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Internalization of external costs in Lithuania and Poland

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Abstract. Abstract. The paper reviews and compares external costs of atmospheric pollution and pollution taxes in Lithuania and Poland and assesses the level of external costs internalization and their impact on atmospheric emissions of classical pollutants in both countries. The analysis of trends of atmospheric pollution by classical pollutants in Lithuania and Poland is presented and policy recommendations based on the main findings of the analysis conducted were developed.

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INTRODUCTION

Externalities occur at all stages of a fuel cycle (Streimikiene, Alisauskaite-Seskiene, 2014; Fouquet et al., 2001), and path to assessing externalities is related with difficulties and uncertainties: it can be reduced by improving fuel cycles, switching between fuel cycles, a more efficient end-use of energy and reductions in energy consumption (Fouquet et al., 2001). The main goal of externalities valuation is achieved when economically efficient allocation of resources is being made – through the integration of externalities in energy prices (Fouquet et al., 2001). This particular integration or the so-called internalization of external costs into the full energy production cost has been considered as the most efficient and flexible policy instrument for reducing negative impacts of energy supply and use (Rafaj, Kypreos, 2007). The main externalities in energy sector are related to outdoor atmospheric pollution caused by fossil fuel burning (Streimikiene, Alisauskaite-Seskiene, 2014; Zamula, Kireitseva, 2013).

The aim of this paper is to compare external costs and atmospheric pollution taxes in Lithuania and Poland and to define the extent of internalization of externalities in commodity prices.

Seeking to achieve this aim the main tasks are:

– to review literature on external costs and their internalization through atmospheric pollution taxes;

- to analyse environmental taxes aimed at promotion of sustainable energy development in Baltics and also in Czech Republic and Slovakia;
- to analyse the trends of classical pollutants development in Lithuania and Poland
- to develop policy recommendations based on the analysis conducted.

The methods applied in the research include: comparative analysis, synthesis and generalization.

1. EXTERNAL COSTS AND THEIR INTERNALIZATION

There are a variety of externalities associated with the production and use of fossil fuel energy that, for various reasons, are not taken into account here. Examples include: Active living benefits from travel mode shifting. City-level studies (Krewitt, 2002) suggest there are substantial health benefits when individuals shift away from car trips to other travel modes involving physical exercise, including biking, walking, and walking to transit stops. However, much of the behavioral response to motor fuel taxes reflects other factors (e.g., longer run improvements in vehicle fuel economy, car-pooling, combining car trips, using transit with minimal walking distance to stops) and people may internalize at least some of the health benefits in their travel mode decisions.

Environmental impacts from fuel extraction, storage, and transportation also related tom external costs. Adverse side effects here include de-spoiling of the natural environment at mining and drilling sites, toxic releases from mine tailings and fuel processing wastes, leakage from fuel storage tanks, oil spills, etc. However, these types of external costs appear to be small in magnitude relative to external costs considered and they are better addressed through other instruments than fuel taxes (Hsue et al, 2008).

There are external costs of foreign energy dependence and the expanding supplies of unconventional oil and gas reduce the share of global supplies coming from regions that might be viewed as unstable. These are called external costs of energy security. In individual cases, policies to promote greater diversity in energy supply may make sense, but it is difficult to develop consistent, cross-country estimates of taxes to correct for energy security concerns (Maca et al, 2012).

Externalities of indoor and outdoor pollutions are very important. The World Health Organization (WHO, 2014) estimates that even more people die prematurely from inhaling indoor air pollution (e.g., fumes from fuel burning in cooking stoves) than from outdoor air pollution. It is important to what extent indoor air pollution – where the households causing pollution are mostly the ones affected by it – should be viewed as an external cost is not entirely clear. Moreover, there is a risk that high prices for taxed fossil fuels may cause switching to untaxed fuels (e.g., biomass, garbage) with equally, or perhaps worse, health effects. More pressing policies might include, for example, incentives for better ventilated stoves and clean fuel alternatives.

Terms of trade have also impact on creation of externalities. If a group of countries collectively price carbon emissions this can result in lower international fuel prices and a transfer from fuel exporters to fuel importers – effectively, a worsening of the terms of trade for the former. From a national welfare perspective, this would represent a co-cost rather than a co-benefit for exporters. But these costs are not considered as it is very difficult to assess them as they depend, for example, on how many countries price carbon and how fuel supply (often in administered markets) responds.

