FACTA UNIVERSITATIS
Series: **Economics and Organization** Vol. 15, N° 4, 2018, pp. 379 - 392
https://doi.org/10.22190/FUEO1804379R

Preliminary Communication

INTERNALIZING ENVIRONMENTAL EXTERNALITIES IN CEMENT INDUSTRY: CASE STUDY FOR THE REPUBLIC OF SERBIA AND SELECTED NEIGHBORING COUNTRIES

UDC 691.54:061.5(497.11)

Snežana Radukić, Dušan Perović*

University of Niš, Faculty of Economics, Niš, Serbia

Abstract. *The paper provided detailed analysis and calculations of external costs in cement industry of the Republic of Serbia and neighboring countries for period of 2010-2016. Internalization of externalities represents a huge challenge for every policy maker in environmental area that has the obligation to calculate the impact of economy on the environment. In fact, many parts of economy have far greater impact on environment than it can be expected and that is one of the reasons for including external costs in total costs of companies. Cement industry is among industries that emit pollutant particles in the air and cause serious environmental problems to local communities. The principal idea of paper is to evaluate external costs of cement production plants in Republic of Serbia, Bulgaria, Hungary and Romania, so in the end rightful solutions can be provided in order to neutralize or minimize environmental impact of cement factories. For this kind of analysis, EcoSense LE (Light Edition) software was used. Analysis of external costs in cement industry will help in expansion of knowledge about internalizing environmental externalities in analyzed countries, where lack of similar studies does not help in solving the problem of environmental externalities in these countries.*

Key words: *environmental externalities, the Republic of Serbia, cement industry, sustainable development, internalization of externalities, external costs*.

JEL Classification: Q51, Q52, Q53.

Received July 28, 2018 / Revised November 02, 2018 / Accepted November 05, 2018
Corresponding author: Dušan Perović
* PhD student at University of Niš, Faculty of Economics
Faculty of Economics Niš, Trg kralja Aleksandra 11, 18000 Niš, Serbia
E-mail: dulep89@gmail.com

INTRODUCTION

Pollution can be defined as a product of certain economic activities with harmful effects to the environment. Although it is harmful, it is also inevitable, since it appears during the production of goods and services with economic value. Therefore, efficiency principle is important and producers should go for gaining higher utility from production process with minimizing production effects on the environment. For every kind of pollution, utility should be calculated in order to start with appropriate actions for solving pollution problems. Before considering any actions, producers and creators of environmental policies should ask themselves two questions. "First, what level of pollution is acceptable from social stance, since every society emits some kind of pollution? Second, how can we control and reduce pollution to acceptable level?" (Harris, 2009, p. 357)

Since there is no production without any kind of pollution, external costs should be recognized by market and become vital part of every market analysis. Most of the economic subjects refuse to include external costs in their balances due to increase of overall costs and possible legal consequences to their businesses. For all producers, the main goal is to gain profit and so they give advantage to economic activities instead of environmental activities. Sometimes optimal economic level of quality is not the best one from environmental aspect, which means economic optimum is not same as environmental optimum. "For instance, from environmental aspect optimal can be total elimination of pollution, while from economic aspect optimal is that point where marginal costs from reducing pollution equal marginal utilities from reducing pollution" (Bošković & Radukić, 2011, p.73)For reaching the right decision about optimal model, producers and policy makers should consider using internalization of externalities, since it is one of the most effective and efficient ways to evaluate impact on the environment.

External costs have origin from different kind of industries such as car industry, chemical industry, tobacco industry, textile and rubber industry. These industries produce huge external costs that are usually not included in total costs of companies. In some countries external costs are up to 5% of country's GDP, which only indicates that external costs are not treated in a proper manner (Hinšt, 2007). Higher amount of emitted pollutant particles not just cause increase in external environmental costs of many countries, but also cause many environmental problems that countries have to deal with. Industry has joint responsibility with traffic and intensive use of non-renewable resources for the high rate of pollution. Problem lies in irresponsible behavior of industries that do not pay attention to environmental issues and continue with use of old technologies that pollute the environment. Additionally, absence of appropriate framework for pollution management is an obstacle for many industries that want to change approach towards the environment (Lucas & Noordewier, 2016).

Cement industry represents a vital part of every national economy, but it is also source of environmental pollution in many countries. All countries with cement industry face this problem, with some of them taking precautions, while some do not do anything at all. For developing countries cement industry can become a serious burden, if they do not recognize any environmental impact and react immediately. In areas such as Western Balkans problem is not just in providing solutions but also in calculating external costs, since methodology for calculating external costs is still not well developed in Western Balkans. Using the EcoSense LE software, the authors will try to calculate external environmental costs in cement industry

of Western Balkan countries and provide adequate solutions for reducing pollution that comes from cement industry. Beside introduction and conclusion, the paper has three more chapters. The first chapter brings brief literature review about internalization of externalities with special emphasizes on internalization in cement industry. In the second chapter, data about cement industry of Serbia and neighboring countries will be presented with methodology that will be used for conducting research. The third chapter gives detailed analysis of external environmental costs in cement industry of analyzed countries with providing and testing several more scenarios for analyzed countries.

