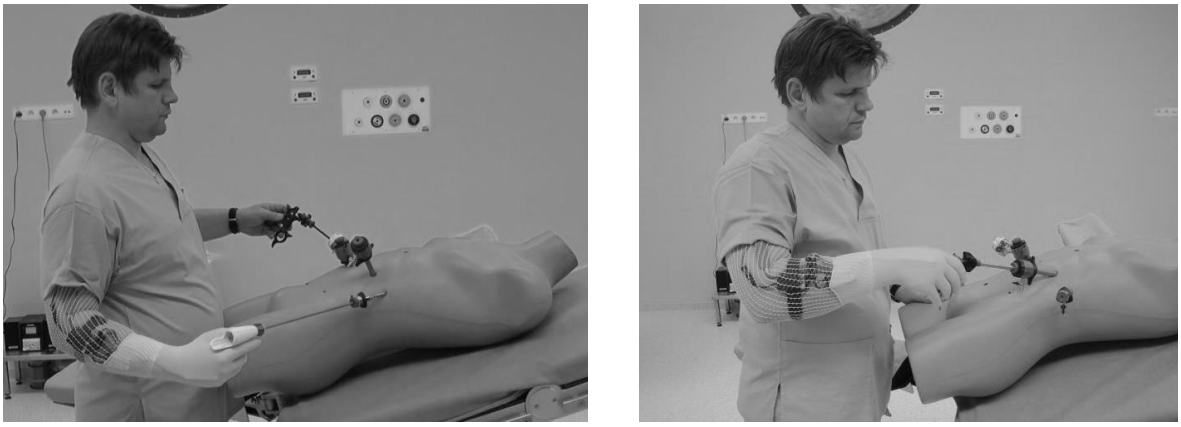


Fig. 1.5 The examples of simulated activities with installed measuring apparatus

The simulation of surgical operations has allowed to determine the following facts that can be helpful in organization of registration of real laparoscopic procedures:

- there was positive verified the way of installation and operation of the measuring apparatus for recording surgeon's body position,
- there was determined the time of installation and start-up time of the measuring apparatus,
- there was established the sanitary conditions which enable the installation and the use of measuring equipment in the real laparoscopic procedures.

The analysis of simulation of bariatric surgery confirmed the identified at the 1st stage the conditions features and restrictions in range of video registration of laparoscopic procedures. The results of stages: 1st and 2nd were the basis for the commencement of the organizational activities in the field of ergonomics in work conditions during laparoscopic procedures.

Analysis of preparatory operations for video recording of laparoscopic surgeries

The purpose of 3rd stage was to determine the potential barriers and limitations associated with the preparatory activities for recording the real laparoscopic procedures. Wherein the preparatory activities contained firstly a development of the timetable of laparoscopic surgery along with information about the medical staff composition and scope of the tasks of surgical team members, and secondly the activities directly before the procedure performed in the operating theater area, including:

- preparation of apparatus for video recording and apparatus for measuring surgeon's body position,
- installation of the measuring apparatus on the surgeon's body,
- starting and verification of the correctness of the measuring apparatus and equipment for video recording.

The installed measuring apparatus on the right hand of the surgeon and the moment of starting measuring apparatus just before surgery are shown in Figure 1.6.

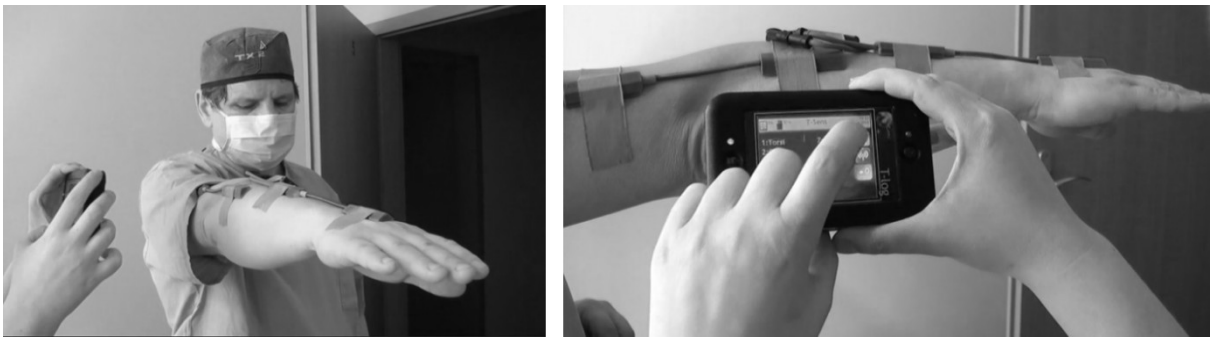


Fig. 1.6 The registration of the way of installation and activation of the measuring apparatus made just before surgery

The results of the preparatory actions analysis indicated the following possible problem situations:

- actions under time pressure,
- the need to start-up of the apparatus several times,
- the occurrence of unforeseen circumstances related to the specific work in a hospital, for example, delays in the initiation of laparoscopic surgeries.

On the basis of the problem situations, the following solutions to facilitate the implementation of preparatory activities for surgery are proposed:

- development of a checklist for verifying the correctness of the installation and starting-up of the apparatus,
- verification of correctness of operation of various components of the apparatus every time before surgery registration.

Analysis of course and recordings of laparoscopic surgeries

The conditions of laparoscopic surgery course revealed the following restrictions disturbing the registration process, as shown in a synthetic manner in Table 1.3.

The identified interference occurring during video recording confirmed, the diag-

nosed at earlier stages, limitations and additionally revealed a new problem areas which have indicated the need to complete guidelines of how to record the laparoscopic procedures. They are as follows:

- preparation of the supplementary equipment of the registration or additional set of batteries in the case of unforeseen circumstances lengthening the duration of surgery,
- earlier diagnosis of composition of the whole surgical team and the preparation of information materials on the purpose, scope and method of performing surgery video recording,
- performance of previous attempt of video recording in lighting conditions similar to those prevailing during surgery, in order to prepare certain recording parameters,
- the ability to change the camera operator due to the burdensome conditions during video recording.

Table 1.3 The limitations occurring during video recording of surgeries

	Cholecystectomy	**Hernioplasty TAPP**	**Sleeve gastrectomy**	**Gastric bypass**
The limitations during video recording				
The necessity of moving the camera operator	X	X	X	X
No possibility of registering the entire surgeon's body	X	X	X	X
Unexpected extension of the surgery			X	X
The lack of agreement with the anesthetists team	X	X	X	X
The incorporation of additional barriers of video recordings, such as screens, additional or new staff etc.	X	X		
The adverse environmental conditions such as high temperature or lack of air circulation	X	X	X	X
No general lighting during surgery	X	X	X	X

During laparoscopic procedures, there was no disturbance on the measuring of surgeon's body position. Figure 1.7 shows the selected images extracted from the video recording of two surgical procedures with the visible sensors of measuring equipment installed on the right hand of the operator.

After finishing the surgery, the surgeons indicated a slight discomfort connected with installed sensors capturing the body positions. However, it was small enough that it does not cause any interference within the course of operational activities.

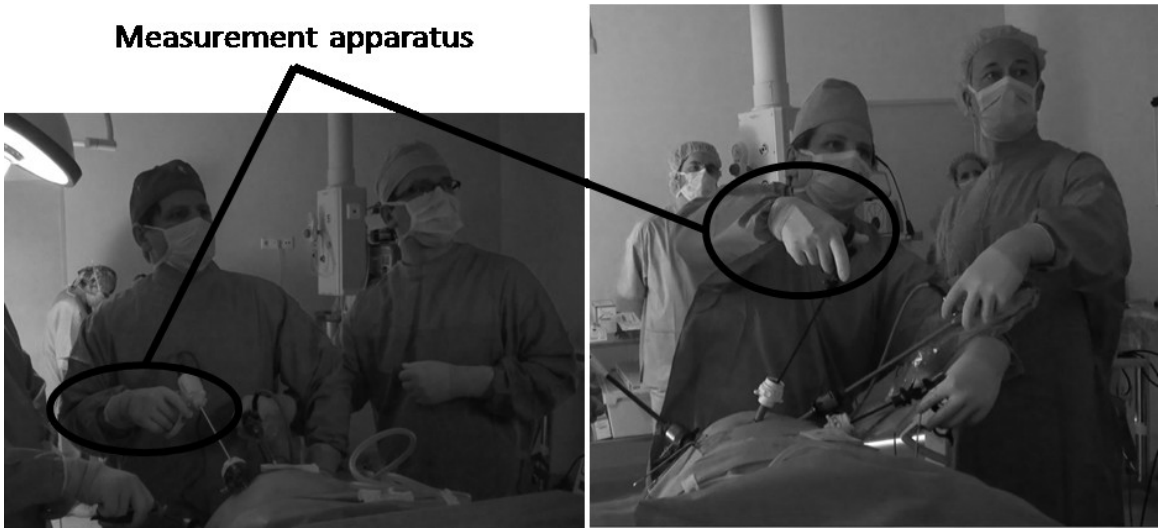


Fig. 1.7 The images extracted from the video recording with the visible sensors for capturing body position

Development of the assumptions for the ergonomic assessment

Considering the conditions and restrictions of research into such a special working environment, which is the operating room during laparoscopic procedures, as well as the essence of ergonomic analysis based on observation methods, the two paths of data processing were defined:

1 Data processing of derived exclusively from the video recording.

2 Data processing from video recordings and recordings of the measurement of surgeon's body position.

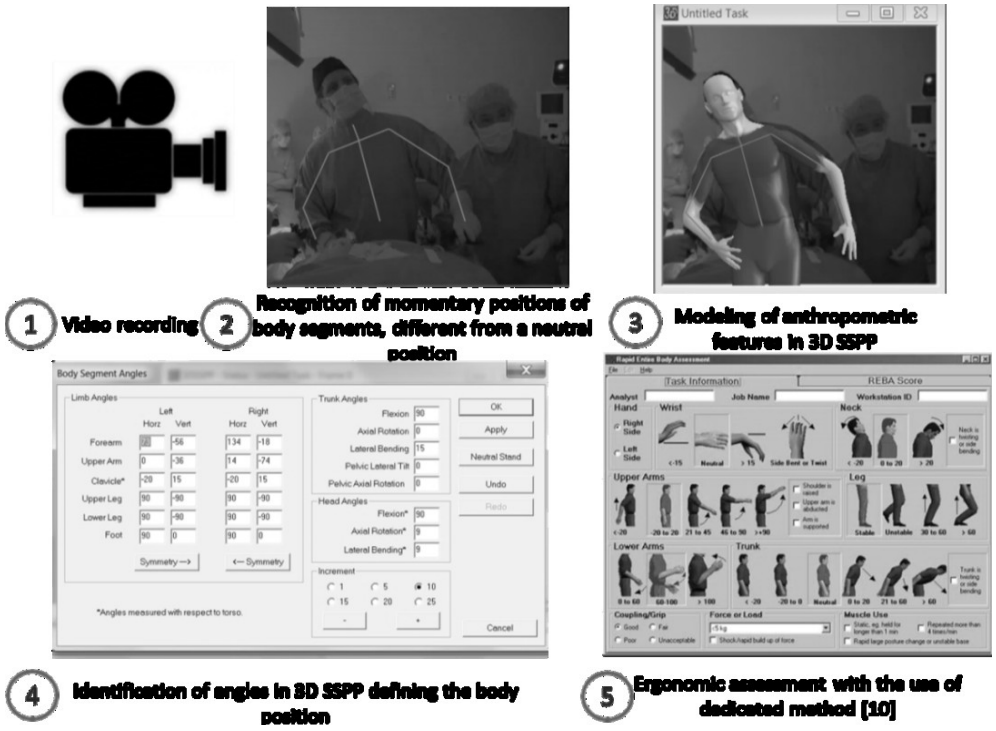


Fig. 1.8 The track of video frames processing for the ergonomic assessment

Both the first and the second path should enable an ergonomic assessment of working conditions of the surgeons during surgery. Depending on the method of ergonomic assessment, the purpose of data processing is to obtain the required input data which are necessary to apply the specified method.

In this consideration the assumption is defined which is narrowing the ergonomic assessment to static load assessment with the use of the method based on the measurement of angular positions of individual body segments. Within the framework of first path the following processing track, enabling the identification of data defining surgeon's postures, was performed (Figure 1.8).

The method of how to use video recording as a basis for ergonomic assessment has been described in detail in the publication [1]. The second path is extended by measuring track representing the manner of data acquisition from sensors capturing body position of a surgeon (Figure 1.9).

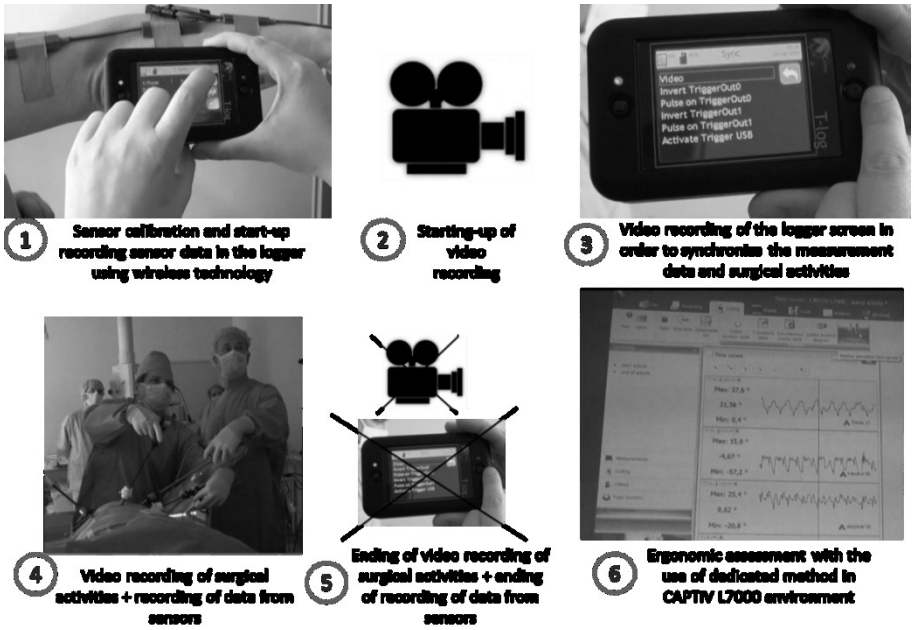


Fig. 1.9 The track of data processing from video recording and measurement recording of surgeon's body position

The presented manner of recording video and measurement data enable integration of video material and measured information on surgeon's body position. Ergonomic assessment in this case can be complex through the use of common software environment as a place of data acquisition as well as ordering information for ergonomic assessment and the analysis of its results. In this case the CAPTIV L7000 is used as the software environment. CAPTIV L7000 is a computer program used to data analysis on how to perform actions. The analysis is conducted on the basis of video recordings and related to them encoded information, for example: concerning the body positions, and also types of activities, physical environmental parameters, etc. Particularly, CAPTIV software environment can be a place for integrating the encoded information and ergonomic methods, such as REBA, RULA or OWAS.

CONCLUSION

The presented in the article issues on how to perform the ergonomic research in the working environment of surgeons is a part of extensive study on improving ergonomics in laparoscopic procedures conducting by the authors. The carried out in the years 2013-2014 video recordings of different types of laparoscopic surgeons allowed to formulate restrictions and specific guidelines to facilitate the planning and organization of the research in such a unique environment which is the operating room (see objective O1). In the paper the prerequisite were determined for the development of the concept of transformation and integration of research material collected for the purposes of comprehensive ergonomic analysis associated with the manner of doing laparoscopic surgeries (see objectives O2 and O3).

The presented description of complex planning of activities and organizational arrangements for video recording of laparoscopic surgeries and body position measurement with specialized motion capture sensors confirms that the careful preparation of the research is the factor determining a high degree of accuracy of the analysis, thus giving the basis for conducting the competent and reliable scientific research.

ACKNOWLEDGEMENT

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THE WAY OF PLANNING AND ORGANIZING RESEARCH IN RANGE OF ERGONOMICS ON THE EXAMPLE OF OBSERVATION OF LAPAROSCOPIC SURGERIES

Abstract: *The article presents the results of studies on the identification and analysis of problem areas concerning aspects of ergonomics in laparoscopic surgeries. The studies were based on the research carried out in both real conditions and simulation conditions. The described methodology and research material refers to the photographic documentation of the operating room and laparoscopic instruments, in addition to performed staged procedure as well as the way of planning the deployment of members of the surgical team and patient positioning. The next step in the research was acquisition of the data concerning the way of performance of bariatric procedures in real conditions with the use of wireless goniometer and torsiometer, made with video recording. The method of carrying out the research as well as the identification of barriers in the process of ergonomic assessment of laparoscopic procedures have allowed the authors to obtain the research material which was the starting point for the development of a research model for ergonomics in laparoscopic procedures.*

Keywords: *Ergonomics, laparoscopy, planning of studies, capturing the body position*

SPOSÓB PLANOWANIA I ORGANIZACJI BADAŃ W ZAKRESIE ERGONOMII NA PRZYKŁADZIE OBSERWACJI ZABIEGÓW LAPAROSKOPOWYCH

Streszczenie: *W artykule przedstawiono wyniki studiów w zakresie identyfikacji oraz analizy obszarów problemowych dotyczących aspektów ergonomii w zabiegach laparoskopowych w oparciu o przeprowadzone badania naukowe w warunkach rzeczywistych jak i warunkach symulowanych. Opisana metodyka i materiał badawczy odnoszą się do wykonanej przez Autorów dokumentacji fotograficznej sali operacyjnej oraz narzędzi laparoskopowych, przeprowadzenia inscenizacji zabiegu jak również zaplanowania rozmieszczenia członków zespołu chirurgicznego oraz ułożenia pacjenta. Kolejnym opisanym etapem badań jest akwizycja danych dotyczących sposobu wykonywania zabiegów bariatrycznych w warunkach rzeczywistych z zastosowaniem bezprzewodowych goniometrów dokonana za pomocą rejestracji wideo. Sposób przeprowadzania badań jak również rozpoznanie barier w procesie oceny ergonomicznej zabiegów laparoskopowych pozwoliły Autorom na uzyskanie materiału badawczego stanowiącego punkt wyjścia do opracowania modelu badawczego w zakresie ergonomii zabiegów laparoskopowych.*

Słowa kluczowe: *Ergonomia, laparoskopia, planowanie badań, przechwytywanie pozycji ciała*

dr inż. Joanna BARTNICKA, mgr Agnieszka ZIĘTKIEWICZ
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze
e-mail: Joanna.Bartnicka@polsl.pl; Agnieszka.Zietkiewicz@polsl.pl

dr n. med. Grzegorz KOWALSKI
S.P.Z.O.Z. Okręgowy Szpital Kolejowy w Katowicach
Oddział Chirurgii Ogólnej z Pododdziałem Chirurgii Metabolicznej i Bariatrycznej
ul. Panewnicka 65, 40-760 Katowice
e-mail: kowalskig_xl@wp.pl

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A COMPARATIVE COMPONENTS IMPORTANCE ANALYSIS OF A COMPLEX TECHNICAL SYSTEM WITH THE USE OF DIFFERENT IMPORTANCE MEASURES

2.1 INTRODUCTION

Reliability theory concentrates on the operation of systems, both in terms of statistics and physics of failure, and is effective when it comes to determining measures for reliability, availability and indices for states of emergency of the operated system.

As for the system as a whole, basic reliability measures such as reliability, availability, MTTF, failure frequency and so on, have great information value in terms of the intact system operation. However, when it comes to system components, these measures give mainly general information on their vulnerability and availability. Thereby, except for a series reliability structure, they do not describe the influence of components being down on the system being down.

The system tolerance for its components failure depends on their reliability and the structure of the system where a particular component is located. So far a series of measures has been proposed to describe the components importance in the system reliability structure considering a particular importance criterion e.g. Vesely–Fussell's, Birnbaum's, Lambert's known as a criticality measure, and many others [9, 13].

It needs to be underlined that different reliability measures lead to different importance rankings, what results from different definitions of measure. That is why the character of a given measure must be taken into account while interpreting the results obtained during the analysis. Apart from differences between given measures in the rankings there are significant differences in the obtained measure values, often of a few orders of magnitude. This complicates the visualization and comparison of components importance results obtained by means of various criteria. Using measures presented in this paper might be helpful to visualize the values of different measures on common charts.

2.2 SELECTED IMPORTANCE MEASURES

The Birnbaum's reliability importance measure IB is the most useful to indicate system components whose reliability parameters should be improved in order to in-

crease the system reliability. IB for a given component does not depend on the reliability of the component in question but on the system reliability structure and reliability of other components. If $\bar{r}(t)=[r_1(t),r_2(t),...,r_n(t)]$ is a system component reliability vector in moment t and $R[\bar{r}(t)]$ is the system reliability which is dependent on the reliability of given components and the system reliability structure then the Birnbaum's reliability importance measure for an *i*-th system component is defined as:

$$I_i^B(t)=\frac{\partial R[\vec{r}(t)]}{\partial r_i(t)}=R[1_i,\vec{r}(t)]-R[0_i,\vec{r}(t)] \tag{2.1}$$

To identify the component whose failure will most probably cause the system failure, the Vesely-Fussell's measure IVF is helpful. If $\Phi[\overline{X}(t)]$ is the system structure function, equal to 0 when the system is down and to 1 when it is up, and it is determined by a binary vector $\overline{X}(t)$ whose elements are equal to 0 when a given component is down and 1 when it is up, then IVF is described as the relation:

$$I_i^{VF}(t)=P\{D_i(t)\,|\,\Phi[\overline{X}(t)]=0\} \tag{2.2}$$

where:

m_i – the number of minimal cut sets containing an i-th component;

$C_{ij}(t)$ – a j-th minimal cut set containing an i-th component and failing in time t;

$D_i(t)=C_{i1}(t)\cup C_{i2}(t)\cup...\cup C_{im_i}(t)$

– a set containing at least one cut set $C_{ij}(t)$ which is down in time *t*.

Another measure helpful to determine the components criticality [11] is ICR proposed by Lambert. Component *ei* is critical if: the system is intact when component *ei* is up, and the system is down when component *ei* is down as well. In a system with a series structure, all components are critical. In other types of structure, the component becomes critical when all other components belonging to a given cut set fail. The criticality measure is described as a conditional probability of event:

$$Cr[\overline{X}(t),X_i=1]\cap[X_i(t)=0]$$

if the system is down in time t what can be shown as:

$$I_i^{CR}=P\{Cr[\overline{X}(t),X_i=1]\cap[X_i(t)=0]\,|\,\Phi[\overline{X}(t)]=0\} \tag{2.3}$$

where:

$Cr[\overline{X}(t),X_i=1]$ – an event when the system is in a state of an i-th component being critical and it is independent of this component's state.

The reliability improvement potential IIP is a similar criticality measure and it can be interpreted as a probability that an *i*-th component is critical and fails in time t what can be expressed by the formula:

$$I_i^{IP}(t)=P\{Cr[\overline{X}(t),X_i=1]\cap[X_i(t)=0]\} \tag{2.4}$$

A component's criticality for a system is well described by the Birnbaum's structural importance measure IBs. It a qualitative measure i.e. its value is independent of time and system components reliability but depends on the system reliability structure. The Birnbaum's structural importance measure for an *i*-th component is defined as a relative

number of system states for which an *i*-th component is critical for the system. Hence, this measure can be described as the relation:

$$I^{Bs}(t) = \frac{\eta_{\phi}(i)}{2^{n-1}} \tag{2.5}$$

where:

$\eta\varphi(i)$ – the total number of critical path set vectors for component *i*

Beside the afore-mentioned importance measures, used to illustrate their application character in this paper, there are others - Bergman's, Natvig's, Barlowa-Proshan's, minimal cut set order and many others which have been left out in this paper because of the extent of the topic [1, 2, 3].

2.3 THE OBJECT OF ANALYSIS

The analysis has been performed on a stern tube lubricating and sealing system installed on a container ship [10, 18]. Fig. 2.1 shows the installation layout.

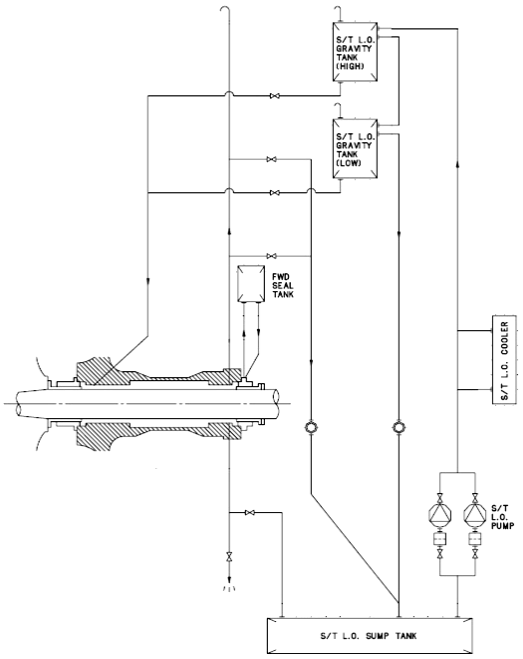

Fig. 2.1 The stern tube sealing system

Source: [18]

The stern tube lubricating and sealing system is responsible for sealing the propeller shaft and providing an appropriately low coefficient of friction in the shaft line. The incorrect operation of the analyzed system might result in:

- flooding the engine room with sea water and sinking the ship;
- the escape of lubricating oil and the sea environment contamination with petroleum products;
- increasing the friction between the cooperating components causing an increase of the tribological pair intensity and decrease of the propulsion efficiency of the vessel (increase of the fuel consumption by the propulsion system).

So, a reliable operation of the analyzed technical system affects the engine room reliability of a single sailing ship and a transportation chain. The analyzed system is one of the critical components of every sea ship. To analyze the influence of the stern tube sealing system components being down, performed an importance analysis [6, 12].

2.4 A DEPENDABILITY SYSTEM MODEL

Table 2.1 shows descriptions of particular system components and their reliability characteristics. It has been assumed in the analysis that the system is renewable and the components have an exponential distribution of time to failure with Lambda [failure/h] parameter and exponential distribution of time to repair with parameter MTTR (mean time to repair) [h]. In the case of E1, the most beneficial repair scenario (immediate docking of the ship) has been assumed. The failure intensity and mean repair time have been assumed based on [14]. The filter-pump system has been duplicated in the model, the analysis has been performed for mean values of parameters of the failure and repair process considering the periodical change of the working and stand-by component. It has been assumed that both branches of the pumping system fail with same failure intensity [4, 5, 7].

Table 2.1 Data on vulnerability and maintenability of given system components

Description	Type	Parameter	Value	Remarks
E1	Repairable component	Lambda MTTR	0,0000292 168	Stern tube seal with bearings
E2	Repairable component	Lambda MTTR	0,0000111 24	Higher gravity tank
E3	Repairable component	Lambda MTTR	0,0000111 24	Lower gravity tank
E4	Repairable component	Lambda MTTR	0,0000058 24	Lube oil cooler
E5	Repairable component	Lambda MTTR	0,0000121 24	Lube oil sump tank
E6	Repairable component	Lambda MTTR	0,0000821 4	Pipelines with equipment
E7	Repairable component	Lambda MTTR	0,0001750 12	Circulation pump no 1
E8	Repairable component	Lambda MTTR	0,0001750 12	Circulation pump no 2
E9	Repairable component	Lambda MTTR	0,0000307 2	Filter no 1
E10	Repairable component	Lambda MTTR	0,0000307 2	Filter no 2

The reliability structure of the system was modeled by means of the fault tree. Fig. 2.2 presents a dependability model. While constructing the tree, a composition level was assumed where system components are responsible for certain process functions so the components match particular machines and devices.

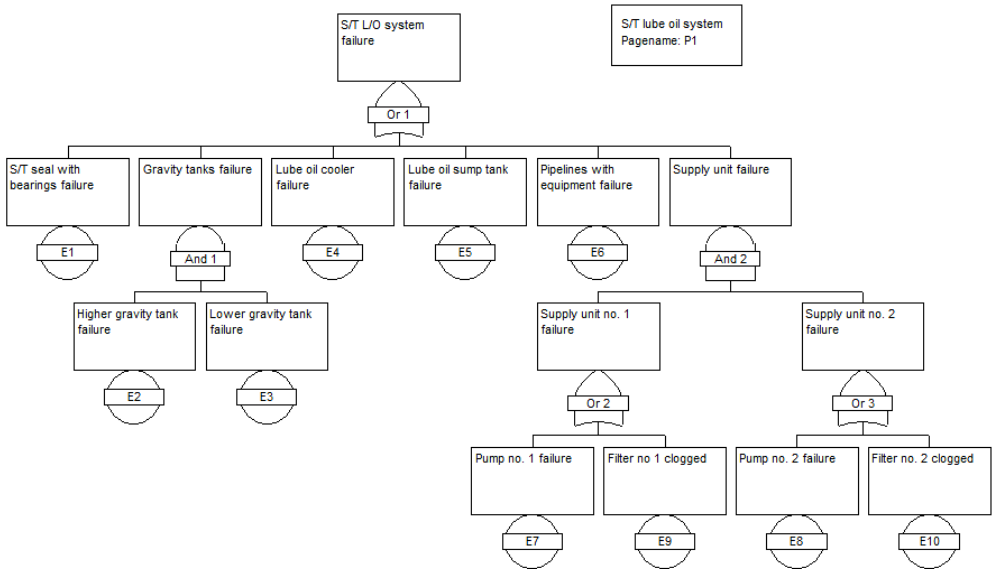

Fig. 2.2 The reliability structure of the analysed system

2.5 SYSTEM COMPONENTS IMPORTANCE ANALYSIS

The importance analysis has been carried out with the use of software CARA Fault Tree ver. 4.1. Academic by Sydvest Software. The following assumptions and entry parameters have been taken for calculation:

- analysis done for top event OR1,
- mission time a year (8760h),
- the level of fault tree modularization equal to 0,
- the maximum, possible size of the analysed minimal cut sets.

Table 2.2 Determined measure values of the analysed technical system

Component	IVF	IBs	IB	ICR	IIP
E1	0,8655800	0,0410160	0,9992400	0,8649300	0,0048730
E2	0,0000127	0,0136720	0,0002658	0,0000126	0,0000001
E3	0,0000127	0,0136720	0,0002658	0,0000126	0,0000001
E4	0,0246610	0,0410160	0,9945000	0,0245260	0,0001382
E5	0,0513170	0,0410160	0,9946500	0,0510420	0,0002876
E6	0,0582920	0,0410160	0,9946900	0,0579820	0,0003267
E7	0,0008019	0,0175780	0,0021440	0,0007973	0,0000045
E8	0,0008019	0,0175780	0,0021440	0,0007973	0,0000045
E9	0,0000235	0,0175780	0,0021396	0,0000233	0,0000001
E10	0,0000235	0,0175780	0,0021396	0,0000233	0,0000001

Table 2.2 shows certain importance measure values (primary measures) calculated by means of Aven's algorithm of exact reliability and availability calculation (ERAC) [17]. Because the values of some measures are very low, it was necessary to show them accurately to the seventh digit after the decimal point.

Due to big differences between the values of certain measures, it is very

complicated to compare them on the same plane as observed in the visualization of the obtained measure values by means of bar charts (Fig. 2.3).

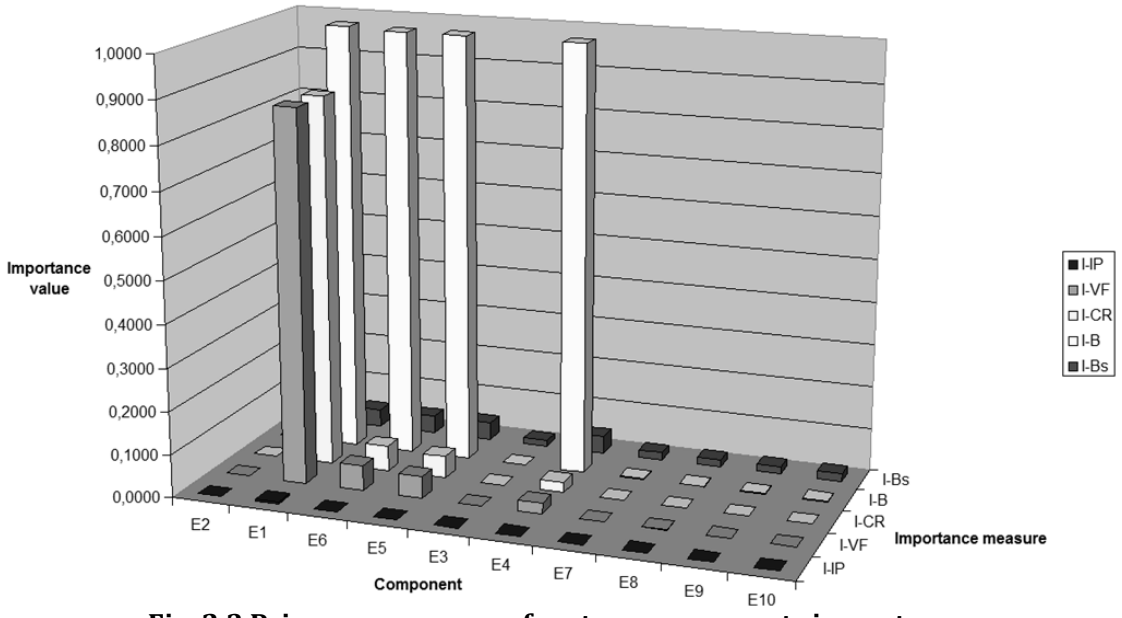

Fig. 2.3 Primary measures of system components importance

2.6 SCALING IMPORTANCE MEASURES

To make the comparison of given importance measure values easier and to use more tools in the multi-criteria analysis of components importance such as radar charts, it is indispensable to process the scaling of measures. Based on the maximum value ϑ of importance measures for all components in time t described as:

$$\vartheta = \max_{i=1,2..n} \{ \bigcup_{I_j = I_1, I_2 ... I_m} [I_j(i \mid t)] \} \tag{2.6}$$

where:

i – the component number in the system;
j – the next mark for a considered components importance measure;
n – the number of system components;
m – the number of used importance measures;

the authors proposes to introduce a scaled coefficient for all measures determined for a *j*-th measure in time t as:

$$\zeta_{j,t} = \frac{\max_{i=1,2...n} I_j(i \mid t)}{\vartheta} \tag{2.7}$$

For the analyzed example:

$$\vartheta = \max_{i=1,2..10} \{ \bigcup_{I_j = \{I^B, I^{VF}, I^{CR}, I^{IP}, I^{Bs}\}} [I_j(i \mid t)] \} = 0{,}99924 \tag{2.8}$$

Particular coefficients ζ for every measure is shown in Table 2.3.

Table 2.3 Scaled coefficients for given measures

Measure	IVF	IBs	IB	ICR	IIP
ζ	1,15	24,36	1,00	1,16	205,06

Multiplying the values of given measures by given scaled coefficients, corrected importance measures have been obtained (marked by an asterisk next to the super-script) what has been presented in Table 2.4.

Table 2.4 Corrected importance measures of the analysed technical system

Name	IVF*	IBs*	IB*	ICR*	IIP*
E1	0,9992400	0,9992400	0,9992400	0,9992400	0,9992400
E2	0,0000146	0,3330800	0,0002658	0,0000146	0,0000146
E3	0,0000146	0,3330800	0,0002658	0,0000146	0,0000146
E4	0,0284691	0,9992400	0,9945000	0,0283345	0,0283347
E5	0,0592412	0,9992400	0,9946500	0,0589680	0,0589681
E6	0,0672933	0,9992400	0,9946900	0,0669857	0,0669858
E7	0,0009257	0,4282388	0,0021440	0,0009211	0,0009211
E8	0,0009257	0,4282388	0,0021440	0,0009211	0,0009211
E9	0,0000271	0,4282388	0,0021396	0,0000269	0,0000269
E10	0,0000271	0,4282388	0,0021396	0,0000269	0,0000269

2.7 RESULTS OF THE IMPORTANCE ANALYSIS

Owing to the proposed transformation, there appear new opportunities in terms of importance presentation and comparative analysis using different importance measures. Fig. 2.4 shows a visualization of scaled importance measures. The measure values which were very small at first were proportionally increased.

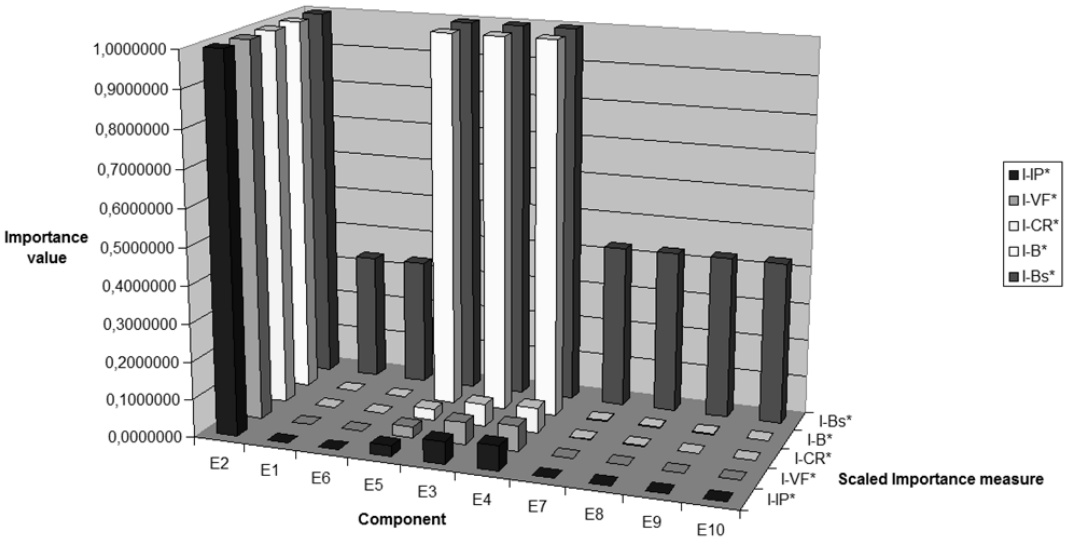

Fig. 2.4 Scaled-down system components importance measures

The applied transformation allows to use radar charts in the importance analysis relying on different relevance criteria of system components. For the analyzed example shown in Fig. 2.5, the visualizations of selected scaled-down importance measures for given system components have been presented. For the presented measures, components E2, E3, E4 and E5 affect the system most strongly.

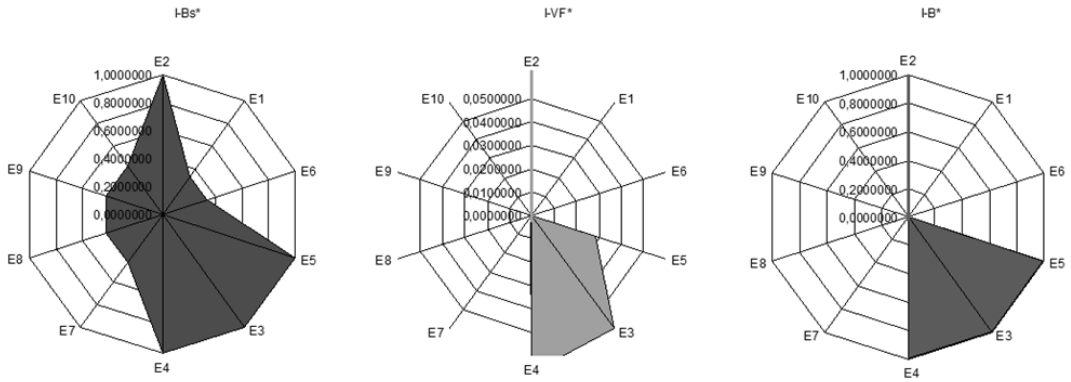

Fig. 2.5 Radar charts of scaled-down importance measures for given system components

While segregating the data series according to the components, it is possible to obtain radar charts showing the values of given measures for every component on the same data plane. Fig. 2.6 presents an example of using this kind of data. Component E2 influences the system operation the most – all of the analyzed measures equal nearly 1 for it when scaled-down.