Outdoor air pollution from fossil fuels is the main externalities being assessed in various studies, including ExternE (EC, 1998; 2003; 2005). The key air pollutant from a public health perspective is fine particulate matter (PM2.5, with diameter up to 2.5 micrometres), which is small enough to penetrate the lungs and bloodstream. PM2.5 can be emitted directly during fuel combustion, or formed indirectly through chemical reactions in the atmosphere involving sulphur dioxide (SO2) and nitrogen oxide (NOx) emissions (WHO, 2014). Intake fractions are then linked to mortality risks. Baseline mortality rates are estimated for diseases (e.g., lung cancer, heart disease) whose prevalence is potentially increased by pollution exposure, using data on age structures for each country and regional average mortality rates by age/type of disease. These baseline mortality rates are then scaled by intake fractions and evidence on how the relative risk for each disease increases with the rate at which pollution is inhaled, to give health impacts per ton of emissions for the three air pollutants. Health risks are then monetized. There is solid empirical evidence suggesting that people's willingness to pay to reduce health risk (WHO, 2004). According to a meta-analysis of several hundred stated preference studies by OECD (2010), each one percent increase in real income increases mortality values by 0.8 percent. Using this statistic, relative per capita income, and a starting value for the average OECD country ($3.7 million per premature death, updated from OECD 2010), infer mortality values for all countries, and hence damages per ton of emissions were developed by various studies (Bridges et al, 2015; Georgakellos, 2010; CASES, 2008; Fouquet et al, 2001).

2. EXTERNAL COSTS IN LITHUANIA AND POLAND

Seven major types of external costs were assessed by applying ExternE methodology during CASES project (CASES, 2008). These main types are: human health (fatal and non-fatal effects), effects on crops and materials. The impact pathway approach was applied and Eco Sense model was used for environmental impact pathway assessment based on ExterneE methodology (EC, 1998; 2003; 2005).

The impact pathway assessment is a bottom-up-approach in which environmental benefits and costs are estimated by following the pathway from source emissions via quality changes of air, soil and water to physical impacts, before being expressed in monetary benefits and costs. The use of such a detailed bottom-up methodology is necessary, as external costs are highly site-dependent. Two emission scenarios were applied for each calculation, one reference scenario and one case scenario. The background concentration of pollutants in the reference scenario is a significant factor for pollutants with non-linear chemistry or non-linear dose-response functions. The estimated difference in the simulated air quality situation between the case and the reference situation is combined with exposure response functions to derive differences in physical impacts on public health, crops and building material.

As air pollutants are transformed and transported and cause considerable damage hundreds of kilometres away from the source therefore the damage caused by secondary pollutants was evaluated as well. European wide modelling was performed during ExternE projects.

The currently available values for classical air pollutants correspond to an average height of release which is very important as with increase of the height the impact is diminishing. During the Cases project external costs of classical emissions of $NH_{3,}$ NMVOC, $NO_{X,}$ PPM_{10}, $PPM_{25,}$ and SO2 were evaluated. For new EU member states Lithuania and Poland external costs of atmospheric pollution were assessed first time during Cases project (CASES, 2008).

As the background concentration of NH3, NMVOC, SO_2 and NOx influence the creation of secondary pollutants there are two further distinctions into values corresponding to conditions in 2010 and values corresponding to possible conditions in 2020 were developed during aforementioned project. It is assumed that in most cases the emissions in 2020 are lower than in 2010. It has to be emphasised that because of non-linear atmospheric chemistry and because of different background concentrations of e.g. NOx and NMVOC, especially with regard to ozone there can occur large differences in [Euro per ton] values.

The project showed that even negative external costs can occur for NOx emission in 2010 regarding ozone. The values of external costs for 2020 have been derived by simulation of a certain emission reduction scenarios in different regions and this has been done for all pollutants from "all sources (e.g., including transport, industry, domestic firing systems, but also combustion plants), and for reduction of emissions of primary particles, SO2 and NOx (e.g., combustion in power plants) only. In Table 1 the external costs values corresponding to "Average Height of Release" are presented in Lithuania, Poland and EU-27 average in 2010 and 2020.

