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Environmental Impact Assessment of Manufacturing Industry Projects

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This article is focused on manufacturing industry and its significant environmental impact aspects coverage in environmental impact assessment (EIA) reports in Lithuania. Firstly, the paper describes how a significant impact can be determined and what sources should be used in its identification. Secondly, the significant environmental aspects related to manufacturing industry are identified. The main result of the paper is the depiction of how identified significant environmental aspects are covered, if they are covered at all, in the EIA reports. The research shows that current EIA practice assesses a negative manufacturing industry impact related to air emissions and direct consumption of natural resources and energy. In general, current EIA practice is concentrated on local and direct environmental impact assessment, while it has the shortcoming to assess an indirect and global impact. Current EIA practice also has a limitation in the evaluation of climate change issues and total cumulative effects of manufacturing industry on the environment.

Keywords: *manufacturing industry, significant aspects, environmental impact assessment.*

Introduction

As manufacturers and industries all over the world are facing the finally voiced demand towards eco-friendly produce, environmental awareness has become a critical aspect in product and process development and an intrinsic part of any business planning and overall strategy (Židonienė and Kruopienė, 2014). Manufacturing industry provides a lot of production materials and products for society and at the same time is related to high-energy consumption and serious environmental contamination. In order to develop less polluting prod-

ucts, services or activities, it is necessary to evaluate a possible negative pressure on the environment in the earliest stage of development and seek for alternative solutions or means which can help to diminish that impact without losing the initial purpose of the action.

As a part of the current worldwide regulatory framework, the Environmental Impact Assessment (EIA) is a compulsory element in project planning and implementation. EIA is a decision tool employed to identify and evaluate the probable environmental consequences of certain proposed development actions in order to facilitate informed decision-making and sound environmental management (Cashmore et al., 2004). It also predicts whether the effects will have a significant impact on the receiving environment after the mitigation control has been implemented (Cornejo 2005). EIA assesses both positive and negative effects and takes into consideration the local impact of proposed projects. In most countries, EIA is applied during the planning or permit approval phase with a goal to determine whether a project is acceptable. Unfortunately, only formal environmental (but not social or economical) standards play a key role (Arts and Faith-Ell 2010, Jos 2013). A considerable research effort has gone into the analysis of EIA since its formulation in 1969, and a number of implementation and effectiveness challenges have been identified through the years of practice.

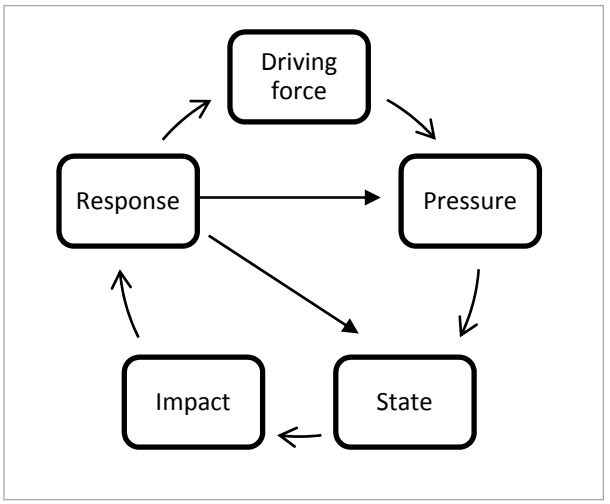
The aim of this paper is to analyse whether current Environmental Impact Assessment practice assesses and covers all significant environmental aspects related to manufacturing industry. Prior to the analysis of manufacturing industry EIA reports, an investigation of significant environmental aspects related to manufacturing industry was held.

Methods

Identification of significant environmental aspects

In terms of activity's impact on the environment, the following 2 aspects play an essential role: identification of the impact and determination of its significance. Eco-Management and Audit Scheme (EMAS) regulation defines the impact on the environment as adverse or beneficial environmental change wholly or partially resulting from the organisation's activity, products or services. The connection between human activity and the impact on the environment can be reflected in the model that has been adapted by the European Environment Agency (EEA), as presented in the Figure 1.