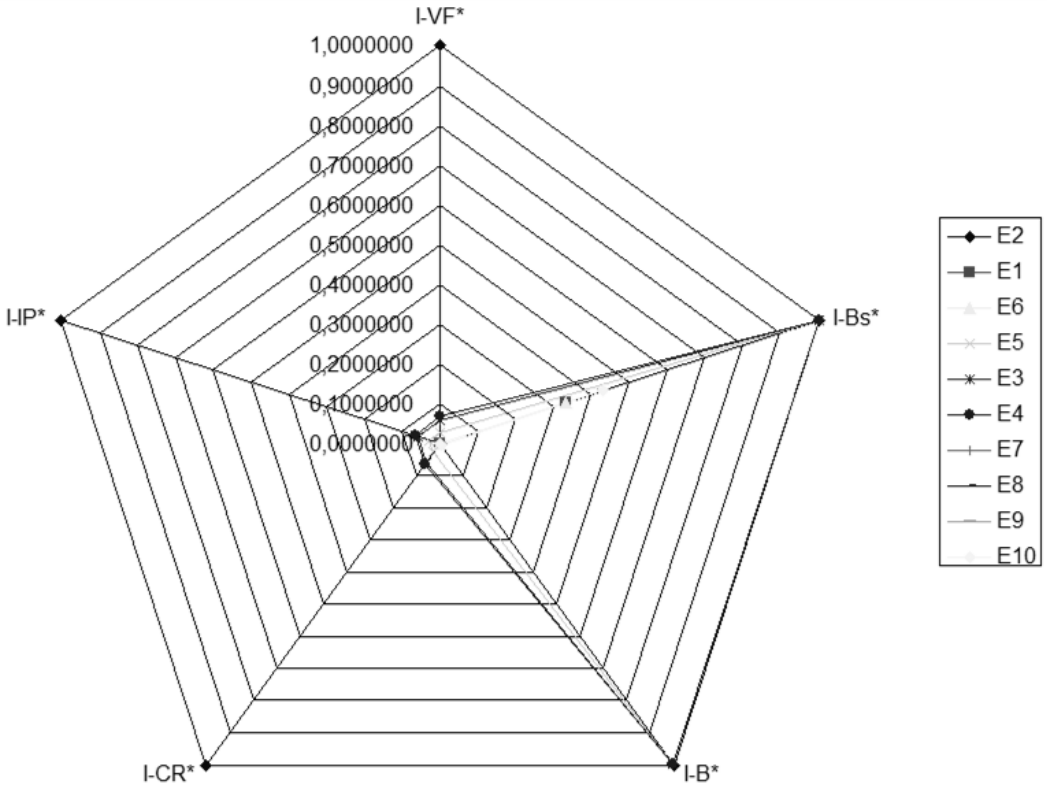

Fig. 2.6 Results of components importance analysis with the use of many criteria after being scaled-down

CONCLUSIONS

The application of scaled-down importance measures allows for a much better (than in the case of primary measures) comparison of different measures leaving an appropriate proportion of a given measure for different system components (all values of a given measure are scaled-down with the use of the same scaled coefficient).

Being scaled-down, the differences between the values of a given measure for different system components are greatly emphasized. It is particularly significant for primary measures of very low values. The scaled-down measures will certainly not be consistent with the basic definition relevant for given measures before scaling e.g. conditional probability of a given event.

The presented methodology of a comparative presentation of importance measure values for complex technical systems might be used in the multi-criteria analysis of components importance. Especially when other than reliability components importance criteria are assumed for the system reliability structure such as structural and parametric criteria [6, 8, 9, 15, 16, 19]. The criteria in question might be the following: safety threat connected with a component failure, repair and system operation interruption costs, maintainability (spare parts availability, repair ergonomics, manpower) etc.

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A COMPARATIVE COMPONENTS IMPORTANCE ANALYSIS OF A COMPLEX TECHNICAL SYSTEM WITH THE USE OF DIFFERENT IMPORTANCE MEASURES

Abstract: *This paper presents a components importance analysis of a complex technical system with the use of selected reliability components importance measures. The analysis was carried out on a propeller shaft stern tube seal of a ship propulsion system. The reliability structure of the analyzed system was modeled by means of the fault tree. For given system components the following were determined: the Birnbaum's reliability and structural importance measure, reliability improvement potential, criticality measure and Vesely-Fussell's measure. A transformation of measures based on rescaling their values has been proposed to simplify the comparative analysis using different measures with reference to the same system components. A transformation process for the analyzed system has been presented together with a results visualization of comparative components importance analysis by means of 3D bar charts and radar charts for a data series determined as system components and importance measures. Comments on the proposed methodology have been presented and other ways of its application have been indicated.*

Key words: *Importance measures, comparative analysis, ship propulsion system*

ANALIZA PORÓWNAWCZA WAŻNOŚCI ELEMENTÓW SYSTEMU TECHNICZNEGO Z JEDNOCZESNYM WYKORZYSTANIEM RÓŻNYCH MIAR WAŻNOŚCI

Streszczenie: *W artykule przedstawiono analizę ważności elementów złożonego systemu technicznego z wykorzystaniem wybranych niezawodnościowych miar ważności elementów. Analizę przeprowadzono na przykładzie systemu smarowania i uszczelnienia pochwy wału śrubowego układu napędowego statku. Strukturę niezawodnościową analizowanego systemu zamodelowano z wykorzystaniem drzewa niezdatności. Dla poszczególnych elementów systemu wyznaczono niezawodnościową miarę ważności Birnbauma, miarę strukturalną Birnbauma, Potencjał przyrostu niezawodności, miarę krytyczności oraz miarę Veseley-Fussell'a, Zaproponowano transformację miar polegająca na przeskalowaniu ich wartości w celu ułatwienia analizy porównawczej wykorzystującej różne miary w odniesieniu do tych samych elementów systemu. Przedstawiono dla analizowanego systemu proces transformacji oraz zaprezentowano wizualizację wyników analizy porównawczej ważności elementów z wykorzystaniem wykresów słupkowych 3D oraz wykresów radarowych dla serii danych ustalonych jako elementy systemu oraz jako miary ważności. Przedstawiono uwagi dotyczące zaproponowanej metodyki i wskazano inne możliwe jej zastosowania.*

Słowa kluczowe: *Miary ważności, analiza porównawcza, okrętowy układ napędowy*

Leszek CHYBOWSKI, PhD
Maritime University of Szczecin
Faculty of Marine Engineering
1-2 Wały Chrobrego St., 70-500 Szczecin, Poland
e-mail: L.Chybowski@am.szczecin.pl

Dorota IDZIASZCZYK, MA
Maritime University of Szczecin
Centre for Maritime Technology Transfer
1-2 Wały Chrobrego St., 70-500 Szczecin
e-mail: D.Idziaszczyk@am.szczecin.pl

Bogusz WIŚNICKI, PhD
Maritime University of Szczecin
Faculty of Economics and Transport Engineering
11 Henryka Pobożnego St., 70-506 Szczecin, Poland
e-mail: B.Wisnicki@am.szczecin.pl

3

EXTENSION OF LONGWALL'S EFFECTIVE WORKING TIME

3.1 INTRODUCTION

The environment in which companies operate is constantly undergoing changes that determine their growth and even survival [5]. Benggtsson and Kock characterized the essence of cooperation stating that competitive cooperation in today's economy seems to be a relation of companies' highest developing potential [3]. Thus, possibilities of overcoming and/or limiting the environmental barriers' influence should be looked for within inter organizational relations [7]. What seems to be an interesting solution is implementation of the case study methodology. The main reason would be the fact that the network theory is in early stage of development and the case study in management studies is used for extensive diagnosis of a studied phenomenon [4]. A created research tool, used for diagnosis of inter organizational relations of a company, should include questions concerning areas like: partners choice, formalization, mutual influence and involvement, cooperation motivation, its benefits and dangers. Therefore it is worth to concentrate not on a single relation between companies but a whole network of a given company's connections in order to fully understand the influence of those correlations on its functioning.

3.2 CHARACTERISTICS OF A MODERN COMPANY

The need to ensure profitability of the coal mining industry and to adapt it into the competitive market of energy resources requires Polish coal mining industry to be adjusted to reality of market economy. It requires changes both technical and organizational and, as a consequence, it forces employment limitations, liquidation of unprofitable mining facilities and restructuring of redundant unproductive assets [8, 11, 14, 15]. Therefore the "Modern Company" is characterized by its technology, economy, market and management.

TECHNOLOGY – introduction of modern machinery, adaptation to ecology requirements.

ECONOMY – calculation of cost and effect, constant calculation of effectiveness, confrontation of actions and expenditures, relation of cost and effect. Optimization of decisions according to effectiveness criteria, accumulation of assets in general.

MARKET – liberalism, free functioning supply and demand market mechanism and marketing as actions adapting a company to external determinants.

MANAGEMENT –oriented towards effective use of assets, machines, human and financial

assets. Implementation of modern devices and effective group management [6, 9].

Therefore, limitation of mining company's costs became a managing priority for the Polish coal mining sector. To realize the main goal which is a mining company's effectiveness, rules must be set in order to limit its costs [6, 8, 11].

3.3 LIMITATION OF COSTS

Technical restructuring of mining facilities requires setting goals which result in so called output concentration consisting in lengthening panel lengths to about 2 thousand meters, lengthening longwalls to about 300 meters and longwall output of 5 thousand Mg/d. This technical goal can be achieved with special attention directed towards:

- providing high reliability of longwall and other technical equipment,
- increasing productivity of machinery which requires their power increase,
- providing sufficient speed of preparatory works adjusted to required progress of a longwall front,
- effectiveness improvement by decrease of culm amount and thus increase of thick output assortment,
- improvement of mining cleanness, especially concerning thin layers which decreases costs of mechanical coal processing and transport,
- improvement of layer demethanization systems in order to achieve daily output,
- layer management leading to achievement of a technical goal.

Effectiveness of a properly designed mechanization system depends heavily on output concentration and limitation of costs. The latter may be divided into two groups: working costs and production costs. Costs are a company's strategic element which must constantly be adjusted to market rules. During realization of a given project (exploitation of a longwall) the highest budget concerns the following assets:

- human (work at a longwall),
- material (equipment purchase or lease cost, its working costs),
- financial (costs of spent capital),
- informative (evaluation, documentation).

The material assets element is a part of a project costs which currently has the biggest influence on the mining facility's productivity and thus it should be limited. To achieve this goal, work organization should be improved in order to maximize the daily utilization of machines and devices. This will lead to increase of a project's productivity and therefore will create possibilities for company's dynamic development.

Movement of a longwall may be hampered by external conditions (natural geological limitations e.g. CH4, water, rockbursts) and organizational conditions. The latter form the biggest obstacle for effectiveness of our actions which we influence and create ourselves. Maximum exploitation of machines' daily working time will result in improvement of longwall's productivity. Organizational conditions hampering effectiveness and improvement of longwall's productivity can be divided into four basic groups: machines,

electricity, ventilation, mining. Extension of maximum effective daily working time of a machine results (without changes in employment policy) in increased unit profit in a ton of coal per one employee. This will lead to limitation of lost costs which means possibilities to be employed by a given longwall [1, 6, 8, 11,14, 15].

3.4 POSSIBLE WAYS OF REALIZATION

Current technological and organizational knowledge states that a longwall is able to work 24 hours a day during a five-day working week, from Monday till Friday. Improvement in work organization should be based on thorough preparation of excavation so that the goal can be achieved. Current limitations of longwall's constant working time can be eliminated by the use of machines and devices qualified for constant work. If a longwall (in a design stage) does not show any geological limitations, the only criteria to limit constant work is the choice of machines, devices and work organization. Basic limitations of longwall's constant movement may be divided into limitations concerning:

- mining – longwall drifts should be secured in advance so that it does not interfere with the longwall progress. Transportation of elements needed for exploitation should proceed on-line.
- machines – providing: media to power machinery, water and compressed air. Another problem is a longwall conveyor's rearrangement which should be executed along with longwall's front movement whereas shortening of a conveyor belt should be executed on Saturdays.
- electricity – machine power supply system should be designed to enable longwall's front movement during a five day period. Alteration of power systems should be done on days free from work e.g. Saturday.
- ventilation – preparation of longwall front demethanization technology, powering and rebuilding of ventilators influencing longwall's constant work.

All maintenance work should be executed on Saturday. Currently, most maintenance work is done on Saturdays so that it does not interfere with the mining process. The only break in the longwall shearer's work (as it is the main indicator of longwall's front movement) should be the result of technological breaks (e.g. inspection, methane measurement, replacement of cutting elements).

3.5 EFFECTS OF COST LIMITATION

This article presents average data concerning work of the mining facility and its "lost" possibilities. The study shows three longwalls of Kompania Węglowa S.A. in a period of one month. The analysis presents a degree of use of longwall shearers in a whole facility during a period of one year. A degree of shearer's use is defined as its work In one Day, starting from 6.00 (first Shift) until 5.59. The analysis presents 4 longwalls exploited within one year. The average degree of use within the analyzed period is a percentage concerning shearer's work only on working days excluding Saturdays, Sundays and holidays. To perform the analysis it was necessary to collect

data concerning working time, malfunctions of mining equipment based on the ZEFIR dispatcher system and from dispatcher systems daily reports from a period of one year. Throughout the whole analyzed year, the mining facility of Kompania Węglowa exploited 4 longwalls (the ones that began or finished their commission in that year were excluded) and the degree of use was within range of 0 to 83.33%. Daily output was in range of 0 to 7920 t/d [10, 11, 12].

Mining facility's results achieved in one month

In relation to achieved results, longwalls had 2 mining shifts, 3 mining shifts, 4 mining shifts and one maintenance shift. They also differed in effective working time [12]. Table 3.1 shows the analyzed period consisting of 20 working days, daily output was different each day and the average was 9452.5 tons. The average unit price was 261.79 zł and the economic sales result reached 2476485.36 zł.

Table 3.1 Daily output, price per Mg, economic sales result

No [Day]	Output netto in [Mg/day]	Unit price [zł/Mg]	Economic sales result [zł]
Monthly amount	189050	5235.93	49529707.3
Daily average	9452.5	261.79	2476485.36

Source: [12]

Table 3.2 shows that during the analysed period average daily stoppages caused by malfunctions and the effective shearers' daily working time was different depending on geological conditions and the systems' failure frequency. Table 3.2 shows possible shearers' daily working time without malfunctions which reaches 55.67% of a day, real 45.18% and daily stoppages caused by malfunctions which consume 10.49% of a day.

Table 3.2 Malfunction-caused daily stoppages, effective shearers' daily working time possible shearers' daily working time without malfunctions

No [Day]		Malfunction-caused daily stoppages		Effective shearers' daily working time		Possible shearers' daily working time without malfunctions	
		[min]	[%]	[min]	[%]	[min]	[%]
1	Sum	9065.00	209.84	39035.52	903.60	48100.52	1113.44
	Average effective working time	453.25	10.49	1951.78	45.18	2405.03	55.67

Source: [11, 12]

Possible production results and lost possibilities of the mining facility

Table 3.3 and Figure 3.1 show that within the analyzed time, average daily stoppages caused by malfunctions, with an additional shift, will rise by 3.5% of a day. Effective shearers' daily working time will rise to 15.06% a day. Table 3.3 presents possible shearers' daily working time without malfunctions which will rise to a level of 18.56% of a day. Effective, average working time of a mining unit would reach 73.23% a day with an additional shift.

Table 3.3 Malfunction-caused daily stoppages, effective shearers' daily working time possible shearers' daily working time without malfunctions depending on a number of mining shifts

	Malfunction-caused daily stoppages		Effective shearers' daily working time		Possible shearers' daily working time without malfunctions		Number of mining shifts
	[h]	[%]	[h]	[%]	[h]	[%]	
Average effetive working time	2.52	10.49	10.84	45.18	13.36	55.67	**3**
	3.36	13.99	14.46	60.24	17.82	74.23	**4**
Difference	0.84	3.50	3.62	15.06	4.46	18.56	**1**

Source: [11, 12]

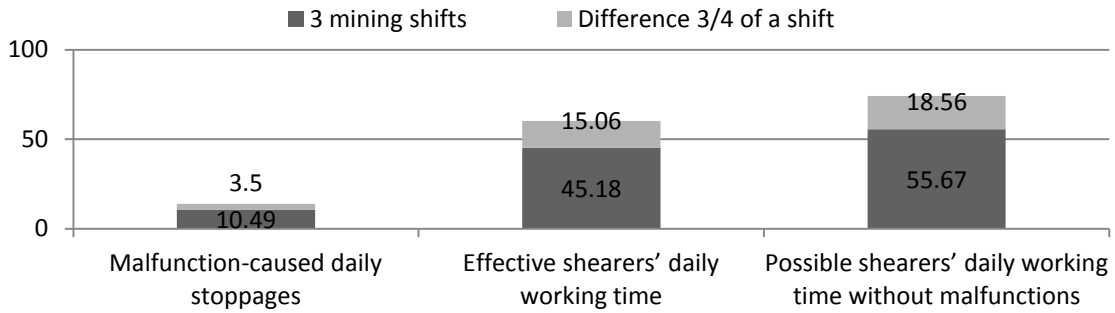

Fig. 3.1 Malfunction-caused daily stoppages, effective shearers' daily working time possible shearers' daily working time without malfunctions depending on a number of mining shifts [%]

Table 3.4, Figure 3.2 and 3.3 that, within the analyzed period, the average three and four shift output and "lost" possibilities of the mining facility reached 3150.8 Mg. The difference in the economic sales result reached 822941.2 zł/day.

Table 3.4 Daily output, economic sales result for 3 and 4 mining shifts and lost possibilities of the mining facility

Number of mining shifts	Output netto [Mg/day]	Economic sales result [zł/day]
3	9452.5	2476485.4
4	12603.3	3299426.6
„Lost" possibilities	3150.8	822941.2

Source: [12]

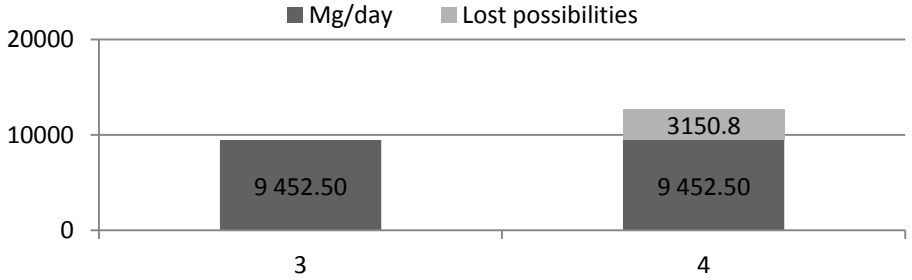

Fig. 3.2 Output netto in Mg/day depending on a number of mining shifts

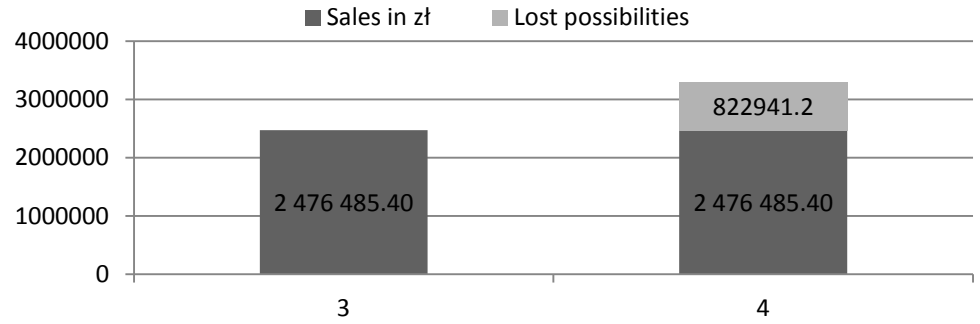

Fig. 3.3 Economic sales result in zł depending on a number of mining shifts per day

Table 3.5 and Figure 3.4 show that, within the analysed period, the average difference of monthly output with three and four mining shifts reached 63016 Mg. Lost possibilities of economic sales result were 16458824 zł.

Table 3.5 Monthly output and economic sales result for three and four mining shifts and lost possibilities of the mining facility

Number of mining shifts	Output netto [Mg/month]	Economic sales result [zł/month]
3	189050	49529708
4	252066	65988532
„Lost" possibilities	63016	16458824

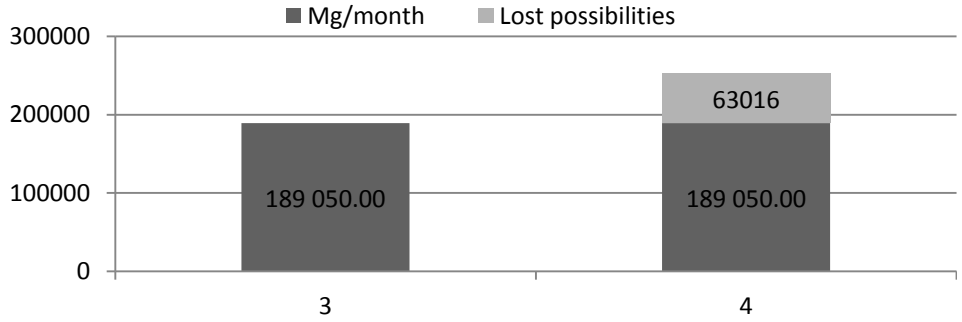

Fig. 3.4 Monthly output netto in Mg/month depending on number of mining shifts

3.6 ANNUAL MINING FACILITY PRODUCTION RESULTS

Table 3.6 and Figure 3.5 show that, within the analyzed period, the average percentage of shearers use was 43.73% and the "lost" possibilities constituted 14.58% of shearers' working time. The average annual output reached 11470 Mg/d, losses (lost possibilities) reached 3820 Mg/d. The average economic sales result was 3002731 zł/d and lost possibilities of the mining facility were 1000910 zł/d.

The analysis was based on the ZEFIR dispatcher system which presents a degree of shearer's use but it is not sufficiently accurate. The data from the system present only the shearer's engaged/disengaged state and does not mention if the shearer's work is a result of mining, idle work or the shearer's maneuvering. More thorough analysis would be possible if it took into account the shearer's engine workload. This would allow to exclude the shearer's idle work or maneuvering movement.

Table 3.6 Average percentage of shearers use, daily output and economic sales result

No	Shearer	Average percentage of use within the whole longwall working period	Average daily output in one year period	Average economic result in one year period - unit price 261,79 [zł/Mg]
		[%]	[Mg/d]	[mln zł/d]
1	Joy 4LS20	34.5	2164	566513.6
2	Electra 1000/A	39.4	2724	713116.0
3	Electra 1000	56.0	4808	1258686.0
4	Eickhoff SL-300	45.0	1774	464415.5
Sum		**43.7**	**11470**	**3002731.0**

Source: [10]

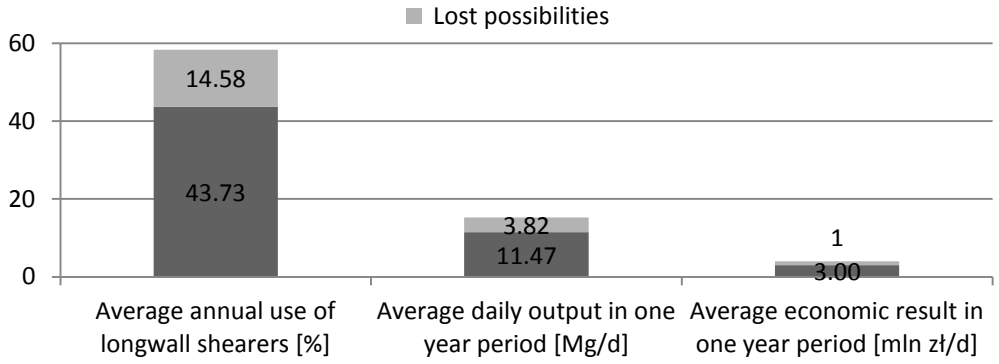

Fig. 3.5 Degree of shearers use, daily output, economic sales result, lost possibilities of the mining facility within one year

Source: [10]

CONCLUSIONS

This work presents comparative analysis of a mining facility, its output, economic sales result, "lost" possibilities, malfunction-caused stoppages, shearers' effective work and possible shearers' working time without malfunctions depending on a number of mining shifts. As a result of constant work i.e. increasing the number of mining shifts to four will increase a degree of use of mining facility's production capabilities which will decrease its losses and improve the facility's economic sales result. The four-shift system makes it possible for the facility to increase its annual working time and annual output by 25% with unaltered employment system. Constant work from Monday to Friday will not lead to increase in employment of mining personnel and costs of wages since longwalls actually work in a four-shift system. The fourth, maintenance shift employs similar number of personnel to the mining shift and that is why those calculations were excluded. What will change is the number of mining staff and the wages costs as the number of personnel employed on Saturdays will slightly increase. Because of the fact that work is planned also for free days, there will not be any dramatic changes in the facility's economic result. However, the cost of wages is not the only cost that changes when constant work system is applied. Intensification of layer exploitation is profitable because of better utilization of equipment and limita-

tion of many elements of unit costs which are part of a fixed cost. Constant work will increase mining facility's entrepreneurship and its personnel's innovative character, creativity and expansively. The constant work system will lead to a decreased number of needed longwalls, simplification of the mine's structure and limitation of investments. The financial result for a mining facility will improve although we know that higher concentration around longwalls does not automatically lead to shortening of active excavations and improvement of other works or expected limitation of mining costs [1, 8, 11]. If a mining facility takes three key factors into consideration, leadership, trust and communication, the managers' attitude towards communication between departments and concentration on long-term goals will play a crucial role in achieving success. Trust is a very important factor in technology distribution and increase of cooperation. Effective communication is connected with attitude towards different conflicts and identification of common goals [2]. Higher production concentration including introduction of additional mining shifts creates only a possibility of costs limitation and that possibility needs to be exploited [1, 8, 11].

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EXTENSION OF LONGWALL'S EFFECTIVE WORKING TIME

Abstract: *The article presents a way to increase annual output of a mining facility by 25% with unaltered employment system. The article presents comparative analysis of a mining facility, its output, economic results of sales, "lost" possibilities, stoppages due to malfunctions, effective work of longwall shearers and their predicted malfunction-free working time depending on a number of mining shifts. Implementation of constant work i.e. increasing the number of mining shifts to four per twenty four hours will allow for enhancement of a mining facility's production capabilities utilization and decrease of a mining facility's losses which will result in improvement of economic results of sales.*

Key words: *Mining facility, output, economic result, "lost" possibilities, malfunctions, effective work of longwall shearers, constant work, number of mining shifts*

WYDŁUŻENIE EFEKTYWNEGO CZASU PRACY PRZODKA ŚCIANOWEGO

Streszczenie: *W artykule przedstawiono sposób wzrostu wydobycia rocznego zakładu wydobywczego, o około 25%, przy niezmienionym systemie zatrudnienia pracowników. Przedstawiono analizę porównawczą zakładu wydobywczego, jego wielkości wydobycia, wyniku ekonomicznego ze sprzedaży, „utracone" możliwości, przerwy spowodowane awariami, efektywną pracę kombajnów oraz możliwą pracę kombajnów bez awarii w zależności od ilości zmian wydobywczych. W wyniku zastosowania pracy ciągłej, tj. zwiększenia liczby zmian wydobywczych z produkcją na dobę, czyli zastosowanie czwartej zmiany wydobywczej umożliwi zwiększenie stopnia wykorzystania zdolności produkcyjnej zakładu wydobywczego, oraz zmniejszy straty zakładu górniczego, co poprawi wynik ekonomiczny ze sprzedaży.*

Słowa kluczowe: *Zakład górniczy, wielkość wydobycia, wynik ekonomiczny, „utracone" możliwości, awarie, efektywna praca kombajnów, praca ciągła, ilości zmian wydobywczych*

mgr inż. Stefan CZERWIŃSKI
Kompania Węglowa S.A.
Oddział KWK Jankowice
ul. Jastrzębska 12, 44-253 Rybnik
e-mail: wychcki@o2.pl

4

CORRELATION BETWEEN EMPLOYERS AND VOCATIONAL EDUCATION IN CREATING COMPETENT GRADUATES AS AN ELEMENT OF REGION DEVELOPMENT

4.1 INTRODUCTION

According to recent surveys, level of vocational education is very low – the main reason is detachment of vocational education system from professional market (employers and craftsmanship organizations) and the education system which does not allow to acquire necessary skills (education time, professional training, multi-job groups, adaptation of educational offer to the needs of a local professional market, school financing system have the biggest influence on current situation). That is why most surveyed employers is convinced that when employing a vocational school graduate they will be forced to carry the burden of preparing the future employee for his professional career almost from scratch. Because of that, many companies resign from accepting students as apprentices which has further negative consequences – they also abandon their membership in craftsmanship organizations (guilds). They are not interested in profits from the membership (e.g. legal assistance, accounting, training etc.) and they perceive those organizations only as cost generating (mandatory membership fees are a huge cost for small manufacturers). As a result, craftsmanship organizations gather only those who, being idealists, are willing to educate new generations of craftsmen [11].

Employer trainings are not popular in small and private firms as they are perceived as additional costs not a long-term investment. That is caused by employers' apprehension about the lack their workers' loyalty after being sent for training. In the professional market such an employee becomes more competitive and he may change his company to one offering higher wages. There are not many company schools, apprenticeships are becoming a thing of the past. That is why students do not have contact with real work done in real life conditions not in school workshops. There used to be company schools and regular ones [11].

Growing importance of knowledge and the speed of changes in progress make employers training a necessity. Trainings improve qualifications, broaden knowledge, increase work efficiency, enable to receive certificates and open possibilities of promo-

tion. Thus it is not strange that we need to educate ourselves, our skills and abilities constantly [1].

4.2 SECONDARY EDUCATION REFORM

In order to enable employers to increase their qualifications and make them able to react quicker to professional market needs, secondary vocational education was reformed on 1 September 2012.

The secondary vocational system had been, up till then, considered to be ineffective, stretched over a long period of time and not fulfilling the needs of both potential employees and employers who found it hard to find qualified personnel in many sectors of the professional market. That situation would escalate with the future increase of population decline. It was necessary to alter the education system both for young people and adults in order to create more chances to adapt education in vocational institutions to the changing situation in the professional market. What was also crucial was a higher degree of employers involvement in creating more effective correlations between professional education and education provided by vocational schools [3].

4.3 STRUCTURE OF THE REFORMED VOCATIONAL EDUCATION SYSTEM

The new model of vocational and lifelong education, introduced on 1 September 2012, changed the education system structure. Young people will be educated on the secondary level (concerning professional education) in 3-year vocational schools, 4-year technical school or a school for the ones with secondary education degree.

Adults will be able to achieve their certificates only after specialized professional courses. They will still be able to improve their general education level in four types of schools:

- primary school for adults,
- middle school for adults,
- high school for adults,
- post-secondary school for adults.

Since 1 September 2011 the secondary education comprises:

- 3-year professional school with a professional certificate after final exams, it allows students to continue their education in the second year of high school for adults,
- 3-year high school – conditions unaltered,
- 4-year technical school – with a professional certificate after final exams and the "Matura" exam,
- post-secondary school – for people with secondary education degree, after final exams students receive a professional certificate,
- 3-year special school – conditions unaltered.

After graduating from the middle school students will have to opportunity to continue their education not only in a public or independent post-secondary schools

but also with an employer as part of professional training. According to the amendment, middle school graduates will also be able to continue their education by attending professional courses as stated in the Ministry of Education regulation from 16.07.2012 concerning cases when it is possible, for public and independent schools for adults, to accept 16 and 15-year-old students or cases when a middle school graduate may continue his/her education on professional qualification courses (Dz. U. z 2012 r., poz. 857). However it will not be possible to continue education during extracurricular activities which will not allow to take professional qualification exams [3].

4.4 PROFESSIONAL QUALIFICATION COURSE

The amendment to the education system made it possible to create additional extracurricular forms of education such as professional qualification courses. Those courses will be led on the basis of a given profession curriculum. Graduation from a course will enable students to take professional qualification exams (organized by provincial examination boards). Details for organization and conducting professional qualification courses are presented in the MoE regulation from 11.01.2012 concerning lifelong education in extracurricular forms (Dz. U. z 2012 r., poz. 186) which was introduced on 1.09.2012. Those courses may be conducted by:

- public schools with professional education in which they specialize in;
- independent schools, with entitlements of public schools, with professional education in which they specialize in;
- public and independent institutions of lifelong education, professional training institutions, vocational development institutions and training centers;
- professional market institutions mentioned in article 6 of the act from 20.04.2004 about promotion of education and professional market institutions with education-training activities (employment agencies, training institutions or public employment services);
- legal and natural persons conducting educational activities mentioned in article 83, act 2.

The new lifelong education form is to be a more effective and easier way, for adults, to deskill and obtain jobs currently required by the professional market. A larger number of institutions offering such an education form will be the chance to reach more people potentially interested in developing or gaining new skills.

The professional qualification course is one of extracurricular forms of lifelong education meant for adults interested in gaining and improving their general knowledge, skills and professional qualifications. For people under 18 years of age education is compulsory – after middle school – it is realized by attending public or independent post-secondary schools and also, according to particular regulations, by professional training with the employer. Exceptions when a middle school graduate can be educated during a professional qualification course are indicated by the regulation of the Ministry of Education.

A professional qualification course may be attended by a person who did not graduate from a middle school if he/she is at least 18 years old. Underage students may attend professional qualification courses if they graduated from a middle school and comply with requirements for realizing their education in this form [3].

Number of participants necessary to organize a professional qualification course is defined by a regulation concerning lifelong education in extracurricular forms. The regulation defines the minimum number of participants of professional qualification courses conducted by public schools, institutions and centers – i.e. 20 people. The number of students may be lower than 20 when approved by authorities. The regulation does not concern other subjects organizing professional qualification courses (e,g. independent schools and institutions) [3].

4.5 CLASSIFICATION OF VOCATIONAL EDUCATION PROFESSIONS

Polish reform the vocational education system is presented in Figure 4.1. Professions mentioned in the classification of vocational education professions are qualifications of level 1, 2 and 3 described by symbols K1, K2, K3 respectively (Fig. 4.2). The classification includes 95 level 1 professions – taught mainly in basic vocational schools. Level 1 professions are also the ones taught in technical schools and post-secondary schools whose proper ministry is the ministry of health, ministry of social policy, ministry of transportation, ministry of marine economy.

Professions taught in technical schools are dominated by level two and three qualifications. Their base qualification is usually the one meant for professions taught in basic vocational schools which form a content-related and curricular framework for further, higher professional qualifications (characteristic for professions taught in technical schools) [3].

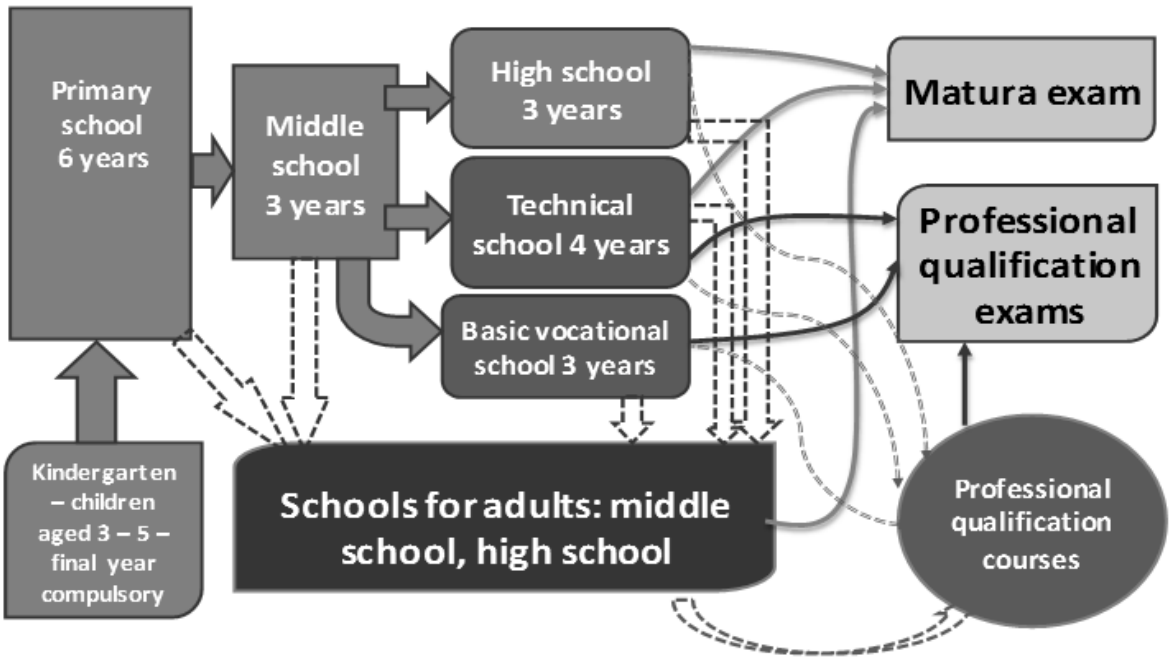

Fig. 4.1 Reform of the Polish vocational education system - Wrocław, 8 April 2011

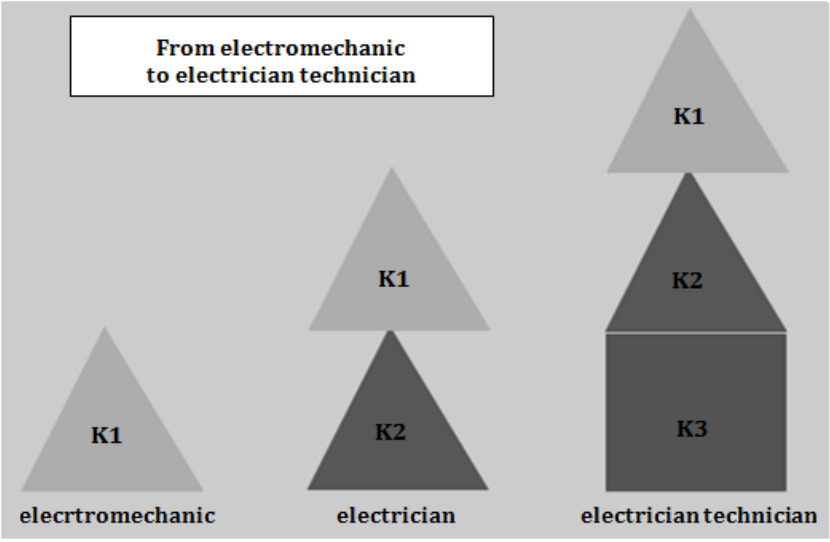

Fig. 4.2 Reform of the Polish vocational education system - Wrocław, 8 April 2011

4.6 FINANCING PROFESSIONAL QUALIFICATION COURSES

In case of schools and educational institutions run by local governments, costs are one of, not the only one, the basis for organizing courses. It is important to take care of potential students who are given a chance by this kind of vocational education to succeed on the professional market [10].