1. LITERATURE REVIEW

Over last three decades, the interest for externalities has started to grow with every new market failure. In the beginning, most of the authors were focused on economic and social aspect of externalities, but later the focus of interest switched to environmental externalities. Although many authors knew about the term externality, studies and research about externalities have started to spread by the end of the 20th century when group of authors laid the foundations for expanding externality theory (Dasgupta & Heal, 1979; Dasgupta & Maler, 1991; Gupta & Prakash, 1992; Bergstorm, 1993; Gupta & Prakash, 1993). Authors have gone deeper into externality theory by marking off specific characteristics of externalities and defining the path for internalizing externalities. Meanwhile, authors have started to get interest in external environmental costs and they provided some detailed studies about environmental externalities (Koomey & Krause, 1997). By calculating external costs, conditions for redesigning many polluting industries were created.

Studies for environmental externalities cover different areas such as traffic, industry, utility services, foreign direct investments and climate changes (Fahlen & Ahlgron, 2010; Sanga & Muntagana, 2016; Štreimikene, 2017; Wang & Li, 2018). In all these areas the authors have first found the source of problem; then they calculated external costs and in the end provided solutions for environmental externalities. Since environmental externalities represent a global problem, many individuals and institutions from around the world have started to deal with it and they have given their contribution in solving environmental externality problem. With spreading the number of global researches, potential solutions to environmental externalities increased with choosing right ones for appropriate situations. Also, many companies have shown interest in solving environmental externalities, so they have started to change their business plans and strategies in order to become more eco–friendly. Changing business habits of companies requires huge changes in management and planning, so there were numerous studies with intention of helping companies to reorganize their businesses (Fierro et al., 2008; Libecap, 2014; Lucas & Noordewier, 2016). These studies helped some companies to change their views towards the environmental issues and to become active participants in changing global environmental awareness. By switching to environmental issues, the door was opened for studies that consider environmental accounting as a crucial part of environmental management in public and private companies (Fahlen & Ahlgren, 2010; Adler & Volta, 2016; Eidelwein et al. , 2018). The goal of introducing environmental accounting was to simplify procedures for discovering possible environmental externalities and to help organizations with planning future environmental

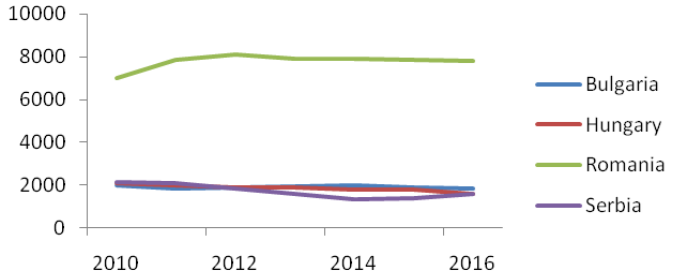
strategies. Another goal was to build open access for all stakeholders to be more familiar with organizations' activities in environmental area.

Although internalization of externalities was introduced with very positive intensions, group of authors opposed this by proclaiming internalization as „ insufficient for solving externality problem" (van den Bergh & Grazi, 2010; Bithas, 2011; Berta & Bertrand, 2014; Weitzman, 2015). Authors found that in the real world where externalities exist, their internalization cannot lead to the sustainability due to specific form of externalities. Environmental externalities are a big problem for solving, since they appear under different conditions and produce effects that sometimes are not measurable.

Cement industry is one of the most important industries, since many other industries use cement as a raw material for their own productions. For a very long time, global cement industry has been growing constantly, which certainly had some effects on both economy and environment. Some studies showed that global cement industry had significant share in global carbon dioxide (CO_2) emissions (Benhelal et al. , 2013; Barros et al. , 2014). Authors showed that 5–7% of global CO_2 emissions were caused by cement plants. Also, for producing one tone of cement, the plant emits about 900 kg of CO_2 to the atmosphere. This is one of the reasons why some cement plants have started to change their technologies and production processes (Ishak & Hashim, 2015; Kajaste & Hurme, 2016). Some cement plants were obliged by law to start with investments into sustainable technologies or to face with penalties for their activities. This brought to allocation of technologies from developed to developing countries where cement companies have continued with their production process. On the other hand, in some areas like China, EU and Switzerland, the cement industry has a totally new image – more sustainable (Branger & Qurion, 2015.; Zhang et al. , 2015; Jibran et al. , 2017). In these areas, cement industry represents a good example of implementing sustainable technologies for achieving not just better economic results, but also for improving environmental performances on micro and macro level. Many cement plants can still produce the same amount of cement without harming the environment.

2. RESEARCH DATA, METHODOLOGY AND HYPOTHESES

The subject of analysis is cement industry and cement plants that operate in Serbia, Bulgaria, Hungary and Romania. Cement industry in these countries has a very long tradition and roots leading back to the middle of the XIX century. At this area 20 cement plants run their business and they experienced many transformations from their founding until today. These cement plans changed their technologies, markets, owners but their primary task never changed and it was the production of cement. As for cement production, it is similar like in the rest of the world and includes the following phases: extraction of raw materials, preparation of raw materials (including grinding and mixing), warehousing of meal, baking of raw material meal, maturing of clinker, milling of clinker into cement, warehousing of cement, packing and dispatch activities. Like in the rest of the world, cement plants in Serbia and selected neighboring countries produce hydraulic cement, which is later being used in construction industry, but also in mining and energetic sector. Technologies in cement plants followed changes in global cement industry with delayed effects that had impact on short run activities of cement plants in Serbia and selected neighboring countries.



