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ECO-EFFICIENCY: TRENDS, GOALS AND THEIR IMPLEMENTATION IN LITHUANIA

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Abstract. Paper aims to explore the progress in eco-efficiency and the course of decoupling of environmental impact from economy growth in Lithuania during 1990–2008. For better interpretation of ongoing changes in eco-efficiency the concept of double decoupling was applied. Decoupling of resource consumption from economy growth is considered as primary decoupling, and decoupling of environmental pollution from resource consumption is considered as secondary decoupling. Energy intensity is treated as indicator of primary decoupling and pollution intensity as indicator of secondary decoupling. Over investigated period an essential primary decoupling took place and final energy intensity was reduced approximately 2.5 times in Lithuania and has converged to the level of EU-15 on average. Transition to the market economy, shift to the modern technologies, increased energy prices and structural changes of Lithuanian economy are considered as the main drivers for this achievement. Progress in secondary decoupling was not so pronounced and pollution intensity is still 2 times higher than in EU-15. Though energy and transport sectors are identified as the main "hot spots" to tackle relatively high pollution intensity, focus on tools and measures benefiting reduction of both energy and pollution intensity are discussed.

Keywords: Eco-efficiency, energy intensity, pollution intensity, sustainable development, transition country, double decoupling.

1. Introduction

Economic growth is strongly linked to resource consumption and environmental burden. Resource extraction, processing, production, consumption of goods and services as well as mobility and leisure activities determine energy and materials flows in socio-economic system. Sooner or later these resources leave socio-economic system in the form of air and water emissions, unused recourses and waste causing a wide range of environmental impacts during the whole life cycle (Bringezu 2003). Despite growing attention to sustainability issues World is still continuing with unsustainable development trends and increasing resource consumption. Therefore the need to re-examine recent development patterns and to put higher priority to absolute decoupling of economy growth from environmental impact are of high importance (Jackson 2009).

To decouple environmental impacts from economy growth is one of the main targets for the Countries in Central and Eastern Europe (CEE) (Juknys *et al*. 2008). These countries have undergone dramatic changes in economic, social, environmental and policy spheres after the collapse of the Soviet Union (Randla *et al*. 2002; Lang 2003; Cherp *et al*. 2003; Cornillie, Frankhauser 2004). According to N. Mžavanadzė (2009) CEE countries had to deal not only with transition from centrally planned economy, but with transition to sustainability at the same time.

Lithuania has launched National strategy for sustainable development (NSSD) in 2003, aiming "to achieve the present (year 2003 – *authors expl.*) development level of EU-15 countries by 2020, according to indicators of economic and social development as well as the *efficiency* in consumption of resources, and not to exceed allowable EU standards, while meeting the requirements of international conventions in the field of minimization of environmental pollution and input into global climate change" (NSSD 2003:12). Renewed National strategy for sustainable development (2009) raises the same general objective and improvement of eco-efficiency is considered as one of the main options to achieve this objective. Double increase in eco-efficiency up to the year 2020 is defined as a main target of Lithuanian NSSD in this field. Having in the mind inherited one of the most energy and material intensive economies in the World (Ürge-Vorsatz *et al*. 2006), the commitment to reach eco-efficiency level of EU-15 countries up to the year 2020 should be considered as challengeable target. An essential eco-efficiency improvement is of importance not only for reaching national goals, but for to complying with international commitments (Schütz, Welfens 2000), for gaining from energy and material savings and increased competitiveness as well as for reducing dependency on imports (Štreimikienė *et al*. 2007).

Recent economic crisis opens opportunities for eco-innovations, i.e. not only traditionally considered technological innovations applied in businesses, but also social innovations, such as innovative public policies, behavioural and lifestyle changes (Bleischwitz *et al*. 2009) and calls

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for "green" economy, encouraging green investments and at the same time contributing to short-term economic recovery and environmentally friendly sustainable growth in the long term (OECD 2009; Barbier 2009).

Though there are numerous studies on the changes of energy (both primary and final) intensity in Lithuania (Miškinis 2002; Cornillie, Fankhauser 2004; Markandya *et al.* 2006; Štreimikienė *et al.* 2007), but energy related pollution intensity is rather seldom addressed and analyzed (Juknys *et al*. 2005; Dagiliūtė 2008). This paper aims to analyze the changes in eco-efficiency (final energy intensity and related pollution intensity) that took place in Lithuania after the collapse of Soviet Union up to the beginning of current world economy crisis and to examine implementation of NSSD goals.