Financing PQCs (Professional Qualification Courses) in schools and institutions run by a county is its educational task (art. 5a, par 2b of the education system act from 19 August 2011).

Financial means for organizing professional qualification courses by public schools and institutions run by a local government and subsidizing public schools run by subjects which are not part of local governments and independent schools with public school entitlements are part of the education general subsidy. The amount of subsidy will be determined by a planned number of a course students presented in the Education Information System according to a status from 30 September in a year preceding the one which a subsidy is counted for.

Public post-secondary vocational schools and public institutions run by local governments may also organize PQCs by order of employers and county employment agencies. In other cases, according to art. 40 of act. 2b from 20.04.2004 concerning promotion of employment, professional market institutions (Dz. U. from 2008 nr 69, pos. 415, with later changes) a county prefect may commit organization of a professional training to an institution created and run by the prefect him/herself. In that case, sources for financing PQCs may come from the Labour Fund or programs financed by the EU.

Public schools organizing PQCs by a legal entity which is not a local government or by a natural person and independent schools with public school entitlements will be given a subsidy from a county budget for each student that passed a professional exam within a given qualification. The amount of a subsidy may not be lower than the amount for one student of a PQC in the part of the education subsidy for local governments [5].

Financing professional courses by other entities may only be realized by [8]:

- payments from course participants,
- payments from employers ordering such courses,
- financial means from the Labor Fund or the EU programs and funds.

On recent years, the accessibility of structural funds have allowed regional and local governments to get involved in the process of changes in vocational education more actively. Some voivodeship governments have taken a role of a coordinator for modernization of vocational education in their area [6].

4.7 PROPOSED ACTIONS SUPPORTING EFFECTIVE COOPERATION WITHIN THE VOCATIONAL EDUCATION REFORM

Effective cooperation between vocational schools and businessmen is beneficial for employers, schools and students. Employers have a possibility of educating their future employees with expected skills, personal and social competence necessary to start work. Students may familiarize themselves with modern technology, gain practical skills to operate the latest equipment, they also have the opportunity to develop such skills as team work, stress and time management.

Contemporary surroundings are becoming a maze of networks and organizations are less able to participate alone in the competition, The need to act in face of changing demands of the market favors creating relations with surrounding entities which can decide companies' development of even survival [2].

Clusters

When speaking about rules of mediation and establishing cooperation between schools and businessmen it is important to mention industrial clusters. The concept of a cluster is becoming very popular as an effective form of cooperation and a platform facilitating interactions between entities creating it. Clusters are an elastic form of cooperation between 3 groups of entities: companies, educational institutions and research entities (science institutions, research institutions) and public authorities, thus they create possibilities for cooperation between education and the world of business.

The main characteristics of a cluster is its competition (competition as well as cooperation between entities, a strategy of mutual creation of values and competition with common goals and endeavors of a given sector, branch or region). The most important areas of a cluster activity around knowledge transfer are [6]:

- benchmarking groups (platforms for analyzing processes and practices employed by own company compared with practices employed by other companies, considered the best in an analyzed area, being a standard)
- research centers specializing in education, training and cooperation programs
- trade institutions (associations, organizations) with a goal to initialize and coordinate actions leading to improvement of particular areas within a cluster.

New educational clusters with connection to industrial ones may be a very interesting solution for the educational market. Zespół Szkół Zawodowych, Powiatowe Cen-

trum Kształcenia Ustawicznego and Centrum Kształcenia Ustawicznego in Wodzisław Śląski are an example of good luster-based cooperation.

Financing according to a German model used in construction business

In countries like Germany and Austria, where the vocational system is mainly dual, training realized with an employer is very important. In companies, students gain professional experience and are prepared for future work. This connection is considered a benchmark all around Europe and is the key factor for Austria's success as an important education and industry center. It is worth to note that the unemployment level among young people in Austria is only 9% and is one of the lowest in Europe. What is important is the fact that in those countries it is the employers who take the financial burden of preparing young people for the professional market [6].

The construction business in Germany utilizes a fund created by all companies called SOKA-BAU. The fund, apart from its vacation compensatory branch (ULAK – Urlaubs und Lohnausgleichskasse der Bauwirtschaft) and additional retirement branch (Zusatzversorgungskasse des Baugewerbes) uses its sources for educating students in professions connected with the construction business. The compulsory deduction is 2% of a ocial fund of construction companies (those with at least 50% of their production/turn over in the sector). The fund finances educational centers (supra-regional institutions developing practical skills), livelihood of students in those centers, scholarships.

Training in a company

Training in a company allows students to familiarize themselves with modern management methods, work organization, utilization of modern technology. Teachers have an opportunity to update their theoretical and practical knowledge. Employers will expand school's learning materials by providing them with materials concerning introduced innovations and offered products. They will also make their products available to schools and practical education institutions to be used during classes [9].

Practical training and theoretical education will be more effective when teachers of theoretical subjects take part in the process of gaining knowledge from a company where their students improve their skills. A compliment for the gained knowledge would be a simultaneous cooperation between science centers, higher education institutions, teachers and gifted students. Introducing them to annals of a profession at universities it would be possible to organize regular meetings to broaden specialist knowledge. That is why teacher-university, teacher-employer relations should last for the duration of the education process (at least once per two weeks). At times of population decline, instead of taking popular and drastic steps like personnel reduction, it is possible to change that fact into an success engaging teachers into training on the basis of the abovementioned relations with a financial support of employment agencies. There are methods of improving teachers' and students' knowledge on the basis of short-term trainings from 1 day to 2 months. Short-term trainings not always reflect the characteristics of a position or its issues. They also leave many questions unanswered.

Time Bank

In order to compensate the financial costs the employers spend on graduates, it would be better to have a time bank rules. They would be based on a connection student – employer; employer- teacher; teacher – school; student- school.

A time bank is an informal self-help based institution, that can exchange unpaid service among its members. The contributors declare what kinds of service they can provide for the benefit of others and the coordinators head it (the service) up to those who need it, according to earlier requirement. The service provided for the benefit of the bank's customers is registered- the easiest clearing unit is an hour, regardless of the market value of the work done. Hours which were earned in such a way could be 'spent' on direct support given by the other member belonging to the system, offering us an interesting service [12].

Gaining the knowledge from people starting to retire

The workers who gained professional experience and knowledge thanks to employers and hard work, take them away at the point they retire. In this way the entrepreneur pays the costs related to introducing a new inexperienced employee. To regain some part of the invested money, for example, one year before the retirement an experienced jobholder may cooperate with the new one, in order to transfer his/her experience and knowledge. The motivation for the experienced worker could be the way of settling accounts – some parts of profits acquired by a trainee are cumulated on a special account and, under the condition a trainee passes the in-house exam, the money will go the retired (misappropriation of funds prevention). In case the intern fails, the money from the account goes to an outer company, to pay for the further schooling. The willingness to work as a retired person would result in greater commitment from both parts, because after some time another intern will have to be instructed.

Retrofitting workshops with new tech – didactic equipment

Changing technology, high costs of modernization, keeping tech-didactic base, the necessity of upgrading teachers' skills cause that vocational training needs greater amount of pecuniary than traditional education. Schools have no chances of vocational education in actual conditions, without a cooperation with employers. What is more, they cannot acquaint students with the latest and most expensive technologies. The cooperation between schools and employers, although better year by year (a lot of instances prove it), still faces a lot of barriers, even if it is advantageous to both parties. For schools, it gives possibilities to adapt the content of education to the employers' and labour market needs, better access to modern technique and technologies. For companies, it is a great opportunity to roll their products out and in further perspective, to recruit well qualified workers. The cooperation with educational environment, employers and social partners is essential prerequisite for achieving high results in vocational education [9]. In case when the occupation requires to be age-appropriate, simulators should be introduced in school workshops.

The internet edu- occupational platform

Great support for both: teachers and students, would be the access to sophisticated scientific and technological knowledge available on the company website. In this way they could get information they need in the exact occupation.

A good example could be the edu- occupational platform called 'foreman and the stuff zone' lead by Jastrzębska Spółka Węglowa S.A., (Jastrzebski Coal Company) which disposes extra resources (useful for those who accustom to mining trade), and free access to updated Polish Norms and parts of data used in a teaching process, without trespassing the companies/partners' business (Fig. 4.3).

Another example how to make use of e-learning technology is PCKU in Wodzisław Śląski. Through the introduction of e-learning classes, the traditional qualifying courses duration is shorter.

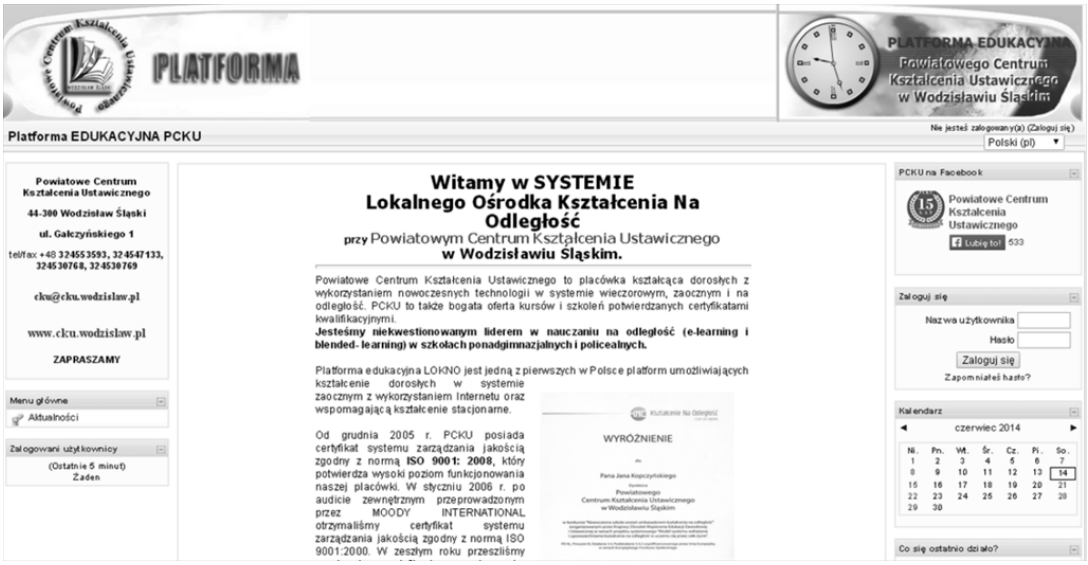

Fig. 4.3 View of educational platform PCKU in Wodzislaw Slaski

It is the National Centre for Supporting Vocational and Continuing Education (pol. KOWEZiU) which is responsible for the idea of creating the professional edu – industrial cluster, based on an internet platform (Fig. 4.4 and 4.5).

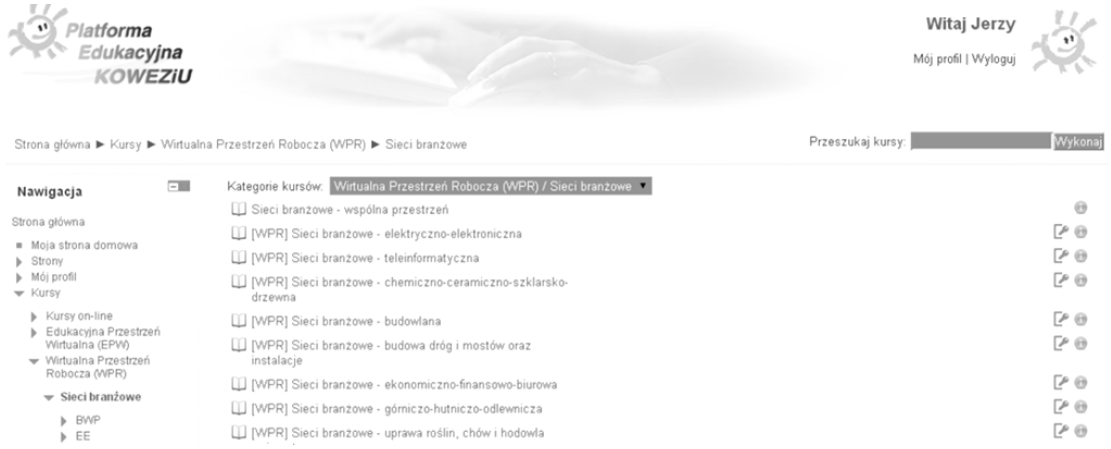

Fig. 4.4 View of branches forming the beginning of a cluster

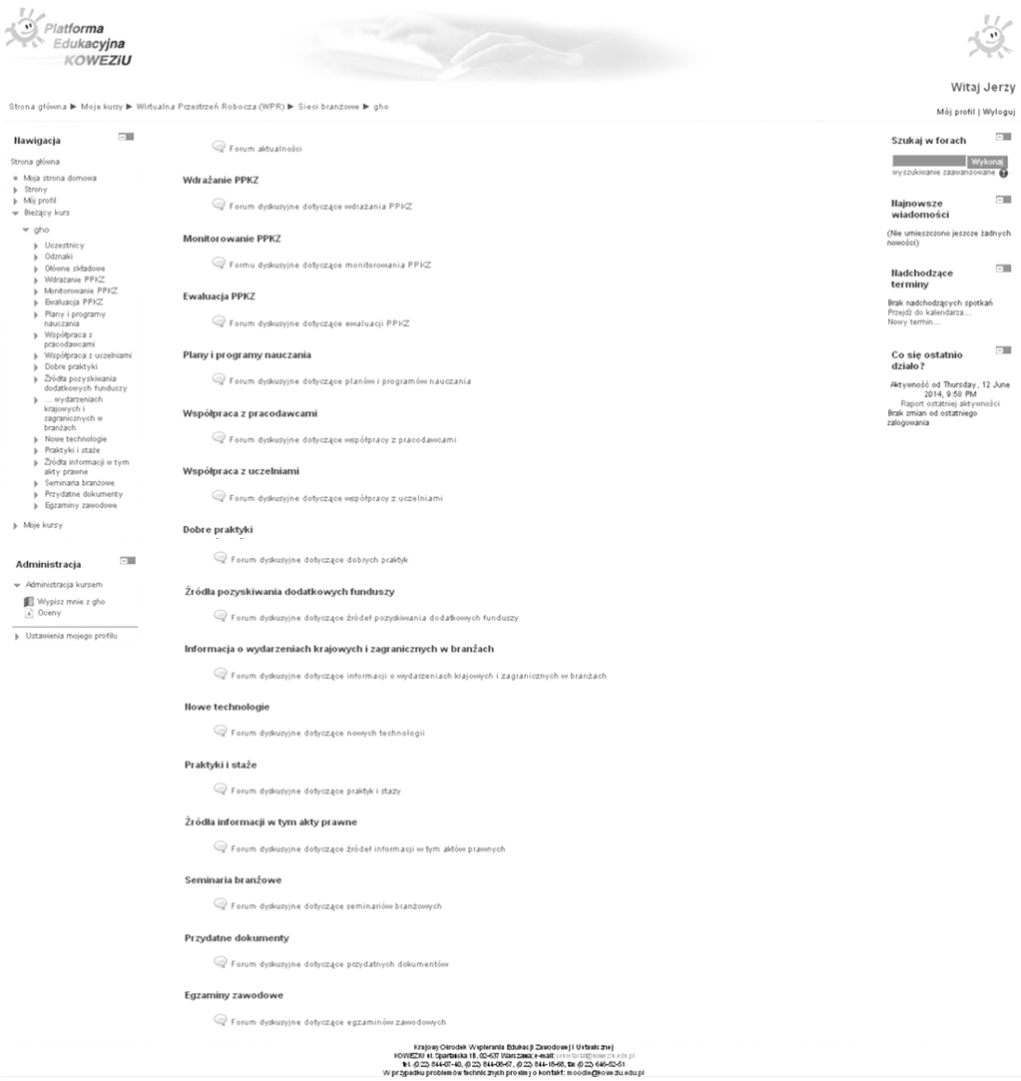

Fig. 4.5 View of the issues in the mining, metallurgical and foundry business

The cooperation between the authors of exam tasks and the employers

If the author, creating the exam tasks, can do an internship in the corporation, it will bring the advantages of exam tasks which are topical and contain, recognized by the employers, actual skills. The vocational school reform allows the branch specialists (after receiving the specific training) to work as tasks authors and examiners. There is also a possibility to create in companies the exam centers, which are allowed by the district exam committee, to run and supervise the exams confirming job qualifications.

4.8 THE REASON OF LACK OF COOPERATION BETWEEN EMPLOYERS AND SCHOOLS

However, the cooperation between schools and companies is still weak, few and far between and unorganized. On the employers side a lot of barriers occur connected with establishing and conducting activities moving towards long-term involvement. The aim is to eliminate obstacles given below and try to establish regular, not occasional, purposeful and long-term cooperation between schools and employers.

The barriers on the employers side [6]:

- short- term and narrow-minded speculating focused on survival and securing on-going business,
- low awareness about long-term benefits to employers, resulting from considering the expertise of workers in the company in longer perspective,
- the economical factor: too low investment outlay given on cooperation by the companies,
- poor level of knowledge in the area of advantages in terms of cooperation between vocational schools, which is one of the methods preventing from shortage of qualified workers,
- lack of worked out contribution strategy in discussion concerning the need of cooperation between schools and companies,
- low motivation to take part in active discussion about competences,
- low level of social business responsibility,
- lack of a local unit that would mediate in initiating, establishing, coordinating and introducing the cooperation of schools and employers,
- complicated and long-term procedures which accompany in creating cooperation,
- organizational issues of the employer, including lack of proper structure, space, entity or person responsible for the issue of cooperation with universities or high schools; lack of appropriate conditions for the organization of the practice;
- Inadequate to the needs of companies, the educational offer, which discourages them to cooperate with schools (many companies complain about the lack of schools in the area, educating the profession the companies are interested in), but does not take action associated with the formation of the offer;
- ignorance concerning the possibility of participating in curriculum development
- reservations about the attitudes and knowledge of teachers, including in the opinion of employers, they do not show interest in the profession, are not up to date, do not follow trends, they are not interested in replenishing knowledge, and sometimes in cooperation with employers;
- difficulties in adapting the program of practical training to the actual capabilities of the employer;
- lack of gratification to encourage employers to become more involved in the process of vocational training,
- major barriers in cooperation with schools in the development and implementation of curriculum, declared by employers were [6]:
    - lack of interest on the part of schools (25%);
    - no time for this type of activity (15.5%);
    - insufficient number of staff (14%);
    - lack of benefit from such activities (13.5%);
    - insufficient knowledge in this area (9%);
    - other (5%).

CONCLUSIONS

The active involvement of employers in the education of young people and close cooperation with the schools could increase the level of practical skills and soft skills of people entering the labor market, (employers often complain about the lack of adequately trained people). As a result, this would lead to a reduction in employers' recruitment problems, reduce expenditure on training new employees and shorten the time period needed to implement them. In addition, reduce the scale of the mismatch between supply and demand on the Polish labor market, and thus the level of youth unemployment. However, many employers do not decide to start cooperation with schools. For the local and regional economy, it is important to introduce well prepared youth to enter the labor market and to provide them with adequate skills sought by employers. The quality education, including vocational education, affects business decisions relating to job creation – locating investments, expanding the scope of its operations [6].

From the employer's point of view, a person with no practical experience requires a lot of time and financial resources to become a useful worker, especially in the absence of practical preparation. (The labor market observer of Wałbrzyskie region, Second partial report). On the other hand, an investment in such a person entails the risk that as soon as she/he gets the knowledge and experience, will go away to another employer, who will offer better pay conditions, and will no longer have to train a new employee. Rational employers prefer searching through the labor market to find experienced workers who have gained practice elsewhere. These types of dilemmas can be eliminated through the implementation of a larger number of practices and internships offered to students and closer cooperation between schools and employers [7].

As long as school cooperation with the employer is located in the category of the budget of the employer covering marketing and advertising, many favorable for pupils tasks may be carried out from the scope of the broad sense of vocational education. These include, among others, educational excursions to the company headquarters, training with the scope of the technology or materials produced at the employer's. Problems arise when the contract provides for free transfer of donations to schools/institutions, such as materials, tools, machinery and equipment to modernize the tech- didactic base of teaching. According to regulations, the donor must pay corporate income tax and VAT, which undoubtedly limits the scale of cooperation between schools and employers at this level. The school can sign an agreement (contract sponsorship) with the employer about receiving free materials, tools, equipment and other products, which conditions are specified so that both parties have measurable benefits. The donor in exchange for his help in the form of techno-didactic equipment, expects a particular form of promoting and advertising their business on the school grounds. Like any contract associated with legal consequences, it should also be signed by the controlling body [6].

The cooperation of employers to improve the quality of vocational education should give young people the preparation for the work, which finds acclaim with all employers and at the same time meets the challenges of the European labor market [9].

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CORRELATION BETWEEN EMPLOYERS AND VOCATIONAL EDUCATION IN CREATING COMPETENT GRADUATES AS AN ELEMENT OF REGION DEVELOPMENT

Abstract: *The work includes information concerning secondary education reform. It presents structure of the education system, qualification courses and the way they are financed, selected recommendations for more effective skills and knowledge acquisition with cooperation with employers and higher education institutions. It also shows concerns connected with the cooperation.*

Key words: *Secondary education, clusters*

KORELACJA PRACODAWCÓW Z SZKOLNICTWEM ZAWODOWYM W KSZTAŁTOWANIU PEŁNOWARTOŚCIOWYCH ABSOLWENTÓW, JAKO ELEMENT ROZWOJU REGIONU

Streszczenie: *W pracy zawarto informacje o reformie szkolnictwa ponad gimnazjalnego. Przedstawiono nową strukturę systemu edukacji. Omówiono kursy kwalifikacyjne oraz sposób ich finansowania. Omówiono wybrane propozycje lepszego pozyskiwania umiejętności i wiedzy przy współpracy z pracodawcą i uczelniami wyższymi. Przedstawiono obawy pracodawców związane ze współpracą.*

Słowa kluczowe: *Szkolnictwo ponad gimnazjalne, klastry*

mgr inż. Jerzy DYCHAŁA
Zespół Szkół Zawodowych
Powiatowe Centrum Kształcenia Ustawicznego
ul. Gałczyńskiego 1, 44-300 Wodzisław Śląski
e-mail: irzj@interia.pl

5

ULTRA-THICK SEAM MINING AT THE ČSM MINE IN THE CZECH REPUBLIC

5.1 INTRODUCTION

Thick and ultra-thick seam mining in underground black coal mines still represents a problem. Modern operational almost all mines in the world has already completely eliminated benching with artificial ceiling, or with lowering the ceiling layer.

Modern types of roof supports allow mining up to the thickness of 6 m, but for technical reasons, the seam is sometimes divided and mined in two benches with the thickness of around 4m, leaving a protective layer of coal seam between the top and the bottom of the bench.

Such method of mining may represent certain risks, such as in areas with the risk of shocks or spontaneous combustion of coal mass from a collapsed protective layer and may be used only after proper assessment of the circumstances.

This method was applied at the ČSM Mine in the Ostrava-Karviná district in the Czech Republic. One of the reasons why this method of extraction was selected was the experience with demanding coalface preparation, equipment and clearing out the facilities, especially roof supports over four meters in thickness.

5.2 GEOLOGICAL LOG AND SEAM STRATIGRAPHY

In the mining field of the ČSM mine, seams 39 and 40 merged and the resulting seam reached a thickness of up to 8.6 meters. These seam profile is shown in Figure 5.1 [6]. This is followed by thick layer of sandstone, which reaches 15 m. The over burden was evaluated with compressive strength of 80 MPa and classified as degree 2-3of the risk of shocks. The average compressive strength of subsoil is 75 MPa. The relatively lower strength of the sandstone overlying layer, compared to other seams of saddle layers, was an important factor when the decision concerning the way of mining was being made.

The seam belongs to theist straits graphic zone of saddle seams and Figure 5.1 shows an example of its development according to the borehole profile CSM-1258/04-CMD, a. s. - CSM1. It is clear from the geological profile in Figure 5.1 that the 4 mover burden seam is a layer of sandy siltstone, up to coal band of 54 cm.

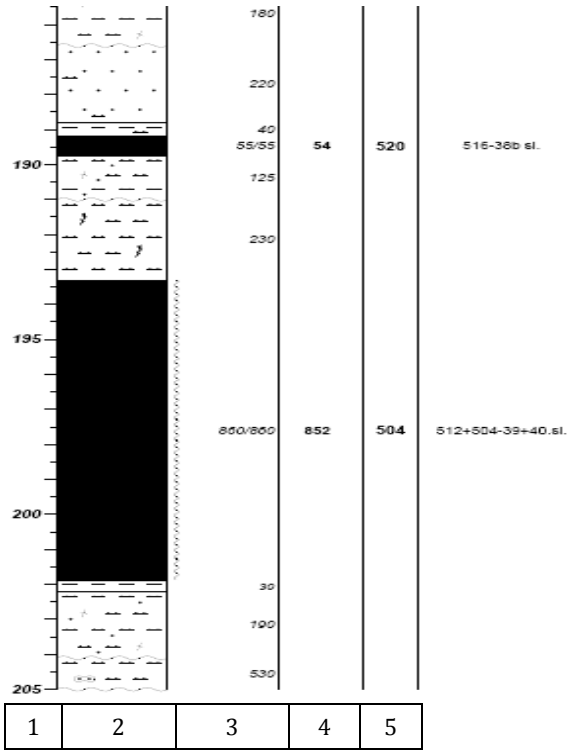

Fig. 5.1 Seam profile 39+40 in a coal field of the ČSM Mine

1. Profile, 2. Thickness, 3. Accepted real thickness, 4. OKD (Ostrava-Karviná Mines) code, 5. Seam number
Source: [6]

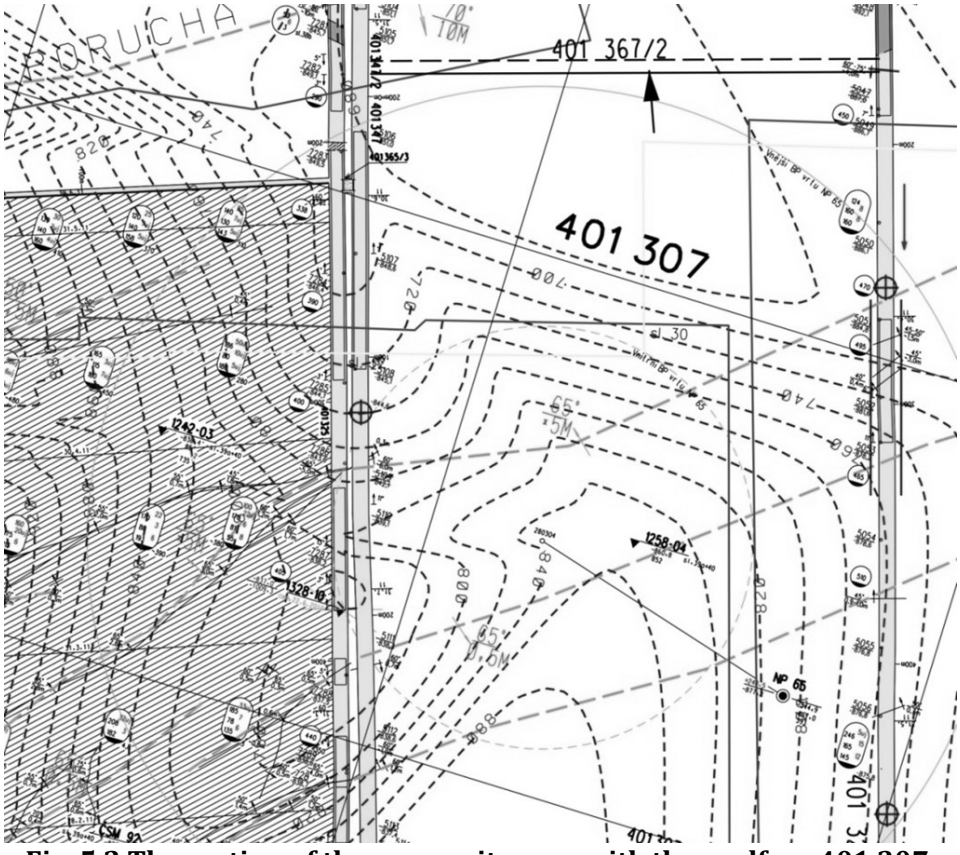

Fig. 5.2 The section of the composite map with the coalface 401 307

Source: [6]

If the strength of the over lying layer were higher and there would be a risk of shock, it would present a problem to keep the protective coal seam [1, 4, 5, 8, 9]. The location of the coalface 401, 307 is clear from the section of the composite map in the upper bench of the seam 40 (Fig. 5.2).

The chart of the equipment in the coalface and in the main entry and the up cast drift is in Fig. 5.3.

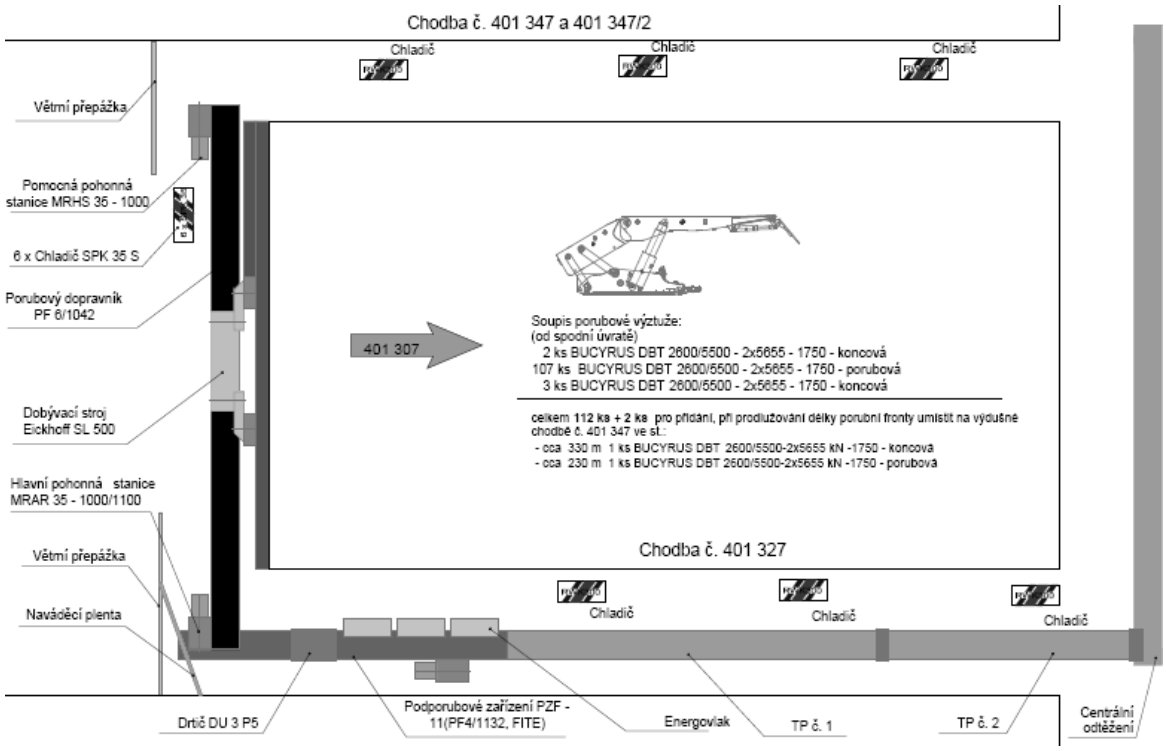

Fig. 5.3 The equipment in the coal face, in the main entry and the up cast drift

Source: [6]

The mining parameters and specifications of the extraction of the coal face 401, 307, on the bench are stated in the Table 5.1. Therefore, the seam with a thickness of up to 8.6 is mined in 2 benches. The thickness of the upper bridge is 4.5 m. The thickness of the seam part, which is left between the lower and upper bench is at least 0.8-1 m.

The lower bench has a mine able thickness of about 3.5 m then. For both benches, the common advancing support DBT2600/5500 was used.

The advancing support DBT2600/5500 has the following parameters [10]:

Section height	2.6-5.5 m
Working Range	3.0-5.5 m
Max. longitudinal inclination	±25°
The distance between the section sat the coalface	1.750 mm
The section step	900 mm
Working pressure max	32 MPa
The reinforcement resistance (for: w > 4,8 m)	886-1088 kNm-2.
The section bearing capacity(for: w > 4,8 m)	271 kN
The section weight	~ 35713 kg

Table 5.1 The coal face 401 307 parameters and the specification of the extraction

	Mine	ČSM SOUTH			Coalface n.	401 307					
TECHNOLOGY	coal cutter		coalface conveyor			collecting conveyor			extraction		
	Eickhoff SL 500		PF 6/1042			PF 4/1132			TP 1201		
Coalface length	[m]	193,6	Extraction capacity			[t/h]	1590	Extraction speed		[m/min]	3
Mined thickness	[m]	4,5	Collecting conveyor capacity			[t/h]	2200	Loading speed		[m/min]	5
Net thickness	[m]	4,5	Coalface conveyor capacity			[t/h]	2000				
Working width (slab)	[m]	0,85	Coalface mining capacity – minimum				1590				
Y (raw mining)	[t/m3]	1,145	*Capacity of the machinery in the line*								
Y (ROTP)	[t/m3]	1,31									
Line operation	[%]	0									
Way of leaching	traditional	yes	total time DS travel	slab	[min]	103,3		reloading time	[min]	bottom dead centre 15	
	with permanent working width			day	[min]	837				upper dead centre 15	
Mining cycle time	[min]	133		Planned operation of the line		[min]	837				
											ROTP
Number of cycles	per shift	2,7	Net working time fund			[min]	1035	Calculated mining		[t/day]	7862
	per 24 hours	8,1						Planned mining		[t/day]	4800
Daily procedure	[m/day]	7									

Source: [6]

The required rein for cementers is tunefully complies with the requirement for a fixed over burden to be150·ms, where ms is the seam thickness [7].

This solution conforms to the present-day economic requirements. The previous methods of benching used so-called artificial ceiling that was formed in different ways. Usually, geo textile was used, for example, in combination with wire mesh. It was placed on the upper bench floor [2, 7]. The left coal bench presents a certain risk because it collapses into a wall cave in the bottom bench. This can result in the risk of condensation. Due to timely preventive measure using nitrogen application, however, the risk of condensation was successfully eliminated.

Figure 5.4 shows how the coal face 401, 307 is prepared for clearing out. Using the mining machine, wide enough space (road) is created, where the assembled reinforcements moved and it is transported to the road [11].

The procedure shown in Figure 5.4, takes place in the following stages: When the coalfaces finished, plane TH reinforcement is clamped under the section on which Demes sieves are put (which is basically are placement for expanded metal). Sometimes plane thrusts were also anchored by bolts, but it does not follow from the layout. In the next stage, using coal cutter(usually a smallertype-AM50, etc.) the pillars cut around, the planes extended and the side TH of the leg is installed.

In the next phase, the drawing shows pulling the section out in the alley. The section is then turned and cleared out towards the main entry [11].

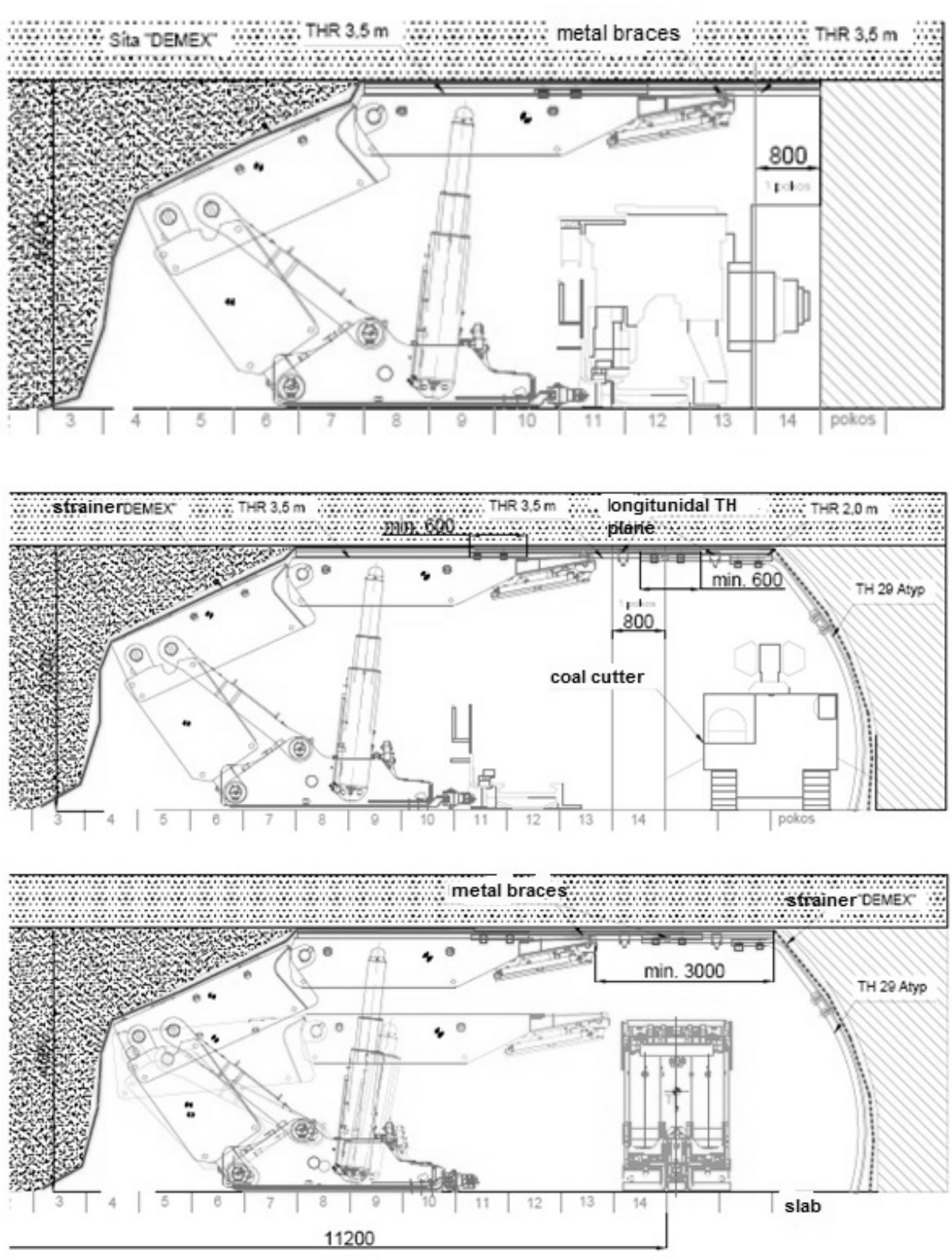

Fig. 5.4 Preparation of the coalface 401 307 for clearing out

Source: [11]

CONCLUSIONS

For the extraction of black coal seam with a thickness of 8.6 m, the method of mining with a coal protective layer can be used, which is economically advantageous. The condition forts application, however, is a detailed assessment of natural conditions. It is necessary to determine whether this is an area without danger of upheaval, or with little risk of this phenomenon, and whether the risk of spontaneous combustion can be eliminated using technical means, such as nitro generalization.