Fig. 1.
The connection between human activity and impact on the environment (EEA, 2012).



The driving force (e.g. industry) puts pressure on the environment, which leads to environmental change. This change influences human health and quality of ecosystems. This may lead to social response (e.g. emergence of legal acts) that will also cause feedback on stimulating factors, pressures and conditions. Therefore, in order to identify the impact that is associated with industry or manufacturing activity, the analysis of the documents that regulate it or environmental initiatives can be carried out.

In view of the impact caused by activity on the environment, various methods of information processing, analysis and forecasting can be applied. The methods can be divided into the following groups (Glasson et al., 2006; Raulinaitis, 2009):

1 *Checklists* – they contain the environmental components the impact on which must be assessed, or the activities the impact of which must be assessed. These checklists do not indicate causalities between the stimulating factor and the response; however, they may prompt issues that need to be addressed.

2 *Matrixes* – they usually include 2 checklists at the same time, i.e. one column may contain operational phases, whereas another column may contain environmental components that somehow may be affected by activity. Matrixes allow elevation of details as to what activity and what its impact may occur, or simply presentation of possible activity stages and possible impacts.

3 *Impact websites* – this methodology is based on the connection between stimulating factor – condition – feedback. It is intended for creation of the schemes of activity impacts' connections. These schemes allow the user to identify the impacts of a particular activity stage.

4 *Multi-layered maps (GIS)* – the essence of this methodology is terrain mapping. First of all, the basic map of the activity location has to be created. Then the maps of various environmental components that may be affected by activity have to be created. Then all the maps are collated and priority elements of the environment or the biggest impact shall be identified in accordance with flaking intensity.

In terms of description and assessment of the activity's impact on the environment, the following characteristics of the impact are also highly important:

- extent of the impact,
- character,
- duration,
- origin,
- and the object of the impact (Koskela, 2011; Raulinaitis, 2009).

In accordance with the extent of the impact, 3 types of the impact may exist, i.e. local, regional or global. The local impact may often influence global environmental changes. For example, greenhouse gas emissions are local; however, they may lead to global warming (Azapagic, 1999).

In order to provide and assess the activity's impact on the environment, it is important to analyse both the direct and the indirect activity's impact. Indirect impact is often much higher than expected. Ekval et al. (2007) found out that the indirect impact of secondary systems of waste management systems, such as the systems of energy and materials production, on the environment was much higher than the direct impact of waste management systems itself.

According to the impact duration, 4 types of the impact may exist, i.e. short-term or long-term, reversible or irreversible.

The analysis of the activity's impact on the environment is usually carried out in accordance with the impact's origin, i.e. in accordance with the nature of activity and the object of the impact, i.e. the affected environmental component. A particular type of activity may be seen as an impact source and its impact on the environment may be analysed. Another alternative is the analysis of the impact caused by the use of specific material or a particular manufacturing process. For example, the biggest impact of textile industry is related to large quantities of chemicals used during the production process and high energy and water needs (Husaini et al., 2011). Food and beverage industry at the European level is responsible for the total consumption of resources (20 to 30%) and influences eutrophication above 50% (EEA, 2012). Cement industry generates more than 5% of all anthropogenic emissions of CO_2 and significantly contributes to SO_2 and NO_x emissions (Feiz et al., 2014). The object of the impact is the affected environmental component. Air (also soil, water or biodiversity) may be seen as an object, and the impact of the activity on its quality may be assessed. Recently, objects of the impact have been defined as the impact on human health, quality of an ecosystem and consumption of resources.

After completion of identification and description of the activity's impact on the environment, it is important to assess its significance. The impact's significance can be understood and determined in different ways; however, according to Wood (2008), it is highly associated with the 1impact's extent and sensitivity of the affected environment. The impact's extent is not equal to the impact's significance. This is reflected in Figure 2 below.