Table 1

External costs in Lithuania, Poland and EU-28 average in 2010 and 2020, Euro 2005, EUR/t

	EU-28	Lithuania	Poland
1	2	3	4
2010			
Human Health			
NH3	9482	4348	9651
NMVOC	584	326	452
NOX	5591	3966	5344
PPM10	1325	390	1185
PPM2.5	24410	10969	25201
SO2	6070	4412	6451
Loss of Biodiversity			
NH3	3266	2229	3703
NMVOC	-67	-28	-51
NOX	903	590	992
SO2	177	139	213
Crops: Regional: crops N deposition & crops O3			
NH3	-183	-11	-96
NMVOC	189	35	114
NOX	328	129	238
SO2	-27	-14	-10
Crops: SO2 - (based on WTM model run - year 2000 - for AL, BA, BY, CH, CS, CY, HR, MD, MK, MT, NO, RU, TR, UA the value for EU27 (EU25) is used)			
SO2	-13	-28	-4
Materials: SO2&NOx - (based on WTM model run - year 2000 - for AL, BA, BY, CH, CS, CY, HR, MD, MK, MT, NO, RU, TR, UA the value for EU27 (EU25) is used)			
NOX	71	74	132
SO2	259	187	497
2020			
Human Health			
NH3	5837	2371	5615
NMVOC	238	56	131
NOX	6620	4653	8401
PPM10	1381	397	1185
PPM2.5	24191	11169	24224
SO2	6673	5017	7618
Loss of Biodiversity			
NH3	3295	2278	3822

1	2	3	4
NMVOC	-48	-25	-46
NOX	868	557	912
SO2	192	143	270
Crops: Regional: crops N deposition & crops O3			
NH3	-183	-10	-98
NMVOC	103	16	55
NOX	435	104	338
SO2	-41	-16	-38
Crops: SO2 - (based on WTM model run - year 2000 - for AL, BA, BY, CH, CS, CY, HR, MD, MK, MT, NO, RU, TR, UA the value for EU27 (EU25) is used)			
SO2	-13	-28	-4
Materials: SO2&NOx - (based on WTM model run - year 2000 - for AL, BA, BY, CH, CS, CY, HR, MD, MK, MT, NO, RU, TR, UA the value for EU27 (EU25) is used)			
NOX	71	74	132
SO2	259	187	497

Some external costs in 2020 were higher (NOx) than in 2010 in all analysed countries. However the major external costs (NH3, NMVOC, SO2) forecasted to be lower in 2020 comparing with 2010 because of implemented various pollution mitigation measures.

As one can see from Table 1 Poland distinguishes with external costs higher than EU-28 for almost all pollutants except NMVOCs and PPM10. Comparing external costs between Poland and Lithuania one can notice that in Lithuania external costs are lower than in Poland for all pollutants and for all investigated periods.

High external costs of atmospheric emissions requires high atmospheric pollution fees to internalize these external costs therefore in the following chapter comparison of atmospheric pollution taxes in Lithuania and Poland was performed.

3. ATMOSPHERIC POLLUTION TAXES IN LITHUANIA AND POLAND

Air pollution taxes are important flexible pollution reduction measure in energy sector as energy sector is the major sources of classical pollutants (SO2, NOX, Particulates, CO, NH3, NMVOC) which are usually being charged by air pollution taxes in major EU member states and other countries all over the world (Chroleu-Assouline, Fodha, 2014; Longo, Markandya, Petrucci, 2008).

Air pollution charges are in place in two thirds of the world countries and cover a range of air pollutant substances, e.g. VOC, NOx, SO2, PM, NH3, heavy metals, CO, hydrocarbons, dust, cadmium, mercury, asbestos; and ozone depleting substances. The most common taxes or charges relate to Sulphur or SO2. Such measures are in place in several central and eastern European countries where they are often complemented by air pollution non-compliance fees (e.g. Bulgaria, Poland, Estonia, Latvia, Lithuania, and Romania). Rates applied vary according to substance covered and country. For example, the tax rate on sulphur emissions in Sweden, Norway and Denmark is between EUR 1,300/tonne and EUR 1,600/tonne; while rates in Italy, France and Spain are lower than EUR 50/tonne.

The tax rates for the main pollutants discharged from stationary sources of pollution are set for one tonne of pollutants discharged into the environment. The tax rates for pollutants discharged into the atmosphere in analysed countries are presented in Table 2.

