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EVALUATION OF GREENHOUSE GAS EMISSIONS AND RELATED ASPECTS: CASE OF THE CZECH REPUBLIC

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Abstract

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The most important drivers of increasing greenhouse gas emissions are increasing world's population, economic development resulting in higher level of productions and consumption, but also unanticipated increases in the energy intensity of GDP and in the carbon intensity of energy. The EU committed to reduce their greenhouse gas emissions by 20% until 2020 or 40% until 2030 compared to 1990 levels of the Kyoto Protocol. The Czech Republic enlarged EU in 2004 as a country from Eastern Europe where usually the heavy industries or agriculture prevail over other sectors. The aim of the paper was an evaluation of the development of greenhouse gas emissions and related aspects in the industry of the Czech Republic. Based on the results was concluded that although greenhouse gas emissions of the Czech Republic are deeply below the Kyoto targets, there are areas for improvements e.g. in case of energy intensities, as well as in case of carbon intensity and carbon productivity, where the Czech Republic reaches worse results than the EU28. Therefore is recommended to decrease greenhouse gas emission and increase gross value added generated by each NACE sector. Both those factors will impact on improvement of energy intensity, carbon productivity as well as greenhouse gas emissions per capita.

Keywords: greenhouse gas emissions, Czech Republic, EU28, energy intensity, carbon intensity, carbon productivity

1. INTRODUCTION AND LITERATURE REVIEW

Climate change is mainly caused by global warning, when the atmospheric concentrations of greenhouse gas emissions are increased due to anthropogenic activities i.e. climate change has been caused mainly by human activity. Human-induced greenhouse gas emissions have grown since the industrial revolution through of burning fossil fuels and further due to increasing world's population and economic development resulting in higher level of productions, consumption, as well as energy consumption (Massai, 2011; Eurostat, 2010). But other important drivers of increasing greenhouse gas emissions are unanticipated increases in the energy intensity of GDP and the carbon intensity of energy (Steven, J., Davis and Caldeira, K., 2010). Further, the European Commission found out that the greatest impact for most common energy consumption is the emission of greenhouse gases, particularly CO_2 from combustion (Bickel, Friedrich, Droste-Franke and Preiss, 2005).

There are several reasons why climate change/ global warming should be resolved and many international organizations and institutions are dealing in details with this issue, especially the World Trade Organizations, the United Nations with its Kyoto Protocol, the European Union with its policy frameworks on energy, the Organisation for Economic Co-operation and Development, the Association of South East Asian Nations, and others. One of the main reason is adverse effect of global warming, when climate change caused by a carbon dioxide (CO_2) causes for example increasing in global average temperatures (Hegerl *et al*., 2007),

sea level rise (Pethica *et al*., 2010), and a higher frequency of extreme weather events (Smith *et al*., 2009). Further according to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change the global greenhouse gas emissions increased by 70% between 1970 and 2004 (Massai, 2011). Due to this fact, the Kyoto Protocol signed in 1997 committed the industrialised countries to limit or reduce their greenhouse gas emissions at least 5% from the 1990 levels in the period 2008–2012, and subsequently its Doha Amendment[1] from 2012 for the second period 2013–2020 with at least 20% reduction's target from the 1990 levels. Subsequently based on the Kyoto Protocol, the EU committed to reduce greenhouse gas emissions at least 8% (currently the European Commission proposes a new reduction target for European greenhouse gases emission of 20% in 2020 and 40%[2] in 2030 compared to 1990 levels). In addition, another reason can be considered the foundation both of the European Climate Change Programme in 2001 with aim to develop the European policy that will achieve the international obligation related to the reduction of greenhouse gas emissions, and the EU Emissions Trading Systems in 2005 as the cost-effective tools for cutting greenhouse gas emissions.