2. Methodology and data issues

Eco-efficiency indicators reflect environment-economy relationship (Spangenberg *et al*. 2002) and increase in eco-efficiency is considered to be appropriate strategy for decoupling of environmental impact from economy growth (Verfallie, Bidwell 2002). Already in Brundland report (WCED 1987) it was stated that resources should be used more efficiently and the concept of eco-efficiency should be incorporated in economic, market and policy issues. Therefore, assessment of eco-efficiency on national level according to Lithuanian NSSD (2003, 2009) is based on the eco-intensity indicators. Two types of eco-intensity indicators are evaluated in this study - energy intensity and pollution intensity.

Amount of goods and services per unit of used natural resources is usually considered as the main indicator of eco-efficiency (WBCSD 2000; Randla *et al*. 2002) and an appropriate tool of decision making for policy makers (UN 2009). However, taking into account that eco-efficiency is only two-dimensional indicator, there is also some criticism on the concept itself (Hukkinen 2001, 2003), mostly related to the lack of environmental consciousness of institutions and insufficient attention to the social issues and rebound effects (Binswanger 2001; Jalas 2002; Barber 2003; Bleischwitz 2003; Mickwitz *et al*. 2006) as well as to the omission of national country peculiarities (Höhne *et al*. 2007). Despite that the inverse of this indicator – eco-intensity (eg. energy intensity) is very often used as indicator of eco-efficiency in national and sector level as well (Cornillie, Frankhauser 2004; Štreimikienė *et al*. 2008; Mendiluce *et al.* 2010). Hence, final energy per unit of gross domestic product (GDP) reflects final energy intensity changes in this study. To avoid the influence of price fluctuations chain-linked GDP is used. For the comparison of eco-intensity indicators with EU-15 countries, GDP is adjusted according PPPs that eliminates the differences in price level between countries and allows meaningful comparison of GDP and derived indicators (final energy intensity in this case) between countries.

Pollution intensity usually is considered as amount of pollutants per unit of GDP (Casler, Blair 1997; Cherp *et al.* 2003; UN 2009). In this article pollution intensity is treated differently, i.e. emission of acidifying compounds (SO_2, NO_x) per unit of consumed final energy is considered as indicator of pollution intensity. Emission of acidifying compounds (SO_2, NO_x) for the comparison between the countries is expressed in their acidifying potential.

As some weaknesses of the concept of eco-efficiency were already discussed, it is obvious that increase in eco-efficiency is absolutely necessary; but it is insufficient prerequisite for sustainability goals (EEA 1999; OECD 2003). To reach absolute decoupling targets and to avoid the impact of rebound effects eco-efficiency has to increase faster than production (GDP). Therefore for the better interpretation of ongoing changes in eco-efficiency the concept of *double decoupling* (Juknys *et al.* 2005) was applied in this paper. Decoupling of resource consumption from economy growth is considered as *primary decoupling*, and decoupling of environmental pollution from resource consumption is considered as *secondary decoupling.* Resource intensity is treated as indicator of primary decoupling and pollution intensity as indicator of secondary decoupling. Taking into account that measures and decisions needed to achieve primary and secondary decoupling are rather different, such treatment of eco-intensity indicators is more useful for analysis of revealed development trends and benchmarking and monitoring of pollution mitigation achievements.

Data from the Department of Statistics to the Government of the Republic of Lithuania (Statistics Lithuania), Ministry of Environment of Republic of Lithuania, Statistical Office of the European Communities (Eurostat), and International Energy Agency are used in this study to reveal the main trends of production (GDP), final energy use, environmental impact and derived eco-efficiency (eco-intensity) indicators.

The research covers the 1990–2008 year period, which is considered as transition period. It is assumed that transition period will last until the main indicators (GDP, incomes, labour productivity, eco-efficiency, etc.) of Lithuania reach the European Union old members (EU-15) level on average. To reveal ongoing changes two periods are distinguished: decline period (1990–1994) and the period of economy growth (1995–2008). GDP has decreased approximately by 40% during first period and has increased 2.3 times during second period (Juknys *et al*. 2008). Due to some lack of data uniformity and limitations air pollution trends and related pollution intensity are presented for the shorter time period, covering 1990–2007 and 1991–2006 time spans.