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ULTRA-THICK SEAM MINING AT THE ČSM MINE IN THE CZECH REPUBLIC

Abstract: *The article presents method of preparing coalface and mining black coal seam with a thickness of 8.6 m. It further states the reasons why the procedure was selected. At the same time, a list of the coalface equipment and technology applied while the coalface was being cleared out after its completion is attached.*

Key words: *Thick seam, mining, geological log, protective layer of coal, coalface, advancing support, shock, spontaneous combustion*

EKSPLOATACJA GRUBYCH POKŁADÓW WĘGLA W KOPALNI ČSM W CZECHACH

Streszczenie: *W artykule przedstawiono sposób przygotowania przodka i wydobycie pokładu węgla o grubości 8,6 m. Ponadto wskazano na powody wyboru procedury. Równocześnie załączono listę wyposażenia przodka oraz stosowane techniki podczas wybierania przodka, aż do momentu jego zakończenia.*

Słowa kluczowe: *Gruby pokład, górnictwo, geologia, warstwa ochronna węgla, przodek, postęp, wstrząsy, samozapalenie*

Ing. Beáta GIBESOVÁ, Doc. Petr ŽŮREK, CSc, Ing. Adéla CIBULCOVÁ,
Ing. Petr URBAN PhD., Ing. Josef CHOVANEC, PhD.
VŠB - Technical University of Ostrava
Faculty of Mining and Geology
17.listopadu 15, Ostrava-Poruba, Czech republic,
e-mail: G.Beata@seznam.cz, Petr.Zurek@vsb.cz, Cibuad@seznam.cz,
Petr.Urban@vsb.cz, Josef.Chovanec@vsb.cz

6

SUPPLY SYSTEM OF FLY ASH FOR MINING PLANTS – ANALYSIS OF THE PROBLEM

6.1 INTRUDUCTION

In Poland, a leading source of heat and electricity is a coal. More than 90% of energy comes from combustion of coal, and therefore Poland is the one of the leading manufacturers of coal combustion products (CCPs) in Europe [19]. The main coal combustion product is the fly ash from black coal, which increasingly is treated as a full blown product, which could be an alternative to the aggregates. It is used in many areas, especially in coal mining and construction industry. Use of this material is essential for economic and ecological reasons, because it allows to elimination of landfills and to protect the other resources.

However, delivery of fly ash to operational places (mines) is a complex system, in which may arise the numerous difficulties both technical and organizational nature, and related to the environmental aspects and health and safety at work. The most important problems in currently existing supply system are, among other:

- the problem of secondary dust emission during loading, transport and unloading of products,
- reliability of supplies,
- choice of mode and means of the transport,
- and the problem of warehousing of fly ashes.

These issues make it necessary to modify existing supply system and seek for alternative solutions, which may allow to reduce or completely eliminate existing difficulties.

6.2 RECOVERY OF FLY ASH IN MINING PLANTS

The characteristics of coal combustion products (CCPs)

The coal combustion products (CCPs) are called fixed products created in the course of transformation of chemical energy of fuel to thermal energy in power plants and CHP plants [21]. These include, in particular:

- fly ash,
- slags,
- mixture of ash and slag.

Depending on the type of fuel and furnaces and also combustion conditions, the form and properties of the waste may be different. According to the Decree of the Minister of environment on the catalogue of waste (OJ 2001.112.1206), all of energetic waste are classified as a group of 10 01 – „wastes from power plants and the other fuels combustion plants" (with the exception a group of 19) [12].

Table 6.1 Selected energetic waste used in underground mining technologies

10 01 – Wastes from power stations and other combustion plants (except 19)	
10 01 01	Bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)
10 01 02	Coal fly ash
10 01 05	Calcium-based reaction wastes from flue-gas desulphurization in solid form
10 01 80	Mixture of ash and slag
10 01 82	Mixtures of fly ash and solid waste with calcium-based flue gas desulphurization (dry and semi-dry method of flue gas desulphurization and fluidized bed combustion)

Source: [12]

Selected energetic waste, which can be used in underground mining technologies presents Table 6.1. The largest group of energetic waste is fly ash (about 80-90%). It is the remnant from the coal or lignite combustion in boilers, that of emissions, in which mineral grains of less than 0,075 mm is more than 50% [7] of all grains. Fly ash is captured by electrostatic precipitators placed on boilers. It has dust form in gray or light brown color and its main components are oxides of aluminium, silicon and iron. Due to the participation of basic components of fly ash, it can be divided into three groups: silicate ashes, aluminum ashes and calcium ashes [16].

In Poland, in 2012 have been produced about 21 million tones energetic waste of which 4,6 million tones was coal fly ash (code 10 01 02) and 3,8 million tones were mixtures of fly ash and solid waste with calcium-based flue gas desulphurization (10 01 82) [11]. A large number of coal combustion products is forcing the Polish Industry to take action aimed at their recovery. Recovery - all activities that do not pose a threat to human life and health or the environment consisting in the use of waste (in whole or part) or leading to the recovery of substances, materials or energy from waste and its use[4]. The duty of disposal or recovery of energetic waste is based on the law of 14 December 2012 on the waste. In Poland, popularization of the energetic waste management deals with Polish Union of Coal Combustion Products which comprising representatives of heat and power plants, enterprises, scientific institutes and research laboratories [16].

The use of fly ash in mining plants

To fly ash can be used it has to meet certain quality standards. Possibilities of the use a wastes are dependent on their properties, e.g. grain size, chemical composition, content of sulphur compounds and, above all, the amount of free CaO. The content of calcium oxides (CaO) of less than 3,5% are classified ash as inactive, 3,5-14% as low active, and over 14% as active [7]. Activity of fly ash is a measure of its fitness to chemical stabilization.

Fly ashes are used primarily in building materials industry, road construction and in underground mining technologies. In recent years, mining industry has become a mass consignee of fly ash, mainly due to implementation a lot of new technologies (e.g. preparation of ash-water slurries) [7]. Currently about 85% of all waste, which are located in mines, is the fly ash and mixtures of fly ash and solid waste with calcium-based flue gas desulphurization.

The main directions of management of fly ash in mines, among other, are [4]:

- grouting of mine carvings,
- liquidation and filling of unnecessary mining workings,
- solidifying backfill,
- preventive fire protection and fire fighting in mines.

Characteristic application of fly ashes in Poland, in mining underground, is their use as a component of materials to filling mining workings where they replace valuable quartz sands. However, they are also used in the form of water slurries to perform anti-explosion dams, to build fields for the recovery of methane, to braking explosions and to liquidation of fire risks [19], which level in Poland is still very high despite the use of increasingly perfect technique for early detection of fires and more effective prevention [10]. All of components, endogenous fire arises in the presence of combustible material, inflow of oxygen and a temperature capable to ignite a coal, through which it comes to the creation of endogenous fire, are present in mine cavings – therefore, it is necessary to their grouting.

Nevertheless, to the recovery of any type of wastes in mines should be approached in an individual way, because depending on the technologies of waste generation, their properties are variables. Lack of proper precautions can lead to serious consequences. The way of the use of waste is determined by the technical services of particular mine which accept waste for recovery. The way of their use in mine works require also relevant records, among others, in plan of mining plant operations. In recent years, the demand of mines for fly ash is gradually increases, therefore it is necessary to use the efficient supply system of this product, which meet the requirements of mine plant as best as possible.

6.3 THE STRUCTURE OF SUPPLY SYSTEM OF FLY ASH

Generally, the system is a collection of mutually and deliberately interrelated elements. The term of supply system should be understood as all elements which are present during physical flow of product from place of origin to place of receipt along with the accompanying the flow of information.

The most important elements of the system are [2]:

- physical flow of goods (transportation),
- organization and flow of information,
- storage/stock management,
- infrastructure,
- costs of the supply chain.

Supply systems can have a different structure depending on number of brokers between the supplier and the consignee. In case of absence of brokers between the links in the supply chain is said to be about the direct system, but if there is at least one broker says about indirect system or mixed system (combined system). Division of supply systems according to their structure, illustrated Figure 6.1.

Analyzed supply system, in which the fly ash flows between power plants and mining plants, has a direct structure. There are three types of flows between links of supply chain: physical flow of goods, flow of information and flow of finance. Organization of physical flow of goods is focused, primarily, on the choice of appropriate mode and means of transport, organization of transport and planning of supplies. This type of flow is assisted by information flow both before, during and after delivery. In turn, the organization of information flow consists in gathering and exchange of information about future demand for fly ashes (their quantity, time and way of delivery). Close cooperation in field of the exchange of information between power plants and mining plant determines the correct realization of supply chain processes. This is very important mainly due to the seasonality of the fly ashes.

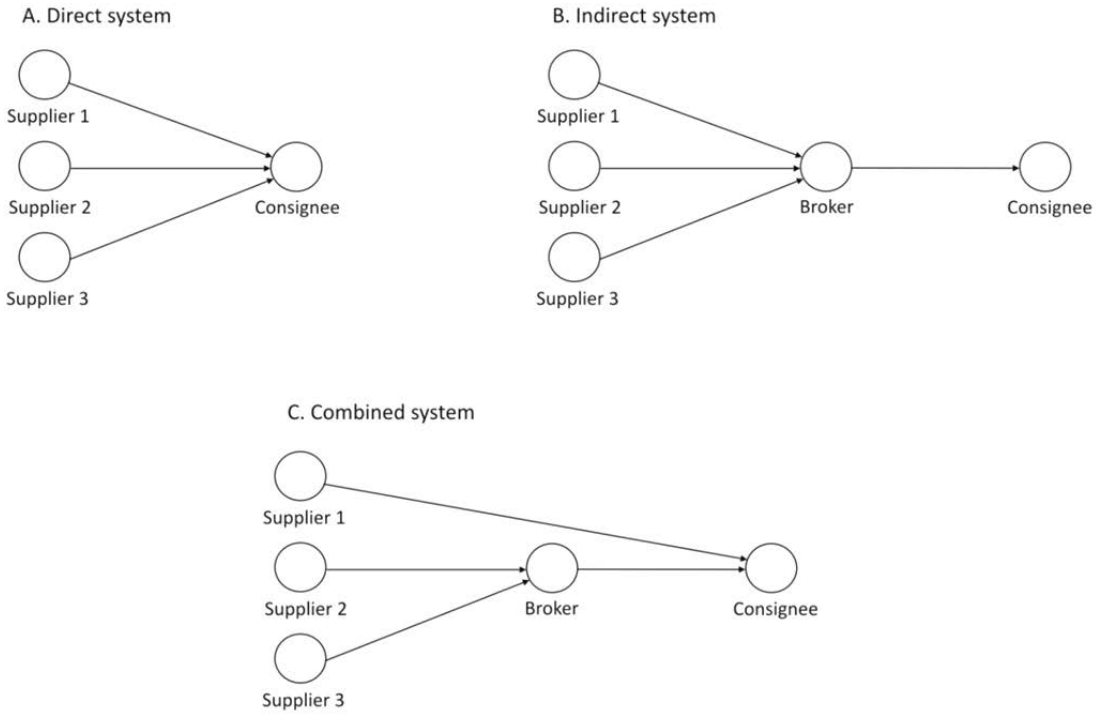

Fig. 6.1 Division of supply systems according to their structure

Source: own work based on [5]

During the heating season (from November to March) there are produced significant quantities of ashes which must be received from power plants due to limited retention of tanks. But while the off-season there is a risk, that need of the mines on the fly ash will not be met. In connection with above situation, the power plants and mines must assist each other. When total synchronization of inflow and outflow of streams is not possible and there are random cases (e.g. endogenous fire), a good solution may be to keep a certain quantity of stock of fly ash on the area of mine.

The whole supply system is burdened with cost of resource consumption of this system, first of all, there are cost of transport, maintenance of stock and processing of information related to these activities.

Example of supply system of fly ash presents Figure 6.2.

Physical flow of product starts in power plants, where the fly ashes from coal are generated. From there, they are transported by pipeline over short distances to retention tanks (silo) where they are temporarily stored. From silos, fly ashes are loaded, by charging sleeves, to the appropriate means of transport, wherein overcomes the main part of route. Transport is organized mostly by external carriers (outsourcing) who have specialized means of transport which are adapted for the carriage of fine-grained materials, as well as they have license to transport of these materials (decision of the Mayor of the city on the authorization for the transport of waste). There are several variants of the carriage depending on the used modes of transport. Each mode of transport has both advantages and disadvantages and the choice of variant is depends on various factors, among others: the location of dispatch and receipt points, costs, access to infrastructure and individual preferences of customers.

After delivery of the product to the customer, follows pneumatic unloading into the place of temporary storage (closed silos) or directly to the places of application of fly ash. According to environmental protection requirements the fly ashes cannot be stored at the opened landfills because of their dusting.

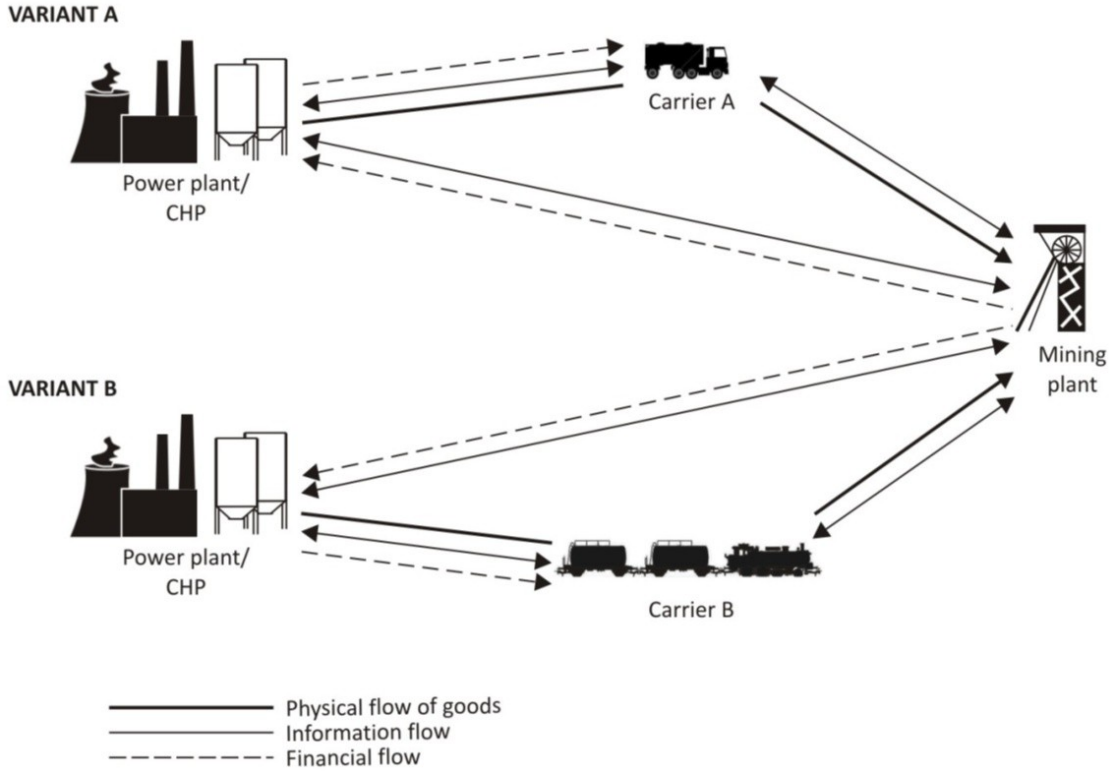

Fig. 6.2 Example of supply system of fly ash for mining plant

6.4 CHARAKTERISTICS OF THE MODES AND THE MEANS OF TRANSPORT USED IN SUPPLY SYSTEM OF FLY ASH

The choice of the modes and the means of transport

The most important point in supply system is the transportation, because it allows for physical flow of product between the supplier and the consignee. Furthermore, the transportation determines to a large extent on the costs of the entire system. Whereas the costs and level of customer service, the companies need to make different decisions related with the transportation. They are focused on the choice of mode, means of transport and the carrier. However, in practice, there is rarely an opportunity of the free choice among all available mode of transport, mainly due to the nature of transported materials and even specificity of same mode of transport [6]. This choice is very limited. Moreover, the important issue is the negative impact of fly ash transport on the environment. It is, above all, problem of dust ashes during their transport, what forces the use of such means of transport which significantly reduces or completely eliminates the problem.

At present, to transport of fly ash, there is used two mode of transport: road transport and rail transport. The choice of mode of transport and the carrier is dependent on many factors, which presents Table 6.2.

An additional, the criterion of the choice, in case of transport of fly ash, may be quantity and systematicity of supplies. In event of lower demand for fly ashes, the good solution can be the used road transport, however, its cost is significantly higher compared to rail transport. This type of transport are characterized by high availability – on the market works much more road carriers than rail carriers. Moreover, road transport may provide the transported goods in any place of destination, because it is not restricted by presence of railroad. The next advantage of road transport is shorter time of fly ash carriage, because it is not require e.g. compilation of long sets of wagons [1].

However, negative aspects of the choice of road transport are dependence of weather conditions and of the intensity of road traffic which can affect on reliability of delivery time. The used of this type of transport raises also social and environmental consequences in the form of air pollution by exhaust fumes and erected dust, communication noise and it causes of congestion (Congestion - coll. traffic jam) in the cities, thus result in decrease of quality of the inhabitants life of this area.

Taking into account the environmental costs, significantly better is rail transport, which does not emit as much harmful compounds in the atmosphere, and additionally does not participate and contribute to formation of congestion, because it move at the dedicated lanes. Another advantage of rail transport is the possibility of the mass transportation over long distance [1] at relatively low cost. Unfortunately the time of carriage by rail is significantly longer than road transport, and additionally its availability is heavily restricted.

Table 6.2 Determinants of the choice of carrier

Criterion	Description
Costs of transport	There are the resultant of such components as: freight rates, minimal weight of cargo, loading and unloading equipment, damage during transport. The costs of components will vary depending on means of transport.
Time of transport	This is the total amount of time that elapses from the moment of release of the product by the supplier until the delivery to the consignee. Includes: the length of time required to pick up and delivery, time of handling and time of loading and unloading.
Reliability of supply	Refers to the regularity of the transport time, which the carrier is able to provide. This is particularly important in the case of the endogenous fire in mine.
Costs of stock	In the case of an irregular of the service, related with time and reliability of the supply, the consignee need to obtain in certain quantity of stock, and thus bear the costs of their storage.
Capacity of transport	The ability of the carrier to provide equipment and device necessary for movement of specific goods, as the fly ashes are.
Spatial availability	The ability of the carrier to provide the service on the desired route. It refers to physical access of the carrier to different objects, e.g. railroad are limited due to natural causes, and they have official approved operating range.
Safety of product	In the carriage time the carrier should protect the transported products against quantitative and qualitative losses.

Source: own work based on [1]

Regardless of which mode of transport will be chosen to carriage of fly ash, it is necessary to use the appropriate means of transport, which must be closed type, due to dusting during the transport. The example of means of transport, which are used to transport of fly ash is illustrated in Figure 6.3.

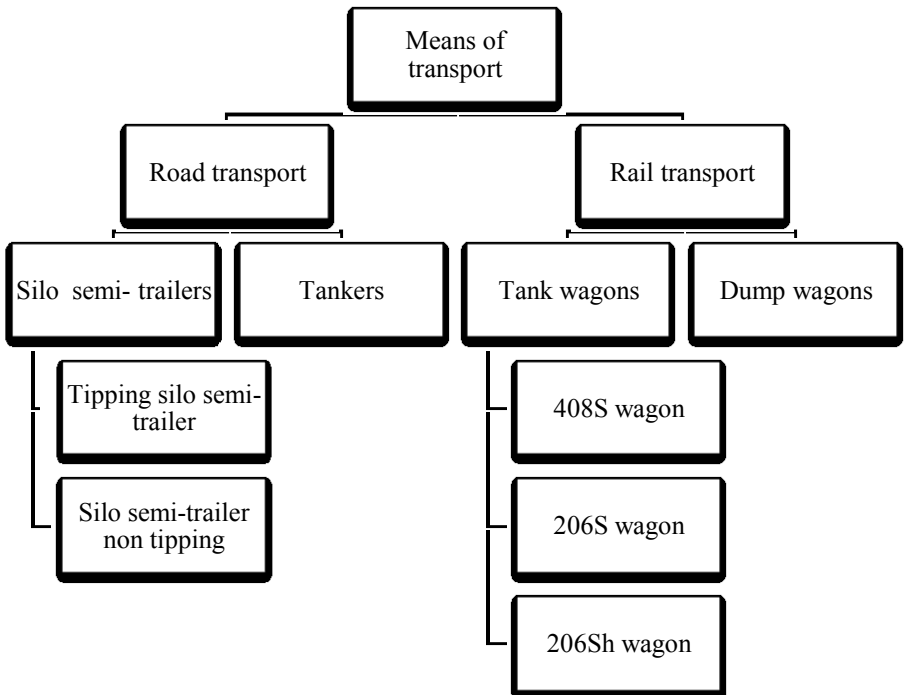

Fig. 6.3 The means of transport which are used to carriage of fly ash

In the road transport are used the tankers and two kinds of semi-trailers. There is the tipping silo semi-trailers and silo semi-trailers non tipping. Both of them are loaded from the top by several manholes. However, they differ by the method of unloading. The tipping silo semi-trailer is adapted to the unloaded by raising the entire silo to the top, and then the cargo is emptied by back channel under pressure through the valve cone [18]. In turn, the unloading of silo semi-trailer non tipping is followed by the holes in the valve cone, which are equipped in vibrating system and the ball valve which supply the compressed air [18]. Everything is linked by a pipe which leads to the rear of the vehicle between its axles. The example of the construction of the silo semi-trailer non tipping is shown by Figure 6.4.

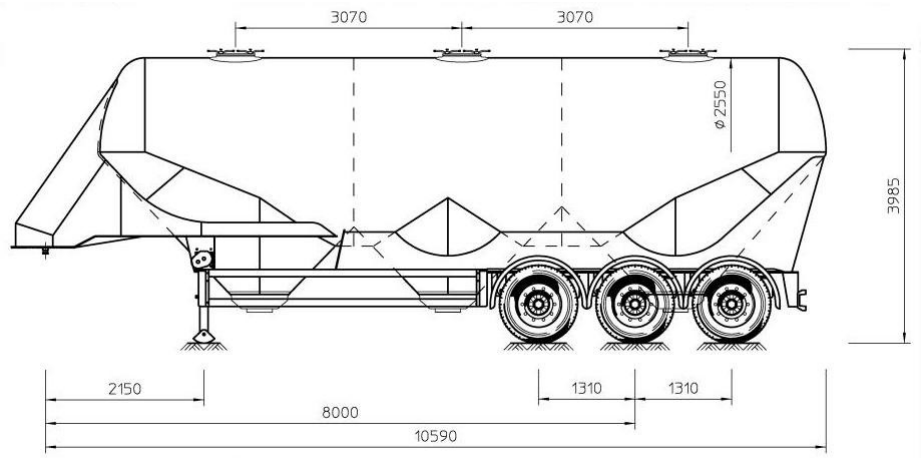

Fig. 6.4 The silo semi-trailer non tipping with a volume of 49 m³ and a capacity of 28,7 t
Source: [15]

The means of transport have a different construction, volume and capacity (from 31 m³ up to 65 m³) which gives the possibility to adapt the mean of transport to the needs and requirements of the customer. An example of construction of tipping silo semi-trailer is presented on the Figure 6.5.

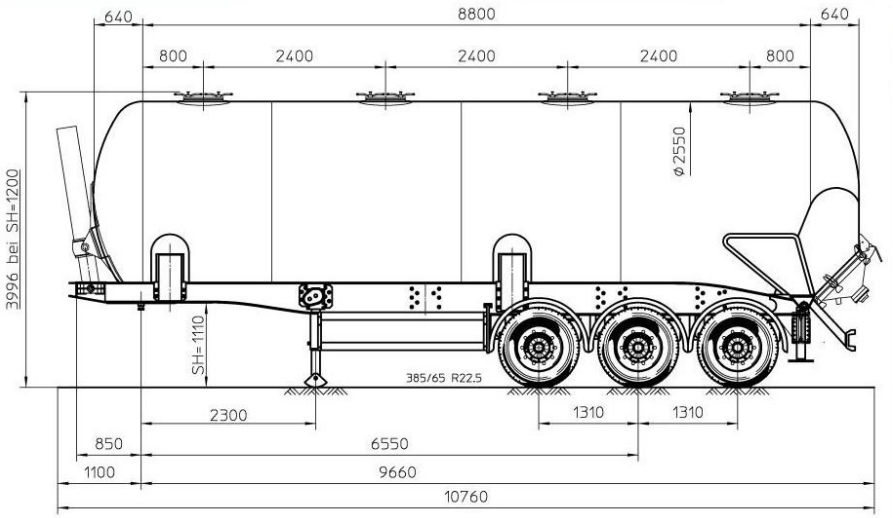

Fig. 6.5 Tipping silo semi-trailer with a volume of 48,3 m³ and capacity of 28,1 t
Source: [15]

Another means of transport are tankers. Their loading is done through charging sleeves, but the unloading is set by the pressure installation that causes the formation of pressure in the tank and supplies the air necessary for unloading [20].

The rail transport of fly ash takes place in a dump wagons with removable roof or in tank wagons. The loading of various types of dump wagons is done usually by loading hole (tilting roof), while they are unloading by gravity after opened the unloading valves [14]. Tank-wagons (206S, 206Sh, 408S) have mostly two, three or four tanks positioned vertically on the axis [8]. Example structure of tank-wagon is illustrated on the Figure 6.6.

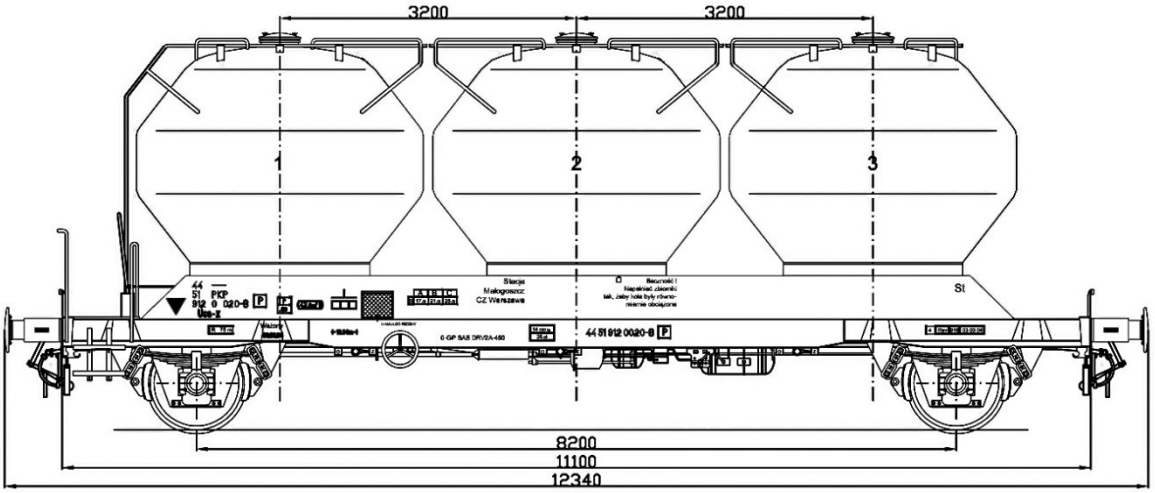

Fig. 6.6 Tank-wagon 206Sh with the volume of 3 x 14 m^3 and capacity of 25 t

Source: [13]

The loading of each type of tank-wagons is done by gravity through charging holes placed on top of tanks. Wagon unloading is achieved by pneumatic installation in over-pressure generated in the interior [8]. The construction of unloading system of wagon allows individual unloading of each tank, or all tanks at the same time [13].

The safety in the transport process

A very important issue during organization of transport process of fly ash is the safety of both humans involved in this process as well as the environment. Road or rail carrier should have experienced staff, which is able to adequately prepare the transportation and predict eventual difficulties which may occur in this process. In the transport process the means of transport may be damaged in an accident or collision, which may cause the escape of cargo on the outside. Equally important is the loading and unloading at the point of destination. Lack of tightness of loading and unloading installations (hoses, valves, etc.) is responsible for quantitative and qualitative losses of cargo (and thus for dusting of the fly ash) therefore, it should be prevented.

Observance of principles of health and safety at work is especially important in case of tipping silo semi-trailer unloading. A person who engaged in the unloading should be equipped in appropriate personal protective equipment and take care of their own safety during opening the upper manhole, e.g. by pinning the harnesses and ropes

which protect against possible fall from the upper deck of the silo. In addition, while tipping silo is lifted up, it is worth paying attention to wind, because it can cause roll over the silo. This type of silo is equipped in additional folding rear props for stabilization during lifting of tank. The construction of the tank should be very durable to prevent the unseal, in case of roll over the silo [17].

Another important requirement is to preserve the purity of the inside of the tank wagons and silos (and they unloading system) to avoid contamination of cargo by the remnants of the previous cargo [18]. It is important especially when there is a change of type of transported materials. The safe solution is the carriage of the same or similar products which tolerates each other. Depending on the type of transported products and the mean of transport, there are used a different washing procedure, e.g.:

- washing with the special cleaning agents (e.g. foam to washing the vehicles),
- cleansing in vapor,
- disinfectants based on the acids and alcohols.

The appropriate condition of purity can be achieved only by cleansing in special washes. Service of washes issue a certificate of purity, which is signed by the driver who thus certifies that the visual control was carried, and states that all parts (tank, hoses, pneumatic system) of vehicle are clean [18].

6.5 IDENTIFICATION OF THE PROBLEMS AND THE PROPOSALS FOR IMPROVEMENT THE EXISTING SUPPLY SYSTEM

Efficient management of supply system is focused on appropriate planning, organizing and controlling of flow of goods. Therefore, in each supply chain it is important to right organization of physical flow of goods and flow of information. Information should be quick and precise in order to facilitate making a good decisions and thus fully satisfy customers needs and requirements. However, the physical supply should characterized by reliability which is, unfortunately, dependent on unforeseen random events and technical and organizational conditions. Currently existing structure and functioning of the supply system of fly ash requires the introduction of changes and improvements or seek for new, alternative solutions.

Identification of the problems of supply system

In general, the problems in the supply system of fly as are related with variable demand for fly ash, retention of storage tanks, flow of information and, above all, with the process of transport. Due to the limited retention of the tanks, the power plants must be in constant contact with consignees and manage the receipts. It requires considerable organizational effort, the more that demand of consignee is variables. Variability of demand is causes e.g. unplanned situations or random events. As far as possible, the suppliers should predict future demand for fly ash, while the consignees should predict future demand for raw materials and, as far as possible, keep a certain amount of safety stock. The most problems in entire supply system generate the process of transport. Each of the conventional modes of transport usually used in supply system

of fly ash has advantages and disadvantages which are contribute to a reduction efficiency of entire supply system. The most important problems related with the process of transport are described in Table 6.3.

Table 6.3 Identification of the problems related with the transport process of fly ash

Modes of transport	Identification of the problems
Road transport	The relatively high cost of delivery compared to rail transport, Create and participate in road congestion, what may negative influence on the reliability of supply, Supplies are dependent on the weather conditions on the road, Generation of environmental and social costs (communication noise, air pollution, exhaust fumes and dust)
Rail transport	Long time of delivery, loading and unloading, Limited spatial availability, The necessity to have access to the rail infrastructure (by the consignee)
Common to both modes of transport	The necessity to clean the means of transport after each carriage, Possibility of dusting during transport, loading or unloading e.g. By leaky installation or in case of traffic accident, Waiting in line for unload in the case of several deliveries at the same time, Aspects of health and safety at work related with process of transport.

Problems indicated in the table have a different nature. Some of them require only appropriate organizational solutions (such as waiting in line for unloading) while other are related for risk of distortions in supply chain, which may include operational random events (e.g. equipment failure) or natural disasters and weather conditions on which the participants of supply chain have no affects.

Another problem in the supply system can be improper communication or lack thereof. Exchange of information and collaboration between the links of supply chain plays a significant role in uncovering weaknesses and in preparation to effective management in case of crisis [9]. Actions should be coordinated both at the level of each link as well as at the level of entire chain. The lack of cooperation in the system impedes the efficient flow of goods and the possibility of forecasting future demand and planning actions.

Underground pipeline transport as an alternative for the existing supply system

One of the unconventional modes of transport is a pipeline transport, in which there are no means of transport and the cargo is moved through the pipelines. This type of transport is characterized by [3]:

- ability to mass movements of selected products,
- low costs of movements,
- high throughput,
- reliability of supplies,
- low spatial availability,
- high speed of transport,

- insusceptibility of cargo to weather conditions,
- low onerousness to the environment,
- high resistance to theft.

One of the essential advantages is that, in the case of pipeline transport there is no congestion, no cargo handling operations and no problem of the empty legs. Furthermore, this type of transport characterized by low onerousness to the environment compared to the others modes of transport [3]. This mode of transport is also a good solution from the viewpoint of the health and safety at work, because each network of pipelines serves only one type of product, thanks to which there is no need to washing the mean of transport, as in the case of other modes of transport, and also there is no risk related with the mutual interaction the transmitted goods.

Currently, pipeline transport is mainly used to the movement of liquid and gaseous goods, however, there is the possibility of its use also to the movement of the bulk materials and fine-grained materials such as fly ashes. Of course, this solution involves enormous financial outlays and a number of research (e.g. geological research or design of the terminal handling devices). At this point, there are two possibilities. The first option is to expand the existing road and rail infrastructure (which is obviously needed) and the fight against transport congestion, risk of distortions in supply chain and environmental degradation. In turn, the second solution is to invest in the development of pipeline infrastructure, which would relieve roads from lorries and from negative environmental impacts.

CONCLUSIONS

In recent years, in mining plants, the use of fly ash significantly increased and therefore so important is reliability of supply system of this product. Unfortunately, currently functioning supply system faces many problems of technical and organizational nature. This situation forces the introduction of changes in the current system or seek for new alternatives.

One of the important issues is the need to improve the flow of information and close cooperation in this field among participants in the supply chain. Better communication in the supply chain may significantly improve the physical flow of product. An essential component of the supply system should be the forecasting future demand and scheduling the supply cycle that would allow to solve the problems related to waiting of the means of transport for the unloading. Another significant problem is the organization of the transport process, which there are used the modes of transport that generate environmental costs and which contribute to create the transport congestion and the reliability of supplies is dependent on weather conditions.

An alternative to the currently used modes of transport can be an underground pipeline transport, which specificity would avoid the mentioned problems present in traditional supply system, however this solution is related to enormous financial effort, the carrying out a number of studies and the development of infrastructure.

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SUPPLY SYSTEM OF FLY ASH FOR MINING PLANTS – ANALYSIS OF THE PROBLEM

Abstract: *The article attempts to evaluate supply system of fly ash between power plants and mining plant. The main aim of this paper is to shown technical, organizational and environmental problems which are related to transport process of fly ash. This paper characterized the fly ash and its recovery. The article also described structure of delivery system, indicated carrier selection criteria, pointed out advantages and disadvantages various modes of transport used in supply chain and presents the possible risks to the safety of persons involved in the transport process. In addition, the paper presents possible improvements of the existing system and proposes an alternative solution.*

Key words: *Supply system, fly ash, waste logistics, transportation*

SYSTEM DOSTAW POPIOŁÓW LOTNYCH NA POTRZEBY ZAKŁADÓW GÓRNICZYCH – ANALIZA PROBLEMU

Streszczenie: *W artykule podjęto próbę oceny istniejącego systemu dostaw popiołów lotnych pomiędzy zakładami energetyki i ciepłownictwa oraz zakładem górniczym. Głównym celem było wskazanie problemów technicznych, organizacyjnych oraz środowiskowych związanych z procesem transportu popiołów lotnych. W pracy scharakteryzowano popioły lotne oraz wskazano miejsca ich zagospodarowania. Opisano również system dostaw i jego strukturę, przedstawiono kryteria wyboru środków transportu oraz przewoźnika, wskazano zalety i wady różnych gałęzi transportu wykorzystywanych w systemie dostaw, a także zaprezentowano możliwe zagrożenia związane z bezpieczeństwem osób uczestniczących w procesie transportu. Ponadto w artykule przedstawiono możliwe usprawnienia istniejącego systemu oraz zaproponowano rozwiązanie alternatywne.*

Słowa kluczowe: *System dostaw, popioły lotne, logistyka odpadów, transport*

mgr Karina HERMANN, dr hab. inż. Witold BIAŁY, prof. Pol. Śl.
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
Department of Safety and Quality Management
ul. Roosevelta 26, 41-800 Zabrze
e-mail: Karina.Hermann@polsl.pl, Witold.Bialy@polsl.pl

7

DETERMINANTS OF MUNICIPAL WASTE MANAGEMENT SYSTEM BASED ON THE PRINCIPLES OF SUSTAINABLE DEVELOPMENT

7.1 INTRODUCTION

Implementation of the conception of sustainable development in frames of waste management system and monitoring the effects of conducting such activities is connected with designing the proper measurement tools. The role of measures in this context not only enables designing a current state of the system but also allows comparing the systems and indicating the processes that require improvement. A practical use of these tools is the basis of assessment of the current state of economy as well as verifies the plans and prognosis concerning the social, ecological and economic aspects.

An integrated system of waste management requires a complex and multi-criteria approach during the measurement of sustainable development of the regional systems. Consequently, the base of indicators and corresponding measures adequately elaborated makes it possible to conduct a reliable assessment of processes and their effectiveness.

A correct design of the local models of waste management based on the unified standards and measures of sustainable development will allow creating a strong system of waste management, which thanks to synergy effects will enable objectives achievement of climate and energy package [10].

7.2 MODELLING ASSUMPTIONS

Modeling of the systems is a tool serving for simulation of the particular solutions. A properly designed model may also constitute a rich information source as well as indicate weaknesses of the system. Considering complexity of the topic, there is a general scheme of system modeling adopted.

The scheme presented (Fig. 7.1) should indicate the need for continuous system improvement on the basis of the weaknesses identified that are the results of analysis of the previously prepared indicators. In effect, the system witness points are of great importance regarding quality control. Designing the model is an obligatory activity as its outcome allows a reliable analysis of the reality with a division into the key objects and processes and also with determination of system boundaries. Cataloguing

the current state of economy is a basis for the analysis and creation of system optimization models, which, due to criteria and conditions adopted, will make it possible to implement the development activities and proceed with their validation. Standardization of procedures may increasingly simplify the system measurement processes due to their effectiveness and functionality and also evaluate their compliance with the principles of sustainable development. An effective use of the resources possessed, achievement of the planned levels of recovery and recycling, application of the best BAT techniques that are accessible as well as minimization of a negative influence on the environment are one of many activities and objectives [7] which have to be faced by each local system. Unification of procedures that realize the same economic, environmental and social objectives should be favorable too and at the same time would enable an effective assessment of the activities conducted.