Some issues can emerge during the development of European environmental policy, namely the EU consists of 28 member states with political and economic differences, with different environmental protection, different energy or carbon intensity of its economy and other different aspects related to greenhouse gas emissions. Based on those facts, each of the EU member state can be considered as absolutely different, mainly in the respect of specific needs related to greenhouse gas emissions and achieving the Kyoto reduction target. Therefore as mentioned (Eurostat, 2010) the individual policy decisions related to the greenhouse gas emissions should be made using timely and reliable information and environment statistics. Moreover as state (Caldeira, K. and Steven J. Davis, 2011), individual policy should take into account international trade, because CO_2 emissions in one country can support consumption of goods and services in another country and increase CO_2 emissions. In addition, it is also needed to monitor environmental trends, evaluate progress and set up environmental targets.

According to the actual 2014 report form the Yale Center for Environmental Law and Policy, the Czech Republic ranks 5th out of 178 countries in the terms of its environmental performance, its position is better than based to the 2002 report (Czech Republic ranked 6th position). The environmental performance is measured through environmental performance index (hereinafter EPI) which ranks how well countries perform environmental issues, specifically protection of human health from environmental harm and protection of ecosystems. However in the respect of emission it is important mentioned partial results of that report, i.e. air pollution, trend in carbon intensity and emissions per KWH. In the terms of air pollution the Czech Republic ranks deeply on 161st (169th in 2002) and compared to European region peer set is air pollution worse by 16% up to 35%. Secondly, in the terms of the trend in CO_2 emissions per KWH the Czech Republic ranks on 56th (same as in 2002) and compared to European region peer set is that trend worse by 15%. Finally in the terms of the trend in carbon intensity the Czech Republic ranks on 25th (same as in 2002) and compared to European region peer set is that trend better by 15%. Industry has been still considered for the largest polluter in the Czech Republic.

Due to this fact the aim of this paper is an evaluation of the development of greenhouse gas emissions and related aspects in the industry of the Czech Republic, and an identification of areas for possible improvements.

2. DATA AND METHODOLOGY

An analysis of the greenhouse gas emission and related aspects was performed on the Czech Republic, which has enlarged of the EU in 2004. Further, there are mentioned EU28 or EU27 as a comparable unit.

The Czech Republic is situated in the Eastern Europe where usually agriculture or/and heavy industries prevail over other sectors than it is usual in the West Europe, where is the shift to the low-carbon industries. Therefore the paper focused on the following questions, i.e. how is a level of greenhouse gas emissions and/or CO_2 equivalent emissions, what industries sectors generated the largest/lowest level of emissions, how is an energy intensity and/or carbon intensity, how is a carbon productivity and how is gross value added in industry sectors. All of those factors and others were analysed at the level of the Czech Republic. Eurostat or European Environment Agency (hereinafter EEA) were used as a source of data set.

At the beginning of the analysis the total greenhouse gas emissions were mentioned in the respect of Kyoto targets. Data was gained from EEA, online data code *env_air_ind*, for the period between 1990 and 2011 and indexed to 1990. The new target for the second commitment period (2013 to 2020) was gained from Doha Amendment[3] which amended the Kyoto Protocol.

1 https://treaties.un.org/doc/Treaties/2012/12/20121217%2011-40%20AM/CN.718.2012.pdf
2 For more details see COM(2014) 15 final
3 see 1.

After that the total **greenhouse gas emissions per capita** and GDP per capita were determined for reference year 2011, as follows:

$$Greenhouse\ gas\ emissions\ per\ capita = \frac{CO_2\ equivalents\ emissions}{Population},\ [tCO_2\ per\ capita] \quad (1)$$

where
CO_2 equivalents emissions represent total CO_2 equivalents emissions of the Czech Republic and cover carbon dioxide (CO_2), followed by methane (CH_4) and nitrous oxide (N_2O). Due to the fact, that those gases have different effects on climate change, they are converted through their global warming potential into CO_2 equivalents. Population represents the value valid on 1 January of individual year. Data was gained from Eurostat and EEA, online data code *env_air_gge* and *demo_gind*. Further, GDP per capita was used from Eurostat, online data code *nama_gdp_c*, measured in purchasing power parities (hereinafter PPP). Both of indicators were compared in the respect to greenhouse gas emissions and GDP in the Czech Republic.