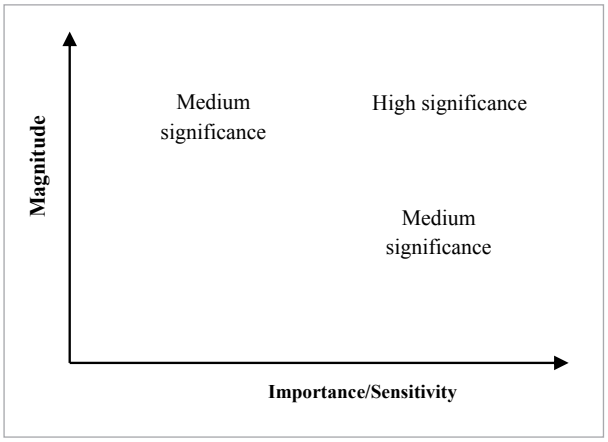
In such a case:

Significant impact = magnitude (extent) ^{x} impact's importance (value).

Regulation of the impact by legal documents often plays the role of a key indicator in determining the impact's significance or priority trends of an environmental policy (Wood, 2008). Poder (2006) recommends to assess

Fig. 2

Functional dependence of the impact's significance on the impact's extent and sensitivity of the affected environment (Glasson et al., 2006).



the following 3 aspects when determining the impact's significance:

1. environmental criteria (the impact's extent, magnitude and duration; or the type, size and frequency of the environmental dimension);
2. applicable legal requirements (such as the limits of emissions and waste water in permissions or regulations);
3. interests of concerned parties (such as public opinion).

Various environmental indicators and their sets may be used also to determine the impact's significance. The expression of the environmental dimension by an indicator indicates priority trends of the impact's assessment (Donnelly et al., 2007). The impact's significance may be assessed by way of an expert survey: by the creation of a reliable sample of experts and by providing them with information about the impact's origin, size and other characteristics (Koskela, 2011). The tables of matrixes are often applied during such assessment.

EMAS regulation recommends to consider the following aspects in order to identify the components of a significant impact and affected environmental components:

- impacts that may be harmful to the environment;
- sensitivity of the local, regional or global environment;
- the impact's size, quantity, frequency and irreversibility;
- existence and requirements of related legal documents;
- needs of concerned parties (EMAS, 2009).

Significant environmental aspects related to manufacturing industry

The current environmental policy of the EU is oriented towards the industry that effectively consumes energy and resources, and carries out the control of greenhouse gas and air emissions. The EU strategy of sustainable development indicates that the impact of industrial activity shall be assessed using a life cycle approach and including all the possible sources of impact.

The main documents of manufacturing processes control are the Directive on Integrated Pollution Prevention and Control (2010/75/EC) and the Directive on Greenhouse Gas Emission Allowance Trading (2009/29/EC). These documents specifically refer to the pollution that is associated with manufacturing activity in the format of certain materials accountancy (SO_2, NO_2, NO_x, Pb, etc.).

The EU Commission Communication on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan (EC, 2008) and the Roadmap to a Resource Efficient Europe (EC, 2011) describe the guidelines of the current EU policy in the context of sustainable development and at the same time highlight the most relevant impact areas that are associated with industry. The essence of these 2 documents is as follows: increase of effective consumption of resources, stimulation of eco-projection and increase of environmental potential of industry through expansion of implementation of environmental management systems.

The significant environmental impact related to manufacturing industry can also be identified through the analysis of various sets of environmental indicators, such EU sustainable development indicators (SDIs) or EEA core set of indicators (CSIs).

According to the mentioned legal acts and sets of indicators, the significant environmental impacts related to manufacturing industry are as follows:

- use of resources:
- direct and indirect energy consumption;
- water consumption;
- emissions of pollutants to the environment:
- air emissions;
- greenhouse gas emissions;
- waste generation:
- hazardous waste generation.