Graph 1 Cement production in Serbia and selected neighboring countries 2010-2016 (in thousand tones)
Source: Statistical offices of Bulgaria, Hungary, Romania and Serbia

Based on graph 1, the cement production in analyzed countries had expressed fluctuations in 2010-2016 timeline. Among the analyzed countries Romania has the highest cement production (8,03 million tons), although from 2010 to 2016 the cement production in Romania was reduced for 0,86%. Other countries have significantly smaller production than Romania and the most of them have decline in cement production. Among these countries Serbia had the highest decline in analyzed period (43,66%).

Table 1 Total emmisions of NO_x, SO_2 and PM_{10} in cement industry of Serbia and selected neigboring countries (in tons)

	2010	2011	2012	2013	2014	2015	2016
NO_x	10637	10456	10579	10397	10178	9939	9925
SO_2	10,29	9,88	9,93	9,55	9,79	9,43	10,25
PM_{10}	96	97	100	83	88	89	93

Source: Sustainable reports of analyzed cement plants

Environmental issue has become one of the most important areas for many cement plants due to their impact on the environment. Like their competitors around the world, cement plants in Serbia and selected neighboring countries emit particles that can harm environment very seriously. Based on the table 1, the emission of nitrate oxides (NO_x) is very high and it was the highest in 2010, when it reached 10.637 tons. Since 2012, the emissions of NO_x have started to decline, but they are still very high at the end of 2016. As for the others, air is polluted most by the particulate matter (PM10), which from 2012 began to decline, while emissions of sulfur dioxide (SO_2) are also emitted from analyzed cement plants but they have the lowest emissions.

Table 2 Total emmisions of NO_x, SO_2 and PM_{10} in cement industry of Serbia (in tons)

	2010	2011	2012	2013	2014	2015	2016
NO_x	1923	1873	2104	1909	1753	1664	1739
SO_2	1,78	1,39	1,32	1,12	1,40	1,23	2,09
PM_{10}	13	10	9	9	8	9	14

Source: Sustainable reports of analyzed cement plants

Based on table 2 every kind of analyzed polluting particles increased from 2010 to 2016, with the exception of NO_x. All cement plants in Serbia passed through several changes in organizing and production activities and some of them even changed owners which all had impact on production and amount of polluting emissions.

Table 3 Total emmisions of NO_x, SO_2 and PM_{10} in cement industry of Bulgaria (in tons)

	2010	2011	2012	2013	2014	2015	2016
NO_x	2236	2117	2009	2123	2085	1968	1909
SO_2	1,88	1,97	2,05	2,01	1,99	1,91	1,86
PM_{10}	16	18	20	19	15	14	13

Source: Sustainable reports of analyzed cement plants

Bulgarian cement plants had a reduction in emissions of polluting particles in analyzed period (table 3). Significant reductions were in emissions of NO_x which was mainly due to the strict control of environmental bodies of EU. On the other hand, Bulgarian cement plants have reduced their emissions by taking participation in European Union Emission Trading Scheme which allowed companies from Bulgaria to take their places recently.

Table 4 Total emmisions of NO_x, SO_2 and PM_{10} in cement industry of Hungary (in tons)

	2010	2011	2012	2013	2014	2015	2016
NO_x	1957	1903	1876	1831	1822	1807	1795
SO_2	1,65	1,60	1,56	1,52	1,55	1,49	1,47
PM_{10}	19	17	17	15	16	14	13

Source: Sustainable reports of analyzed cement plants

Hungarian cement plants had a significant reduce in cement production from 2010 to 2016, which had impact on emissions of polluting particles. Based on table 4, it can be seen that emissions of NO_x, SO_2 and PM_{10} in cement industry of Hungary were reduced. At the same time all of cement plants in Hungary have started to use technologies that improve environmental performance of places where plants are located. These technologies are based on capturing emissions of polluting particles, improving the efficiency of resources and creating conditions of establishing circular economy principles inside cement plants in order to minimize waste and polluting effects.

Table 5 Total emmisions of NO_x, SO_2 and PM_{10} in cement industry of Romania (in tons)

	2010	2011	2012	2013	2014	2015	2016
NO_x	4521	4563	4590	4534	4518	4500	4482
SO_2	4,98	4,92	4,97	4,90	4,85	4,80	4,83
PM_{10}	48	52	54	50	49	51	53

Source: Sustainable reports of analyzed cement plants

Among all analyzed countries Romania is the biggest producer of cement, which had an impact on increasing the level of pollution caused directly from cement plants in Romania. Based on table 5 only PM_{10} emissions increased, while the emissions of other polluting particles were reduced. In total, Romanian cement plants give crucial contribution to overall

emissions of polluting particles among the analyzed countries and if one needs to start somewhere with measures for improving environmental performance, it must be in Romania. Although Romania places huge efforts in reducing the overall impact of cement plants emissions, several obstacles stand in the way. First of all, Romanian cement is one of the most demanded ones in the world and it is one of the leading export products of Romania. Second, although law authorities try to reduce the level of emissions by implementing laws, on the other hand plants owners invest very little in innovative and clean technologies which can additionally help in improving environmental conditions. Third, Romanian participation in carbon trading markets and schemes is low and so it must be improved in the following years in order to reduce total emissions. After overcoming these obstacles Romanian cement industry can make huge efforts in reducing overall emissions of polluting particles in Romania.