3. Results and discussion

3.1. Energy intensity trends

Changes in final energy intensity, i.e. final energy used per unit of GDP, are presented in Figure 1. As it can be seen, final energy intensity changes took rather irregular character during economy recession period (1990–1994) and only slight (approximately 10%) decrease in energy intensity was registered from 1990 until 1994. The main changes in final energy intensity took place during the period of economic growth starting from the year 1995. During this period final energy intensity decreased nearly twofold, from 123.8 to 66.5 kgoe/1000 Lt.

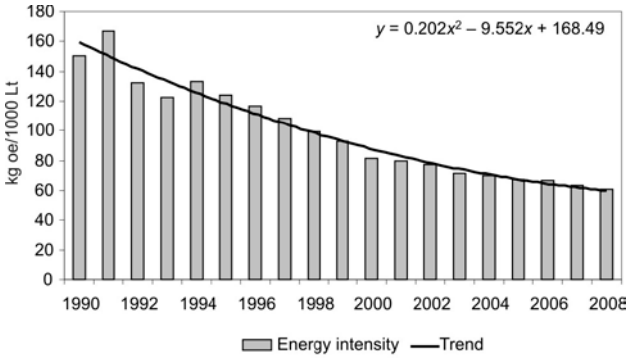

Fig. 1. Changes in final energy intensity in Lithuania during 1990 – 2008 year period

In overall terms in year 2008 final energy intensity was 2.5 times lower compared to that in 1990 in Lithuania. Transition to the market economy, modern technologies as well as essentially increased energy prices (since 1995 the energy prices for the final users increased more than 4.5 times) resulted in these positive from the point of sustainability changes. Significant decrease in final energy intensity in industry and transport sectors (Dagiliūtė 2008) as well as the essential structural changes of Lithuanian economy and the largest increase in share of value added in commercial sector, which is the least energy intensive, had a positive impact on decrease of energy intensity as well (Štreimikienė *et al*. 2008).

Comparison of final energy intensity in Lithuania and EU-15 countries is presented in Figure 2. Final energy intensity in Lithuania was approximately 2.5 times higher than that in EU-15 at the very beginning of transition period. Taking into account very fast progress, final energy intensity in Lithuania exceeded this indicator for EU-15 countries only by 12% and 7% in the year 2002 and 2006 consequently.

According to A. Markandya *et al*. (2006) Lithuania had to converge to the level of energy efficiency of EU-15 in 2005. Conclusion can be made that Lithuania has fulfilled this forecast (Fig. 2) and has reached strategic target for final energy intensity – to reach 2003 (2002) year level of energy intensity in EU-15 (NSSD 2003, 2009). And currently more attention should be paid for maintaining these decreasing trends and to reach higher decoupling targets. Therefore, the need of the revision and setting of the new, more challenging goals has arisen.

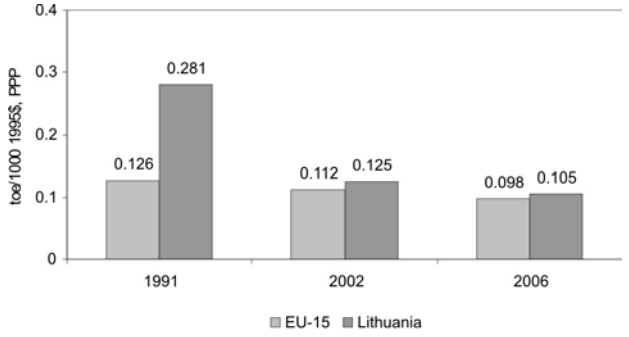

Fig. 2. Comparison of final energy intensity in EU-15 and Lithuania

Attention should be also paid for correct international comparison of indicators with GDP as denominator (energy intensity, etc.). In such indicators GDP should be expressed by using purchasing power parities (PPPs), i.e. currency conversion rates that eliminate the differences in price level between countries allowing meaningful comparison of GDP and derived indicators between countries. In the cases when this rule is neglected (EEA 2005, Eurostat 2009), a misinterpretation of obtained results is possible and misleading conclusions on extremely high potential to reduce energy intensity (regarding both final energy and gross inland energy consumption intensity) several times in CEE countries can be made.