It is important to note that the impact can occur not only directly during manufacturing activity itself, but also during energy production or during production of additional materials required for production processes and by transportation of materials and waste. In order to carry out a comprehensive assessment of the planned manufacturing activity's impact on the environment, it is necessary to include the above identified aspects in the assessment.

After completion of identification of significant impacts on the environment associated with manufacturing activity, the reports of manufacturing activity's impact on the environment were analysed in order to determine whether all significant impacts are covered in EIA reports. Eight manufacturing industry EIA reports (or more than 50% of the total manufacturing reports during 2008–2013 in Lithuania) were analyzed. All the reports were related to manufacturing industry, that main outcome was a real product. Due to confidential information, there is no possibility to reveal exact names of evaluated EIA reports.

Results

The results of the analysis of the identified significant aspects related to manufacturing industry in the EIA reports are shown in Table 1.

Table 1 shows that the following significant aspects are being assessed in the EIA reports:

- the emissions of planned activity to the air;
- direct consumption of natural resources;
- direct energy consumption;
- local and direct impact of activity on the environment;
- mitigation measures for emission reduction.

The biggest limitations are associated with indirect assessment of the impact caused by activity.

The information about air emissions was presented in all the EIA reports; however, only in 2 reports the accounting of air emissions was not limited to the assessment of particular matter, NO_x, CO_2 and volatile organic compounds. When speaking about the expression and nature of the activity's impact on the environmental air,

Table 1

The assessment of identified significant aspects of manufacturing activity's impact on the environment in the EIA reports

Aspect	Number of reports	
	Assessed	Not assessed
1	2	3
EIA assesses the emissions of planned activity to the air	8	-
EIA assesses greenhouse gas emissions	2	6
EIA assesses the emissions of planned activity to the water	2	6
EIA assesses direct* consumption of natural resources (water)	8	-
EIA assesses direct* energy consumption	8	-
EIA assesses indirect** energy consumption	-	8
EIA assesses the impact of natural resources consumption on the environment	-	8
EIA provides the opportunities of reduction of resources consumption	2	6
EIA assesses formation of hazardous waste	6	2
EIA assesses the direct* impact of planned activity on the environment	7	1
EIA assesses the indirect** impact on the environment	1	7
EIA assesses the global impact of planned activity on the environment	-	8
EIA assesses the local impact of planned activity on the environment	8	-
EIA provides the mitigation measures for emission reduction	7	1

* direct impact means energy or natural resources consumption (quantitative) in order to meet operational needs;
** indirect impact means the impact that occurs during extraction and transportation of raw materials, energy production.

the following existing assessment characteristics can be identified:

- assessment of air pollution caused by activity in regard of the company's territory and its adjacencies;
- the nature of the assessed impact – manufacturing equipment and transport that moves within the boundaries of the company's territory;
- the calculation of air pollution is carried out in accordance with technical characteristics provided by various devices, safety data sheets of the materials used, and normative indicators of technological processes;
- air emissions are expressed numerically, i.e. ton of pollutants per year, g/s, mg/Nm^3 or mg/m^3;
- the estimated quantities are compared with threshold limit values (TLV);
- in order to forecast and model air pollution dispersion, the methodologies of pollutants accounting and dispersion are used, e.g. AIRMOD;
- the background concentrations of pollutants are considered during modelling.

The assessment of pollution to the environmental air in the EIA reports is presented in Figure 3.

Although greenhouse gas emissions are a very important environmental aspect related to manufacturing industry, it was assessed only in 2 EIA reports.

The main indicator that describes the impact of planned manufacturing activity on environmental waters in the reports analysed is the quantity of water consumed (m3 per year); industrial and domestic needs are highlighted. The quantity of surface waste water generated is also calculated. The information regarding possible pollutants of waste water was presented only in 2 cases; however, emphasis is always given to the fact that waste water drained will be cleaned up to the minimum requirements and pollution will not exceed the threshold limit values of pollutants. The scheme of assessment of the impact on water is presented in Figure 4. Exactly in the same manner as in the case of assessment of air pollution, only the assessment of direct consumption of water resources in the company's territory is carried out.