Cement plants are important parts of Western Balkans national economies, but on the other hand they have strong impact on the environment, which is not measured through external environment costs. By emitting polluting particles in the air, cement plants can cause serious diseases or harm fertile land and in the end they can avoid legal consequences if there is no appropriate environmental legislature. Every implementation of environmental legislature should be followed by internalization of external environmental costs in order to provide efficient and effective penalty system for all subjects that pollute environment. Internalization of environmental externalities is also a basis for introducing some economic instruments in environmental area that will be more focused on solving environmental problems than on increasing budget of the state (Magdalinović – Kalinović & Radukić, 2016). Internalization of external environmental costs should be the first step in optimizing economic and environmental goals through choosing right social and business model for the whole society that is facing some sustainability difficulties (Radukić et al. 2014).

Basic methodology for estimating external costs in cement industry of Western Balkans has been taken over from the European Commission project ExternE – External Cost of Energy, methodology 2005 Update, developed by the Institute of Energy Economics and Rational Use of Energy (IER), University of Stuttgart. The developed methodology has been called Impact Pathway Approach (IPA) and it starts with activities of polluters and it is finished with monetary amount of damage. In the middle of this approach are emissions of the polluters, immissions and expected impact on health or on environment. For purpose of the project, the University in Stuttgart developed the software EcoSenseWeb V1.3 that carefully followed defined methodology (Preiss & Klotz, 2008). This software integrates atmospheric pollution dispersion models with receptor databases (population, land–use, infrastructure and ecosystem) for whole Europe. Based on the level of emissions, software determines spatial distribution of emissions, expected negative consequences to health and environment and estimated monetary amount of damage. EcoSenseWeb V1.3 was primarily designed for estimating external environmental costs in electricity production, but it has been modified to support other industries that have impact on environment.

EcoSenseWeb V1.3 contains all relevant data and models for estimating distribution of pollution in air, water or land with simulating atmospheric pollution dispersion for any kind of pollution in Europe. For simulating different models and scenarios primary sources of pollution are being used (in radius 10 x 10 km from the source of pollution) through Gaussian model of local dispersion. Typical primary sources of pollution in cement industry are NO_x, SO_2, PM_{10} and they are all considered in analysis for Western Balkans.

EcoSenseWeb V1.3 can also estimate pollution impact on health, agricultural areas, land, water, biodiversity and infrastructure since it contains data about receptors in all administrative regions of Europe. Database contains data about population, agricultural crops, list of material goods, meteorological, ecosystem and land–use data. For estimating external environmental costs population density and ecosystem structure are considered. For estimating pollution impact on people's health EcoSenseWeb V1.3 uses Concentrate–Response Function (CRF) that can lead to answers about primary pollution sources impact on people's health. The highest shares in external costs is taken by the costs that are the consequences of harmful impact of pollution on people's health, and they represent an important part of analysis. Although EcoSense LE cannot provide detailed analysis like EcoSenseWeb V1.3, it can help in estimating external environmental costs that were caused by pollution.

For the purpose of this research the following hypotheses have been tested:

H1: Every significant increase in cement production brings higher external environmental costs for cement plants in Serbia and selected neighboring countries.

H2: Costs of health impact have the highest share in external environmental costs of cement plants in Serbia and selected neighboring countries.

For testing the hypotheses, the software EcoSense LE was used. This software is a reduced version of EcoSenseWeb V1.3 which is available to students and scientific workers for scientific purpose only. For calculating external costs of cement plants, input of the emissions of polluting particles is required (in this case NO_x, SO_2, PM_{10}). After inputting values of emissions EcoSense LE will calculate the exact value of external costs in the required place through available GIS and database.. For this research, the input data are values of polluting particles in sustainability report of analyzed cement plants, while EcoSense LE will provide additional data like impact on health, agricultural lands and ecosystem. In order to see the impact on health, agricultural lands and ecosystem EcoSense LE provides several interesting variables through their monetary value. These variables are: costs of mortality, costs of reducing yields of agricultural crops or costs of damaging biodiversity. Costs of mortality include costs that caused mortality on some territory. These costs include costs of medicaments and medical care and other accompanying costs for persons that were infected by pollution and had to look for rightful treatment. Costs of reducing yields of agricultural crops include all costs that lead to reducing quality of agricultural land from infecting the land to treating it and to potential loss of agricultural workers. Costs of damaging biodiversity include all costs that were accompanied by changing conditions in biodiversity due to increased pollutions. Changes in number of plant or animal species, reducing green surfaces and trees, producing disasters like acid rains are included in costs of damaging biodiversity and they must all be taken very seriously.