3.2. Pollution intensity trends

Changes in environmental pollution intensity (amount of pollutants per resource unit consumed) are presented in Figure 3. As it is seen from the presented data, decrease in air pollution intensity was not so pronounced as in the case of energy intensity.

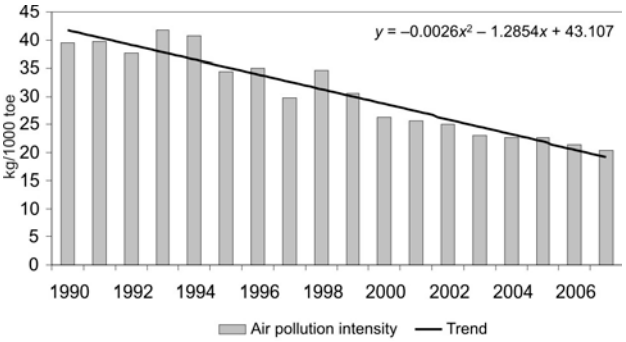

Fig. 3. Changes in air pollution intensity in Lithuania during 1990–2007 year period

Air pollution intensity fluctuated almost the whole period under analysis and even some increasing trend during transitional downturn period (1990–1994) was recorded. This unsustainable trend could be explained by diminished environmental control at the beginning of transition period and increased consumption of relatively low quality fuels during the energy blockade. Along with economy growth from the year 1995 air pollution intensity started to decrease gradually. In overall terms air pollution intensity decreased 1.9 times during the whole investigated period. Positive changes in pollution intensity are mostly related to changes in economic structure and increase in less polluting fuel consumption (natural gas, liquid gas and recent legislation for limiting sulphur in the fuel oil), but not wide implementation of special air pollution mitigation measures. As the research of Dagiliūtė (2008) reveals pollution intensity in energy sector (together with household sector) was mainly responsible for overall pollution intensity in Lithuania.

Comparison of air pollution intensity in Lithuania and EU-15 countries is presented in Figure 4. It is necessary to note, that in the very beginning of investigated period (1990) difference in air pollution intensity (amount of emitted pollutants per unit of consumed energy) was not so considerable and pollution intensity in Lithuania

was approximately 1.5 times higher than in EU-15 countries on average.

Furthermore, along with active implementation of different pollution mitigation measures, including catalytic converters in transport sector, air pollution intensity in EU-15 countries was reduced almost two times during the following decade and the difference in air pollution intensity between Lithuania and EU-15 countries has increased and achieved almost 2.5 times in 2002 (Fig. 4).

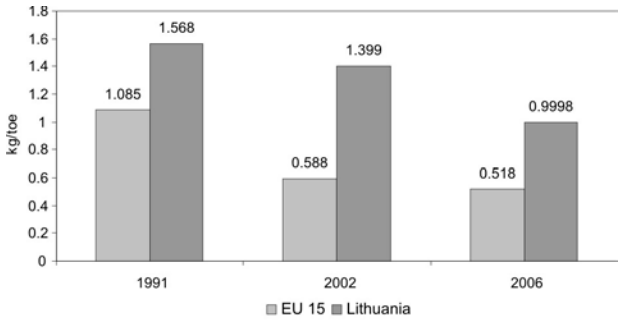

Fig. 4. Comparison of air pollution intensity in EU-15 and Lithuania (according to acidifying potential)

Despite some reduction of this difference in the end of investigated period, air pollution intensity in Lithuania still is approximately 2 times higher than in EU-15 countries (Fig. 4). Therefore a strategic goal to reach eco-efficiency level of EU-15 countries up to the year 2020 remains a rather complicated task in the case of air pollution intensity.

3.3. Decoupling course

The course of primary and secondary decoupling for Lithuania and EU-15 countries are presented in Figure 5. Completely different starting points and measures applied in energy and pollution fields resulted in big differences in proportions of primary and secondary decoupling courses in Lithuania and EU-15 countries.