In terms of consumption of natural resources and energy, all the reports contain the information about direct activity needs. The information about the quantities of raw materials, additional materials or semi-products is presented. The impact that occurs during extraction of raw materials or production of additional materials and semi-products is not included in the assessment thresholds.

The same situation appears to be with energy consumption. Direct energy needs are identified in all the reports both for manufacturing processes and building maintenance needs. In 2 of 8 cases, the information about the energy need for 1 ton or 1 unit of production

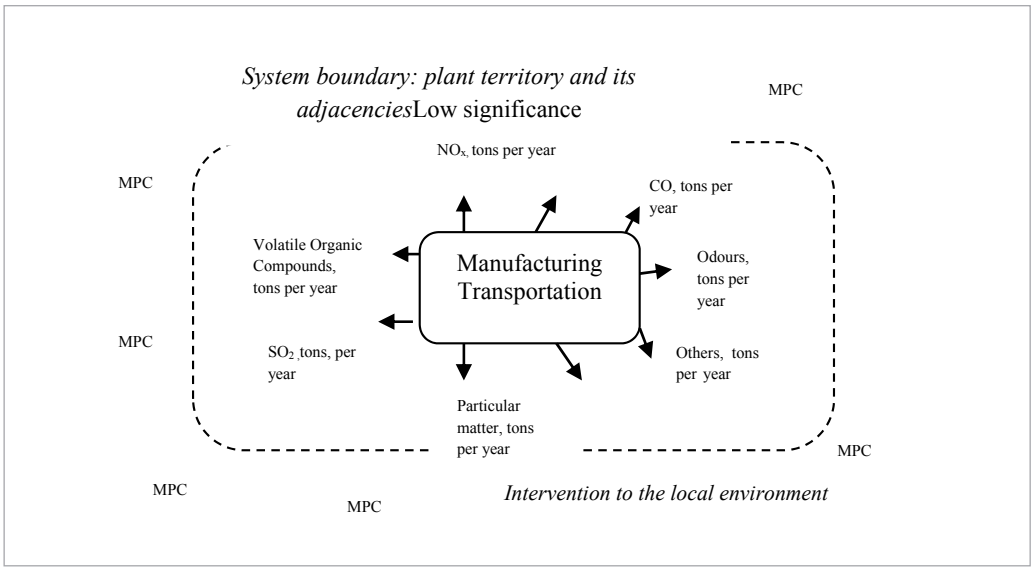
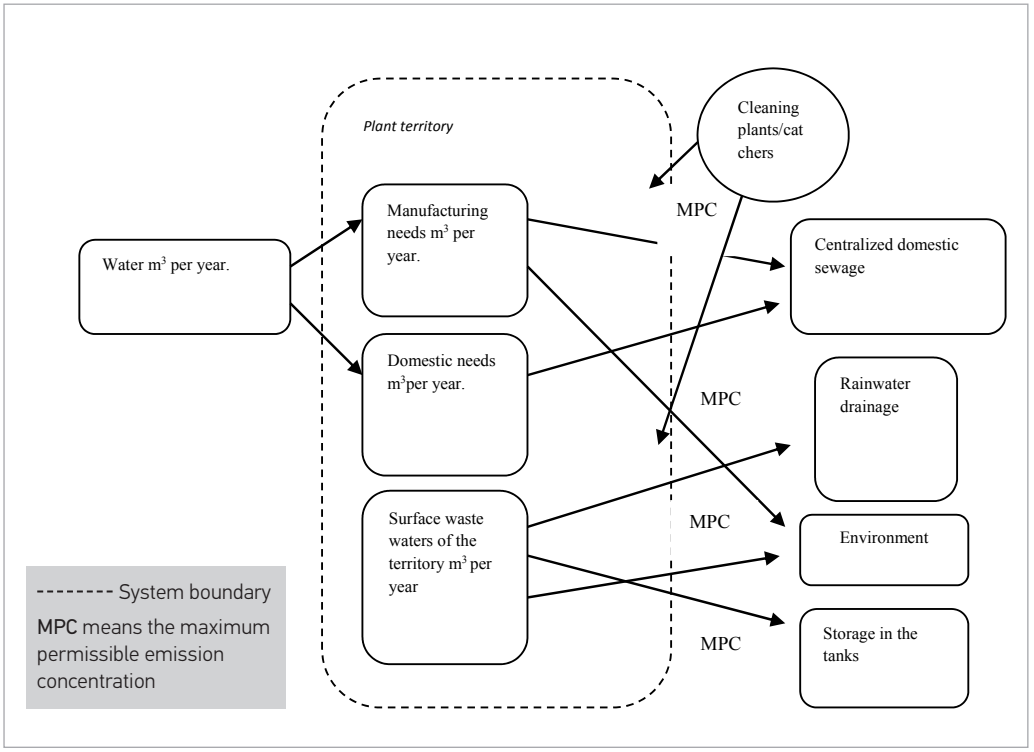