As another indicator for the evaluation of greenhouse gas emissions was used the **indicator of energy intensity** (hereinafter EIa), followed by **carbon intensity**. Both of them can be identified based on the Kaya identity (Nakicenovic, N., 2004; Nakicenovic, N. *et al*., 2000). Energy intensity is measured as a ratio between the gross inland energy consumption (hereinafter GIC) and economic output (GDP) for a given period, i.e. the amount of energy required to produce a unit of economic output.

$$Energy\ intensity\ (EIa) = \frac{GIC}{GDP}\ [1000\ TOE\ per\ GDP] \quad (2a)$$

or

$$Energy\ intensity\ (EIb) = \frac{FEC}{GVE},\ [1000\ TOE\ per\ Million\ EUR] \quad (2b)$$

where
GIC represents the quantity of energy consumed within the borders of a country, including energy consumed in the form of electricity, heating and transport. It is the sum of GIC of solid fuels, liquid fuels, gas, nuclear energy, renewable energies, and other fuels. The GIC is calculated by adding primary production and recovered products of energy together with total imports and changes in stocks minus total exports and bunkers. Because different fuels have different energy contents and are measured in various units, it is necessary to convert all fuels to a single meaningful unit, specifically to oil equivalents. Thus, GIC is measured in thousands tonnes of oil equivalents (TOE). *GDP* is measured in millions of PPP and allow the comparison of levels economic activity of different sized economies irrespective of their price levels. Another way for determination of energy intensity (hereinafter EIb) is through gross value added (hereinafter GVE) generated by individual sector of industry, specifically as final energy consumption (hereinafter FEC) in industry divided by GVE, i.e. the amount of energy required to produce a unit of gross value added. As was mentioned before in case of consumption, FEC is also measured in thousand tonnes of oil equivalents and GVE is measured in million EUR (determination of GVE is mentioned below in formula 5).

Data for the Czech Republic was gained in Eurostat, online data code *nrg_100a* and *nama_gdp_c* for the period between 1995 and 2012. The energy intensity gives an indication of the effectiveness with which energy is being used to produce added value. Thus reductions in this indicator means that less energy is needed to produce the same level of output. The EIb was breakdown by industries according to NACE sections (sections A to S). Analysed period was from 2008 to the last available year, 2011.

The last indicator for the evaluation of greenhouse gas emissions was chosen the indicator of **carbon intensity** (hereinafter CI). The carbon intensity shows how CO_2 intensive energy use is in different countries, i.e. how many tonnes of CO_2 emissions are generated to meet the energy needs. Its determination can be also made through the Kaya identity as a ratio between the greenhouse gas emissions (CO_2 equivalents) and GIC for a given period.

$$Carbon\ intensity\ (CI) = \frac{CO_2\ equivalents\ emissions}{GIC},\ [tCO_2\ per\ TOE] \quad (3)$$

where
CO_2 equivalents emissions include total emissions in selected years and GIC energy consumed within the borders of a country measured in thousands TOE. Data for the Czech Republic was gained in Eurostat and EEA, online data code *env_air_gge* and *nrg_100a*, for the period between 1995 and 2011.

An analysis of **greenhouse gas emissions by source** (CO_2 equivalent) was based on data set from Eurostat or EEA, online data code *env_air_gge*, for the period from 1990 to 2011. Among main source of greenhouse gas emissions are considered five sectors, namely energy, industrial processes, solvent and other product use, agriculture and waste. Further, another detail analysis was performed to breakdown **CO_2 equivalents emissions by economic activity** accordingly to NACE[4] for

4 NACE is the Statistical Classification of Economic Activities in the European Community

analysed period from 2008 to 2011 and for reference year 2011 in case of a chart. Data for the Czech Republic and EU28 was gained from Eurostat/EEA, online data code *env_ac_ainah_r2* and was breakdown both by industries according to NACE sections and separate CO2 equivalents. Analysed NACE sections[5] cover sections A to S, section T and U were excluded due to lack of data. The air emissions in the form of CO2 equivalents are measured in tonnes. Data follows the residence principle, i.e. it records emissions from resident units' activities, regardless where they occur.