Rather weak primary decoupling, i.e. decoupling of energy use from economic growth, indicating 1.28 time decrease in final energy intensity during investigated period is characteristic for EU-15 countries and growth of energy use was stopped only in the very end of investigated period (Fig. 5). Though considerable secondary decoupling (decoupling of air pollution from the use of energy resources) indicating double decrease in pollution intensity (amount of emitted pollutants per unit of consumed energy) took place in EU-15 countries over the same period. Implementation of efficient air pollution mitigation measures, including catalytic converters for mobile pollution sources and more wide use of less polluting fossil fuel (natural gas), as well as alternative energy sources, can be considered as the main reasons of these positive, from the point of sustainability, changes (EEA 2005). These changes resulted in absolute decoupling of environmental pollution from economy growth and final energy use in EU-15. Contrary pattern of decoupling course is characteristic for Lithuania‘s development. Primary decoupling is very impressive and, as it was mentioned in section 3, energy intensity was reduced 2.5 times over the investigated period.

Even at the beginning of transition period, when a very sharp economic depression took place, the use of energy resources decreased much more rapidly than GDP and as it was noticed in OECD report (1999) positive decoupling took place (Fig. 5). From 1995 during economy growth period further slight decrease in final energy consumption took place and even after 2001, when especially fast growth of GDP has started, energy consumption grew much slower than economy and relative decoupling was achieved.

Secondary decoupling in Lithuania has started only in 1996 and some negative secondary decoupling, i.e. increase in amount of emitted pollutants per unit of consumed energy, can be noticed at the beginning of transition period (Fig. 5). In comparison with EU-15 countries relatively weak secondary decoupling in Lithuania could be considered as a consequence of reduction of air pollution due to deep economic depression and reduced energy consumption, but not certain air pollution mitigation measures, i.e. main international obligations for air pollution reduction were also fulfilled without implementation of special environmental protection measures and additional efforts (Randla *et al*. 2002; Juknys *et al.* 2008).

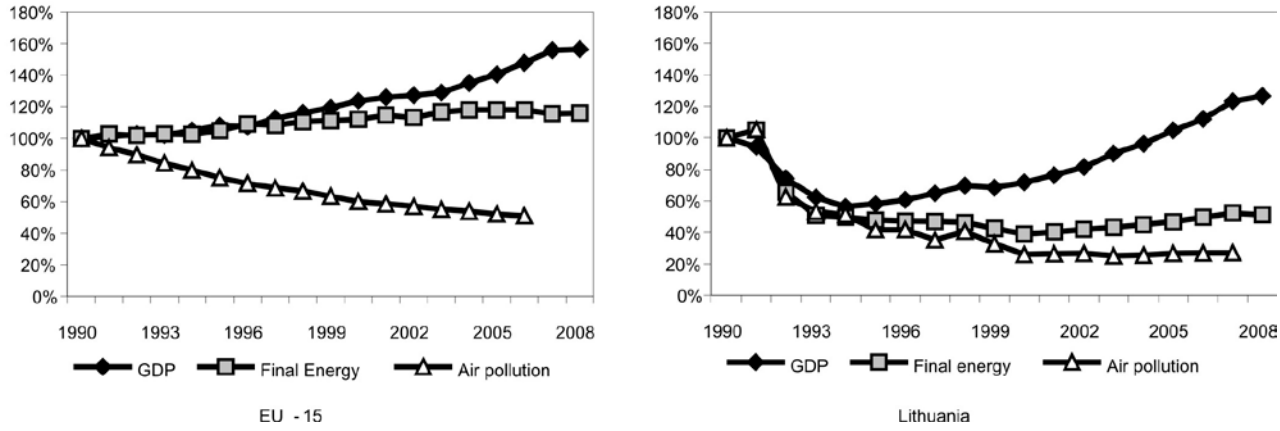

Fig 5. Comparison of primary and secondary decoupling courses in Lithuania and EU-15 countries (1990 = 100%)

3.4. Some insights on main factors and policy implications for eco-efficiency and double decoupling

Data shows that final energy consumption is mostly driven by transport (37%), household (28.4%) and industry (19.7%) sectors in Lithuania recently (Table 1).