Fig. 3
The scheme of air pollution assessment in EIA reports, where MPC means the maximum permissible emission

Fig. 4
The scheme of water assessment in EIA reports



was presented. However, such expression was calculated by simply dividing the quantity of energy consumed (kWh per year) by the quantity of output (tons per year or units per year). The energy of raw material extraction or processing was not included in such assessment.

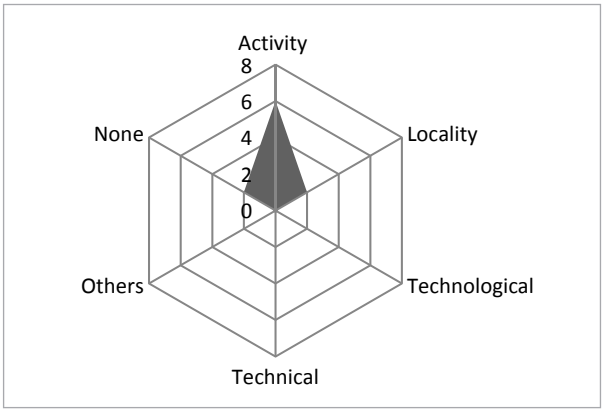
Only 2 reports provided the opportunities for reduction of resources and energy consumption by submitting proposals regarding the development of manufacturing processes in the future and the increase in the effective use of resources. The opportunities for reduction of pollution emissions were provided in 7 of 8 EIA reports. The measures are usually provided for reduction of air emissions by installing filters or closed circulatory systems.

All the reports contain appropriate information about the quantities of waste generated during manufacturing activity, waste management options and hazardous waste generation and its storage.

In accordance with legal requirements, the analysis of alternatives is seen as an essential integral part of EIA. The purpose of the EIA analysis of alternatives is to find the optimal operational solution in regard of locality, manufacturing processes or technologies. In the case of the analysed EIA documents, 6 reports of 8 contained the alternatives which consisted of "0" alternative (when the activity is not carried out) and the alternative "of performance of planned economic activity". The latter always has more advantages. In the case of only 1 report, weighted matrix was presented that convinces why the alternative "of performance of planned economic activity" is more favourable than "0" alternative. The analysis of alternatives is intended neither for the analysis of materials used during activity nor for the alternatives of technological processes. Only the analysis of the situation after implementation of activity is carried out. Two reports contained description of alternatives of a locality. Too small premises and poor accessibility were seen as the criteria of refusal from the localities. The alternatives that were analysed during the EIA process are presented in Figure 4.

The analysis of alternatives is also important from the perspective of sustainable industrial development because they help to find the ways of business that are

Fig. 5
The alternatives analysed in EIA reports



more environmentally friendly. In this case, EIA does not match with this objective because the analysis of alternatives is slow and usually limited to operational or non-operational alternatives.