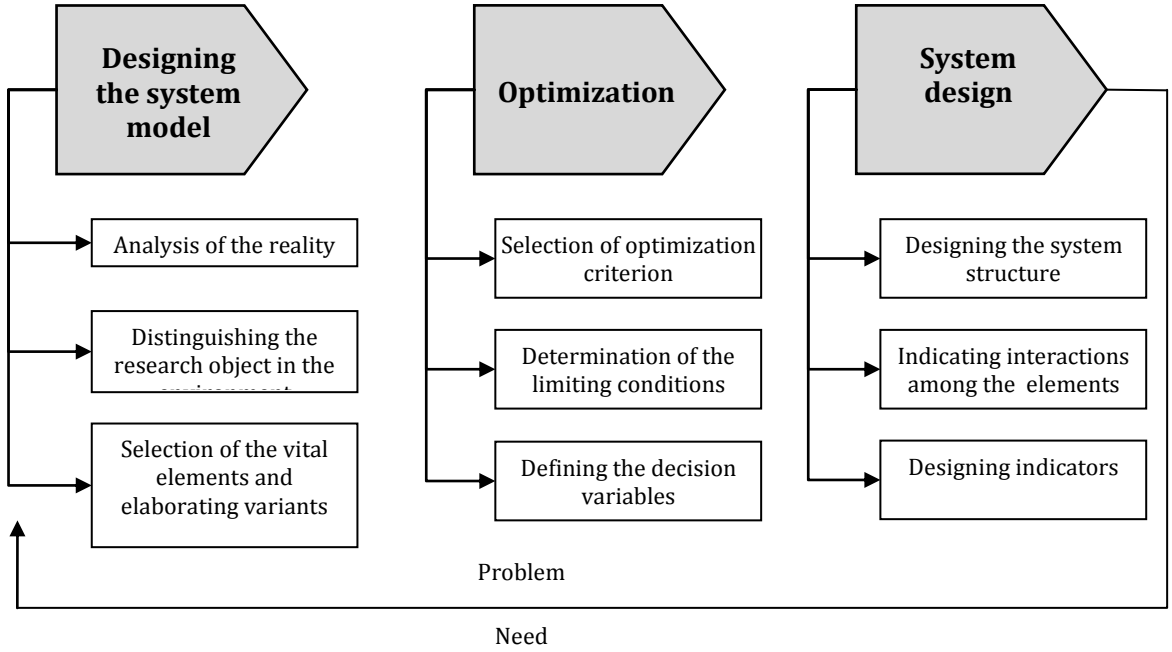

Fig. 7.1 A general scheme of system design process

Source: own work based on [5]

Depending on the particular objective of the analysis, the degree of modeling the reality does not always have to include all the elements. The processes and its boundaries correctly distinguished are a basis for all possible research on models, therefore their proper identification determines the usability of analyses. Consequently, it may be assumed that when constructing the model we copy the details of reality that bring the most precise and concrete information and examination itself enables a detailed analysis as much as it is needed in the particular place and time. In connection with the above, various models are often adopted in the way that helps to distinguish the most important information without involving the elements that have a previously defined objective from the point of view of research.

When trying to systematize the most important stages of model construction the following activities should be included [5]:

- analyze the needs and objective of system modeling,
- identify the object of modeling,
- determine boundaries of the analysis and at the same time model conditions and limitations,
- choose system elements that will be a basis for research and analyses,
- determine the interaction between the model features,
- verify correctness of the model designed,
- test the model,
- accept the model.

The aforementioned points are the main activities that each designer should do. The level of their particularization as well as possible variants extending the range of the analysis only depend on the person responsible for designing and on the level of the scale of works. What is important, the aforementioned activities cannot be treated independently. The results of each one constitutes a reference point for other activities which, due to their specificity, may become a decision element and in case of inconsistencies – induce a return to the previous stages and their repeated verification. The modeling process is an iterative process and in its result the created algorithm of conduct should include such activities the choice of which will enable making a loop. Therefore, it may be stated that in all cases the process of system design – deciding about its architecture, should realize all the requirements, objectives and include the limitations that were ascribed to the previous modeling phases.

It would be a truism to say that in order to design the system model properly it is necessary to obtain knowledge about its characteristic features and specificity. The database previously built concerning the system and its environment is a basis for problem recognition as well as for selecting the most important information from the point of view of research conducted. Ordering information is not an easy task. When building the model one should pay attention to data accessibility, measurement possibilities and their standardization. The quantitative values are necessary when making model description and verification of the solutions available. Identification of the decision problem is connected with determining the following values [5]:

- parameters – unchangeable values, previously known or a priori indicated, being a basis for calculation during resolving the problem itself,
- decision variables – the variables that need to have their value determined and that are the goal of resolving a particular research problem,
- limitations – expressed in a form of system of equations, expressions that include the decision variables previously determined,
- criterion function – also called as objective function or quality indicator that ascribes the searched values of decision variables to the solution.

7.3 VITAL FACTORS OF SUSTAINABLE DEVELOPMENT

A complex analysis of the integrated system of waste management is not an easy task in the view of sustainable development. A range of criteria and conditions

that should be included in the indicators designed are aimed at facilitating the assessment of developed phenomena and their result should be easy to interpret and justify scientifically. Proper data quality and regular measures updating in terms of compliance with the law is a key issue in frames of practical application of these tools.

During literature cataloguing one may encounter various attempts of elaborating the sustainable development indicators. Considering the division of sustainable development conceptions into three basic aspects, the division of the indicators selected was also designed according to the social, economic and ecological area [11].

Social assessment indicators

The social aspect constitutes an integral part of sustainable development philosophy, expressing at the same time the citizens' business as a foundation of law and waste management system elaborated. Taking into account all citizens' rights and obligations, the need for activities integration is suggested that would include both environment protection as well as active participation in frames of the activities undertaken. The prior aspects of pro-social actions, according to sustainable development, are compliant with three main perspectives that are graphically presented in Figure 7.2.

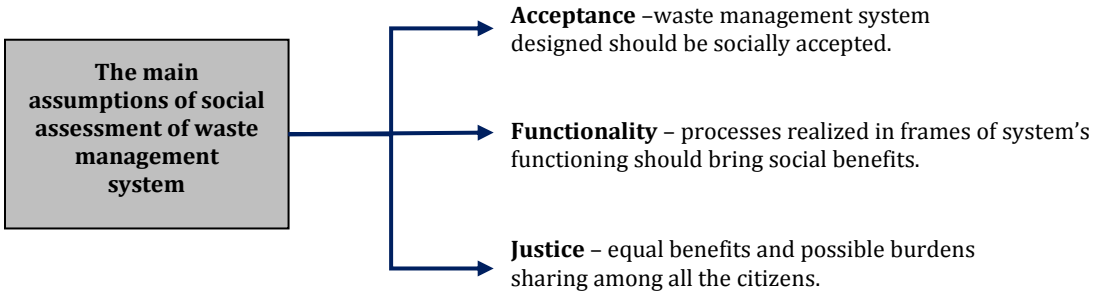

Fig. 7.2 The main assumptions of social assessment

Source: own work based on [2]

Waste collection, transport and processing belong to subsystems that affect the society the most and at the same time are subject to a detailed analysis. All the burdens connected with the processes undertaken in frames of waste management are of direct influence on all the residents, therefore the tasks are important that are supposed to minimize this negative influence. Controlling these phenomena is possible thanks to such indicators as, among others [2]:

- indicator that quantitatively expresses dour nuisance that is produced during waste collection/transport/processing in a particular municipality;
- indicator of subsystem's convenience of functioning, being an equivalent of residents' convenience, proximity of waste bins from the place of residence has a great influence on this indicator;
- indicator of urban land development which includes the share of infrastructure connected with functioning of waste management system in the total area of particular municipality;
- indicator of noise level – calculated for each subsystem;

- indicator of traffic intensity that present the share of using the transporting network and increase in traffic level when using infrastructure in frames of waste management system's functioning;
- employment quality in system's subsystems – including a total number of workplaces in waste management.

The aforementioned ratios are only a part of complex system assessment concerning each examined social aspect. The values being a result of application of various formulas constitute a basis for analyses in case of research and comparisons of waste management subsystems.

Economic assessment indicators

An economic aspect of the sustainable development is tied to a specific technical and organizational system which is examined in the determined time horizon. Separation of the boundaries of the system, in order to subject to analysis the most important costs and income related to the functioning of the system, is also significant from the point of view of research. A group of priorities that constitute the grounds of the defined indicators for the analyses is also assigned to economic assessment. Their graphic presentation is included in Figure 7.3.

Fig. 7.3 The main assumptions of economic assessment

Source: own work based on [2]

In case of economic analyses of the private economic subjects – the greatest attention is paid to economic indicators. Balancing income and expenditures, and therefore determining the financial possibilities, is a basis for planning further investments and improvement of the system. The economic aspect can be assessed by the use of, among others, such indicators as:

- indicator of the total annual cost of waste management subsystem per one household (per capita),
- indicator of the total annual cost of waste management system per one household (per capita),
- indicator calculated based on income from recovery and recycling,
- indicator of the cost of waste management, calculated in relation to the GDP of the municipality,
- indicator of subsidies/grants calculated per capita.

Within the studies concerning the economic aspect of the activity of the system, some areas can be shown that are a basis for the proper actions increasing income of the municipality or making possible to decrease its costs. One should remember that 'the best does not mean the cheapest', therefore, in case of sustainable development accepting this aspect as the main one is unacceptable. The weights ascribed to all the areas of research are at one level, thus the suggested improvement actions are a resultant of it.

Environmental assessment indicators

Environmental assessment conducted as a part of activities for sustainable development is a highly complex analysis that may utilize many methods and tools. In order to systematize the main directions of environmental research, a scheme illustrating the areas and objectives of the analyses was prepared: (Fig. 7.4).

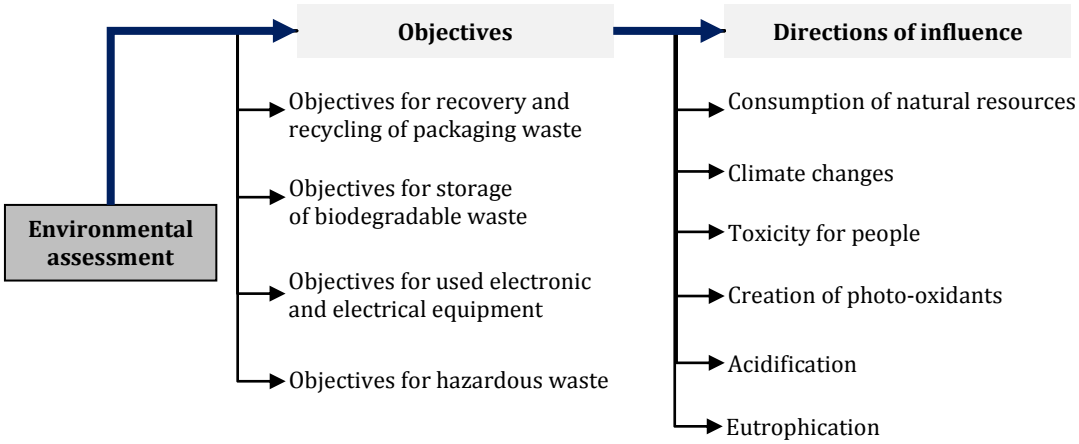

Fig. 7.4 The components of environmental assessment

Source: own work based on [2]

One should also note the general principles of dealing with waste [3], which are a basis for planning of municipal waste management on both state and municipal levels, among them we include:

- the principle of prevention – action related to minimizing the amount of the generated waste in order to protect the natural environment,
- the precautionary principle – actions need to be taken that are aimed at reducing the negative influence of waste (especially of hazardous waste) on the health of people and on the natural environment,
- the principle of proximity and self-sufficiency – the units responsible for creating the system should organize its realization in such a way, as to take into consideration the localization of the installations of waste processing.

Among the general principles of dealing with waste we also include the following principles: the polluter pays and the extended responsibility of the producer. Those principles refer mainly to industrial waste, which is not a subject for these considerations.

The hierarchy of dealing with waste, not mentioned before, constitutes a basis for any actions related to waste management, treats the principle of prevention, which is the most desired action, as the priority. The actions taken in case of the examined areas and their compliance with the hierarchy are the subject of the qualitative analysis of the system, while in the quantitative assessment the following indicators, among others, may be taken into account [2]:

- indicator of the climate change, which examines the influence of anthropogenic emission on the radiative properties of the atmosphere, including absorption of thermal radiation;
- indicator of toxicity for the human health – taking into consideration the level of influence of harmful substances emitted into the environment;
- indicator of photo-oxidants – which concerns the creation of active chemical compounds such as ozone, as a result of the influence of solar radiation on some of the primary types of air pollution;
- indicator of acidification – related to the negative influence of the soil, ground and surface water;
- indicator of eutrophication – determining all influences of fertilizer substances, including the most important ones – nitrogen and phosphorus, which contribute to adverse changes in the natural environment;
- indicator of the level of recovery and recycling of packaging waste – calculated as the sum of particular packages leaving the sorting and MBP plants as well as the plants for thermal waste processing;
- indicator of restricting the amount of storage of biodegradable waste – calculated in relation to the number of biodegradable waste in the year 1995 [4].

The results achieved thanks to the use of chosen indicators enable designing an intervention field, at the same time being a stimulus for more detailed analyses. A correctly presented model should be an image of the implemented changes and also should simulate the effects of the implemented actions [6]. The choice of the best solution is not an easy task – all of the designed variants characterize different strategies and are the results of individual approach to the weights of the chosen indicators.

7.4 ASSUMPTIONS FOR DESIGNING THE INDICATORS OF WASTE MANAGEMENT SYSTEM – THE RESULTS OF AUTHORS' RESEARCH

As a part of the pictorial presentation of the topic of the paper, the main guidelines for creating the measurement indicators of the model of waste management system were created.

The analysis of the current state of waste management, the basis for which the information was taken from the data of GUS (Central Statistical Office) [8] and the National Waste Management Plan 2014 [7], made it possible to prepare the following summaries.

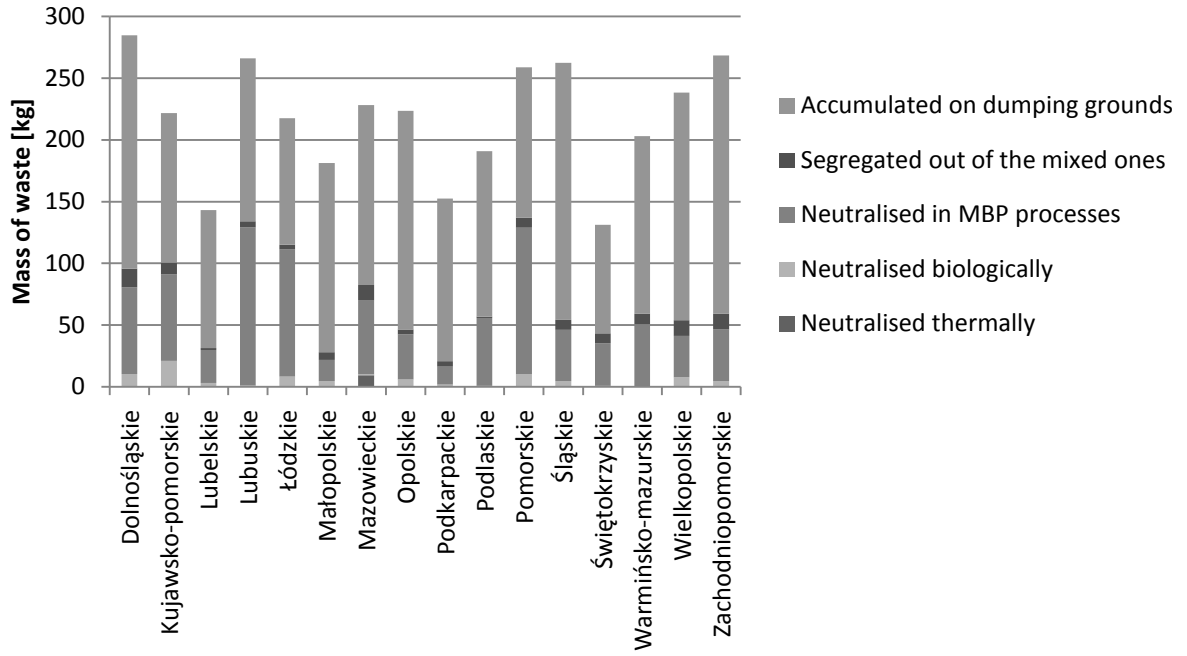

Fig. 7.5 The share of waste disposal per capita divided by provinces

Source: own work based on [8]

One of the main areas for analyses of waste management system is the level of disposal. Indicators (Fig. 7.5), prepared in such way allow illustrating the share of appropriate practice with collected waste per capita in the examined region. In the year 2012, on average, 68% of waste was deposited in landfills – these negative results present the scale of the problem with incorrect waste management in each province.

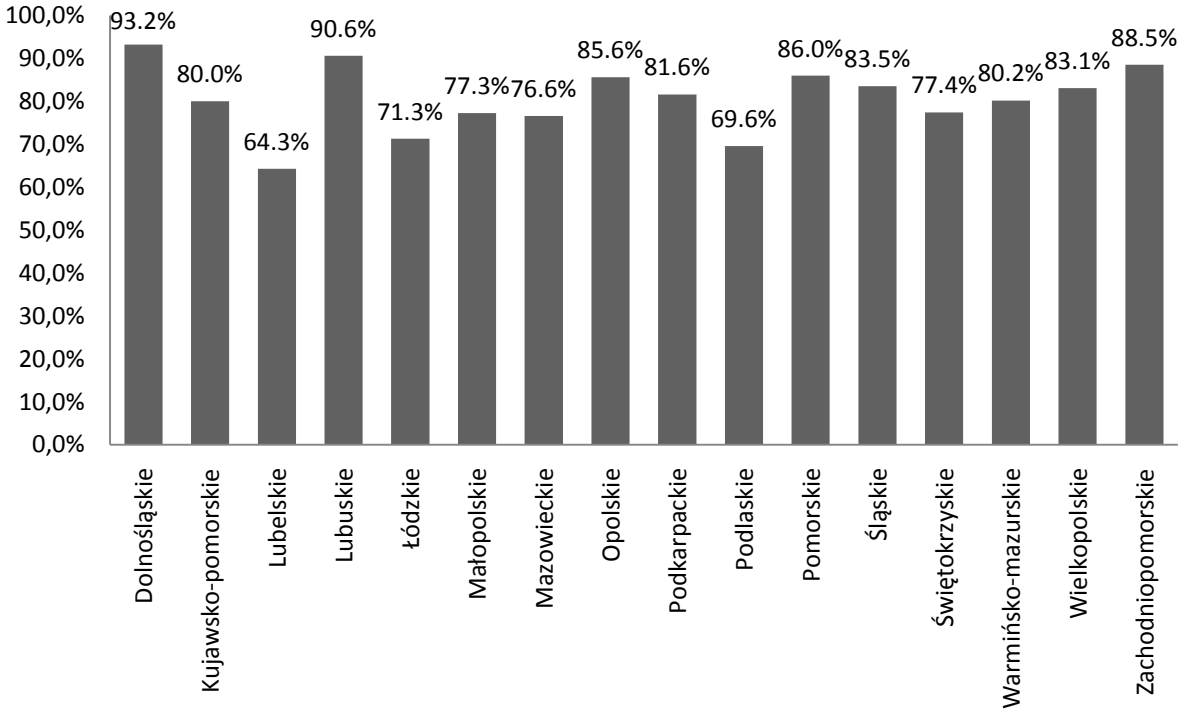

Fig. 7.6 The share of residents included in the collection of waste divided by provinces

Source: own work based on [8]

The share of residents in the system of waste collection is another significant indicator. The expected value which each municipality should strive to reach is 100% - such a result would mean participation of all the residents in waste management system. The reality however, often verifies the objectives and expectations – the calculated share for the year 2012 in each of the provinces is presented on a chart (Fig. 7.6). These results show the need for taking immediate actions, increasing involvement of the residents which should minimize the uncontrolled handling of waste by the people who are not included in the system.

The economic aspect may be verified thanks to the use of the indicator of the share of ecological funds in the total sum of funds allocated to waste management (Fig. 7.7). The correctly designed data are a valuable piece of information for those deciding about the possibilities of increasing the share of additional, external funds as a part of financing new actions – and therefore they make benchmarking possible in the area of ways of funding the pro-ecological undertakings.

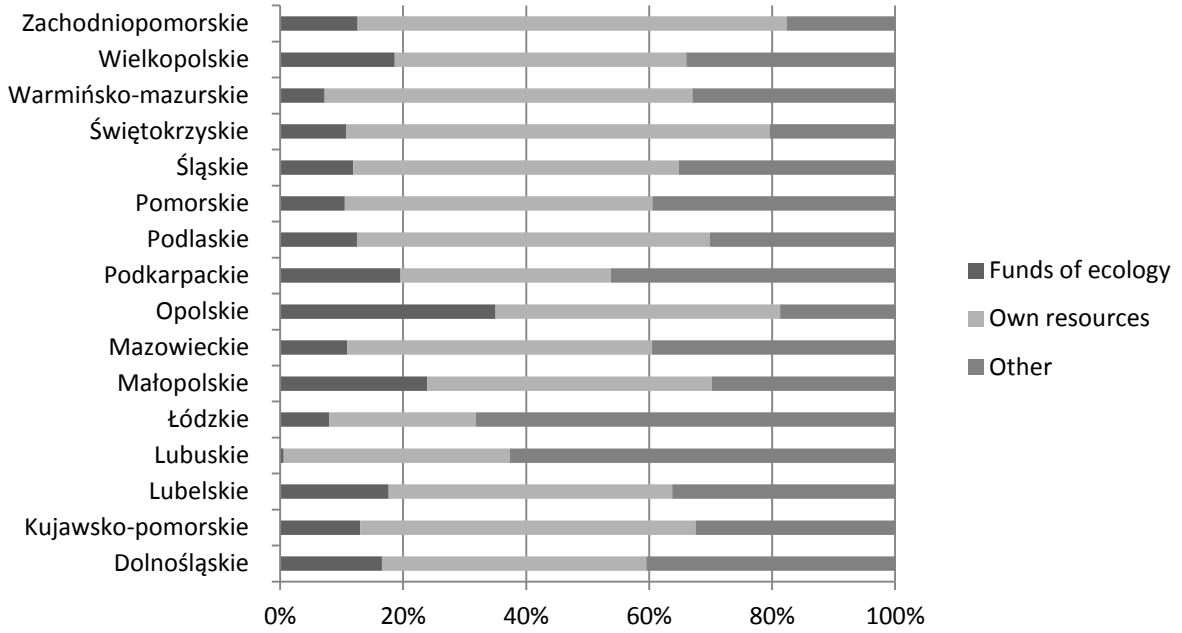

Fig. 7.7 The share of means of financing waste management

Source: own work based on [8]

Valuable information, in the view of the research object and analyses, may also be acquired by confronting the values of the indicators on the field of Europe. In this study, the example of greenhouse gas emissions has been brought up (Fig. 7.8) which also may be taken into consideration during the course of the analyses of the current situation against the background of the European average. This data is extremely significant during the works on further legislative changes, which are supposed to use good practices of the best management systems and implement those actions which will enable meeting all the EU requirements.

The values of the included variables presented above are an entry point for making the creation of the model, based on which improvement of the system will be possible. The diametric differences between the received and expected value are a signal for

taking actions explaining this negative phenomenon. The causes can be in statistical errors that often deviate from reality or they can actually show the weak points of the system. The historical data, which may illustrate the trend of changes and predict the future amounts is also significant from the point of view of research. Such analysis enables a more detailed approach to the topic and at the same time allows identification of those areas that require improvement actions.

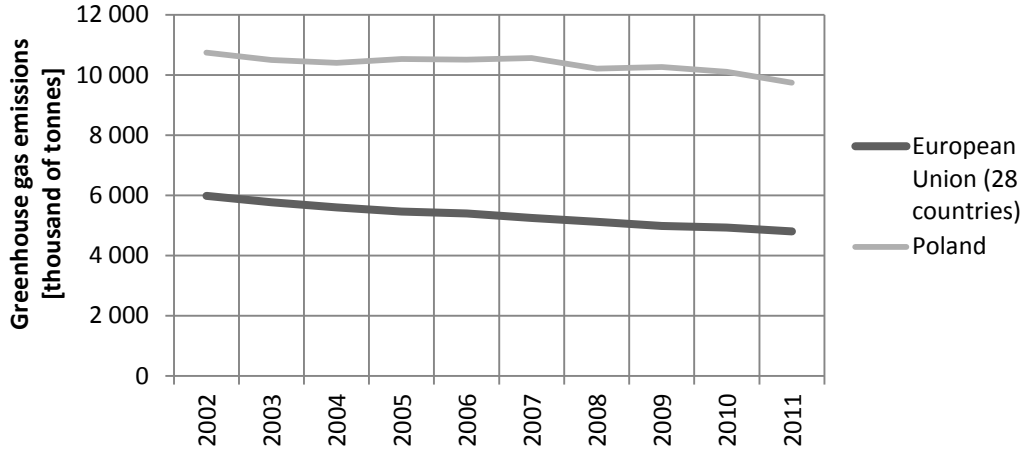

Fig. 7.8 The emission of greenhouse gases in Poland and in the EU

Source: own work based on [12]

CONCLUSIONS

During the works on the attempt to model the waste management system, there were key areas of activities observed that were the grounds for elaborating the assumptions. Literature cataloguing and own research were the basis to create an image of waste management system with indication of the important needs in the view of the analysis. The aspects of sustainable development determine the most important system features, therefore their proper and regular monitoring should be a vital element of the process of effectiveness assessment.

In case of building the system based on the domestic and European regulations, special attention should be paid to monitoring and control of the basic rules connected with the correct organization of waste management, including:

- providing the planned recycling level of biodegradable waste, planned level of energy recovery,
- fulfilling technical and organizational requirements imposed by the law in force,
- organizing a selective collection of segregated and non-segregated waste,
- encompassing 100% residents of the analyzed area concerning collection,
- organizing a proper functioning of the Point of Selected Municipal Waste Collection,
- providing adequate infrastructure that enables correct waste gathering and collection (bags, bins, containers),
- waste collection optimization with assumptions of sustainable development philosophy,

- selection of the best municipal waste recovery and neutralization techniques,
- extending residents' education how to make a correct municipal waste collection,
- quality control of the research conducted.

Thanks to listing the information above it is possible to conduct the effectiveness assessment of waste management system along with ecological, economic and social aspects of its functioning that are an effect of the results and weights adopted for the particular indicators. It may be a basis for system monitoring and all possible repair actions that are aimed at improvement of the weaknesses. Designing a set of indicators for waste management in frames of sustainable development conception may bring many benefits, for example:

- development control in frames of designed policy, strategy, objectives,
- making reliable comparisons between the subsystems or local and European systems,
- database ordering that concerns the most important information about, among other, environment, waste flow and costs of system's functioning,
- providing vital information that enable communication among all the system participants,
- designing important development factors and facilitating operational planning.

Integrated and rational approach to system organization requires standardization from the managers which would allow a correct analysis and assessment of all the subsystems along with the activities subordinated – consequently, it is necessary to conduct a proper system modeling with the inclusion of all the possible processes and determination of the assessment indicators. For this purpose it may become essential to create a coherent list of indicators enabling preparation of a clear reporting system of data directed to, among others, realization of 20/20/20 objective, what allows notification of the level of obligations' fulfillment that result from climate and energy package.

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DETERMINANTS OF MUNICIPAL WASTE MANAGEMENT SYSTEM BASED ON THE PRINCIPLES OF SUSTAINABLE DEVELOPMENT

Abstract: *Creating an indicator that monitors sustainable development is one of the most difficult methodological and implementable tasks in waste management system. A need for unification and standardization of control procedures is a stimulus for system modeling. Its objective will be to create a set of indicators for waste management.*

In the paper there is an authors' attempt presented concerning distinguishing the key areas of waste management system that enable application of indicator mechanism. The problems of using the chosen indicators were examined for the particular province systems of municipal waste management, allowing at the same time comparisons and distinguishing the key problems in the analyzed areas.

Key words: *Sustainable development indicators, sustainable development, waste management system*

DETERMINANTY SYSTEMU GOSPODARKI ODPADAMI KOMUNALNYMI OPARTEGO O ZASADY ZRÓWNOWAŻONEGO ROZWOJU

Streszczenie: *Tworzenie wskaźnikowego monitoringu zrównoważonego rozwoju to jeden z trudniejszych zadań metodycznych i implementacyjnych w zarządzaniu systemem gospodarki odpadami. Potrzeba ujednolicenia i standaryzacji procedur kontroli jest bodźcem do modelowania systemu, którego celem będzie stworzenie zestawu wskaźników gospodarki odpadami.*

W artykule przestawiono autorską próbę wyodrębnienia kluczowych obszarów systemu gospodarki odpadami w ramach których możliwa jest aplikacja mechanizmu wskaźnikowego. Problematyka wykorzystania wybranych wskaźników została opracowana dla danych wojewódzkich systemów gospodarki odpadami komunalnymi, umożliwiając tym samym porównanie i wyodrębnienie kluczowych problemów w analizowanych obszarach.

Słowa kluczowe: *Wskaźniki zrównoważonego rozwoju, zrównoważony rozwój, system gospodarki odpadami*

mgr inż. Karolina JĄDERKO, prof. dr hab. inż. Barbara BIAŁECKA
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze, Poland
e-mail: Karolina.Jaderko@polsl.pl; Barbara.Bialecka@polsl.pl

8

ORGANISATIONAL ASPECTS OF EXECUTION OF THE LOCAL REVITALISATION PROGRAMMES IN THE LARGEST CITIES IN POLAND - INDICATION OF DIRECTIONS OF FURTHER RESEARCH

8.1 INTRODUCTION, RESEARCH SAMPLE

Management of the urban revitalization processes on the level of the city demands designing dedicated organizational structure acting on behalf of the executive body – i.e. mayor of the city. The qualifications of the members of the structure should reflect the requirements and interdisciplinary character of the renewal processes themselves. The structure should also have decisive power strong enough to make difficult and unpopular decisions that may be encountered when executing projects and conducting the process. The research was conducted on the group of 65 cities with the rights of the district, 42 of which responded to the questionnaire.

8.2 GENERAL REMARKS ON STRUCTURES RESPONSIBLE FOR URBAN REVITALISATION

One of the decisions that must be taken along with accepting the whole revitalization program is determination and foundation of the structure and model of functioning of the executive entity. It is required by the program itself, but also by the regional authorities' requirements and indications for preparation Local Revitalization Programs [7]. The local need for establishing a dedicated executive structure results from the fact that a wide co-operation with business and society partners is absolutely crucial and it usually exceeds the regular fields of activity of the municipal office or city council. The entities involved in urban regeneration on the level of the city can be divided into three groups:

- local government – both executive and regulatory bodies (i.e. the mayor and the council),
- managing and implementing body – coordinating implementation of the program on behalf of the local government and its partners,
- executive entities – responsible for implementation of particular projects.

One issue that may be considered as ambiguous is the division of duties between managing and executive bodies, as at the first sight they may interfere. But the intention of the author is to emphasize that the managing body is responsible for the execution of the program as a whole and implements municipal actions, whereas the executive entities are all other organizations or individuals who are not the municipality and who contributed to the program with their own projects.

The execution of the program is a complex process so it requires particular competence and abilities to perform the coordination activities of actions undertaken both by public and private bodies.

In the indications published by the regional governments acting as the Managing Authorities for EU-funded Regional Operational Programs for 15 voivodeships in Poland it was underlined that each Local Revitalization Program, apart from the diagnostic part, had to determine the way of implementation. Due to the fact that most of the programs were rather unrealistic, the assumptions for their implementation were rather provisional. Only a small group of the largest cities decided to establish a less temporary structures. In 57% of the cities it was declared that within the municipal office there had been established a dedicated organizational section responsible for urban renewal. Adequately in 43% of the offices there was no section in duties of which revitalization had been included. The main reason for this given by the respondents was the lack of determination and consequence in execution of the programs that had caused maintaining of such a section as futile. It was observed then that in the situation of lack of external financial support for these processes resulted in resignation of their execution and not establishing structures responsible for them. In case when such a section existed, it was located in the following departments:

- architecture, city and spatial planning,
- strategic planning and city development,
- acquisition of external financing.

Seldom did it function as a separate section or department. On the graph below (Fig. 8.1) there is presented the distribution of declarations regarding creation of structures responsible for the execution of urban renewal process. Lack of a bar for Świętokrzyskie region results from lack of response from the cities from this part of the country. In case of regions whose representatives indicated lack of dedicated organizational section responsible for revitalization, its duties had been spread on various departments and units. They also indicated lack of communication among them as an issue that had led to difficulties in execution of the program and conducting the process. Basing on the size of the city (number of inhabitants), the following distribution (Fig. 8.2) was achieved. It should be noticed that in the group of cities having more than 240k and less than 320k inhabitants, there were no declarations that such a section had been established. In the majority of the cities it was stated that a half of them had had such a section or unit. In the group of the smallest cities, 80% of them declared establishing of such a unit. It should be emphasized that this statistic comprises only the cities which participated in the research.

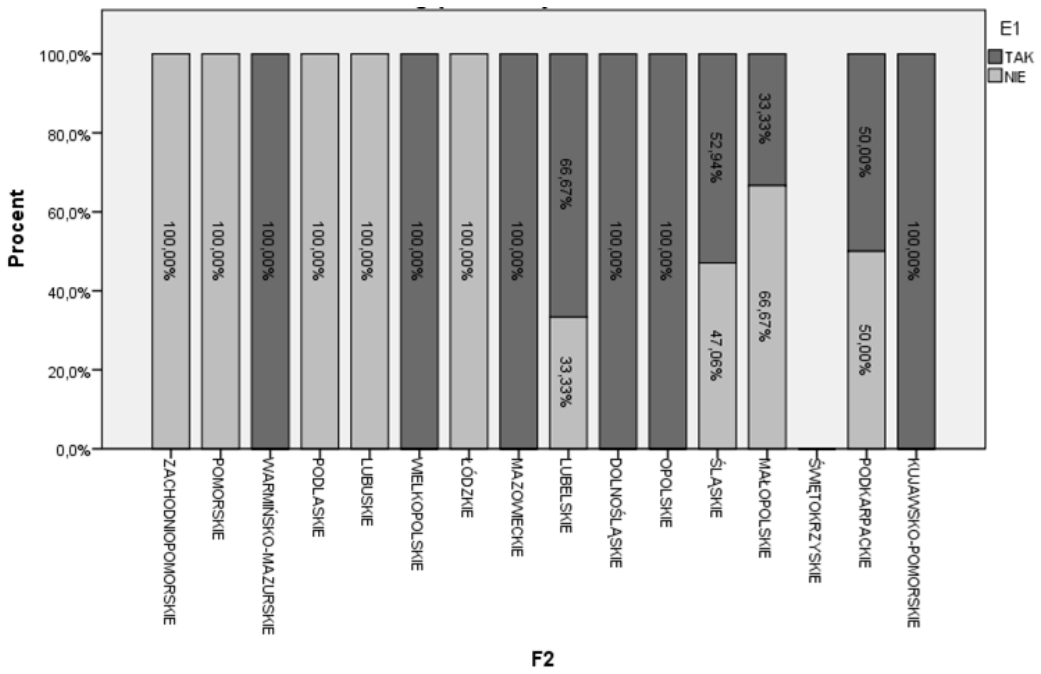

Fig. 8.1 Regional distribution of organizational sections responsible for revitalization

Basing on the data delivered by the representatives of 24 cities an average number of jobs in such a unit or section was determined – 2.96. It is not the number of employees, but the number of work contracts meaning full time jobs. The minimum number of employees responsible for the execution of revitalization processes was 1, the maximum was 7 with standard deviation equal 1.73.

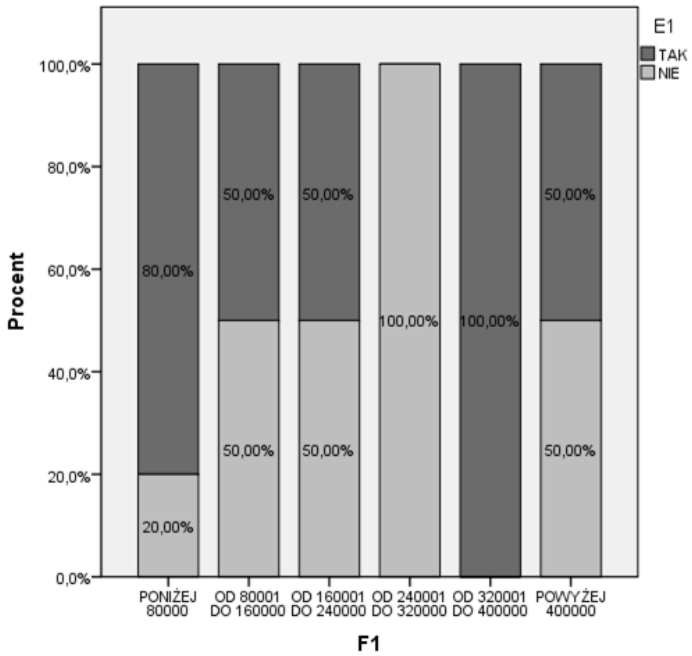

Fig. 8.2 Organizational section responsible for revitalization based on the size of the city

The representatives of the cities responsible for implementation of the renewal

processes in most cases (93%) also participated in the planning activities. Their level of knowledge and competence in determining the problems and need if the degraded areas was extremely high, which should be considered as a serious advantage.

Assuming that the program is implemented, it is also necessary to indicate a person who is personally responsible for the decision making for the revitalization process as a whole and particular projects. The decision making process means also monitoring, evaluation and initiating the modifications to the program. The distribution of the answers was presented on the graph below (Fig. 8.3).

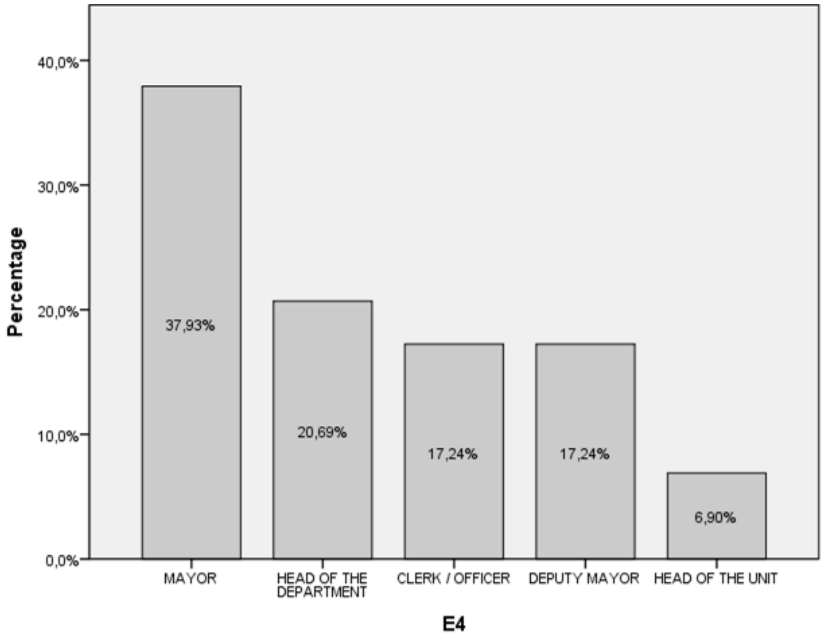

Fig. 8.3 Centre of responsibility for execution of revitalization process

The graph was prepared basing on the answers provided by the representatives of 29 cities. It may be assumed that the ones that did not give answers, had not also determined any centre of responsibility for execution of the processes, which may suggest that they are not implemented at all or only in a limited scope. In almost 38% cases, the responsibility for execution of urban regeneration was laid directly upon the mayor of the city, in every fifth city – the person in charge was the head of the department. Similar results were achieved for the positions of a regular officer and deputy mayor of the city. The least frequent indication was for the position of the head of the section/unit.