The last part of the analysis of greenhouse gas emissions represent a **carbon productivity of an economy** measures a productivity of individual industry sectors in the respect of CO_2 emissions generated by its processes i.e. how many million EUR of gross value added is attributed to the one tCO_2 equivalents generated in the individual sectors of the economy Carbon productivity is defined as the ratio between gross value added and CO_2 equivalents emissions calculated for a calendar year and breakdown by economy according to NACE sections. Gross value added is measured in Millions of euro (at prices of the previous year) and emissions in tonnes, therefore the carbon productivity is measured in Million EUR per tCO_2.

$$Carbon\ productivity = \frac{GVE}{CO_2\ equivalents\ emissions}, \quad [\text{Million EUR per } tCO_2] \quad (4)$$

where

$$GVE = Output - intermediate\ consumption. \quad [\text{Million EUR}] \quad (5)$$

GVE is the net result of output valued at basic prices less intermediate consumption valued at purchasers' prices. Output consists of the products created during the accounting period. Intermediate consumption consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. The goods and services may be either transformed or used up by the production process. Data for the Czech Republic was gained from Eurostat online data code *nama_nace21_k*, and was breakdown by industries according to NACE sections (sections A to S). Analysed period was from 2008 to the last available year, 2011.

3. RESULTS

Based on the **Kyoto Protocol** signed in 1997[6], the industrialised countries committed to limit or reduce their greenhouse gas emissions at least 5% from the 1990 levels (the Kyoto base year) in the period 2008–2012. However the EU15 as a party of Kyoto Protocol agreed on the joint target for the 8% reduction in its greenhouse gas emissions. This commitment was valid only for the countries who were a member of the EU[7] in 1997, respectively in 1998 when EU15 signed the Kyoto Protocol. Other countries that have joined the EU since 2004, specifically in 2004, 2007 and 2013, are excluded from it i.e. they are not party to the Kyoto Protocol. However that new EU member states are considered to be also obliged to implement the Kyoto Protocol under Article 2 of the Council Decision 2002/358/EC and the Decision 2006/944/EC. Thus the Czech Republic shall also reduce its emissions by 8%. Further, due to the fact that the Kyoto Protocol expired in 2012, the Doha Amendment, which amended the Kyoto Protocol, was negotiated in Doha on 8. December 2012. Based on this Amendment the new commitments for Parties to the Kyoto Protocol were agreed for the second commitment period from 1 January 2013 to 31 December 2020. The EU28 and individual EU member states agreed on the 20% reduction in its greenhouse gas emissions. For more details about reduction targets of the Czech Republic and EU28 see Tab. I below.

As can be seen in case of EU28, the 20% reduction's target is going to be reached and the level of greenhouse gas emission of the Czech Republic is deeply below the 8% reduction's target, as well as 20% reduction's target. Based on the results, it could be considered that the Czech Republic is not now committed further to reduce its greenhouse gas emissions, because its emissions are deeply below the targets.

However, another detail analysis presents different results. Based on the determination of **greenhouse gas emissions per capita**, the Czech Republic represent 12.73 tCO_2 per capita that is

5 A – Agriculture, forestry and fishing. B – Mining and quarrying. C – Manufacturing. D – Electricity, gas, steam and air conditioning supply. E – Water supply, sewerage, waste management and remediation activities. F – Construction. G – Wholesale and retail trade, repair of motor vehicles and motorcycles. H – Transportation and storage. I – Accommodation and food service activities. J – Information and communication. K – Financial and insurance activities. L – Real estate activities. M – Professional, scientific and technical activities. N – Administrative and support service activities. O – Public administration and defence, compulsory social security. P – Education. Q – Human health and social work activities. R – Arts, entertainment and recreation. S – Other services activities. T – Activities of households as employers, undifferentiated goods- and services-producing activities of households for own use. U – Activities of extraterritorial organisations and bodies.