Table 2

Air pollution tax rates in Lithuania and Poland, valid since 2015, EUR/t

	Lithuania	Poland
Ammonia	4.0	-
Carbon monoxide	24.0	20
Heavy metals	3,855	9,110
Nitrogen oxides	196	120
Solid emissions (particulates)	61	-
Sulphur dioxide	104	120
Volatile organic compounds	4.0	-

Source: EUROSTAT.

As one can see from information provided in Table 2 almost for all classical pollutants except sulphur dioxide Poland applied lower rates than in Lithuania. This indicates very low level of internalization of external costs in Poland. In the following chapter the trends of classical pollutants having negative impact on human health will be compared in Lithuania and Poland.

4. DYNAMICS OF CLASSICAL POLLUTANTS IN LITHUANIA AND POLAND

Outdoor air pollution is one important environmental issue that directly affects the quality of peoples' lives. Despite national and international interventions and decreases in major pollutant emissions, globally the health impacts of urban air pollution continue to worsen, with air pollution set to become the top environmental cause of premature mortality. Air pollution in urban centres, often caused by transport is linked to a range of health problems, from minor eye irritation to upper respiratory symptoms in the short term and chronic respiratory diseases such as asthma, cardiovascular diseases and lung cancer in the long term.

Particulate matter and ground-level ozone are now generally recognised as the two pollutants that most significantly affect human health (WHO, 2004; 2014). Long-term and peak exposures to these pollutants range in severity of impact, from impairing the respiratory system to premature death. In recent years, up to 40 % of Europe's urban population may have been exposed to ambient concentrations of coarse PM ($PM_{2.5}$) above the EU limit set to protect human health. Up to 50 % of the population living in urban areas may have been exposed to levels of ozone that exceed the EU target value. The fraction of the PM which is thought to be the most poisonous are less than 2.5 micrometres across and are called $PM_{2.5}$. Epidemiological studies conducted over the past twenty years have reported significant associations between short-term and long-term exposure to increased ambient PM concentrations and increased morbidity (*e.g.* cardiovascular and respiratory diseases) and (premature) mortality. $PM_{2.5}$ is readily inhalable and because of their small size is not filtered and reaches the upper part of the airways and lungs. Those smaller than 2.5 μm penetrate deep into the bottom of the lung, where they can move to the blood stream, thus allowing many chemicals harmful to human health to reach many internal organs and causing a wide range of illness and mortality including cancer, brain damage and damage to the fetus. Fine particulate matter ($PM_{2.5}$) in air has been estimated to reduce life expectancy in the EU by more than eight months.

Although it is commonly assumed that there is no threshold below which health effects of PM are unlikely to occur, the recent update of the WHO Air Quality Guidelines for PM proposed that guidelines should be set to minimize the risk of adverse effects of both short-and long-term exposure to PM. These values are set at 20 μg/m3 as an annual mean and 50 μg/m3 as a daily mean for PM_{10}, with corresponding values of 10 μg/m3 and 25 μg/m3 for $PM_{2.5.}$ In Table 3 the dynamics of urban population exposure to air by particulate matter $PM_{10\ in}$ Lithuania and Poland and EU-28 average is presented. There are no statistical data in EUROSTAT for urban population exposure to air pollution by particulate matter $PM_{2.5.}$ In Lithuania therefore just comparison in urban population exposure to air pollution by particulate matter PM_{10}, was compared between Lithuania and Poland.

Table 3

Urban population exposure to air pollution by particulate matter PM_{10}, micrograms per cubic metre

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU (28 countries)	27	28	30	28	26	26	26	27	25	24
Lithuania	23	23	20	21	19	23	27	23	20	24
Poland	32	35	42	32	31	35	39	39	37	33

Source: EUROSTAT.

As one can see from information provided in Table 3 in Lithuania the urban population exposure to air pollution by particulate matter PM_{10}, was stable during 2004-2013 period just in 2013 some increase can be noticed. In Poland the increase of urban population exposure to air pollution can be noticed however in 2013 significant decrease is obvious. Comparing with EU-28 average one can notice that in Lithuania urban population expose to air pollution was lower during all investigate period however it was higher than WHO Air Quality Guidelines for PM_{10} which are set at 20 μg/m3 as an annual mean. For Poland during investigated period urban population exposure to particulates matter PM_{10} was significantly higher than EU-28 average and in 2013 was almost twice higher than WHO Air Quality Guidelines norm.