8.3 THE ROLE AND SCOPE OF ACTIVITIES OF THE OPERATOR OF REVITALISATION – EXECUTIVE UNIT

Successful execution of urban renewal process, apart from indication the responsible unit or section, requires also precise definition of its scope of activity. The function of the revitalization operator may be located either within the structure of the municipal office or as an external body under supervision of the local government. In extreme case it can be totally independent entity acting on behalf of all the stakeholders the process.

The least sophisticated organizational solution of the renewal operator is its location in the structure of the municipal office with direct reporting to the mayor or his proxy. Due to the complexity of revitalization formalization of the structure is necessary, moreover, it should be appropriate to management standards of the office as a whole. It means that the mayor who is responsible for designing the organizational structure of his whole office and local administration may:

- include the tasks related to revitalization in the activities of existing department (by extending its scope of actions),
- determine a new unit/department responsible exclusively for urban renewal within the structure of his office,
- establish a new local government agenda as an external entity under his absolute supervision,
- extend the scope of activity of an existing external municipal organization.

The crucial issue here is the competence of the unit, regardless of the aforementioned solution used, of being an organizer and animator of cooperation of various types of organizations and stakeholders, instead of being a simple implementing unit of investment projects. Extending the scope of activities of an existing structure causes serious threat, that its prospective actions in revitalization will be polarized. It means that the preferred ones will be similar to its regular activity, where its experience is strong enough to lower the risks to an acceptable level. In such case it is likely that the operator will concentrate on the projects that are close to its normal operations. It is crucial then, that the operator is granted a sound level of independence in taking actions and decisions. Very limited practice in Polish cities proves that attempts to locate the function of the operator as an external entity may lead to better performance of the processes, higher flexibility and better communication with the stakeholders. Advantages and disadvantages of particular solutions were provided in the table (Table 8.1).

Foreign experience proves that setting the operator outside the municipal office leads to better results in planning and execution of the Local Revitalization Program. The sine qua non condition is establishing efficient mechanisms of its reporting to and controlling by the local decision makers, but also partner relations between local government and the operator. The exception to the rule may be the British experience, where on the national level there were established the Urban Development Corporations functioning locally as QUANGOs (quasi-autonomous non-governmental organizations), but rather independently from actual problems of the local communities [5]. Transferring the execution of the regeneration program to another organization will not release local authorities from any responsibility, neither for failure nor for success. This directly interferes with the local political context. Regardless of any solution chosen for implementing the program, partner cooperation of the local government bodies and the operator is absolutely necessary. The rules and conditions of cooperation with the representatives of local authorities and level of autonomy in decision making must be also determined. According to K. Skalski, the executive organization (operator) must be

treated as a buffer between the local community and the government [6]. Although it operates on behalf of the authorities it may be a more trustworthy partner for the local than the officers, particularly when unavoidable, unpopular and politically difficult decisions are concerned. Lack of regulations in Polish law results in the activities of the municipalities taken in any form which makes them difficult to compare. Besides, establishing the executive body as an external organization will surely increase the cost of implementation, as its activities will be the only ones instead of "by the way" actions taken along regular operations of the municipal office. As indicated by K. Skalski, the budget for execution should be calculated as a percentage of the budget of all revitalization projects, which – in case of many Polish cities – will be an enormous amount of money [6].

Table 8.1 Advantages and disadvantages of establishing the operator as an internal/external entity

	Operator	
	Internal unit	**External entity**
Advantages	Higher level of motivation to execute the process Better level of knowledge of local context and specificity Easier and more efficient coordination of activities within the structure of the municipal office	Higher level of independence in action and creating solutions Better possibilities of building an interdisciplinary team of professional consultants and experts Easier cooperation with business and local communities, higher level of trust in social participation
Disadvantages	Prone to lobbying, political pressure and lower autonomy of actions and decisions Shortages of specialists, necessity of ordering external expertise, mainly with the use of public procurement, that makes the process take longer time	Lower motivation for action Risk of copying template solutions Difficulties in establishing permanent cooperation with municipal administration

Source: [3]

Seldom do the programs reflect real problems, instead they just group some projects designed by the municipal authorities. The breakthrough solution in this case, proposed by the author of the paper, is proportional co-financing of the executive body by all the stakeholders. In the financial plan of the program this input can be counted as own contribution. Due to the financial issues, the solution for implementing the revitalization program acceptable by the local government and non-reject able by other stakeholders is location of the execution of the program within the structure of the municipal office.

8.4 COOPERATION WITH THE STAKEHOLDERS

Almost 70% of the respondents from the municipalities, where the programs are implemented declared that the representatives of the municipal organizations

participated in the execution process. The quality of the cooperation was assessed at 3.67 in five grade scale, with standard deviation 0.88. The distribution of the answers is shown in the graph (Fig.8.4).

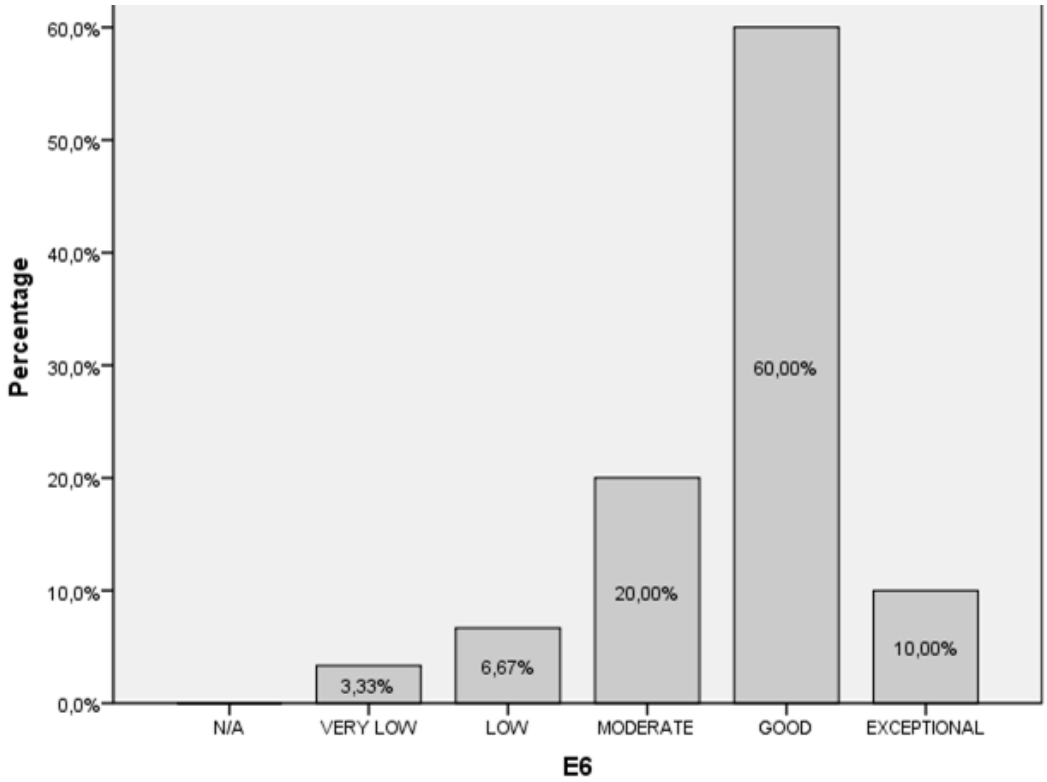

Fig. 8.4 Distribution of the assessment of quality of cooperation with municipal organizations

It is quite clear that the cooperation is satisfactory. The respondents did not indicate any particular features or determinants of cooperation, so it was neither good nor bad. They only said that it was good enough to undertake joint efforts for executing projects.

New approaches for public management, i.e. New Public Management (NPM) or public governance, assume higher participation of local communities in the management processes of the municipality [2]. Particular role was foreseen for non-governmental organizations whose share in implementing public tasks should be significantly increased [1]. Public governance on the other hand assumes higher participation of the stakeholders in the decision making and managerial processes. The subject of management in this case is not only the process, but the network of mutual relations between private, public and non-governmental sector. D.F. Kettl indicates that one of the key aspects of NPM is increase of capability of the public sector in shaping and executing socially important programs [4].

As far as the cooperation with the NGOs is concerned, in almost two thirds of the municipalities it virtually did not exist. This indicates that implementation of the latest approaches for public management was unsuccessful which caused a serious threat to the revitalization as its execution is hardly possible without the representatives of the

third sector. Close cooperation was declared only in three regions – Łódzkie, Pomeranian and Western Pomeranian. The quality of cooperation with the NGOs was marked 3.56 with rather high standard deviation od 1.09. The distribution of notes five grade scale is presented on the graph (Fig. 8.5).

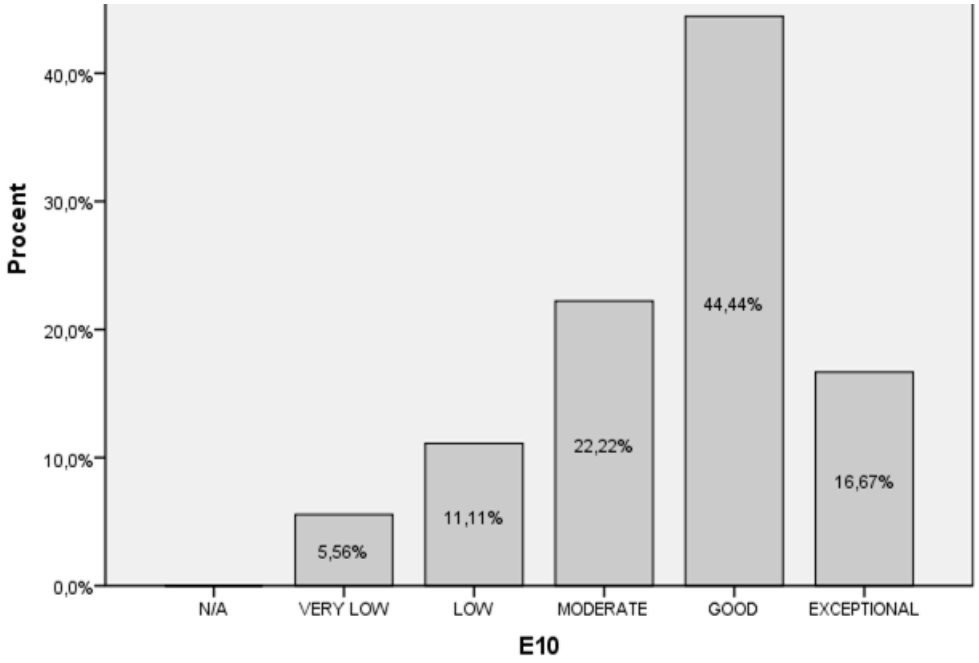

Fig. 8.5 Distribution of the assessment of quality of cooperation with NGOs

Comparing the assessment of cooperation of the operator (executive unit) with municipal organizations and NGOs it is noticeable that their averages are close but the spread of notes is higher for the third sector. The respondents, however, were unable to justify their answers.

Increasing direct social participation in execution of the regeneration process is also crucial from the perspective of New Public Management as they are the closest beneficiaries of the projects. It is done mainly by organizing meetings with the locals where pending actions, projects, new challenges and needs are discussed. In more than 65% of the cities such meetings took place at least once over the period of implementation of the program. The distribution of attitudes of the participants of the meetings is presented on the graph (Fig. 8.6).

According to the declarations given by the representatives of the municipalities, the most common was the demanding attitude presented in 57.14% cases. In a half of he cities only some of the representatives presented their opinions, whereas the majority just came to listen. The voice of the public was constructive in 42.86%. Readiness for taking responsibility for actions and engagement in the projects was presented only in every seventh case. Only in 20% of cases it was indicated that the local community took an active part in the meetings and wanted to co-create the regeneration process. In a quarter of the sample the dominating attitudes were: passiveness and reluctance.

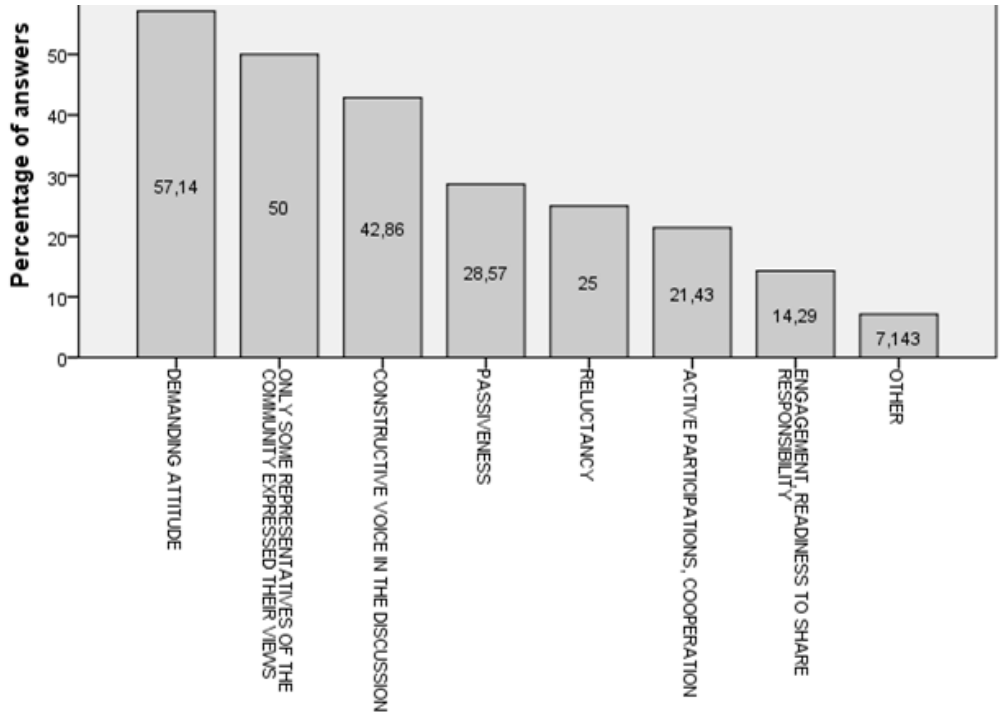

Fig. 8.6 Attitudes of the representatives of the local community presented during the meetings

CONCLUSIONS

Effective and efficient execution of Local Revitalization Programs, apart from financial resources, needs also preparation of dedicated organizational structures. The research conducted in the largest cities in Poland leads to the conclusion, that they are prepared in an insufficient level to deal with the challenges of urban regeneration. Many programs have been implemented in a limited scope, partly because of limited financing, partly because of lack of instruments for implementation and monitoring of the plan. The proposals for establishing an operator of the program are well explored in the literature, so the only issue here is selection of one adequate to the needs and preferences of the local authorities. The directions of prospective research of the author will concentrate on instruments of implementation and monitoring as well as on inclusion of assumptions of New Public Management or Public Governance to urban regeneration processes.

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ORGANISATIONAL ASPECTS OF EXECUTION OF THE LOCAL REVITALISATION PROGRAMMES IN THE LARGEST CITIES IN POLAND - INDICATION OF DIRECTIONS OF FURTHER RESEARCH

Abstract: *The article presents organizational aspects of execution of the Local Revitalization Programs in the largest cities in Poland. Basing on the study of literature there were indicated the directions of further development of organizational structures and identified possible solutions. Directions of further research basing on the paradigms New Public Management and Public Governance, as well as of further developments of managerial methods were also defined.*

Key words: *Execution of revitalization processes, stakeholders, New Public Management, governance*

ORGANIZACYJNE ASPEKTY WDRAŻANIA LOKALNYCH PROGRAMÓW REWITALIZACJI NAJWIĘKSZYCH POLSKICH MIAST - OKREŚLENIE KIERUNKÓW DALSZYCH BADAŃ

Streszczenie: *W artykule przedstawiono aspekty organizacyjne realizacji lokalnych programów rewitalizacji w największych miastach w Polsce. Bazując na studium literatury zidentyfikowano kierunki dalszego rozwoju struktur organizacyjnych i wskazano możliwe rozwiązania w tym zakresie. Określono również kierunki dalszych badań w oparciu o paradygmaty nowego zarządzania publicznego (New Public Management) i Public Governance, a także działania autora w obszarze dalszego rozwoju metod zarządzania.*

Słowa kluczowe: *Wdrażanie procesów rewitalizacji, interesariusze, Nowe Zarządzanie Publiczne*

Tomasz SZULC, Ph.D., MeRSA
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze, Poland
e-mail: Tomasz.Szulc@polsl.pl

9

UTILIZATION OF GAS HEAT PUMPS FOR HEATING AND AIR CONDITIONING IN SMALL AND MEDIUM SIZED ENTERPRISES

9.1 INTRODUCTION

Small and medium sized enterprises (SMEs) have seriously varying demands for heating and/or cooling necessary for their proper operation. Some of them have demand comparable with large-scale production plants. Although technologies applied by them can't always be the same due to e.g. lack of space, infrastructure etc., use of innovative methods to meet demands can be based on various new technologies, among which the VRF (VRF – Variable Refrigerant Flow) gas heat pump is of great importance.

SME sector has been highlighted by the European Union as very important for economy, which is reflected in the EU regional development policy as well as in Small Business Act for Europe [4]. SME sector is the base of all modern European economies [8]. Its role is visible through influence on European regional economy, thus actions of authorities in favor of inspiring and supporting development of SMEs should be an answer to requirements of this sector.

Contribution of the SME sector to the GDP of Poland is significant. In terms of structure of the enterprise input, SMEs generate every other zloty (47.3%), whereas the smallest companies account for nearly every third zloty (29.4%) generated. The share of medium-sized enterprises is three times smaller (10.1%) as compared to microenterprises, and the contribution of small enterprises is nearly four times lower (7.8%) [7].

For this reason, promotion of innovative methods in this sector ought to be of enormous importance for their further development. Nevertheless, generation of electricity and thermal energy in Poland is presently based in over 93% on hard and brown coal. What's more, energy intensity per capita is very high and will probably result in an increase of energy consumption in power and heat production in the near future [3]. Therefore it is necessary to diversify sources of primary energy in favor of natural gas. These assumptions are part of energy and environment policy of Poland as well as European Union [1, 2, 6, 9]. Following from these assumptions, major infrastructural investments are planned for better accessibility to natural gas and increase of its share in final energy production.

In the office buildings, hotels and similar facilities now under construction, air conditioning becomes a standard, and it is common, that such buildings have independent heating, air conditioning and ventilation systems, that are driven by electricity. Necessity of air conditioning during daytime in the summer increases peak load. Such high demand for electricity requires operation of more generation units and also gives increase to the air pollution.

Similar situation of peaks in consumption of electricity took place in 1980s in Japan and was connected to strong economic growth, causing a rise in energy use. For this reason, Japanese Government has ordered and financed scientific program with goal of developing new solutions allowing production of the required amount of heating/ cooling energy, associated with reduction of both electricity consumption and pollution of natural environment. In few years, such a new technology has been developed – Gas Heat Pumps (GHP), relying on the use of gas-driven engine in heat pump system working in Variable Refrigerant Flow (VRF) mode. Gas heat pumps allow combining heating and cooling as well as hot water production in a single installation using natural gas or LPG, which reduced electricity consumption in peak hours. In addition, the design, construction and operation costs of heating and air-conditioning systems were reduced.

9.2 GAS HEAT PUMP TECHNOLOGY BY GHP AISIN

Developed by AISIN Group, the GHP technology involves the use of an internal combustion engine fueled by gas to drive the compressor unit working in the high-performance heat pump system with variable refrigerant flow (VRF). The heat produced by the engine is used in this system as a source of supply of the heat pump cycle in the heating mode, while in the cooling mode it allows to eliminate the losses associated with the process of defrosting the evaporator, that occur in traditional electrical heat pump systems. The internal combustion engine applied in the GHP AISIN technology differs from the constructions used in the automotive industry. It was designed at the TOYOTA Research and Development Center specifically for use in the GHP AISIN gas heat pumps. This engine works in the Miller cycle, which is characterized by a shortened compression stroke and lower compression pressure, and thus lower temperature. This design allows for a significant increase in engine performance and a reduction in NO_x emissions, compared with traditional Otto cycle internal combustion engine. AISIN GHP engine can be powered by natural gas or LPG. High efficiency of this heat pump system is in addition increased through the use of engine speed modulation and electromagnetic clutches for compressors, depending on the current system load. In the GHP AISIN heat pump uses the R410A refrigerant of the latest generation, which allows for the most effective liquefaction and evaporation in the heating and refrigeration cycle.

9.3 OPERATING IN HEATING MODE

During operation of the heat pump in heating mode the refrigerant R410A is heated using the heat from the cooling system of the internal combustion engine, which in this case acts as a lower source of heat, if compared with traditional systems

of ground-source heat pumps. When R410A refrigerant is heated, it evaporates, and the vapors of low performance go to the compressor, where they are compressed and their temperature rises. Heated and compressed, the refrigerant goes to the internal unit, where heat is transferred into the room, followed by its condensation. The refrigerant then goes back to external units, where it is heated using the heat of the engine, evaporates and goes to the compressor, and then repeats the entire cycle. The principle of operation of gas heat pump GHP AISIN in heating mode is presented in Figure 9.1.

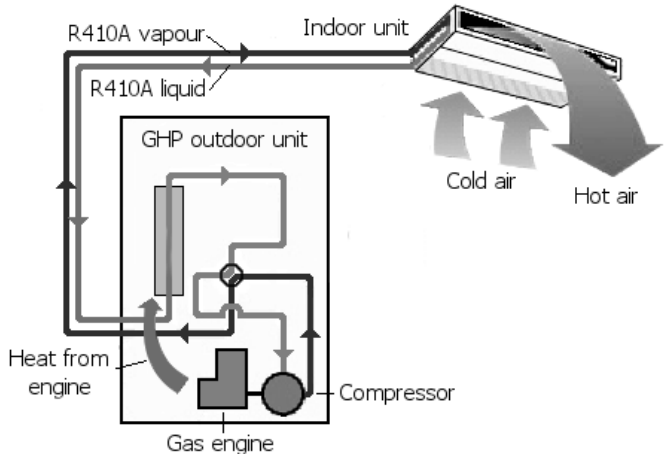

Fig. 9.1 Operation principle of gas heat pump GHP AISIN in heating mode

9.4 OPERATION IN COOLING MODE

During operation in cooling mode, heat pump refrigerant R410A goes to the internal units, where it is vaporized and at the same time picks up heat from the air conditioned spaces, so that the vapor of low performance goes to the compressor.

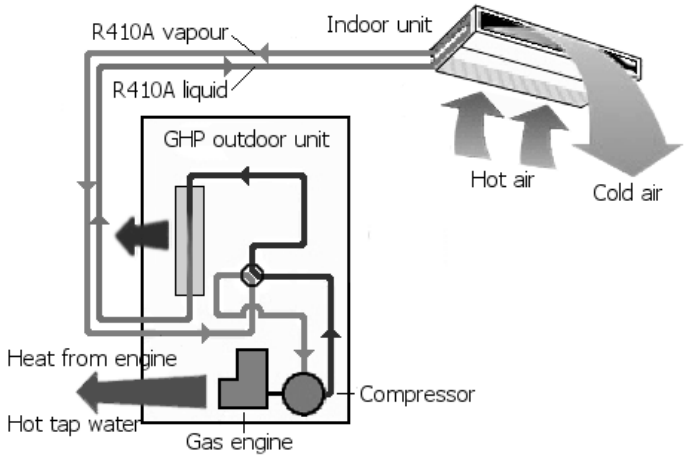

Fig. 9.2 Operation principle of gas heat pump GHP AISIN in cooling mode

Compressed refrigerant goes to the heat exchanger, where it is condensing and putting heat into the ambient temperature outside the building. Liquefied refrigerant then goes back to the internal units, where it evaporates, and the entire cycle is repeated. The heat, generated by the engine in this mode, can be used for production of domestic hot water. The principle of operation of gas heat pump GHP AISIN in cooling mode has been presented in Figure 9.2.

9.5 REDUCTION IN ENERGY CONSUMPTION AND OPERATING COSTS

Application of gas internal combustion engine in the heat pump GHP AISIN allows to get a specific thermal power/cooling, passed into the building at a lower cost in comparison with electric heat pumps EHP.

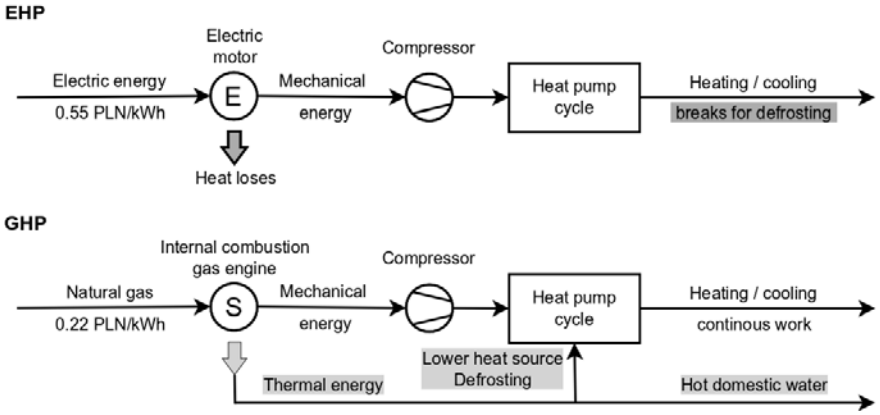

Fig. 9.3 Energy utilization in electric (EHP) and gas (GHP) heat pump systems

Cost of electricity (0.5 PLN/kWh) is greater than the cost of energy obtained from burning gas (0.18PLN/kWh). Therefore, if the energy contained in the gas is delivered to the process in which it is effectively transformed into heat/cooling, it is possible to obtain significant savings in operating costs. Such a highly-efficient gas fuel conversion into useful energy takes place in the GHP devices, where it is used in addition to heat from the cooling system of internal combustion engine and the heat contained in combustion gases (Fig. 9.3). That system allows to reduce operating costs up to 40%, compared to traditional technologies.

9.6 WORK WITHOUT INTERRUPTION FOR DEFROSTING

Because of the use of heat from the cooling system of the internal combustion engine, GHP AISIN does not require work in the reverse flow of the refrigerant (required for the necessary defrosting and proper operation), as it is in the case of electric heat pump EHP (Fig. 9.4).

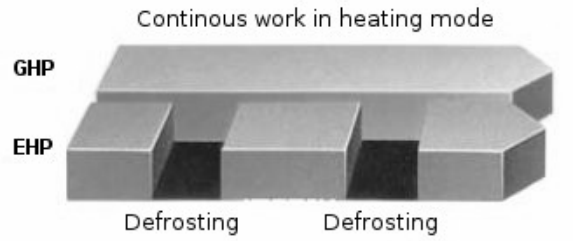

Fig. 9.4 Difference in continuity of operation for gas (GHP) and electric (EHP) heat pumps in heating mode

In addition, TOYOTA high efficiency gas combustion engine allows for very rapid heating of the premises, even at the lowest outside temperatures.

9.7 ENVIRONMENTALLY-FRIENDLY TECHNOLOGY

Application of GHP AISIN devices in HVAC systems means reducing the amount of primary fuel, that must be used to produce a given quantity of energy required to ensure thermal comfort inside the building. Natural gas is the cleanest source of energy currently used in the combustion process, because of the high calorific value of natural gas and LPG as well as the composition of exhaust gases, compared to the pollution caused by burning coal in conventional power plants if one takes into account the entire cycle of generating electricity in the power plant fueled with coal together with the transmission of this energy to the end user. When the later is compared with the installation of GHP AISIN, where clean burning process of gas is carried out directly to the place of use of the generated energy, the volume of CO_2 emissions into the atmosphere in the AISIN GHP technologies is nearly 50% less than in traditional technology.

High gas utilization efficiency (GUE) of the AISIN GHP technology means that this solution is very effective and allows to reduce primary energy demanded by building for heating/cooling and leads to reduction of greenhouse gas emissions, The R410A refrigerant, applied within the GHP AISIN, is characterized by close to zero impact on the ozone layer and is recognized as the best for use in air conditioning systems. Reduction in energy consumption and CO_2 emissions and the use of R410A refrigerant also allow to apply for a very favorable loan for the purchase of gas technology for the protection of the environment, financed by the National and Regional Environmental Protection Funds.

9.8 LONG LASTING OF GHP AISIN DEVICES

GHP AISIN devices are made in Japan in factories of AISIN, which is part of TOYOTA Group. Excellent quality of their parts and precision of manufacturing and assembling assure their durability and reliability. Special construction of gas engines allows for many years of performance at a minimal costs of maintenance. Exchange of spark-plugs, wedge-belts and motor oil top-up is usually required after 5 years of operation or every 10000 hours of running time, while oil exchange needs to be done once for 15 years. Quality of workmanship in gas heat pumps GHP AISIN ensures continuous operation of installations and significantly reduces maintenance costs.

9.9 APPLICATIONS

Because of different power outputs of external GHP AISIN units (which can be joined into the larger groups) and possibility to utilize the gained heating/cooling energy in different arrangement of internal units and ventilation switchboards (Dx, AWS, AHU, HWK), GHP systems can be used in a broad scope of investments. Among the most common uses of GHP AISIN the following locations should be pointed out:

- hotels,
- banks,
- office buildings,
- car showrooms,

- research institutes,
- apartment buildings,
- entertainment centers,
- hospitals,
- schools,
- small- and medium-sized manufacturing plants.

CONCLUSIONS

Structure of primary sources of energy in Poland, where hard coal is a major energy resource, shows a need for development of modern, high-productive gas technologies. This is important for reduction of natural resources consumption as well as for natural environment protection. This problem is most important in small- and medium-sized enterprises (SMEs), for which energy management decides about development prospects. Diversity of energy management in such enterprises depends on their scope of activity, access to energy carriers and energy policy. For this reason, implementation of up-to-date methods of energy supply should be very important for SME development.

GHP AISIN gas heat pumps technology is an example of such highly-efficient primary energy conversion from gas to useful heating/cooling energy, and delivering them directly to the designed facility. GHP AISIN gas heat pumps technology, which is now available in Poland, is complete from both technique as well as technological point of view and is, at present, the most efficient solution for broad scope of uses in places, where demand for heating, air conditioning and domestic hot water exists.

Solutions used in GHP AISIN technology provides many benefits, which are visible at every stage of investment completion:

- design:
    - demand for one only project for both heating and air-conditioning,
    - reduction in piping required,
    - grouping of equipment in one location (roof or next to the building)
    - greatly reduced or even no need for boiler room,
    - possibility to use different system of supplying the building with energy (Dx, AWS, air system or their combination),
    - possibility of using the hot water produced in HWK system in a capacity, that allows to abandon alternative energy sources, such as solar panels;
    - option to join units into bigger systems,
    - high quality of design from the architectural point of view;
- installation:
    - reduction in labor and material costs due to only one installation being necessary for heating, air-conditioning and hot water production,
    - easiness of assembly of the GHP equipment, piping and internal collectors,
    - no need for additional ground works, necessary in ground-coupled heat pump systems,

- simplification of work management of media distribution from a single source;

- use:
  - reduction of energy consumption,
  - reduction of gaseous emissions to the atmosphere,
  - convenient and self-induced use of heat and/or cold generated in the system,
  - suitable control of internal collectors and of the entire system,
  - high durability and reliability of GHP installations,
  - possible extended warranty (up to 5 years),
  - possibility of connecting GHP system to remote monitoring and visualization of working parameters and conditions.

In the next few years, large number of ongoing as well as planned investments in Poland, will cause an increased energy demand for heating, air-conditioning and ventilation. Taking into account the limitation in electricity supply for newly-designed buildings, it seems necessary to consider implementation of new technologies, efficiently converting accessible sources of primary energy. This shows the profit from using gas heat pump technology GHP. Furthermore, also the energy priorities of both the European Union and Poland are an argument showing the possible broad scope of use and development of GHP technology, which is a very attractive solution when compared to those currently in use.

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UTILIZATION OF GAS HEAT PUMPS FOR HEATING AND AIR CONDITIONING IN SMALL AND MEDIUM SIZED ENTERPRISES

Abstract: *In the article, an innovative method of space heating and cooling in small and medium sized enterprises is presented. Principles of the gas heat pump technology (GHP), its advantages and influence, limiting the impact on the natural environment, as well as decreasing primary fuel resources and reducing costs of using the energy in enterprises are discussed. Various types of locations, where presented technology gives results, are indicated.*

Key words: *Space heating and cooling, gas heat pumps, natural environment, energy management, SME, GHP*

INNOWACYJNA METODA ZAOPATRYWANIA MAŁYCH I ŚREDNICH PRZEDSIĘBIORSTW PRODUKCYJNYCH W CIEPŁO I ENERGIĘ ELEKTRYCZNĄ

Streszczenie: *W artykule przedstawiono innowacyjną metodę zaopatrywania w energię cieplną i elektryczną małych i średnich przedsiębiorstw. Omówiono zasady mikrokogeneracji gazowej MCHP XRGI, jej zalety, wpływ na ograniczenie oddziaływania na środowisko naturalne oraz ograniczenie kosztów użytkowania energii w przedsiębiorstwach. Przedstawiono również instrumenty wsparcia dla inwestorów oraz użytkowników instalacji z wykorzystaniem MCHP XRGI.*

Słowa kluczowe: *Energia cieplna, energia elektryczna, mikrokogeneracja, środowisko naturalne, gospodarka energią, ŚMP, MCHP XRGI, instrumenty wsparcia*

dr inż. Tomasz WAŁEK, dr Piotr KALETA
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze
e-mail: Tomasz.Walek@polsl.pl; Piotr.Kaleta@polsl.pl

10

RADIO FREQUENCY IDENTIFICATION IN SUPPLY CHAIN MANAGEMENT

10.1 INTRODUCTION

Supply chain management is the management of material, information and finance through a network of organizations (i.e. suppliers, manufacturers, logistic providers, whole sales distributors and retailers) that aims to produce and deliver products or services for the consumers [8]. It includes the coordination and collaboration of processes and activities across different functions such as marketing, sales, production, product design, procurement, logistics, finance, and information technology within the network of organizations. The desire to cut supply chain costs has pushed radio frequency identification. Technology, an e-tagging technology that can be used to provide electronic identity to any object. RFID is not a new technology. It was first used in the Second World War to identify aircraft. But the application of this technology (described in the paper) in supply chain management is new.

The aim of the paper is presentation of possibility of using RFID technology in supply chain management. Especially paper concentrate on examples of using this technology in various industries and also on benefits of RFID.

10.2 THE HISTORY OF TECHNOLOGY

The service sector has been using barcode technology since the mid-1970s. Barcodes appear on almost every purchase, from soft drinks to automobiles. The code itself is made up od the series of wide and narrow parallel lines and spaces and can store as many as 20-30 characters per inch of coded information's. Research and development in barcoding technology has led to the development of the new two-dimensional code which contains a stack of as many as 90 one-dimensional barcodes each just three-hundredths of an inch high. New developed barcodes allows user to maintain a large block of information about each product – manufacturer, cost price, order size, weight, etc. High-speed laser scanners read the new barcode quickly and retrieve the information for continual monitoring [20].

But not in all cases this technology was the best solution. Sometimes the barcodes a unreadable and we can't use scanner. Because of that there is a new technology – RFID – radio frequency identification. This technology originated in the 1940 when the US government used transponders to distinguish friendly aircraft from enemy aircraft [5]. Also, in the 1950s, other technical developments in radio and radar along with the IFF

exploration of long range transponder systems for identification was conducted. These development also led to future patents for RFID technology [20]. Through the 1970s, the federal government primarily used the systems for tracking livestock and nuclear material. Radio tags have been used commercially in so-called closed loop systems for delivering packages, handling luggage, tracking food in supermarkets and monitoring highway tolls in the 1980s and 1990s. In 1997 Mobil installed an RFID system called "Speedpass" the lets you wave tag in front of the gas pump to record your transaction and debit your credit card [14]. In 1980 the Bay Area Rapid Transit (BART) installed RFID system to provide equal access to the system for disabled individuals. Under the new system disable people were issued an ID tag at no charge [11]. To operate the system, the disabled person holds the tag close to the reader to activate station elevators [5]. In 1999 with the help of scientist at the Massachusetts Institute of technology a consortium companies formed center for continued research into the nature and use of radio frequency identification. The consortium had a new idea about how organizations could identify and track their assets. The new vision underlying automatic identification of objects.

Today the RFID technology can not only be enterprise assets, but also the movement of products, containers, vehicles and other assets across vast geographical areas. [29]. The RFID method is considered by many experts to be the successor of OMR systems, especially in the area of bar codes applications. Already for a few years, there are implementations of RFID methods, which successfully complete or replace the bar codes methods [9]. Between 1999 and 2003, the Centre gained industry acceptance of the passive RFID tagging system with the support of more than one hundred large end-user companies. The industry support is evidenced in the fact that some of the biggest retailers in the world – Albertsons, Metro, Targret, Tesco, Wal-Mart and U.S. department of defense have initiated plans to use this technology to track goods in their supply chain [20].

10.3 THE USE OF TECHNOLOGY

Barcoding technology has become very important to all industries including manufacturing and services. But there were some problems witch this technology. Some situations have environmental condition, such as temperature, dirt or hazardous contamination, that make optically scanning the barcodes on a label ineffective. In those cases a different technology, called radio frequency identification (RFID), is often preferred. RFID does not require the tag or label to be seen to read its stored data.

For a nominal price a RIFD tag is attached to the product in the initial stages of manufacturing that follows the product down the supply chain all the way to a retail setting, and finally into the hands of the customer. There, it can again be scanned while in a box or crate, saving labor. In a retail setting, the tag can serve as the price tag count on the tag for warranty information after purchase. Consumers can RFID does not require the tag or label to be seen to read its stored data. RFID uses radio waves to capture data from tag, rather than optically scanning the barcodes on a label. RFID

systems have three primary components:

- the tag or transponder,
- the reader,
- the computer.

An important promise of RFID technology is to cut costs and deliver a wealth of information that helps firms more effectively understand, predict, and respond to customer demand. RFID not always is the best solution. It is an enabler that allows firms to change their supply chain processes for the better. RFID technology is used in a range of applications. More specifically, it has useful applications in the following industries (Table 10.1):

- shipping and distribution,
- retail industry,
- manufacturing sector,
- agriculture, cattle and food production;
- health care,
- pharmaceutical,
- government,
- gaming industry,
- security industry.

Table 10.1 The use of RFID technology in various industries

Industry	The use of technology
Shipping and distribution	In this industry, RFID technology enables suppliers to accurately determine the location of a pallet, to track its journey through the supply chain, and to make instantaneous routing decisions. At a major trucking and logistics provider company, RFID tags are embedded in the fleet of 2600 trucks. At the service center, the tag automatically determines what loading/unloading activities are needed and assigns an appropriate crew to service the truck [16]
Retail industry	RFID technology offers a very significant advantage over bar coding. Wal-Mart's initiative and move in using the technology was heralded as the most important tech development for retailers since the barcode. RFID tags continually gather information as products move from shelves to the checkout counter. The technology not only helps the retailer to reduce labor and manual costs, it also curbs shoplifting and boosts store [13].
Manufacturing sector	This sector has been finding different ways to derive value out of this technology. For example, manufacturers are using RFID product tracking mechanisms to ensure accuracy. Parts can be individually tagged and tracked throughout the manufacturing proces while on the production line. Parts received from the production plant can be tracked throughout the assembly process. This certainly helps manufacturers with their carefully scheduled just-in-time (JIT) assembly lines. Tags containing equipment specifications can be attached to enable easy upgrading. Similarly, tags can be used to keep track of usage, availability, location, and maintenance of material handling equipment. Procter & Gamble (P&G), for example, believes that RFID technology can help the company to track where every item is in the manufacturing process and supply chain [25].
Health care	RFID technology can be used in health-care industries to improve quality and reliability. In the US Navy, RFID tags, embedded in wristbands, are used to identify patients and update their status automatically. A British firm is using RFID tags to match blood samples to patients [21].