3. FINDINGS AND DISCUSSION

The central part of research is oriented towards the estimation of external environmental costs, but there are other elements of research that should be explained. First, Disability–Adjusted Life Year (DALY) represents value that quantifies the burden of disease from mortality and morbidity. It shows the number of years lost due to illness, disability or early death and it also express number of "healthy" years that population lost due to pollution. Second, Potentially Disappeared Fraction (PDF) expresses total area that is under the impact

of pollution, but sometimes PDF can have even wider impact although calculations say something else.

Table 6 Estimation of external environmental costs in cement industry of Serbia for 2010 – 2016

	2010	2011	2012	2013	2014	2015	2016
Health impact							
DALYs(Mortality)	166,60	162,23	182,21	165,32	151,85	144,13	150,72
DALYs(Morbidity)	69,23	67,41	75,70	68,69	63,08	59,89	62,63
DALYs(Total)	235,83	229,64	257,92	234,01	214,93	204,02	213,35
Monetary value (in millions of €)	19,71	19,20	21,56	19,56	17,97	17,06	17,84
Impact on crops and materials							
Crop loss (in hundreds of €)	782,63	762,29	856,31	776,95	713,46	677,23	707,75
Material loss (in hundreds of €)	247,54	240,99	270,63	245,52	225,59	214,10	224,02
Impact on ecosystem							
PDFs (in millions of m2)	7,28	7,10	7,97	7,24	6,64	6,31	6,59
Monetary value (in millions of €)	4,30	4,18	4,70	4,27	3,92	3,72	3,89
Total costs (in millions of €)	25,05	24,39	27,40	24,86	22,83	21,67	22,66

Source: Authors' calculations

Based on table 6 several trends can be seen. Until 2012 all values have been declining, but in 2012 they all reached higher values. For instance, total DALY was 257,92, health impact costs were 21,56 million €, crop losses were 856,31 hundred €, while total external environmental costs were 27,40 million €. From 2012 all external environmental costs have started to decline and in 2015 they were at minimum (21,67 million €). In 2016 all costs have started to grow again, which will bring new environmental problems. In the analyzed period the overall external environmental costs for Serbian cement plants were 168,86 million €. By comparing production of cement and total external costs average costs per ton can be pulled out. In the case of Serbia these average external costs in the analyzed period were 0,07 €/t.

Table 7 Estimation of external environmental costs in cement industry of Bulgaria for 2010 – 2016

	2010	2011	2012	2013	2014	2015	2016
Health impact							
DALYs (Mortality)	109,41	103,60	98,32	103,89	102,03	96,31	93,42
DALYs (Morbidity)	36,47	34,54	32,79	34,64	34,00	32,10	31,13
DALYs (Total)	145,88	138,14	131,11	138,53	136,03	128,41	124,55
Monetary value (in millions of €)	11,95	11,32	10,74	11,35	11,15	10,52	10,21
Impact on crops and materials							
Crop loss (in hundreds of €)	1.980,50	1,875,10	1,779,42	1,880,41	1,846,76	1,743,13	1,690,67
Material loss (in hundreds of €)	195,15	184,80	175,41	185,33	182,01	171,81	166,66
Impact on ecosystem							
PDFs (in millions of m^2)	1,16	1,09	1,04	1,10	1,08	1,02	0,99
Monetary value (in millions of €)	0,68	0,64	0,61	0,65	0,64	0,60	0,58
Total costs (in millions of €)	14,81	14,03	13,31	14,07	13,81	13,04	12,65

Source: Authors' calculations

Table 7 shows that Bulgarian cement plants had a decline in external environmental costs until 2013, when they increased to 14,07 million €. From 2013 external environmental costs have started to fall again and in 2016 they were 12,65 million €. As in the case of Serbian cement plants, health impact costs were very high, but here crop loss costs were significantly higher than in Serbia and in 2013 they reached 1,88 million €. It is also interesting that although total external environmental costs are lower than in Serbia, they are very high since they have covered less area than in case of Serbian cement plants. Total external environmental costs for analyzed period are 95,72 million €. As for the average external costs per produced ton of cement, they were 0,14 €/t.

Table 8 Estimation of external environmental costs in cement industry of Hungary for 2010 – 2016

	2010	2011	2012	2013	2014	2015	2016
Health impact							
DALYs (Mortality)	189,95	185,68	183,05	178,66	177,78	176,31	175,14
DALYs (Morbidity)	79,16	76,96	75,87	74,03	73,67	73,06	72,57
DALYs (Total)	270,11	262,64	258,92	252,69	251,45	249,37	247,71
Monetary value (in millions of €)	22,48	21,86	21,55	21,03	20,93	20,75	20,61
Impact on crops and materials							
Crop loss (in hundreds of €)	1.739,37	1.691,38	1.667,38	1.627,39	1.619,39	1.606,05	1.595,39
Material loss (in hundreds of €)	348,28	338,67	333,86	325,85	324,26	321,57	319,43
Impact on ecosystem							
PDFs (in millions of m^2)	4,56	4,43	4,37	4,26	4,24	4,20	4,18
Monetary value (in millions of €)	2,69	2,61	2,58	2,52	2,50	2,48	2,47
Total costs (in millions of €)	27,26	26,50	26,13	25,50	25,37	25,16	24,99

Source: Authors' calculations

Unlike cement plants in Serbia and Bulgaria, Hungarian cement plants have only downward trend for all analyzed values. Health impact costs are very high in Hungary and they are even higher than in Serbia and Bulgaria. Crop loss costs were 1,7 million € in 2010, while in 2016 they were 1,5, which means that crop loss costs were reduced for 9,02%. External environmental costs were the highest in 2010 (27,26 million €), but in next six years they were reduced for 9,08% and they were 24,99 million € in 2016. Total external environmental costs for Hungarian cement plants in analyzed period were 180,91 million €, which is higher than in Serbia and Bulgaria. Average external costs per ton of produced cement in Hungary are 0,07 €/t, which is the same as in Serbia and less than in Bulgaria.