Table 1. Proportions of final energy consumption by the end-users in Lithuania. *Based on: Eurostat*

	1990	1995	2000	2008
Agriculture	8.2%	4.4%	2.6%	2.4%
Industry	34.4%	22.1%	20.9%	19.7%
Transport	20.6%	22.6%	28.1%	37.0%
Services	17.7%	15.0%	12.5%	12.4%
Households	19.0%	35.7%	35.9%	28.4%

Hence, the main possibilities for further final energy intensity reduction are mostly viable in transport and housing sectors, not neglecting the importance of the industries. As it was already discussed changes towards more efficient transport fleet and modes could be beneficial for energy savings in transport sector. Another promising possibility to increase energy efficiency in household sector is renovation of soviet style blockhouses. Considerable potential (30%) for energy saving in such houses is estimated. However, measures for promotion of renovation initiatives have appeared rather ineffective and the whole renovation process has been stagnating recently. Some reconsideration of financing and subsidising schemes should be discussed in order to achieve some significant influence of this program to final energy consumption in household sector. According to Užšilaitytė and Martinaitis (2010) depending on the improvement of energy efficiency of the public buildings renovation could also have significant positive effects not only on energy savings, but economic and environmental benefits, especially in the terms of CO_2 emission.

One of the other possibilities for increased final energy efficiency and reduced pollution is faster progress in implementation of modern environmental friendly technologies in Lithuanian industries. As recently production based on high technologies covers only 4–5% of general industry production, increasing this indicator up to 20–25% until 2020, as foreseen in National strategy for sustainable development, is one of the most challenging tasks for Lithuanian industry sector.

In general, measures for resource (not only energy) intensity reduction to secure further primary decoupling and to de-link environmental impact from economic growth in accordance with NSSD goals should be foreseen and clearly indicated on national and economy sector level. Revision of foreseen goals for resource consumption efficiency and more pronounced decoupling of environmental impact from economic growth is needed.

Though transport and household sectors are the main final energy consumers, their input to the related air pollution differs due to the differences in fuel mix and distinct consideration of the sectors. Thus, regarding air pollution, transport and energy sectors are the main contributors to air pollution, causing emission of more than 80% of all acidifying compounds and highly influencing pollution intensity in Lithuania (Dagiliūtė 2008). Hence, both transport and energy sectors should pay much more attention to implementation of environmental impact mitigation measures and essential reduction of emitted pollutants per unit of consumed energy.

Number of passenger cars per 1000 inhabitants has more than tripled over the 1990–2008 period in Lithuania. This fast growth of transport car fleet outweighed the gains of renewed car fleet, improved fuel quality, and changed structure of fuel consumption and pollution from transport sector is growing lately (Dagiliūtė 2008). Increasing transport intensity is mainly responsible for high concentrations of such pollutants as NO_x, SO_2 and others (Baltrėnas *et al*. 2008). Therefore, more strict implementation of "polluter pays" principle in transport sector and promotion of more efficient and "green" cars as well as public transport and other means of environmentally friendly mobility forms (bikes, roller-skates, walking) are of high importance.

Another "hot spot" responsible for high air pollution intensity is energy sector itself and especially large combustion plants, which input consists of up to one third of acidifying pollutants emission in Lithuania. Situation should be improved with the implementation of EU directive on large combustion plants (2001/80/EC), which puts tighter limits for SO_x and NO_x emissions. The biggest energy enterprises (Vilnius, Kaunas and Mažeikiai power-plants) have got a transition period until 2015 for the implementation of this directive. Nevertheless, hopefully significant improvements will be achieved before 2015 since reduction of air pollution is indicated as one of the main priorities in Lithuanian Operational Programme for Promotion of Cohesion for 2007–2013 (2007). Financing from Cohesion Fund for installation of modern equipment for cleaning and control of pollutants in these energetic objects is foreseen.

At the same time it is necessary to note, that most environmental pollution mitigation measures (catalytic converters, air cleaning facilities in energetic objects, etc.) are still mainly based on "end of pipe" technologies. Most of them are not able to solve real environmental problems and only delay or translocation of these problems is a result. In this case it is necessary to remind position of German Green party, which strictly argued against production and implementation of catalytic converters at the end of last century (Becker 1995). Two main arguments were used to explain this position. Firs of all, production of catalytic converters needs a lot of expensive materials and energy and cause additional environmental pollution during entire life-cycle. And secondly, reduction of air pollution resulted from broad implementation of catalytic converters can stop expensive efforts of car constructors to design motors with essentially low fuel consumption and will cause further growth in fuel consumption. Data presented in Figure 5 confirm this pessimistic forecast and increase in the final energy consumption by 16% is registered in EU-15 countries during the 1990–2008 period. Especially fast growth of energy consumption was characteristic namely for transport sector and even 30% increase in final energy was registered in this sector during the same period (Eurostat). Having in