Industry	The use of technology
Agriculture, cattle and food production	Increased government regulation about food traceability in the USA and a mandate from the European Union (EU) for tightened traceability requirements beginning in 2005 has pushed RFID technology into food sourcing. RFID can help these traceability requirements at a reasonable cost. The technology should also reduce recall costs by increasing the ability of the manufacturers to identify and recall only the affected items. Similarly, RFID technology is used to secure the identification of cattle by means of inserting a tag into the stomach of an animal, enabling accurate records for automated farm management [15, 17]. The tag may be attached to animal in one of three modes, namely ear tags, subcutaneous injection, or ruminal bolus. The bolus has been identified as the best tamper proof animal identification tag provided it is implanted at the right age and weight of animals [4].
Pharmaceutical	The drug industry uses RFID technology to self-police in the fight against thieves and counterfeiters. For example, Purdu Pharma, the manufacturer of the popular painkiller OXYContin, is using RFID tags to track shipment of its theft-prone drug. Pfizer is planing to put the radio tags on bottles of its widely counterfeited Viagra drug by the end of 2005. With RFID tags, pharmacists will be able to identify counterfeit drugs and law enforcement officers also will be able to quickly check whether bottles they recover have been reported stolen [5].
Government	This sector is another emerging application area for RFID. Government agencies are using RFID technology for supply chain management, inventory, security, and military strategies. The Army uses tags on supply containers for detecting shock and variances in temperature. These tags have a range of up to a mile to enhance supply management capabilities. The Navy, on the other hand, uses RFID tags for weapon management, with a range of less than six inches to protect sensitive data. Weaponry data collected by RFID tags reveal anything from materials to capabilities and mission details [3, 6].
Gaming industry	This industry has been finding other ways to derive value out of this technology. For example, the Wynn Las Vegas Casino is using radio tags on Betting chips to deter counterfeiting, card-counting and other illegal behavior. Casino executives envision RFID transforming the way they operate table games. The casino is installing RFID readers and PCs at game tables. Dealers can take a quick inventory of chips that have been wagered. In addition to monitoring wagers, the technology will let dealers or cashiers see when the value of the chips in front of them does not match the scanners' tally. The casino industry is also planning to use the technology to help casinos keep tabs on how much players bet and how long or often they play for incentive programs [12].
Security industry	Giant retailers and manufacturers aren't the only adopters of RFID technology. RFID seems to be moving quietly into the people-tracking realm, especially in the area of monitoring children. Lauren Scott of California, the $2 million-a-year apparel company, will launch a line of pajamas with RFID tags sewn into the hems. RFID readers installed at various points throughout a house will be able to scan the tags within a 30-foot radius, and will trigger an alarm when boundaries are breached [28].
Timber	In Brandenburg the RFID technology is tested for its performance in low distance positioning and data transfer outdoor condition. RFIDE tags complement the route description and help carriers to localize the exact position of the lorries and of woodpiles. Additionally, RFID can be used for pile identification and data exchange all along the timber transport chain [27]
Library	The application of RFID system speeds effectively the work of a library by combining the activation of antivol RFID label and the registration of book's lending into one operation, even in case of several books at once, what had to be done sequentially in case of using of bar codes readers. The popularity of RFID among librarians is caused mainly by facilitating to conduct the inventory of the library methods [9].

Signaling between the reader and the tag is done in several different incompatible ways, depending on the frequency band used by the tag. Tags operating on LF and HF bands are, in terms of radio wavelength, very close to the reader antenna because they are only a small percentage of a wavelength away. In this near field region, the tag is closely coupled electrically with the transmitter in the reader. The tag can modulate the field produced by the reader by changing the electrical loading the tag represents. By switching between lower and higher relative loads, the tag produces a change that the reader can detect. At UHF and higher frequencies, the tag is more than one radio wavelength away from the reader, requiring a different approach. The tag can backscatter a signal. Active tags may contain functionally separated transmitters and receivers, and the tag need not respond on a frequency related to the reader's interrogation signal [10].

An Electronic Product Code (EPC) is one common type of data stored in a tag. When written into the tag by an RFID printer, the tag contains a 96-bit string of data. The first eight bits are a header which identifies the version of the protocol. The next 28 bits identify the organization that manages the data for this tag; the organization number is assigned by the EPC Global consortium. The next 24 bits are an object class, identifying the kind of product; the last 36 bits are a unique serial number for a particular tag. These last two fields are set by the organization that issued the tag. Rather like a URL, the total electronic product code number can be used as a key into a global database to uniquely identify a particular product [19].

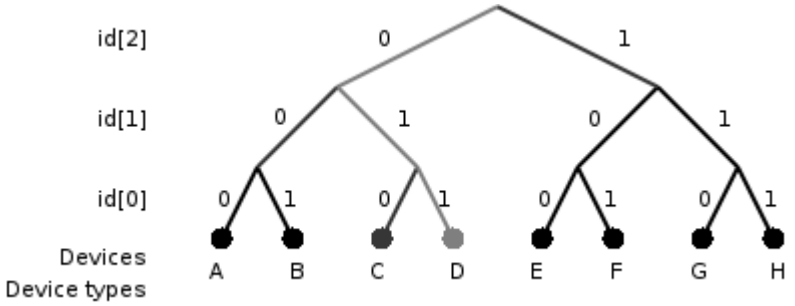

Fig. 10.1 An example of a binary tree method of identifying an RFID tag

Source: [24]

Often more than one tag will respond to a tag reader, for example, many individual products with tags may be shipped in a common box or on a common pallet. Collision detection is important to allow reading of data. Two different types of protocols are used to "singulate" a particular tag, allowing its data to be read in the midst of many similar tags. In a slotted Aloha system, the reader broadcasts an initialization command and a parameter that the tags individually use to pseudo-randomly delay their responses [23]. When using an "adaptive binary tree" protocol, the reader sends an initialization symbol and then transmits one bit of ID data at a time; only tags with matching bits respond, and eventually only one tag matches the complete ID string [7]. Both methods have drawbacks when used with many tags or with multiple overlapping readers. Bulk reading is a strategy for interrogating multiple tags at the same time, but lacks sufficient precision for inventory control.

RFIDs are easy to conceal or incorporate in other items. For example, in 2009 researchers at Bristol University successfully glued RFID micro-transponders to live ants in order to study their behavior [1]. This trend towards increasingly miniaturized RFIDs is likely to continue as technology advances. Hitachi holds the record for the smallest RFID chip, at 0.05mm × 0.05mm. This is 1/64th the size of the previous record holder, the mu-chip`s. Manufacture is enabled by using the silicon-on-insulator (SOI) process. These dust-sized chips can store 38-digit numbers using 128-bit Read Only Memory (ROM) [30]. A major challenge is the attachment of antennas, thus limiting read range to only millimeters.

10.4 BENEFITS OF TECHNOLOGY

Organizations who take the time to understand the technology's capabilities and limitations can increase their revenue growth, lower costs, reduce inventory, better utilize fixed assets and gain favor with retailers. The main benefit of using RFID technology is reducing human intervention. Because of that the benefit of having fewer humans hands involved is reduced errors, which produces reduced costs, faster throughput, and reduced damage and returns. The overall implication of reduced human intervention, given the high cost of salaries, benefits and the cost of management associated with crews of human workers, is a dramatic reduction in operating costs. Automated toll systems are a prime example of how the lack of human intervention saves both time and money [29]. Some of the most important benefits that business is able to gain by using this technology are [2, 5, 18]:

- enhanced visibility into customer needs;
- enhanced visibility along the supply chain;
- accurate and timely asset tracking;
- smart product recycling;
- streamlined or better managed business processes within the company;
- improved productivity by generating the fastest and lowest;
- cost method of acquiring the data;
- improved velocity by responding to demand signals faster;
- better utilization of fixed assets, resulting in lowered;
- capital asset requirements;
- reliable and accurate order forecasts;
- reduction in inventory costs including stock-out and holding costs;
- improved technology return on investment;
- improved accuracy by reducing the opportunity for human error;
- increased productivity and dramatically reduced operating costs;
- improved product quality and reliability including traceability;
- improved supply chain management by better tracking transportation and warehousing channels;
- improved counterfeiting identification, theft prediction, and faster recalls;
- gaining favor with retailers to better position products on shelves,

- increased efficiency,
- higher information storage,
- automated stock control,
- very durable,
- possibility of tags reusable.

The advantages of RFID vs. barcode technology [2]:

- no line of sight requirement,
- the tag can stand a harsh environment,
- long read range,
- portable database,
- multiple tag read/write,
- tracking people, items, and equipment in real-time.

But there are a few important social and ethical risks [31] that must be realized, especially in regard to the healthcare environment. Monahan and Fisher researched the ethical and social risks of RFID devices being implanted into humans via observational studies and staff interviews in twenty-three United States hospitals using RFID technology The first risk they identified in their study was that patients who opted to receive the RFID tag were receiving expedited care. Secondly, Monahan and Fisher found that doctors tended to trust the information obtained from the RFID tags over the information the patients themselves provided. This raises a large concern pertaining to the accuracy of the information on the tags. If the information on a patient's tag were to be incorrect, it is possible that the care administered to the patient could be doing him or her harm. The third and final risk discovered in this study was that patients who do not know the extent of the capabilities of the RFID tags may actually be endangering themselves. A patient's ignorance of the chip's capabilities may cause them to assume that the chip can do things that it cannot, leading to a very false sense of security [22].

CONCLUSION

Nowadays the RFID technology is increasingly using in various industry as: shipping and distribution, retail, manufacturing, agriculture, health care, pharmaceutical, government, gamin, security, timber, library etc. in supply chain management process. Many benefits described in the paper causes the possibility of wide use of this technology. Because of benefit of having fewer humans errors it can lead to reduced costs and faster throughput. Also reduced damage and returns are important problems from logistic and also quality management point of view. On this basis we can say that the RFID technology will develop and will be implemented to other industries. But there are some concern regarded to RFID relevant to cost of the technology and also social and ethical risks' that must be realized.

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RADIO FREQUENCY IDENTIFICATION IN SUPPLY CHAIN MANAGEMENT

Abstract: *Presented paper concentrate on using RFID (Radio Frequency Identification) technology in supply chain management. Today the RFID technology can not only be enterprise assets, but also the movement of products, containers, vehicles and other assets across vast geographical areas. Supply chain management is the management of material, information and finance through a network of organizations (i.e. suppliers, manufacturers, logistic providers, whole sales distributors and retailers) that aims to produce and deliver products or services for the consumers. The aim of the paper is presentation of possibility of using RFID technology in supply chain management. In the paper there is a presentation of the history of RFID technology, the possibility of use of RFID in various industries and the analysis of benefits of RFID from supply chain management point of view (as fewer humans hands involved reduced errors reduced costs and so on). Also there is a brief description of potential risk of the technology especially in regard to the healthcare environment. Nowadays the RFID technology is increasingly using in various industry as: shipping and distribution, retail, manufacturing, agriculture, health care, pharmaceutical, government, gamin, security, timber, library etc. in supply chain management process. Many benefits described in the paper causes the possibility of wide use of this technology.*

Key words: *RFID, supply chain management, RFID benefits, RFID risks*

IDENTYFIKACJA RADIOWA W ZARZĄDZANIU ŁAŃCUCHEM DOSTAW

Streszczenie: *W artykule skoncentrowano się na wykorzystaniu technologii RFID (ang. Radio Frequency Identification) w zarządzaniu łańcuchem dostaw. Obecnie technologia RFID może być wykorzystywana do wspomagania procesów logistycznych organizacji, takich jak w szczególności: przepływ towarów, kontenerów, pojazdów i innych aktywów na terenie rozległych obszarach geograficznych. Zarządzanie łańcuchem dostaw jest zarządzanie materiałami, informacją i kwestiami finansowymi poprzez sieć organizacji (np. dostawców, producentów, dostawców usług logistycznych, hurtownie dystrybutorów i sprzedawców detalicznych), którego celem jest produkować i dostarczać produkty i usługi dla konsumentów. Celem publikacji jest przedstawienie możliwości wykorzystania technologii RFID w zarządzaniu łańcuchem dostaw. W pracy przedstawiono historię technologii RFID, możliwość wykorzystania RFID w różnych branżach i analizę korzyści zastosowania RFID do zarządzania łańcuchem dostaw. W publikacji zawarto również krótki opis potencjalnego ryzyka omawianej technologii, zwłaszcza w odniesieniu do środowiska naturalnego i zdrowia. Obecnie technologia RFID jest coraz częściej wykorzystywana w różnych branżach takich jak: transport morski i dystrybucja, handel detaliczny, produkcja, rolnictwo, opieka zdrowotna, przemysł farmaceutyczny, bezpieczeństwo, produkcja drewna, biblioteki itp., w procesie zarządzania łańcuchem dostaw. Wiążące się z nią liczne korzyści, opisane w publikacji powodują możliwość szerokiego stosowania tej technologii.*

Słowa kluczowe: *RFID, zarządzanie łańcuchem dostaw, korzyści RFID, ryzyko RFID*

dr hab. inż. Radosław WOLNIAK, prof. Pol. Śl.
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze, Poland
e-mail: Radoslaw.Wolniak@polsl.pl

11

COMPUTER AIDED SUSTAINABLE DEVELOPMENT REPORTING - INTEGRATION WITH ERP PACKAGES

11.1 INTRODUCTION

The notion of corporate social responsibility (CSR) and reporting practices are complex and multidimensional. There exists many different approaches, standards and guidelines and consequently indicators to be reported which makes it not easy to prepare such report not to mention about its comparability. In order to support and facilitate reporting practices it can be applied computer programs enabling partial automation of the reporting process. In this paper an analysis of functioning of this kind of software was conducted with drawing the attention to the effects in the field of CSR reporting which can be achieved in this way. The purpose of this paper is to present a comparison of different approaches and solutions in the field of computer assisted sustainability reporting with a special focus on ERP software. In this paper the authors use the terms of sustainability reporting and CSR reporting interchangeable.

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11.2 CORPORATE SOCIAL RESPONSIBILITY REPORTING– THE BASE OF THE ISSUE

Implementation of Corporate Social Responsibility (CSR) principles into economic practice is a difficult task. On the one hand, the concept of CSR is not easy to explain and contains the entire range of issues. In the narrow sense according to some experts the concept focus mainly on social issues and in a wide sense, which is compatible with the views of the authors of this paper, reflects the idea of sustainable development concept at the enterprises level [8, 13]. So different meaning of CSR concept caused that emerged a number of standards relating to the issue. The problem is not only the implementation of the principles and requirements of corporate social responsibility in the organization but also a matter of measuring the extent to which an organization is in the issues involved. To do this, using the appropriate indicators, measure the involvement of specific organizations into CSR concept. To make such comparison had a sense the data must be complete and compatible. Achieving this requires the creation of reporting systems of corporate social responsibility actions undertaken by the individual companies. Each country creates its own systems enabling to look at this problem from a different point

of view (detailed information on system solutions of sustainability reporting in different countries can be found in the). In terms of community involvement activities often are divided into obligatory and voluntary activities. In this case, the area of mandatory activities include basic economic activity of the organization. And the area of the voluntary activities consists of three groups of actions [4]:

- projects in a commercial environment,
- investments into local communities,
- philanthropic activity.

Organization to demonstrate that the above examples of activities have been implemented must somehow prove that they took place and in an appropriate manner communicate about their results, for example by means of CSR report.

Speaking of sustainability we can distinguish two approaches. The first approach is based on the requirements of the specific norms and standards, and the second rely on entirely voluntary approach to the concept of corporate social responsibility and the reporting process. It is worth noting that the CSR reporting process is not easy because of the different solutions used in each country and a plurality of used indicators. In the literature, the following are the most important issues in this field [7]:

- the problem with defining key performance indicators,
- sensitive of the information for different audiences,
- non-financial information have a smaller value in many cases and they are irreverent,
- CSR reporting is expensive,
- there is too little knowledge about the companies reporting,
- problems with continuation of corporate social responsibility reporting.

The major international guidelines on corporate social responsibility reporting include the Global Reporting Initiatives (GRI) guidelines. Particular countries often refer to the guidelines by creating local solutions in this area. The popularity of these solutions contained in the GRI are confirmed by the fact that till June 2011 up 2889 organizations around the world have developed sustainability report prepared in accordance with these guidelines. These guidelines in a very detailed manner regulate the content of the report, which should include the following elements [9, 10]:

- strategy and profile – a description of the organization strategy with reference to the sustainable development issue, a review of the structure of the organization and scope of the report,
- approach to the management – contains a description of the organizational structure, policies, management systems and efforts to involve stakeholders,
- performance indicators included in the three areas – economic, environmental and social.

11.3 PHASES ORGANIZATIONS ADVANCEMENT IN THE IMPLEMENTATION OF INFORMATION SYSTEMS FOR REPORTING ON CORPORATE SOCIAL RESPONSIBILITY

To be able to prepare good and credible reports in the field of corporate social responsibility organization shall ensure control over all the necessary information. This information should be readily processed and presented in a user-friendly form. Usually, in order to collect, aggregate and present data in terms of corporate social responsibility organizations speak, from the tools, the three solutions, which are to ensure the transparency of the process [11]:

- office software such as word processors and spreadsheets – most companies begin to create their reports using such solutions, because they are simple and require no additional training, or expense, but very quickly, those organizations that engage seriously in the process of corporate social responsibility reporting come to the point where beginning to realize the limitations of this kind of tools;
- software dedicated for reporting corporate social responsibility, it is usually the next step that you take those companies that want to ensure the quality and ease of reporting on corporate social responsibility, including the possibility of aggregating data and convenient charting;
- fully integrated reporting system connected to the ERP, in this case, the reporting of corporate social responsibility at the level of information technology becomes integrated with the management of the entire organization, supply chain management, resource management, quality, safety, finances, etc.

This is consistent with the literature on the subject decrypted in the paper, which also sets out three approaches – the methods of computing systems management [5]. The company, which wants to implement software management support system easy see that this is a serious problem. The basic choice that is in front of the company is the decision whether it would be advantageous to purchase one of the existing programs on the market, or they may want to create own solution. Each of these approaches has its advantages and disadvantages. The company wishing to design own, tailored to the requirements of the software can have them outside (outsourcing) or execute a program within their own company. Similarly to the previous case, each solution has specific advantages and disadvantages.

Each of the three possible solutions is worth considering and can be effective or not, depending on many factors. Decision-making process, which is aimed at the selection of one of the solutions is not easy and should include a number of important parameters. Therefore, it is worth to post a few tips to determine in which situations, a specific solution may be the best [5]:

- finished programs are worthy using when: there is need for rapid implementation of the system, we do not have qualified staff specialists, our management system does not differ substantially from the sector standards;
- external outsource company, designing custom systems should be used in the following situations: when there is a good market companies, with experience

in designing custom programs in the industry such as ours and we want to reduce costs but do not have sufficient potential to self-creation system;

- the same value system design when: a management system in the organization essentially differs from the standard, we have a well-qualified team of specialists, we do not have sufficient funds to take advantage of existing solutions, does not depend on us during the implementation.

However, keep in mind that these guidelines are not mandatory, therefore, always planning and designing specific systems must carefully analyze the specificity of the company, the needs, the availability of specific solutions, and available funds, to select the most efficient solution in a given situation. The order of the phases in the implementation of software to support the reporting of CSR is shown in Figure 11.1. Mentioned phases determine the level of organization advancement in this field. In practice, usually the organization initially uses the lower level solutions that lead to a situation in which they are restricted and further development of reporting forces the transition to the next phase.

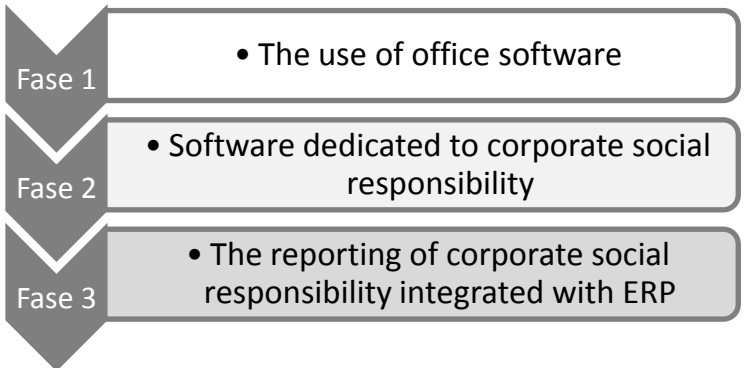

Fig. 11.1 Phases of advancement of the organization in the process of corporate social responsibility computerization

Source: on basis [11]

11.4 INTEGRATION OF CORPORATE SOCIAL RESPONSIBILITY REPORTING AND ERP

As was mentioned in the previous section of the paper, the integration of computer aided social responsibility with ERP software is considered the most advanced solution on both the computer and management point of view The organization at the strategic level needs to integrate all kinds of reports that it created. Various reports and various reporting systems may in fact provide different data. It should ensure their compatibility in terms of: completeness, reliability, risk management, business continuity, compliance with relevant standards, etc.

Integrated ERP systems play an important role in aided information technology within modern companies. This class of systems has the ability to support and integrate almost all areas of activity of the company and can significantly support various levels of management reporting, monitoring and analysis of business processes [1]. ERP systems/DEM (Enterprise Resource Planning) are currently the latest developments and MRP systems (Material Requirement Planning) and MRP II (Material Resource Plann-

ing). Those standards are complementation of the earlier standards of financial management – management accounting, control, liquidity, cost accounting, corporate social responsibility, etc. Among its there are also many additional features included in ERP: supplier chain management and planning activities of the company at various levels – from strategic to operational [12]. ERP systems is a system covering the whole process of supply, production and distribution, which integrates the various sectors of the company, improves the flow of important information on its operation and allows you to instantly respond to changes in market demand. This information is updated in real time and available at the time of the decision. One of the major differences between the specification of the ERP, and the other is the use of constraint-based, bi-directional planning and optimization mechanisms built into the possibility of electronic connections in the supply chain and sales [6].

Given into account the completeness of the solution is certainly the best to fully integrate reporting of corporate social responsibility with the ERP system. However, not in every case, such a solution can be applied. Before an organization to take decisions in this regard, it must consider the possible problems that may relate to matters such as:

- costs – a fully integrated system is costly and for this reason it is not always the optimal solution for small business;
- owned IT infrastructure – extensive systems require modern infrastructure, if the organization does not have any such distributions may result in additional costs.

When these problems appear to be large enough that the organization is not able to implement the reporting system of corporate social responsibility is fully integrated with ERP alternative is the so-called action in the cloud. However, this manner of conduct will not be in this publication further developed. Made by KPMG to review the existing solutions (their list is shown in Table 11.1) in the field of computer-assisted reporting of CSR allowed to draw the following conclusions [11]:

- almost 89% of the packages are suitable for small-sized companies (< 25 employees), while 94% of the packages are suitable for 25 - <100 users. All packages are suitable for 100 or more users;
- the packages are applicable within various sectors (e.g. aviation, agriculture, energy, shipping, industry, real estate and transportation);
- more than 82% of the packages have worldwide coverage and all packages offer English language. Nevertheless, packages that do not have worldwide coverage do cover key markets in the Netherlands, UK, North, Central and South America.

Taking into account the functionality of the tested software its concentrates on the most areas that occur in a typical ERP software on the issues that may affect the reporting of corporate social responsibility. In Table 11.2, the most important features of this software together with an indication how often a specific functionality occurs. Data collected using the software can be used by internal and external stakeholders of the organization. External stakeholders may for example be informed of the potential scenarios that may occur at the creation of the data used Corel software.

Table 11.1 The software which contains modules to support the reporting of corporate social responsibility

Manufacturer	Software
CA® Technologies	CA® ecoSoftware
CRedit360 Ltd	CRedit360
CSR Nordic ApS	CSR-System
CSRware,® Inc.	Sustainability Resource Management (SRM)
Dakota Software Corp.	ProActivity Suite
dmStrategists, LLC.	SBP360
e3 Solutions Inc.	Carbon Management Tools – e3CAT, e3Clip and e3 ECM
Enablon®	Enablon SD
Hara Software Inc.	Hara Environmental and Energy Management (Hara EEM)
Locus Technologies	Locus ePortal, Locus RMM (Resource Management Module)
Oracle®	JD Edwards EnterpriseOne Environmental Accounting &Reporting Oracle Environmental Accounting & Reporting Sustainability Reporting Starter Kit for Oracle® Hyperion® Financial Management
SAP®	Sustainability Reporting and Analytics Solutions
SAS®	Sustainability Reporting
Systar Pty Ltd	iSystain™
WeSustain GmbH	WeSustain Enterprise Sustainability Management (ESM)

Source: [11]

Table 11.2 Functionality of software with modules to support the reporting of corporate social responsibility

Functions	The percentage of software in which the function exist [%]
Detailed annual assessment	100
Strategic implementation Monitoring and reporting	94 94
Scenario analysis Projections Decision and engagement tools	82 82 82
Workflow management Risk assessment	78 78
Guidelines and data resource Financial analysis & costing Automatic data collection from meters	70 70 70
Supply Chain analysis Simple estimate	62 62
Guidance Carbon offsetting	50 50
CDM Tools	42
Life cycle assessment	34

Source: [11]

Virtually all ERP programs, which were analyzed in the report, included most of the functionality relating to corporate social responsibility reporting. For example, issues relating to strategy, scenario analysis and decision process occurred in 82% of the programs. Problems occur when we begin to talk about the more specialized functionalities. In such a situation, it turns out that not every program has them, and hence the decision to implement a particular program is not always clear.

Issues such as automated data collection, analysis of the continuity of the analysis of LCA, etc. are only a part of the software and are not always available, even in very complex packages the best companies.

Very important problem associated with corporate system responsibility reporting is the process of preparing reports on corporate social responsibility. Because of that it's significant problem to look into the functionality of the programs in this regard. A reporting format is important when you want to ensure compatibility reports, as well as the information contained directly used in other software, such as statistical analysis, etc. In assessing the software that the organization wants to implement, we must first consider the following five issues:

- Is there a function to administer the external information supply?
- Is there a possibility to graphically display management reports?
- Is there a possibility to create standard management dashboards?
- Does a list or report generator come as standard?
- Can reports be exported to MS Word and MS Excel?

In the process of compiling reports on corporate social responsibility very important step is to identify areas that will be subject to reporting and detailed definition of indicators. These indicators are the most frequently should be consistent with the standards of the GRI and address issues related to: the economy, the environment, social issues, human rights and social responsibility. Most large software packages like ERP, allows you to define indicators in all needed fields of corporate social responsibility areas. As is clear from the quoted KPMG report all analyzed ERP programs allow the reporting of corporate social responsibility in accordance with the guidelines of the GRI tight. In contrast, 53% of packages allow the use of other solutions. Most packages offer a wide functionality in the selection of indicators that can be easily defined.

CONCLUSIONS

Summing up the discussion presented in this paper it can be concluded that for large and medium-sized organizations the implementation of corporate social responsibility reporting is best supported using large ERP software packages. Many companies, especially manufacturing ones, have already have such systems and the issue is only in the use of these features, which relate to corporate social responsibility in terms of the reporting process. There is no problem when an organization wants to prepare standard, typical reports in accordance with GRI methodology because practically all programs of this type have sufficient functionality. Problems can occur only in such situation where we need a very advanced functionality related to, for exam-

ple, the automatic implementation of the data from measurement devices, life cycle analysis, etc. In this situation the organization must carry out a detailed analysis of commercially available software and choose the one that will ensure the best functionality, compatible with the needs of the organization.

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COMPUTER-AIDED SUSTAINABILITY REPORTING – INTEGRATION WITH ERP PACKAGES

Summary: *The paper presents issues concerning the possible application of computer software in the field of corporate social responsibility reporting. In particular, attention was paid to solutions where the software is part of a large ERP software packages. There is in the article an analysis of the existing ERP software from the perspective of its possible use for reporting corporate social responsibility and the scope of issues that the software includes.*

Key words: *Corporate social responsibility, reporting, ERP, computer aided management*

SPRAWOZDAWCZOŚĆ ZRÓWNOWAŻONEGO ROZWOJU WSPOMAGANA KOMPUTEROWO – INTEGRACJA Z PAKIETAMI KLASY ERP

Streszczenie. *W publikacji przedstawiono kwestie dotyczące możliwości zastosowania oprogramowania komputerowego w zakresie raportowania społecznej odpowiedzialności biznesu. W szczególności zwrócono uwagę na rozwiązania w przypadku których oprogramowanie to jest częścią dużych pakietów programowych klasy ERP. W artykule przeanalizowano istniejące oprogramowanie ERP z perspektywy jego możliwości wykorzystania do raportowania społecznej odpowiedzialności biznesu i zakresu zagadnień, które dane oprogramowanie obejmuje.*

Słowa kluczowe: *Społeczna odpowiedzialność biznesu, raportowanie, ERP, komputerowe wspomaganie*

dr hab. inż. Radosław WOLNIAK prof. nzw. w Pol. Śl., dr inż. Patrycja HĄBEK
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze
e-mail: Radoslaw.Wolniak@polsl.pl; Patrycja.Habek@polsl.pl

12

DISAGGREGATION PROBLEMS USING DATA DERIVED FROM POLISH AIR POLLUTANT EMISSION MANAGEMENT SYSTEM

12.1 INTRODUCTION

The establishment of the NED database at the end of 2010 was strictly associated with the development of the Polish national law on air pollutant emission management [4]. Before, the necessary data has to be collected only for purposes of centralized country-level air emission management in distributed system. Establishment of the NED resulted also with simplification of administrative procedures on fulfilling selected international obligations, described widely in [2] or [17].

Data collected in the NED database is mainly focused on matters of country-level air pollutant emissions management. Structure of arrangement of the data is described in details in adequate national Polish regulation [5]. The simplified structure of the data collection is presented in [21]. There are various pieces of information gathered i.e.: emission (annual amount of air pollutants or greenhouse gases released to the atmosphere), geographical coordinates of emitters (as a part of installation), information on technology and air pollutant control devices, fuel used and other.

Pieces of enumerated data, is being submitted to the National Centre for Emission Management as an annual obligation and is partly applied also for purposes of fulfilling of international obligations (national air pollutant emission inventory [10]).

The application of data provided by the NED database is connected with using selected methods of data integration and correction. These types of operations are frequently applied especially during aggregation of the emission data to obtain the value of national annual emission of air pollutant from particular kind of anthropogenic activity.

12.2 MATERIALS AND METHODS

Bottom-up and top-down approach

Simplified structure of reporting data is presented in the figure below (Fig. 12.1). Particular installation (fuel combustion installation or other kind, defined as significant, in the context of emitted air pollutants [5]) is basic data structure in the NED database. Installation is combined from emission sources (e.g. boiler, furnace, hearth) joint with conduits (not distinguished in the figure above). Installation and emission source are

also joint (using conduits) with the emitter (primarily stack, or another place of release of air pollutants to the atmosphere). Geographical coordinates (longitude and latitude) are assigned to the point of releasing of the air pollutants to the atmosphere (emitter).

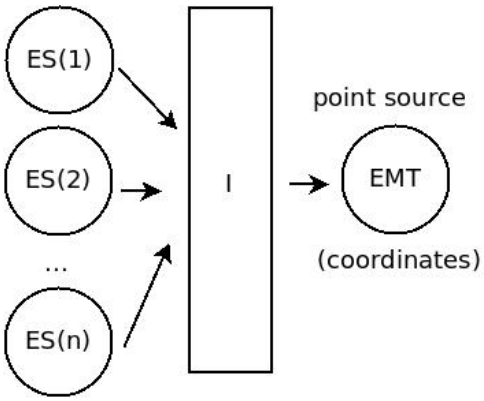


Fig. 12.1 Simplified structure of objects in the NED database (own analysis) ES(1), ES(2), . . . , ES(n): emission sources; I: installation; EMT: emitter

Presented kind of arrangement system (primarily point sources) is commonly known as the 'bottom-up' approach, considering primarily the point source of emission as a basic activity. The opposite, named 'top-down' – basing mainly on estimations using combination of the regional (national) data derived from statistical surveys (activities of emission sources) and typical, average values of emission of particular pollutant corresponding to the unit of product – emission factors (described in details in [24]).

Data derived from the NED can be classified as the area between 'bottom-up' and 'top-down'. Selected categories (e.g. combustion of fuels in public utility plants) are completely corresponding to the official statistics provided by the Polish Central Statistical Office. For categories related to the surface activity (such as emission of air pollutants from agriculture – especially animal breeding or fertilizers application) the compliance is significantly lower due to various discrepancies, data inconsistency and uncertainties associated with emission estimation.

For practical applications, the analysis using only one of enumerated approaches ('bottom-up' or 'top-down' only) is carrying out very rarely. Commonly during emission inventory compilation the combination of those two approaches is simultaneously used.

Combustion of fuels in stationary sources

Emissions of air pollutants from combustion of fuels in stationary sources are included in the national air pollutant emission inventory [10]. Scheme presenting compilation of 'bottom-up' also 'top-down' approaches is shown in the figure below (Fig. 12.2). Emissions sources described as PP and IPP are derived from the NED database and split between main Polish administrative units (provinces), (area of Poland is split between 16 main administrative units (provinces, voivodships) corresponding to NUTS 2 statistical classification provided by EUROSTAT). The rest of categories (CHP, HP, REF, COKE, MIN) are currently estimated with using top-down approach [10].

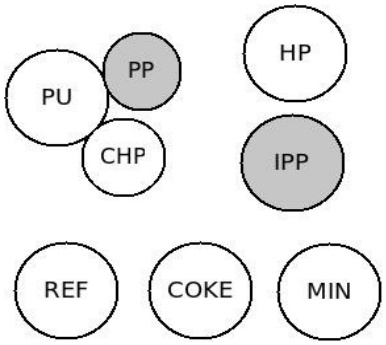


Fig. 12.2 Compilation of bottom-up and top down approaches: air pollutant emissions from the Polish energy sector (combustion plants)

Bottom-up approach marked with grey color.
PU: public utility plants, PP: power plants, CHP: combined heat and power,
HP: heating plants, IPP: industrial power and CHP plants,
REF: petroleum refining plants, COKE: solid fuel processing plants (coke production plants),
MIN: power and CHP plants in coal and lignite mines.

However the category including PP and IPP plants is able to split between Polish provinces manually ('bottom-up' approach), for obtaining the split of whole energy sector the data disaggregation is needed.

Disaggregation and spatial allocation

Disaggregation of air pollutant emissions, known also as downscaling process in this context, is widely described in [1, 3, 6, 9, 12, 13, 16, 18]. In majority of cases is basing on the choice of kind of representative value (a type of disaggregation factor, also combination of several factors), named surrogate. The assumptions are that the surrogate should be transparent for particular sector, corresponding to emission of air pollutant from particular sector (or group of emission sources).

Frequently, as the surrogate is being assumed value directly related to the estimated emission, it can be amount of goods produced (e.g. energy, heat, gasoline or another), fuel consumption, employment in particular sector or also economical factor typical for particular region (e.g. GDP per capita in particular province). Specific kinds of surrogates can be also assumed basing on emission data derived from the data collection such as the NED database (this particular type of splitting factor is known as 'spatial surrogate'). Structure of derivation of surrogates from the NED database is presented in the figure below (Fig. 12.3).

Disaggregation of top-down estimation (split into administrative units or smaller areas, e.g. grids used for purposes of modeling) is connected with problem of choice of proper spatial allocator for emission. Indirect allocator could be established by the value representing the unique features of analyzed area. In case of emission inventory compilation the spatial allocator can be also a result of modeling. Surrogates are not only way of disaggregation. More and more frequent way of splitting emission data are use of spatially oriented statistical methods [8, 14, 7]. The advantage of application spatial statistics in comparison to using surrogates is possibility of work in both scale approach: regional [7] and local [22].

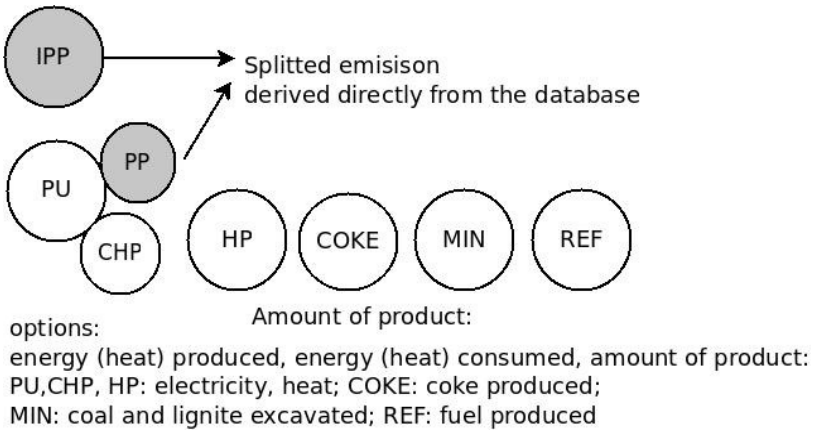


Fig. 12.3 Derivation of surrogates using data derived from the NED database

The one of the most popular way applied for purposes of spatial analysis is kriging. This kind of spatially oriented statistical estimation (geostatistical) is described in details in [7, 20, 23] and many other. Kriging (as a class of algorithms) is a base for another geostatistical estimations and is also described with the acronym 'BLUE' (Best Linear Unbiased Estimator) [23]. The idea of kriging is to estimate the value of continuous parameter z in the neighborhood of the point x0 with using of linear weighted combination of values of the parameter z from the neighborhood of x0 using random functions and regionalized variables theory.

Kriging algorithm optimizing the weights of values 'in the neighborhood' to obtain the error of mean value equal to 0 and also minimize the variance of error in that model. The basic procedure of kriging estimation is described in equations below.

$$\hat{Z}(\boldsymbol{x_0}) = \sum_{i=1}^{n} w_i Z(\boldsymbol{x_i}) \tag{12.1}$$

$$R(\boldsymbol{x_0}) = \hat{Z}(\boldsymbol{x_0}) - Z(\boldsymbol{x_0}) \tag{12.2}$$

$$R(\boldsymbol{x_0}) = \sum_{i=1}^{n} w_i Z(\boldsymbol{x_i}) - Z(\boldsymbol{x_0}) \tag{12.3}$$

$$E[R(\boldsymbol{x_0})] = E[\sum_{i=1}^{n} w_i Z(\boldsymbol{x_i}) - Z(\boldsymbol{x_0})] = \sum_{i=1}^{n} w_i E[Z(\boldsymbol{x_i})] - E(Z(\boldsymbol{x_0})) \tag{12.4}$$

$$E[R(\boldsymbol{x_0})] = \sum_{i=1}^{n} w_i E(Z) - E(Z) \tag{12.5}$$

$$E[R(\boldsymbol{x_0})] = (\sum_{i=1}^{n} w_i - 1) E(Z) = 0 \tag{12.6}$$

$$\sum_{i=1}^{n} w_i = 1 \tag{12.7}$$

Where denoted:
(12.1) – linear, weighted average of the values 'in the neighborhood',
(12.2) – residual value: estimation error,
(12.3) – residual value as combination of n+1 random variables,
(12.4), (12.5) and (12.6) – expected value of estimation error,
(12.6) – assumed stationarity of random values,
(12.7) – assumed no bias for estimation.