Cement industry of Romania has the highest production among the analyzed countries, but it also has huge impact on the environment. Based on table 9, two trends of environmental impact can be seen. Until 2012 cement production grew in Romania, but also external environmental costs. Among analyzed countries Romania had the highest costs from health impact (31,53 million € in 2012) and crop loss (3,13 million € in 2012). From 2012 all external costs have started to decline and in 2016 they were 36,75 million €. Total external environmental costs for Romanian cement plants in analyzed period were 259,98 million €, which is higher than in other analyzed countries. Compared to other analyzed countries, Romania has the highest external costs per ton of produced cement and the average costs in analyzed period were 0,21 €/t.

Table 9 Estimation of external environmental costs in cement industry of Romania for 2010 – 2016

	2010	2011	2012	2013	2014	2015	2016
Health impact							
DALYs (Mortality)	279,54	282,13	283,80	280,34	279,35	278,23	277,12
DALYs (Morbidity)	103,72	104,71	105,35	104,03	103,66	103,27	102,87
DALYs (Total)	383,26	386,84	389,15	384,37	383,01	381,50	379,99
Monetary value (in millions of €)	31,05	31,34	31,53	31,14	31,03	30,91	30,79
Impact on crops and materials							
Crop loss (in hundreds of €)	3.114,03	3.134,52	3.164,55	3.122,98	3.111,96	3.099,56	3.087,17
Material loss (in hundreds of €)	598,89	604,41	607,99	600,57	598,44	596,05	593,68
Impact on ecosystem							
PDFs (in millions of m^2)	3,90	3,93	3,96	3,91	3,90	3,88	3,87
Monetary value (in millions of €)	2,30	2,32	2,33	2,31	2,30	2,29	2,28
Total costs (in millions of €)	37,07	37,41	37,64	37,17	37,04	36,90	36,75

Source: Authors' calculations

CONCLUSION AND RECOMMENDATIONS

Cement industry has an important role in every national economy and it is also the case with Serbia, Bulgaria, Hungary and Romania. In the last two decades cement plants in Serbia and selected neighboring countries were facing severe challenges that had impact on business environment of cement plants. All cement plants were forced to change the way they operate their businesses in order to stay competitive and avoid possible shut down. Although cement plants have modified and upgraded their business activities, they still have to make huge effort in solving environmental problems that they are causing.

The analysis for 2010 – 2016 showed that cement plants in Serbia and neighboring countries caused total external environmental costs of 705,47 million € from emission of polluted particles. Cement plants in Romania and Serbia cause the highest pollution and therefore these countries have the highest external environmental costs. Serbia had an increase in cement production in 2012 and in 2016, Bulgaria had an increase in 2013, while Romania had an increase in 2011 and 2012, which were all followed by increase in external environmental costs. Therefore, H1 hypothesis can be accepted. As for the H2 hypothesis, it can also be accepted since health impact costs are very high in all analyzed countries and they have the highest share in total external environmental costs of all countries. High health impact costs also show how risky cement production can be to the health of nearby population and it also reduces "healthy" years of population through DALY. Crop loss costs are also much higher in all analyzed countries and they can have serious effects on devastating quality agriculture lands which can only bring new problems to local population.

Measuring external environmental costs can help in providing appropriate solutions to environmental challenges that many areas are facing. By knowing the exact costs, appropriate planning and measures can be provided in order to improve environmental performances of area that is contaminated with pollution. Cement plants should think about investing into new technologies that do not pollute environment and that will help in

improving business performances. This means that cement plants should think more about sustainable strategies that will bring benefits to them. Cement plants should also invest in environmental education of workers or hire environmental professionals that will take care about environmental activities. Also, it is important that there is good cooperation between cement plants, local population and legal authorities. Legislature must define laws with strict penalty policy that will force polluters to behave more sustainably and pay more attention to environmental issues. Providing appropriate software for tracking pollution will be a step forward. This software can be used by health or agriculture institutions to see the level of pollution, count external costs and inform legal authorities about polluters' activities. Cement plants can think about emissions market that already exists in Europe and trade with emissions, which will help in reducing pollution, but this can also help cement plants to get additional assets for improving their businesses through sustainable funding programs since they can be recognized as companies that care about environmental awareness. Cement plants in the Republic of Serbia and neighboring countries should think more about their environmental policies and consider their future directions, because sustainability issue will become more important in the future and so it is better for all them to start right now from remodeling their business which will help cement plants to be prepared for future challenges that they will be facing.