mind rebound effects of growing road passenger and freight transport on energy consumption, focus on energy intensity reduction and low fuel consumption and hybrid cars (or alternative means of transport) would not only allow to reduce energy intensity and secure absolute primary decoupling, but to mitigate air pollution as well, in Lithuania and entire EU. However, taking into account that air pollution intensity in Lithuania is almost two times higher than in EU-15 countries, implementation of "end of pipe" environmental protection technologies, including catalytic converters in the mobile pollution sources and air cleaning facilities in large combustion plants is absolutely necessary option to achieve further secondary decoupling. Promotion of renewable energy sources is very important option to reduce air pollution and emissions of green house gases. Recently (2010) adopted National strategy for development of renewable energy resources aims to increase share of renewable energy resources in final energy up to 23% until 2020. Hence, specific measures and active actions are needed to implement this strategy and increase the share of renewable resources in the final energy balance.

4. Conclusions

1. After reestablishment of independence significant progress in energy intensity reduction was achieved and significant primary decoupling, i.e. decoupling of resources consumption from economy growth, was a characteristic feature of Lithuania's development. Only during the period after the adoption of NSSD (2003) GDP increased nearly 50%, while final energy consumption increase reached barely 8%.

2. Final energy intensity was reduced 2.5 times during investigated (1990–2008) period in Lithuania and almost converged to the level of EU–15 countries and new more challengeable targets for eco-efficiency growth are necessary.

3. Secondary decoupling, i.e. decoupling of air pollution from energy use, is too weak and air pollution intensity is still 2 times higher as compared to EU-15 on average.

4. The main possibilities to reduce pollution intensity are to focus on polluter pay principle and special air pollution mitigation measures in transport and energy sectors. In general, priority to the measures for reduction of final energy intensity (primary decoupling) should be given. Putting focus on more efficient use of final energy would be beneficial itself and also would help to deal with air pollution problems.

5. Recent economic crisis opens and reopens opportunities for sound solutions (eco-innovations) in all spheres of life that could lead to long term improvements in eco-efficiency. Presented concept of double decoupling builds ground for more operational application of the results of eco-efficiency assessment and facilitates decision making.

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EKOLOGINIS VEIKSMINGUMAS: TENDENCIJOS, TIKSLAI IR JŲ ĮGYVENDINIMAS LIETUVOJE

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Santrauka

Straipsnyje analizuojama Lietuvos pažanga ekologinio veiksmingumo srityje ir poveikio aplinkai atsiejimas nuo ekonomikos 1990–2008 m. Įvykusiems ekologinio veiksmingumo pokyčiams įvertinti pritaikyta dvigubo atsiejimo koncepcija. Energijos intensyvumas traktuojamas kaip pirminio atsiejimo, t. y. ekonomikos augimo atsiejimo nuo energijos išteklių naudojimo, rodiklis, teršimo intensyvumas – kaip antrinio atsiejimo, t. y. aplinkos teršimo atsiejimo nuo energijos vartojimo, rodiklis. Per analizuojamą laikotarpį pavyko atsieti ekonomikos augimą nuo energijos vartojimo, galutinės energijos intensyvumą Lietuvoje sumažinti maždaug 2,5 karto ir beveik pasiekti ES-15 vidurkį. Perėjimas prie rinkos ekonomikos, modernių technologijų, išaugusios energijos kainos ir struktūriniai Lietuvos ekonomikos pokyčiai laikomi pagrindiniais šią ekonomikos ir aplinkos požiūriu svarbią pažangą lėmusiais veiksniais. Pažanga antrinio atsiejimo srityje buvo ne tokia didelė ir taršos intensyvumas, t. y. į aplinką patenkančių teršalų kiekis suvartotos energijos vienetui, Lietuvoje yra vis dar apie du kartus didesnis nei ES-15. Energetika ir transportas įvardijami kaip pagrindiniai sektoriai, kuriuose reikia skirti daugiau dėmesio atitinkamoms priemonėms, siekiant mažinti didelį taršos intensyvumą.

Reikšminiai žodžiai: ekologinis veiksmingumas, energijos intensyvumas, taršos intensyvumas, darnus vystymasis, dvigubas atsiejimas.

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