Many reports focus on accounting of the amount of waste generated and the ways of waste management. In newer reports, other management methodologies are used, such as material-flow-balance. However, EIA documents also provide a lot of redundant information. This is especially true about quotations of laws, technical characteristics of pollution modelling measures or provision of general statistical information, especially in public health impact assessment. Often such information does not affect decision-making.

It is also important to draw attention to the influence of rapporteurs on particularity and quality of reports. The analysis revealed that the reports of larger consulting companies that prepare EIA documents were larger; they contained more graphics and more detailed information about environment. Mathematical dispersion models are used to forecast air pollution. However, it should be noted that EIA reports on different activities prepared by the same consulting company are very similar to each other, and some sentences or paragraphs are identical. The content of EIA reports prepared by smaller consulting companies is much more concise; however, this does not mean that such reports are not comprehensive. Several samples analysed contained concise information, which was structurally appropriate and very clear.

Conclusions

1 The analysis of environmental legislation and initiatives as well as environmental indicators associated with industrial activity reveals that the significant impact of manufacturing activity on the environment is associated with:

consumption of resources:

- consumption of energy;
- water consumption;

emissions of pollutants to the environment:

- air emissions;
- greenhouse gas emissions;
- emissions to water;

waste formation:

- formation of hazardous waste.

2 The assessment of Lithuanian manufacturing industry EIA reports reveals that the following significant aspects associated with manufacturing activity are covered by EIA procedure:

- the emissions of planned activity to the air;
- direct consumption of natural resources;
- direct consumption of energy;
- local and direct activity impact on the environment;
- foreseen opportunities of emissions reduction.

3 The following significant aspects related to manufacturing industry are not covered by EIA:

- activity's impact on climate change;
- the impact of natural resources consumption on the environment;
- indirect consumption of energy;
- cumulative and global impact on the environment;

4 The study reveals that limited attention is paid to the development of activity alternatives and their assessment in EIA reports.

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Gamybinės veiklos poveikio aplinkai vertinimas

Gauta:
2015 m. balandis
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2016 m. balandis

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Sparti šiuolaikinės pramonės plėtra lemia didėjančias apkrovas mūsų gyvenamajai aplinkai. Visuomenė vis daugiau dėmesio skiria aplinkos kokybei ir vis dažniau išsako reikalavimus išsaugoti gamtą kitoms kartoms, tai tikras iššūkis intensyvios plėtros srityje – pramonei reikia ne tik kurti produktus, kurie būtų palankūs aplinkai, bet ir orientuoti savo veiklą į kuo mažiau taršią gamybą. Su šiuo iššūkiu gamintojai susiduria visame pasaulyje. Norint sukurti mažiau taršius produktus ar paslaugas, vykdyti mažiau taršią veiklą, reikia kuo ankstesniame jų kūrimo etape įvertinti galimą neigiamą poveikį aplinkai ir ieškoti alternatyvių sprendimų ar priemonių, galinčių sumažinti tą poveikį neprarandant pirminio veiklos tikslo.

Viena iš šiuo metu egzistuojančių ir teisiškai reglamentuotų bei privalomų priemonių, padedančių įvertinti planuojamos gamybinės veiklos poveikį aplinkai ir numatyti neigiamo poveikio sumažinimo priemones, yra poveikio aplinkai vertinimas (PAV).

Šiame straipsnyje siekiama išsiaiškinti ar dabartinė PAV sistema užtikrina, kad vertinimo metu yra išanalizuojamas visas su planuojama veikla susijęs reikšmingas poveikis aplinkai. Tyrimų objektu yra pasirinkta gamybinė pramonė ir jos reikšmingas poveikis aplinkai. Straipsnyje apžvelgiama reikšmingo poveikio nustatymo metodika ir atliekama 8 gamybinių veiklų poveikio aplinkai vertinimo ataskaitų analizė, išryškinant esminius esamos sistemos trūkumus ir privalumus.