REFERENCES

Adler, N. & Volta, W. (2016). Accounting for Externalities and Disposability: A Directional Economic Environmental Distance Function. *European Journal of Operational Research*, 250 (1), 314-327.

Barros, C.A., Gil-Alana, L. A. & Garcia. F.P. (2014). Stationarity and Long Range Dependence of Carbon Dioxide Emissions: Evidence for Disaggregated Data. *Environmental and Resource Economics*, 63 (1), 45-56.

Benhelal, E., Zahedi, G., Shamsaci, E. & Bahadori, A. (2013). Global Strategies and Potentials to Curb CO_2 Emissions in Cement Industry. *Journal of Cleaner Production 51*, 142-161.

Bergstorm, S. (1993). Value Standards in Sub-sustainable Development – On the Limits of Ecological Economics. *Ecological Economics*, 7 (1), 1-18.

Berta, N. & Bertrand, E. (2014). Market Internalization of Externalities: What is Failing? *Journal of the History of Economic Thought*, 36 (3), 331-357.

Bithes, K. (2011). Sustainability and Externalities: Is the Internalization of Externalities a Sufficient Condition for Sustainability? *Ecological Economics*, 70 (10), 1703-1706.

Bošković, G. & Radukić, S. (2011). Troškovi rešavanja ekoloških problema i cene industrijskih proizvoda [Costs for Solving Environmental Problems and Prices of Industrial Products]. *Ekonomski horizonti*, 13 (1), 67-81.

Branger, F. & Quiron, P. (2015). Reaping the Carbon Rent: Abatement and Overallocation Profits in the European Cement Industry, Insights from an LMDI Decomposition Analysis. *Energy Economics 47*, 189-203.

CRH (2018). *Sustainability report*, database. Retrieved from: https://www.crh.com/sustainability. Accessed on 08 July 2018.

Dasgupta, P.S. & Heal, C.M. (1979). *Economic Theory and Exhaustible Resources*. Cambridge: University Press.

Dasgupta, P.S. & Maler, M. (1991). *The Environmental and the Emerging Development Issues*. The Proceedings of the World Bank Conference n Development Economics. Washington, D.C : World Bank.

Eidelwein, F., Collatto, D.C., Rodrigues, L.H., Lacerda, D.P. & Piran, F.S. (2018). Internalization of Externalities: Development of a Method for Elaborating the Statement of Economic and Environment Results. *Journal of Cleaner Production*, 170 (1), 1216-1327.

Fahlen, E. & Ahlgren, E.O. (2010). Accounting for External Cost in a Study of Swedish District – Heating System – An Assessment of Environmental Policies. *Energy Policy 38*, 4909-4920.

Feng, X.Z., Lugovoy, O. & Graus, W.C. (2015). Co-controlling CO2 and NOx Emission in China's Cement Industry: An Optimal Development Pathway Study. *Advances in Climate Change Research*, 9 (1), 34-42.

Fierro, D.C., Hart, S. & Redondo, Y.P. (2008). Environmental Respect: Ethics or Simply Business? A Study in the Small and Medium Enterprise (SME) Context. *Journal of Business Ethics*, 82 (3), 645-656.

Gupta, A.K. & Prakash, K. (1992). *Choosing the Right Mix: Market, State and Institutions for Environmentally Sustainable Industrial Gr*owth. Working Paper No. 1066. Ahmedabad: Institute of Management.

Gupta, A.K. & Prakash, K. (1993). *On Internalization of Externalities*. Working Paper No. 1128. Ahemdabad: Institute of Management.

Harris, J.M. (2006). *Environmental and Natural Resource Economics: A Contemporary Approach*. 2nd edition. Boston: Houghton Mifflin.

Heidelberg Cement Group (2018). *Sustainability report*, database. Retrieved from: https://www.heidelbergcement.com/en/sustainability-report. Accessed on 09 July 2018.

Hinšt, Z. (2006). Europske studije o eksternim troškovima u prometu [European Studies about external costs of transport]. *Ekonomski pregled*, 57 (11), 778-788.

Hungarian Central Statistical Office (2017). *Statistical Yearbook of Hungary*, database. Retrieved from: https://www.ksh.hu/apps/shop.kiadvany?p_kiadvany_id=21188&p_lang=EN. Accessed on 08 July 2018.

Ishak, S.A. & Hashim, H. (2015). Low Carbon Measures for Cement Plant – A Review. *Journal of Cleaner Production 103*, 260-274.

Jibran, M., Zuberi, S. & Patel, M.K. (2017). Bottom-up Analysis of Energy Efficiency improvement and CO2 Emmission Reduction Potentials in the Swiss Cement Industry. *Journal of Cleaner Production*, 142 (4), 4294-4309.

Kajaste, R. & Hurme, M. (2016). Cement Industry Greenhouse Gas Emissions – Management Options and Abatement Cost. *Journal of Cleaner Production*, 112 (5), 4041-4052.

Koomey, J. & Krause, F. (1997). *Introduction to Environmental Externality Costs*. Boca Raton: CRC Press.

LafarageHolcim (2018). *Sustainability Report*, database. Retrieved from: https://www.lafargeholcim.com/Sustainability-reports. Accessed on 10 July 2018.