In Table 4 the dynamics of urban population exposure to air pollution by ozone is presented in Lithuania, Poland and EU-28 average.

Table 4

Urban population exposure to air pollution by ozone, micrograms per cubic metre day

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU (28 countries)	3491	3677	4478	3611	3580	3648	3368	3705	3502	3373
Lithuania	2909	5048	4621	1891	3653	2110	1416	3057	2722	2478
Poland	3031	3954	4574	3244	3543	3092	2806	3388	3526	3062

Source: EUROSTAT.

The indicator shows the population-weighted concentration of ozone to which the urban population is potentially exposed. The principle metric for assessing the effects of ozone on human health is, according to the WHO recommendations, the daily maximum 8-hour mean. Ozone effects should be assessed over a full year. Current evidence is insufficient to derive a level below which ozone has no effect on mortality. However, for practical reason it is recommended to consider an exposure parameter which is the sum of excess of daily maximum 8-h means over the cut-off of 70 ¼g/m3 (35 ppb) calculated for all days in a year.

In the period 2001-2013, 14-65 % of the urban population in EU-28 was exposed to ambient ozone concentrations exceeding the EU target value set for the protection of human health (120 microgram O_3/m^3 daily maximum 8-hourly average, not to be exceeded more than 25 times a calendar year, averaged over three years and to be achieved where possible by 2010). The 65 % of the urban population exposed to ambient ozone concentrations over the EU target value was recorded in 2003, which was the record year. There was no discernible trend over the period until 2004. In Lithuania urban population exposure to air pollution by ozone was lower than EU 28 during all investigated period however it is also significantly higher than EU target value. In Poland urban population exposure to air ozone pollution was lower than EU average during investigated period however negative trend of increase can be noticed.

Dynamics of other classical pollutants (SO2, NOX, NH3 and NMVOC) having negative impact on health in Lithuania and Poland is presented in Figure1-Figure 4.

As one can see from Figure 1 in Poland SO2 emissions have halved during 2004-2013 period. In Lithuania the same trends of SO2 emissions can be noticed however the reduction during the same period was about 30%.

As one can see from Figure 2 NOx emission were growing during 2004-2008 period and started to decline since 2009 in Lithuania and since 2011 in Poland. Lithuania and Poland achieved small NOx emission reduction (8-10%) in 2013 comparing with year 2004.

As one can see from Figure 3 though NH3 emissions were increasing during 2004-2007 in Poland since 2008 they started to decrease and in 2013 reached 2004 level. In Lithuania NH3 emissions started to decrease in 2007 and in 2013 were almost 10% lower than in 2004.

As one can see from Figure 4 NMVOC emissions in 2013 have increased in Poland comparing with year 2004. In Lithuania NMVOC have decreased by almost 20% in 2013 comparing with year 2004.

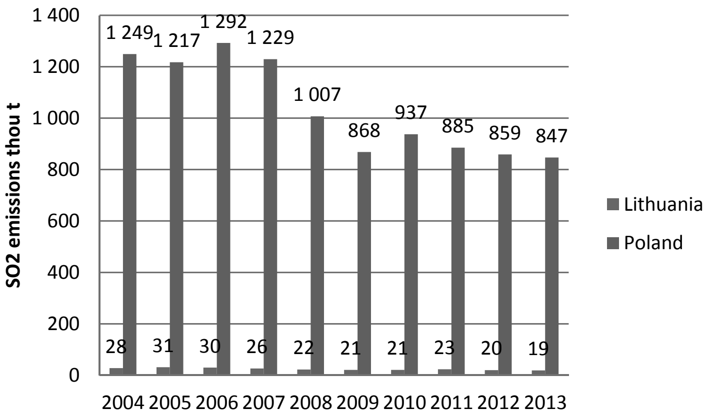

Figure 1. Dynamics of SO2 emissions in Lithuania and Poland in 2004-2013

Source: EUROSTAT.