Data analysis

Derived data on emission of NO_X and SO_X from stationary combustion sources located in Silesian Province (point source data submitted for 2011). Applied procedure of data analysis is shown in the figure below. The data was corrected before, accordingly to the procedure described in [22]. Before application of the procedure described above, the spatial continuity is analyzed using variogram analysis (described in details below) (Fig. 12.4).

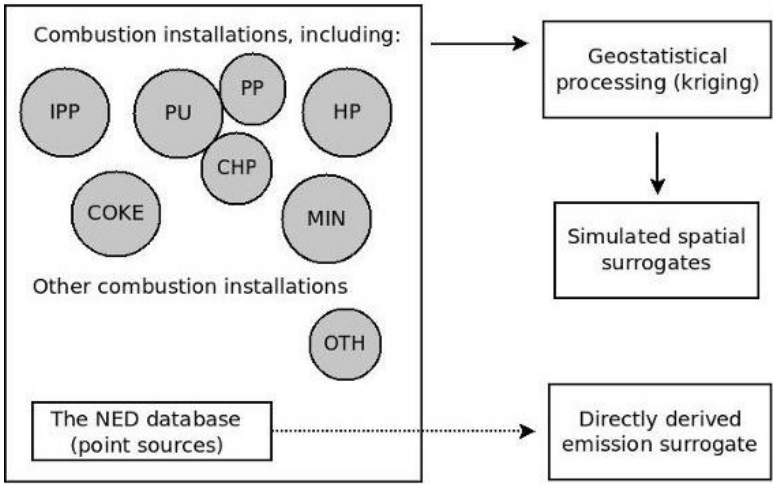


Fig. 12.4 Applied procedure of data analysis

For purposes of analysis there was applied spatial continuity analysis using variograms. Variography described in details in e.g. [20, 23] was applied to originally submitted data to the NED database (as above, considered as point source emissions). Theoretical semivariograms for purposes of kriging estimation (for analyzed pollutants) were built basing on empirical (generated) variograms (variogram clouds). Manual fitting was applied. Kriging simulation was applied to the anisotropic semivariograms, which were chosen due to analysis of stationary sources.

Ordinary kriging estimation was applied in areas of size 500×500 [m^2] using geostatistical R package 'geoR' [11, 19]. Results of conducted analysis are presented in the next section.

12.3 RESULTS AND DISCUSSION

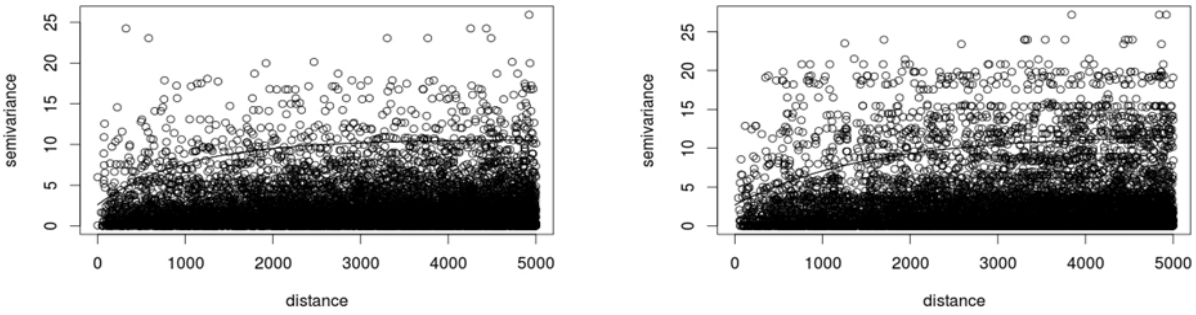
Empirical semivariograms

Basing on generated variogram clouds (presented in the figure below) there were assumed theoretical semivariograms. Parameters of manual fitting are enumerated below:

NO_X: sill = 8 [$\log_{10}(kg)^2$], range = 1000 [m],
practical range = 2996 [m], nugget = 2.6 [$\log_{10}(kg)^2$],

SO_X: sill = 9 [$\log_{10}(kg)^2$], range = 1500 [m],
practical range = 4494 [m], nugget = 2.7 [$\log_{10}(kg)^2$].

For both pollutants was assumed exponential model of semivariogram. Generated variogram clouds with fitted formulas (basing on parameters included above) are presented in the figure below (Fig. 12.5). Semivariograms presented above are typical for large datasets with discontinuous values. Shape of variogram clouds suggests that should be used auxiliary statistical tool or supportive data transformation more advanced than logarithmic [15].



a) NO_X **b) SO_X**

Fig. 12.5 Variogram clouds and assumed theoretical semivariograms

distance = [m], semivariance = [$\log_{10}(kg)^2$]

Ordinary kriging

Simulated values of annual NO_X and SO_X emission from stationary combustion sources (included standard error values) are shown in figures below (Fig. 12.6). In that particular case, the kriging process is both: an estimation (estimates spatial distribution of emission) and also simulation (distribution is simulated due to application random variable theory and functions of co regionalization). Presented values for whole area of Silesian Province are limited only for stationary combustion sources. It can be observed not very strong correlation between results for NO_X and SO_X.

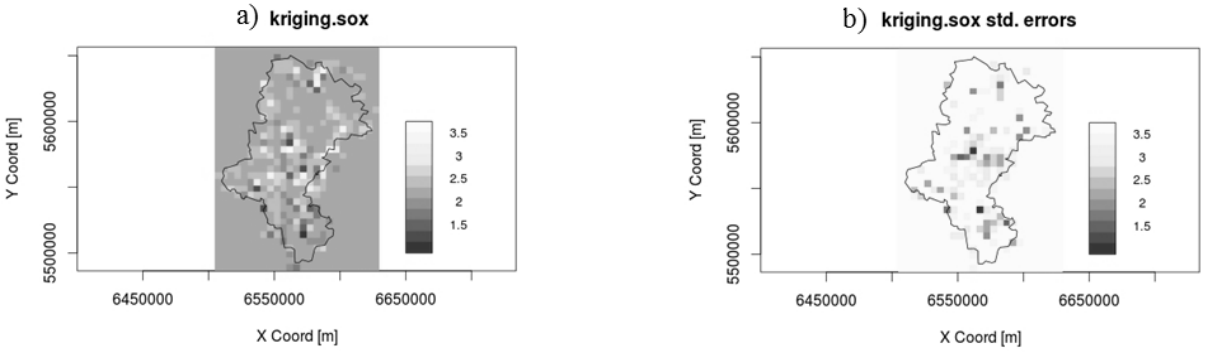


Fig. 12.6 NO_X

Values marked red (kriging) are located in places with the lowest values simulated (Fig. 12.7). In opposite – the highest values of standard error of estimation are located comparably, in places of the lowest input values of emission. This fact indirectly confirms hypothesis on occurrence of discontinuous areas. Anisotropic semivariograms were applied due to constant spatial distribution of analyzed objects (fuel combustion installations).

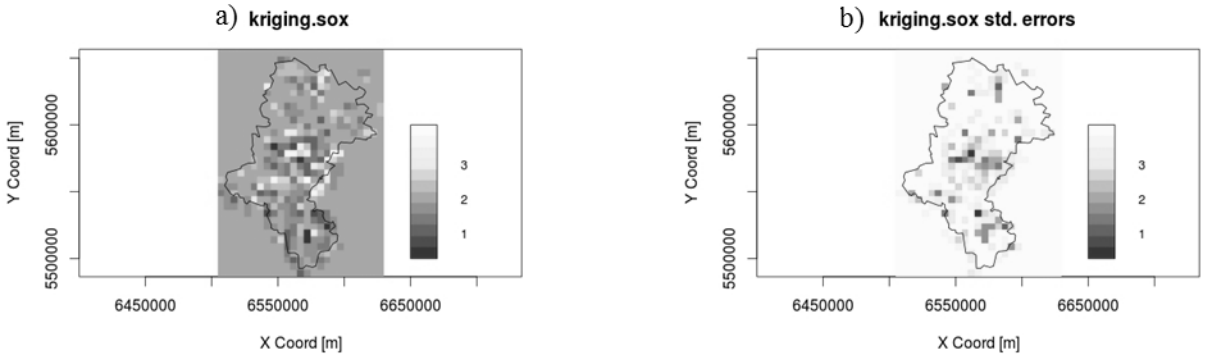


Fig. 12.7 SO_X

CONCLUSIONS

Geostatistical analysis and modeling is becoming more and more popular device applied for spatial data, especially in cases of analysis of discontinuous areas. Specific case of Polish conditions, where the significant part of air pollution is still generated by combustion processes, causes that analysis of environmental effects of the power and energy sector is still current topic.

Application of elements of geostatistical analysis can be potentially high-effective auxiliary tool in emission inventory, especially in case of analysis emissions from stationary sources also with selected downscaling problems, such as disaggregation. Results of that kind of analysis can simplify obtaining spatial surrogates sufficient for dealing with current problems of emission management, especially downscaling the emission data. Geostatistical methods, such as ordinary kriging procedure applied to the data on air emission submitted by installation operators to the NED database can provide the estimation of error of the emission assessment. Results of analysis carried out for fuel combustion installations located in Silesian Province (2011), presented in Figures 12.6 and 12.7 and kriging standard error estimations (presented in Figures 12.6b and 12.7b).

Analysis carried out with using original input data on emission of air pollutants (SO_X and NO_X)

Derived from the NED database is one of the first this type analysis conducted in Poland, however the geostatistical methods are widely applied, e.g. [3, 7, 8, 9]. This type of analysis (analyzed data located in only one province) can be compared to analysis provided by Leopold [7], however unmodified procedure of analysis are not possible to apply in case of whole country due to scaling problem and other downscaling issues. Elaborated analysis (especially part on kriging estimation) highlighted several issues connected with consistency of data collected in the NED database.

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DISAGGREGATION PROBLEMS USING DATA DERIVED FROM POLISH AIR POLLUTANT EMISSION MANAGEMENT SYSTEM

Abstract: *This paper presents analysis carried out with using data provided by the Polish system of air pollutant emissions management – the National Emission Database (NED; data from 2011), established by the National Centre for Emissions Management at the Institute of Environmental Protection – National Research Institute.*

The NED database was established primarily for purposes of country-level air pollutant emission management also financial matters in environmental management (environmntal taxes). The first analysis: [21] also the second [22] have shown that the data collected in the NED database can be treated as an effective, supporting device in national air pollutant emission inventory for purposes of fulfilling international obligations (i.e. UN ECE LRTAP Convention [17]).

In this paper are shown selected problems with emission downscaling and disaggregation for purposes of reporting with using data on emission of nitric oxides (NO_X) and sulphuric oxides (SOX) from stationary combustion sources derived from the NED database.

Key words: *National Emission Database, emission inventory, downscaling, disaggregation, Poland*

PROBLEMY DYSAGREGACJI Z WYKORZYSTANIEM DANYCH POCHODZĄCYCH Z POLSKIEGO SYSTEMU ZARZĄDZANIA EMISJAMI ZANIECZYSZCZEŃ POWIETRZA

Streszczenie: *W niniejszej pracy przedstawiono wyniki analizy danych o rocznej emisji (dane za rok 2011) tlenków azotu (NOX) oraz siarki (SOX) zgłoszonych przez operatorów stacjonarnych instalacji spalania paliw, zlokalizowanych w województwie śląskim, w ramach sprawozdawczości krajowej prowadzonej przez Instytut Ochrony Środowiska – Państwowy Instytut Badawczy, w Krajowym Ośrodku Bilansowania i Zarządzania Emisjami.*

Przedstawiona analiza potwierdza użyteczność krajowego systemu zarządzania emisjami w aspekcie prowadzenia analiz związanych z dysagregacją oszacowań krajowej emisji zanieczyszczeń do powietrza.

Słowa kluczowe: *Krajowa baza, inwentaryzacja emisji, dysagregacja danych, Polska*

mgr inż. Damian ZASINA
Institute of Environmental Protection – National Research Institute
Warsaw 00-805, 132/134 Chmielna Str.
e-mail: Damian.Zasina@kobize.pl

dr hab. inż. Jarosław ZAWADZKI, prof. PW
Warsaw University of Technology
Faculty of Environmental Engineering
Warsaw 00-653, 20 Nowowiejska Str.
e-mail: J.J.Zawadzki@gmail.com

13

DEVELOPMENT OF CLUSTER THEORY – BIBLIOGRAPHY STUDY

13.1 DEFINITION AND TYPOLOGIES OF A CLUSTER

Clusters constitute one of many concepts of territorial forms of production organization which include among others: „industrial district", "industrial cluster", "production chain", "growth pole", "innovation environment", "local production system". Concepts synonymous to clusters are presented in Table 13.1.

Table 13.1 Synonymous concepts to the concept of clusters

Concept	Researcher
Industrial district	A. Marshall, G. Becattini
Growth pole	F. Perroux, O. Hirschman
Development blocks	Dahmen E.
Competence blocks	A-Ch. Fridh
Industrial complex	I, Drejer, F., (S. Kristensen K. Laursen)
Production chains	D. Jacobs, A. P. De Man
Technopoles	Castells M., Hall P.
Innovative systems	Lundval, Edquist, H., J. Braczyk, P. Cooke, M. Heidenreicha
Innovative milleux	Researchers of Groupe de Recherche Européen sur les Milieuc Innovateurs
Learning regions	Asheim, Simmie
Networks	OECD

Source: [4]

Most scholars who deal with the discussed issue believe that the clusters theory was created by Alfred Marshall (1842-1924). He studied selected industrial centers in Great Britain paying attention to their location and production profile. The result of his studies was the concept of industrial district, which explained the reasons and benefits of companies working in geographical vicinity. He presented his observations in a book called Principles of Economic.

Among other scholars who developed the theory of clusters there are: Francois Perroux, Giacomo Becattini, Paul Robin Krugman and Michael E. Porter. F. Perroux introduced the concept of a "growth pole" understood as a grouping of industries around a central core of key industry. The premise of the concept proposed by the

French economist was that growth poles affect the polarization of economic growth [22].

G. Becattini, who studied Italian industrial agglomerations, drew on Marshall's theory and noticed that the reason behind the agglomerations' successes were industrial districts as defined by Marshall. Additionally, Becattini highlighted the importance of social and cultural conditions for the local production. He defined industrial district as a social and territorial unit where local companies merge with local communities and their traditions [1].

Krugman is believed to have created the theory which explains the reasons for global urbanization. According to this American Nobel-winning economist, operating within clusters brings about economies of scale relating to transport and trade costs [19]. The term 'cluster' in the economic sense was first used by Michael E. Porter. According to Michael Porter "a cluster is geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in particular fields that compete but also co-operate" [23]. The other definitions of a cluster which can be found in the literature are presented below:

- cluster is a geographically bounded concentration of similar, related or complementary business, with active channels for business transactions, communication and dialogue, that share specialized infrastructure, labour markets and services. And that are faced with common opportunities and threats [25];
- cluster – localized agglomerations of firms in the same or related industries [8];
- cluster is a group of inter-related industries. They have two key elements. Firstly, firms in the cluster must be linked. Secondly, groups of inter-linked companies locate in close proximity to one other [38];
- cluster is a group of business enterprises and non-business organizations for whom membership within the group is an important element of each member firm's individual competitiveness. Non-business are often a critical element in the success of the cluster [2];
- cluster is sectoral and geographical concentrations of enterprises that produce and sell a range of related or complementary products and, thus, face common challenges and opportunities [34];
- clusters are geographically proximate firms in vertical and horizontal relationship, involving a localized enterprise support infrastructure with share developmental vision for business growth, based on competition and cooperation in a specific market field [6].
- a cluster is a process-conditioned structural and functional organizational system which operates according to the laws and administrative regulations in a certain socio-economic environment and whose efficiency is affected by its external as well as internal environment together with the patterns in which these coincide with and influence one another, which in turn are all affected by common systemic processes, especially those of homeostasis, synergy, entropy, specialization and equivalence [21].

On the basis of these definitions we can see that the attributes of a cluster which are given most frequently are the following:

- geographical proximity of connected enterprises operating in related sectors,
- interactions and horizontal and vertical interconnections between firms and public and scientific research institutions,
- competition and cooperation.

Using different definitions of a cluster and different identification methods leads to a conceptual and empirical confusion. Therefore, numerous attempts at classifying clusters are made in the literature [3, 4, 10, 11, 24, 29, 30, 38]. According to Jacobs and de Man all clusters can be divided into three categories stressing the diverse nature of economic activities taking place in them [11]:

- a regional concentration of business activity of firms from related sectors, usually connected with knowledge centers (science and research centers, universities etc.),
- vertically integrated production chains, narrowly defined sectors, in which the successive stages of the production process are the cluster's core; networks around the core of the cluster's largest firms,
- clusters as entire sectors or industries defined on the basis of highly geographically aggregated data.

According to Meyer – Stamer there are three types of clusters defined on the basis of their organisational structure [11]:

- clusters similar to Italian industrial districts, where there are connections mainly among specialized companies in SME sector. Companies within this type of cluster are highly specialized, mutually competitive and they trust their partners. The cooperation of the companies within such a type of cluster allows them to be flexible within their field, makes them highly productive and creates a great innovative potential.
- hub-and spoke clusters, where there are hierarchical connections among local companies and a large group of companies in SME sector. This type of cluster relies mainly on the power of big corporations, and at the same time is flexible and uses its many advantages mainly relating to the cost.
- satellite clusters with the key participation of small and medium enterprises which depend on outside companies, whose location advantage mainly relates to lower production costs.

Similar typology is presented by A. Markusen [20]. Apart from the three types mentioned above he proposes a fourth type, so called state-based industrial district. The basis of such a cluster are public or non-profit institutions such as a research unit, a university or government administration. The development of companies within such a cluster depends on whether it is possible to transfer technologies from the "base" institution to other cluster entities.

Rosenfeld, after Enright suggested a classification according to the cluster's stage

of development, paying special attention to the role of social capital. On this basis he distinguished the following [25]:

- active clusters – those which have achieved a critical mass and whose members function as an effective system using the existing potential for creating a competitive edge within the cluster. An important element of clusters of this type are social institutions creating a friendly atmosphere,
- latent clusters – clusters which have achieved a critical mass due to the number of firms from a given sector, but which cannot yet make use of synergy effects due to the absence of relevant public institutions,
- potential clusters – clusters which could come into existence if additional conditions/resources were provided. Usually these are clusters which require support from the state in the form of financial resources.

According to Gordon and McCann, there are three forms of territorial organization of production clusters. [9]:

- the model of pure agglomeration,
- the industrial-complex model,
- the social-network model.

The differences among the above forms regard mainly:

- the size of the companies within the groups,
- the nature of relations between the companies,
- the characteristics of the area,
- analytical approach.

According to Gordon and McCann it is crucial to match the studied subject with the forms of the production organization identified by scientists. Specialist literature divides clusters by the character of the activity. Thus, there may be defined four types of clusters [26]:

- industrial clusters,
- agricultural and food production clusters,
- service clusters,
- advanced technology clusters.

Another classification of clusters will be connected with the country of their origin. There are three models of clusters [37]:

- the Italian model – based on informal connections between companies with strong family bonds,
- the Danish model – there, a network broker coordinating the cluster activities plays and important part,
- the Dutch model – characterized by a cooperation of enterprises with a research and science institution.

According to M.H. Best there are two models of clusters: static and dynamic. Static clusters work with limited innovations taking advantage of the economics of location.

Dynamic clusters, however, are characterized by being innovative, by their constant perfection of processes, employees and services. According to Best most industries work on the basis of the static cluster model [26]. The criterion of cluster classification adopted by OECD is their innovative character. The Organization of Economic Co-operation and Development distinguished the following [36]:

- clusters based on knowledge – clusters grouped around research institutes and universities due to an immediate access to basic and public research done by these institutions,
- clusters based on economies of scale – systems based on large scale of production, and the innovative efficiency of the companies is based on the knowledge gained elsewhere, especially with regard to innovations of production process,
- clusters relying on the supplier – the companies tend to acquire technologies, mainly as capital good and intermediate products; their innovative character is defined by the ability to cooperate with the service providers,
- clusters of specialized suppliers – the companies spend considerable amounts on research and product innovations and usually cooperate closely with clients and users.

UK Department of Trade and Industry has applied the following typology of clusters [38]:

- clusters based on the value added chain,
- aggregation of related sectors,
- regional clusters,
- industrial districts,
- network,
- innovative environment.

Dijk and Sverisson propose a similar cluster typology. Main criterion is the cluster development stage. The scientists define the following types of clusters [10]:

- local cluster – companies situated close to one another, their operation is mainly imitating products,
- local market – geographical grouping of the companies operating within similar industries which concentrate mainly on product development, looking for niches and developing sales strategies,
- local network – there is a division of labour between the companies; the main operation is connected with complementary activities and gaining access to entities within supplementary industries and to clients,
- innovation cluster – its characteristic feature is developing innovations which can be later imitated in different locations,
- industrial area – a concentration of cooperation connections within an identifiable group of companies.

Researchers working within the project called SIECI {NETWORKS} carried out in Poland, in Silesia proposed the following models of clusters [16]:

- traditional cluster (regional, industrial) – small and big companies produce goods that belong to traditional sectors; the companies compete with one another (horizontal model) or operate along the value chain; the cluster may have a fixed structure, however, it is not essential, there might be informal agreements based on high level of trust; the cluster may be represented by a leader or a coordinator who will be responsible for gaining funds for its development; the value of traditional cluster for the economy lies in maintaining the production and consequently jobs and creating an industrial centre of a certain reputation and competitive potential; traditional clusters may still be discovered and supported thanks to regional and national programs offering financial support, among other things,
- innovation cluster – innovation-oriented cluster seeking financial support and know-how, within the cluster there are competing entities as well as R&D units, which may act as coordinators; the development of innovation clusters is affected by regional and national policies which focus on the development of businesses; so far in Poland clusters of this type have been organized and based on a leader or a group of leaders (Dutch model); trust is limited due to the innovative character of the ideas,
- network cluster – the companies within the cluster make up an organized network which has got a network broker gathering information on the sources of innovation, units completing the innovations and providing other business-related services; such network provides the flow of information as far as carrying out innovation programs is concerned.

The above classification is based on three mechanisms identified in the course of research which influence the structure of the cluster model:

- shaping of trust within clusters,
- structure and streamlining of knowledge management,
- specification of coordination and structure dimensions of clusters.

On the basis of the above cluster classification it can be observed that many authors stress the network character of the connections between the members of the cluster [7, 9, 10, 16, 23, 25, 30]. It must be emphasized, however, that one cannot identify cluster as network. The differences and similarities between a cluster and a network are shown in Table 13.2. According to Caron and Pouder clusters can be divided into two main types: technological and industrial. The researchers believe that these two types of clusters evolve from different regional resources and their growth depends on various technological industries. Besides, they gather resources in different ways, they have different capacities and they develop different competitive advantages.

Table 13.3 presents the differences between technological and industrial clusters.

Table 13.2 Network versus luster

Cluster	Network
Similarities	
Investing in the creation of relationships Creating and strengthening information channels Transfer of resources between firms Economic and legal independence of the companies Mutual benefit Dependence on resources controlled by other companies	
Differences	
Clusters have open 'membership' Clusters are based on social values that foster trust and encourage reciprocity	Networks have restricted membership Networks are based on contractual Agreements
key benefits: Clusters generate demand for more firms with similar and related capabilities Clusters attract needed specialized services to a region	key benefits: Networks make it easier for firms to engage in complex business, Networks allow firms access to specialized services at lower cost
Clusters take both cooperation and competition Companies concentrated in a certain location Clusters have collective visions Action on the outsider	Networks are based on cooperation Geographical proximity is not important Networks have common business goals Action insi de

Source: [25, 26]

Table 13.3 The differences between technology and industry clusters

Feature	Technology luster	Industry luster
Regional redources	Inventors with idiosyncratic technical knowledge Entrepreneurs with idiosyncratic entrepreneurial insight Accumulated entrepreneurial experience (knowledgeable attorneys, investors etc.) Institutional infrastructure: universities, research units, venture capital, networks, labs, large customers	Suppliers, distributors, skilled labor Ondustry-specific specialists, consultants, service providers Institutions such as trade associations
Source of regional competitive advantage	Technology transfer capability in the region Different markets	Tier suppliers with related products and services, reduced costs of supply, reduced supply uncertainty
Growth driver	The formation of new businesses, including spin-offs	Attracting new subcontractors, suppliers and competitors, and thus, easier access to the entire network
Key regional vulnerability	Uncertainty about the effects of technology implementation (possible boom or bankruptcy). The risk of using one technology, hence the need for greater diversification	The dependence of the region from one industry.
Strategic analogy	Diversification associated with the ability to create synergies by sharing resources	The concentration of one type of industries with vertical linkages

Source: [5]

13.2 CLUSTER DEVELOPMENT PROCESS

Most definitions quoted in chapter 1 present a static (structural) nature of a cluster. However, some researchers (Rosweld, Motoyama, Stachowicz, Mrozowicz, and Góra) see cluster as a dynamic structure based on relations and connections among the entities within. They believe that clusters should be seen as a process. A process is a set of interconnected resources and activities which transform the input state into the output state. A development of any system is a chronological series of changes to this system. Thus, a cluster development process is understood as a set of resources and activities existing from the moment of a cluster's formation to its decline or transformation.

Mrozowicz [21] stresses the importance of dynamic functions carried out within a cluster and proposes a cluster model that demonstrates the relations between the static elements of a discussed structure and dynamic processes carried out within the structure (see Table 13.4).

Table 13.4 Structural and functional attributes of a cluster

Structural attributes of a cluster **Cluster as an organizational structure**	**Functional attributes of a cluster** **Cluster as an organizational process**
Government institutions, local government, authorities and administration of different levels Universities, research and development centers, science institutes Bridging institutions, business environment, consulting companies, business incubators, development agencies, technology transfer centers, industry associations Financial, insurance, consulting, technical and legal institutions Enterprises, manufacturers, suppliers, clients, service providers, sales centers Infrastructure and industrial parks together with superstructure Government and a programs Policy of land utilization of a given administration area	Generating and maintaining the market advantage by applying consistent policy as a result of proper recognition and use of specific local resources Aggregation of entities up to the cluster critical threshold Local concentration of cluster entities Cooperation and competition within functional bonds (formal and informal) Vertical and horizontal cross-sector connection networks within same or similar industries Transfer of organization resources (production, knowledge, marketing strategy, etc.) Creating the atmosphere of internal identity, organization culture and ethical behavior towards key partners and competitors Creating and promoting local business culture and innovations

Source: [21]

13.3 CLUSTER'S LIFE CYCLE

Clusters have their life cycles. An appropriately identified development stage of a cluster is an important element in developing a proper policy for its development. One of the most comprehensive sources on clusters mentions 5 cycles of a cluster's life [39]:

- agglomeration – a region has many firms and institutions, however, there is no co-operation,
- formation phase – co-operation and network connections appear between the entities of the agglomeration;
- development phase – the cluster continues to develop, the number of entities and the strength of connections between them increase; the region becomes

an attractive place for new firms; the cluster starts being visible;

- the mature form – the critical mass is achieved; the cluster has relationships with external entities and regions; internal dynamics in the form of the creation of new spin-up, spin-off and joint-venture firms is visible.
- the decline or transformation phase – endogenous and exogenous changes taking place on the market e.g. those connected with technology or recipient's needs may lead to the cluster's decline; to prevent it the cluster evolves into another one or divides into several clusters focusing its activity around new industries, technologies or products.

L. Knop proposes a cluster life model accounting for crises that may occur during its development. According to the author of the model, recognizing their reasons at various stages makes it possible to seek new preventive measures, which are in turn the basis for the cluster's further development. Figure 13.1 presents the discussed model.

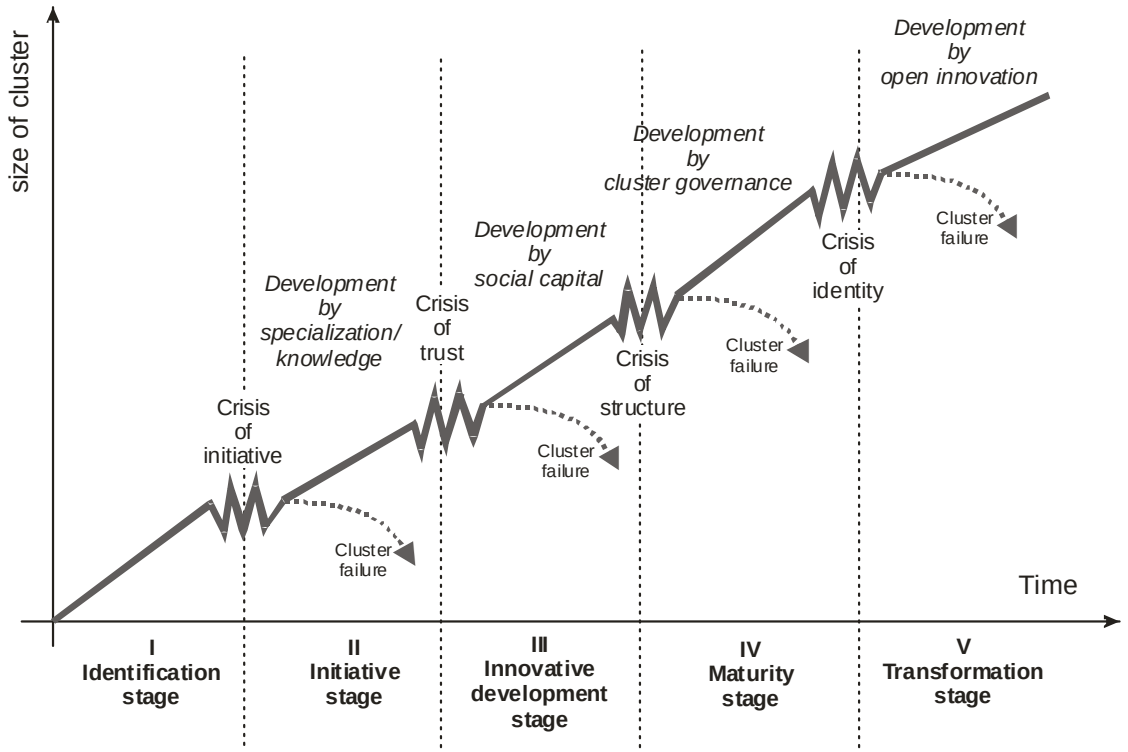

Fig. 13.1 Model of cluster life-cycle with the crises occurring through the process

Source: [13]

13.4 STAGES IN THE FORMATION AND DEVELOPMENT OF CLUSTERS

Many new guides have appeared in recent years on the process of formation and development of clusters/cluster initiatives. (for example [33, 34, 35, 38, 39]). The stages of cluster building suggested by various institutions are shown in Table 13.5.

It is a fact that one universal model for cluster formation and development cannot be created. However, as the table above indicates, 4 basic stages can be identified for all the clusters:

- identifying a cluster,
- preparing the vision and the mission,
- working out a co-operation strategy,
- implementing the plan and monitoring.

Table 13.5 Cluster formation stages

No	Cluster linked over Europe [33]	International Organisation For Knowledge Economy and Enterprise Development [39]	National Research Council of Canada [40]
1	Building social capital	Building trust	Diagnosis: the analysis of the region and social capital
2	Strategic connections development	Connections	Activation: identifying a support person/group and the most important players
3	Defining the vision and strategy	Indicating the vision and strategy	Action plan: Where are we going ?
4	Taking action	Undertaking an activity	Implementation: starting and maintaining the process.

Different activities are undertaken in different stages (Table 13.6) and different methods and tools are used for these activities.

Table 13.6 Activities undertaken in respective cluster development stages

Development stage	Activities
Identifying a luster	Building an interest and participation Defining key industries Specifying the cluster's strong and weak points Analyzing the enterprises
Preparing the vision and the mission	Formulate a technological specialization Defining activities to be undertaken Preparing a road map for the cluster Specifying methods for monitoring and activity assessment
Working out a cooperation strategy	Choosing a desired management structure Specifying an entity to manage the cluster Preparing an R&D program
Working out a co-operation strategy	Preparing a program to develop the cluster's competitive position
Implementing the plan and monitoring	Integrating partners in order to achieve the critical mass Financing Managing the luster Checking whether the activities within the cluster are compliant with the needs of the main players

Source: [33]

Stachowicz proposed a particularly interesting Model for the Cluster Organization Process. According to him a cluster process is a social capital management process. The concept of the model is based in the assumption that clustering should be organized, analyzed, and assessed in three dimensions [27]:

- streamlining the notion, realization, completion and development of the clustering purpose
- streamlining clustering as a process of social capital management,
- streamlining clustering as a learning process – organizing the organization knowledge.

Accepting Stachowicz's assumptions and adopting three streamlining mechanisms of cluster management on the basis of social capital (chosen mechanisms of streamlining of cluster management on the basis of social capital: 1 - forming trust within clusters, 2 - forming and streamlining knowledge management, defining clusters' coordination and structural dimensions), the research team working on SIEĆ project proposed a clustering model and characterized its individual stages. Table 13.7 presents the list of the stages of cluster formation and development as well as the streamlining mechanisms of clustering.

Table 13.7 The stages of cluster formation and mechanisms to rationalize the process of clustering

Cluster formation stages	Knowledge management	Coordination of activities, the structure of the cluster	Confidence	Funding
Stage I - the identification of needs	Selective globalization of knowledge	Loose form of meetings arranged by the principal initiator	The low level of confidence	External
Stage II - the cluster initiative	Concentrated globalization of knowledge + selective "diffusion of knowledge"	Thematic meetings - ideas of participants, the implementation of the central coordinating	Trust based on the realization of efficiency expectations.	External
Stage III - the increase in cluster	Concentrated diffusion of knowledge	Appointment of the Organization Coordinating the operation of the cluster	Trust based on expectations of axiological.	External + internal
Stage IV - the maturity of the cluster	Creating new knowledge	Developing standards of the network	Creating relational norms	Internal + external
V stage - the transformation	Transfer and diffusion of new knowledge for innovative projects	Entrepreneurial super organizations	Development of social and professional relations	Internal + external

Source: [15]

Knop and Olko analyze the applied degree of formality in the cooperation networks activities and formalization cycles of network activities and observed that the network form does not emerge immediately but is shaped in the process of evolution (see Fig. 13.2). After analyzing several dozen of cooperation networks and clusters the researchers formed a model that accounts for the specifics of the cluster formalization in the system of changes to the degree of formality over time [14].

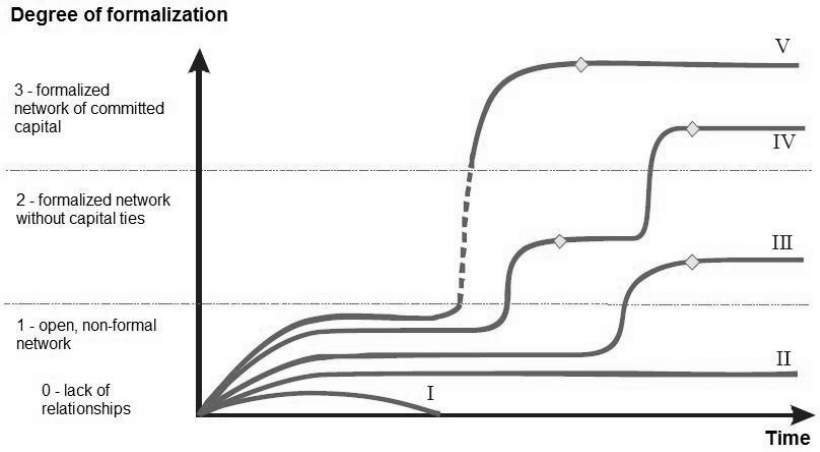

Fig. 13.2 Processes of the network's formalization

Source: [13]

The cycles presented in Figure 13.2 have the following qualities [14]:

I – Network entities at the initial stage of formalization share knowledge and recommend one another, however, due to lack of perspectives the network disintegrates;

II – Network is open, informal and acts in this form permanently;

III – Initially the network is open. After some time of acting together on the basis of mutual trust the members of the network decide to start a formal cooperation e.g. and an alliance based on an agreement, a society, a foundation. Starting a formal relation may be the basis for capital formalization, which is a next step in the formalization process;

IV – A cooperation network initially is open and informal in character and then progresses to the second level of formalization (capital form). Within the cycle the structure passes all degrees of formalization which allows the members of the network to build their mutual trust gradually.

V – A cooperation network starts out as an open network where the first formalization step is to take a capital form i.e. the third degree of formalization.

CONCLUSIONS

The approaches to clusters presented in chapters 2 and 3 show that a cluster is a complicated form, which must be seen as both a structure and a process in relation with socio-economic conditions within the cluster and its environment.

The typologies presented in thi paper deal with numerous and very diverse criteria. Their choice may depend on the aim of the research being carried out as well as on the sector under analysis, the number and the kind of cluster members under review, the cluster's size, the market strategy applied etc. Unfortunately they are not sufficient to classify the cluster explicitly, which means that at the same time one cluster can be put into at least two categories within one classification. A good example may be the typology proposed by OECD, British Department of Trade and Industry, van Dijk and Sverisson, and scholars involved in project SIEĆ.

On the basis of literature research it can be stated that activities, methods and tools for cluster formation and management have already been developed. Their choice depends of course on the cluster's development stage. The activities, methods and tools suggested in numerous guides are mainly concerned with the formation of cluster initiatives.

In studies dealing with the process of formation and development of clusters the work of Polish scholars plays an important role. The model of cluster life cycle and the mechanisms of its formation presented in this chapter provide a new perspective on the complexity of clustering and imply that it is necessary to account for such management components as social capital and trust.

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DEVELOPMENT OF CLUSTER THEORY – BIBLIOGRAPHY STUDY

Abstract: *The Cluster Theory raises a lot of interest among scientists and government institutions. Internationally, there have been many studies published and empirical research conducted which help broaden the knowledge of clusters. The analysis of literature presented in this article indicates that the comprehension of the nature of creation and development of clusters requires knowledge of management, economics and economic sociology. The Cluster Theory must be viewed in relation to questions such as: regional development, relations within regional business structures, innovation, competitiveness and social capital.*

Key words: *Cluster definitions, cluster attributes, clusters types, cluster dynamics*

ROZWÓJ TEORII KLASTRÓW – STUDIUM LITERATURY

Streszczenie: *Teoria klastrów wzbudza duże zainteresowanie zarówno wśród naukowców jak i instytucji rządowych. Na arenie międzynarodowej powstało wiele prac oraz przeprowadzono liczne badania empiryczne, które pozwoliły zgłębić wiedzę o klastrach. Zaprezentowana w niniejszym artykule analiza literaturowa wskazuje, iż zrozumienie istoty tworzenia i rozwoju klastrów wymaga wiedzy w zakresie nauk o zarządzaniu, ekonomii i socjologii gospodarczej. Teorię klastrów należy rozpatrywać w odniesieniu do co najmniej takich kwestii jak: rozwój regionalny, relacje w ramach regionalnych struktur działalności gospodarczej, innowacyjność, konkurencyjność firm oraz kapitał społeczny.*

Słowa kluczowe: *Definicje klastra, atrybuty klastra, typy klastrów, dynamika klastra*

dr inż. Iwona ŻABIŃSKA
Silesian University of Technology
Faculty of Organization and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze
e-mail: Iwona.Zabinska@polsl.pl


WYDAWNICTWO
P.A.NOVA