Libecap, G.D. (2014). Addressing Global Environmental Externalities: Transition Costs Considerations. *Journal of Economic Literature*, 52 (2), 424-479.

Lucas, M.T. & Noordewier, T.G. (2016). Environmental Management Practices and Firm Financial Performance: The Moderating Effect of Industry Pollution – Related Factors. *International Journal of Production Economics* 175, 24-34.

Magadlinović – Kalinović, M. & Radukić, S. (2016). Economic Effects and Regulatory Limits in Implementation of Environmental Taxes. *Facta Universitatis. Series: Economics and Organization*, 13 (4), 427-438.

National Institute of Statistics (2017). *Statistical Yearbooks of Romania*, database. Retrieved from: http://www.insse.ro/cms/en/content/statistical-yearbooks-romania. Accessed on 07 July 2018.

National Statistical Institute of Bulgaria (2017). *Statistical Yearbook 2017*, database. Retrieved from: http://www.nsi.bg/sites/default/files/files/publications/God2017.pdf. Accessed on 07 July 2018.

Picazo – Tadeo, A.J. & Prior, D. (2009). Environmental Externalities and Efficiency Measurement. *Journal of Environmental Management*, 90 (11), 3332-3339.

Preiss, P. & Klotz, V. (2008). *EcoSenseWeb V1.3 User's Manual & Description of Updated and Extended Draft Tools for the Detailed Site – dependent Assessment of External Costs*. Sttutgart: Institute of Energy Economics and Rational Use of Energy (IER).

Radukić, S., Popović, Ž. & Radović, M. (2014). Optimization of Economic and Environmental Goals by Multicriteria Analysis Models. *Strategic Management*, 19 (2), 33-40.

Sanga, C.J. & Mungatana, E.D. (2016). Integrating Ecology and Economics in Understanding Responses in Securing Land-use Externalities Internalization in Water Catchments. *Ecological Economics 121*, 28-39.

Statistical Office of the Republic of Serbia (2018). *Statistical Yearbook of Serbia*, database. Retrieved from: http://www.stat.gov.rs/en-us/publikacije. Accessed 06 July 2018.

Šterimikiene, D. (2017). Review of Internalization of Externalities and Dynamics of Atmospheric Emissions in Energy Sector of Baltic States. *Renewable and Sustainable Energy Reviews 70*, 1131-1141.

Titan Group (2018). *CSR and Sustainability Report*, database. Retrieved from: http://www.titan.gr/en/corporate-social-responsibility/csr-and-sustainability-report. Accessed on 08 July 2018.

Van den Bergh, J.C.J.M. (2010). Externality or Sustainability Economics? *Ecological Economics*, 69 (11), 2047-2052.

Wang, J., Hu, X. & Li, C. (2018). Optimization of the Freeway Truck Toll by Weight Policy Including External Environmental Costs. *Journal of Cleaner Production* 184, 220-226.

Weitzman, M. L. (2015). Internalizing the Climate Externality: Can a Uniform Price Commitment Help? *Economics of Energy & Environmental Policy* 4, 29-49.

Zhang, S., Worell, E. & Graus, W. C. (2015). Evaluating Co-benefits of Energy Efficiency and Air Pollution Abatement in China's Cement Industry. *Applied Energy* 147, 192-213.

INTERNALIZOVANJE EKOLOŠKIH EKSTERNALIJA U INDUSTRIJI CEMENTA: STUDIJA SLUČAJA ZA REPUBLIKU SRBIJU I ODABRANE SUSEDNE ZEMLJE

U radu je izvršena analiza, ali i kalkulacija eksternih troškova u industriji cementa u Republici Srbiji i susednim zemljama za period 2010 – 2016. Internalizovanje eksternalija predstavlja veliki izazov za sve donosioce odluka, a naročito za one u oblasti zaštite životne sredine koji su u obavezi da na adekvatan način procene uticaj ekonomskih aktivnosti na životnu sredinu. U suštini, mnogi segmenti ekonomije imaju daleko veći uticaj na životnu sredinu, nego što se to može zamisliti i zato je neophodno da eksterni troškovi postanu sastavni deo ukupnih troškova preduzeća koja zagađuju životnu srednu. Industrija cementa spada u red industrija koje emitiju štetne emisije zagađujućih materija u vazduh čime znatno smanjuju kvalitet vazduha i stvaraju problem lokalnom stanovništvu. Osnovna ideja rada je da se procene ekološki eksterni troškovi u industriji cementa Republike Srbije, Bugarske, Mađarske i Rumunije kako bi se ponudila adekvatna rešenja za neutralizovanje ili minimizaciju uticaja cementnih pogona na životnu sredinu. Za potrebe istraživanja korišćen je softver specijalizovan za zagađenja u industriji pod nazivom EcoSense LE (Light Edition). Analiza eksternih troškova u industriji cementa doprineće širenju znanja o ekološkim eksternalijama u industriji cementa, što će naročito biti od značaja za analizirane zemlje u kojima nedostatak sličnih istraživanja u velikoj meri otežava process rešavanja ekoloških eksternalija.

Ključne reči: *ekološke eksternalije, Republika Srbija, industrija cementa, održivi razvoj, internalizovanje eksternalija, eksterni troškovi*