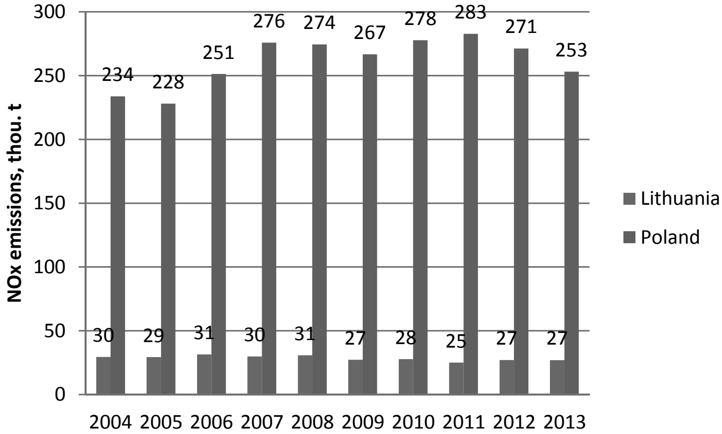

Figure 2. Dynamics of NOx emissions in Lithuania and Poland in 2004-2013

Source: EUROSTAT.

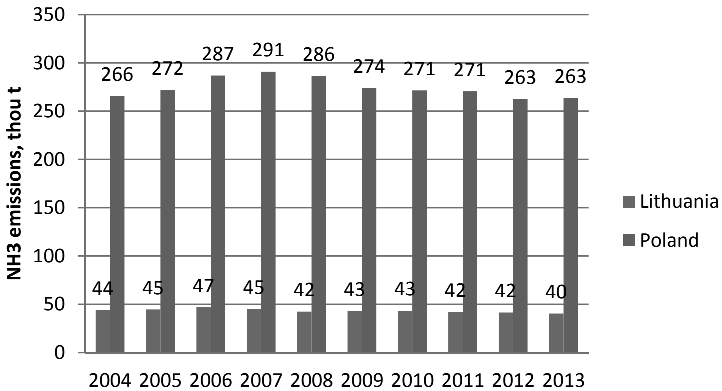

Figure 3. Dynamics of NH_3 emissions in Lithuania and Poland in 2004-2013

Source: EUROSTAT.

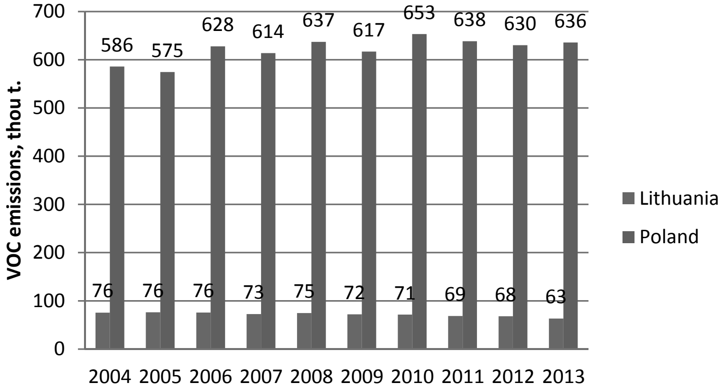

Figure 4. Figure 2. Dynamics of NMVOCs emissions in Lithuania and Poland in 2004-2013

Source: EUROSTAT.

CONCLUSIONS

Poland distinguishes with external costs higher than EU-28 for almost all pollutants except NMVOCs and PPM10. Comparing external costs between Poland and Lithuania one can notice that in Lithuania external costs are lower than in Poland for all pollutants and for all investigated periods.

High external costs of atmospheric emissions requires high atmospheric pollution fees to internalize these external costs however pollution fees in Poland are lower almost for all pollutants except SO2 emissions.

Analysis of dynamics of classical pollutants emissions indicated that Poland achieved very good results in reduction of SO2 emissions during 2004-2013 periods as SO2 emissions have halved during this period in Poland. In Lithuania the same trends of SO2 emissions can be noticed however the reduction during the same period was about 30%,

Dynamics of all other classical pollutants emissions in Poland was not such favourable like in the case of sulphur dioxide though some decrease can be noticed during investigated period for all atmospheric pollutants except NMVOC.

As regards the urban population exposure to air pollution by particulate matter PM_{10}, and by ozone, which are the most dangerous for human health and cause high external costs of human health Poland distinguishes with significantly higher values comparing with EU-28 average for particulate matter $PM_{10.}$ In addition though in Poland urban population exposure to air ozone pollution was lower than EU average during investigated period some negative trend of increase can be noticed. The increase of urban population exposure to air pollution by PM_{10} can be noticed in Poland however since 2013 some decrease can be noticed.

High pollution fees for SO2 emissions together with other policy measures had positive impact on SO2 emissions reduction during investigated period however low air pollution fees or absence of such fees do not provide for significant progress in atmospheric pollution reduction like in the case of Lithuania.

The improvements of environmental tax systems give a relevant and strong motive for the sustainable development and pollution reduction in the countries. Internalization of external costs and increase of pollution taxes would allow reducing air pollution in flexible way. The evolution of pollution taxes is necessary in Poland by greening tax system and shifting from benefits such as labour and profit taxing to pollution and resources taxing.

REFERENCES

Bridges, A., Felder, F. A., McKelvey, K., & Niyogi, I. (2015). Uncertainty in energy planning: Estimating the health impacts of air pollution from fossil fuel electricity generation. Energy Research & Social Science*, 6*, 74-77.

CASES (Cost Assessment of Sustainable Energy System) (2008). Development of a set of full cost estimates of the use of different energy sources and its comparative assessment in EU countries, EC.

Chiroleu-Assouline, M., Fodha, M. (2014). From regressive pollution taxes to progressive environmental tax reforms. European Economic Revue, 69, 126-142.

European Commission (EC) (1998). Externalities of fuel cycles 'ExternE' Project. National Implementation Programme. DGXII, Science, Research and Development, JOULE.

European Commission (EC) (2003). External costs: research results on socio-environmental damages due to electricity and transport. Directorate-General for Research, Directorate J-Energy, Brussels.

European Commission EC (2005). ExternE – externalities of energy: methodology 2005 update. Directorate-General for Research, Sustainable Energy Systems, Brussels.

Fouquet, R., Slade, R., Karakoussis, V., Gross, R., Bauen, A., Anderson, D., (2001). External costs and environmental policy in the United Kingdom and the European Union. Occasional Paper 3. Centre for Energy Policy and Technology, Imperial College, London. http://www3.imperial.ac.uk/portal/pls/portallive/docs/1/7294722.PDF.

Georgakellos, D. A. (2010). Impact of a possible environmental externalities internalisation on energy prices: The case of the greenhouse gases from the Greek electricity sector. Energy Economics*,* 32, 202-209.

Hsu, S., Walters, J., & Purgas, A. (2008). Pollution tax heuristics: An empirical study of willingness to pay higher gasoline taxes. Energy Policy, 36, 3612-3619.

Krewitt, W. (2002). External costs of energy – do the answers match the question? Looking back at 10 years of ExternE. Energy Policy, 30, 839-848.

Longo, A., Markandya, A., & Petrucci, M. (2008). The internalization of externalities in the production of electricity: Willingness to pay for the attributes of a policy for renewable energy. Ecological Economics*, 67*(1), 140-152.

Máca, V., Melichar, J., & Ščasný, M. (2012). Internalization of External Costs of Energy Generation in Central and Eastern European Countries. Journal of Environment & Development*, 21(2)*, 181-197.

Markandya, A., (2003). Expected external costs and their structure characterizing electricity options and their role in the strategic assessment of these options. Conference on Electric Power Supply in the 21st Century, Warsaw.

Rafaj, P., & Kypreos, S. (2007). Internalisation of external cost in the power generation sector: Analysis with global multi-regional MARKAL model. *Energy Policy, 35*(2), 828-843.

Streimikiene, D., & Alisauskaite-Seskiene, I. (2014). External costs of electricity generation options in Lithuania. Renewable Energy*, 64*, 215-224.

Streimikiene, D. (2014). Comparative Assessment of Environmental Indicators of Quality of Life in Romania and Lithuania, *Economics and Sociology*, Vol. 7, No 1, pp. 11-21. DOI: 10.14254/2071-789X.2014/7-1/2

OECD, 2010. Taxation, Innovation and the Environment. Organization for Economic Cooperation and Development, Paris, France.

WHO (2014). Public Health, Environmental and Social Determinants of Health. World Health Organization, available at: www.who.int/phe/health_topics/outdoorair/databases/en/.

WHO (2004), Water, Sanitation and Hygiene Links to Health: Facts and Figures updated March 2004, WHO Library Cataloguing-in-Publication Data, Geneva.

Zamula, I., Kireitseva, A. (2013). Environmental Liabilities Arising from the Transactions with Atmospheric Air as an Accounting Object, *Economics and Sociology*, Vol. 6, No 2, pp. 190-200. DOI: 10.14254/2071-789X.2013/6- 2/17