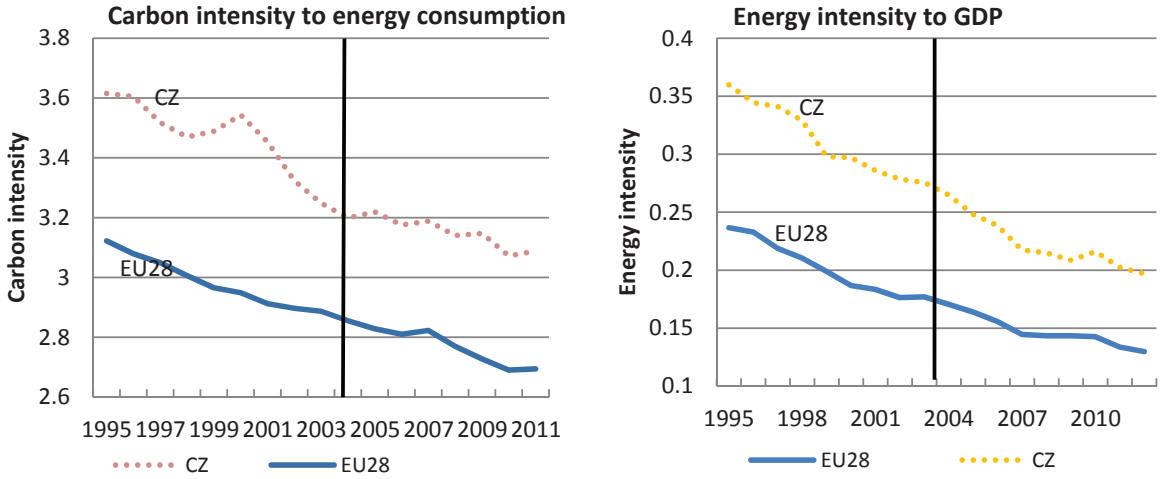
6 However, the Protocol entered into force on 16. February 2005, after the Russian's ratification of the Protocol.

7 Belgium, France, Italy, Luxembourg, Germany, Netherlands, Denmark, Ireland, United Kingdom, Greece, Portugal, Spain, Finland, Austria, Sweden.

I: *Greenhouse gas emissions and agreed reduction targets at the Czech Republic**

	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009	2010	2011	Targets**	
													2008–2012	2013–2020
EU28	100	93.45	91.77	93.45	93.68	93.24	93.13	92.22	90.33	83.78	85.74	83.07	..	80
CZ	**100**	**76.95**	**74.53**	**73.94**	**74.76**	**74.43**	**75.34**	**75.67**	**72.92**	**68.46**	**70.43**	**68.42**	**92**	**80**

* Kyoto base year emissions; Index = 100
** Targets for 2008–2012 are set in Kyoto Protocol, Annex B. Targets for 2013–2020 are set in Doha amendment to the Kyoto Protocol from 8 December 2012.
Source: EEA, Eurostat, online data code env_air_ind, Doha amendment



1: *Energy intensity to GDP (EIa) and carbon intensity to energy consumption at the Czech Republic, 1995–2011/2012*
Source: Eurostat, online data code: nama_gdp_c, env_air_gge, nrg_100a, own processing

above of EU28 average (9.07 tCO_2 per capita). Others indicators of evaluation of greenhouse emissions, namely the **energy intensity** and **carbon intensity**, show that the Czech Republic, although the trend of both indicators is decreasing, has higher level of energy intensity as well as carbon intensity than the average of EU28. For more details see Fig. 1 above.

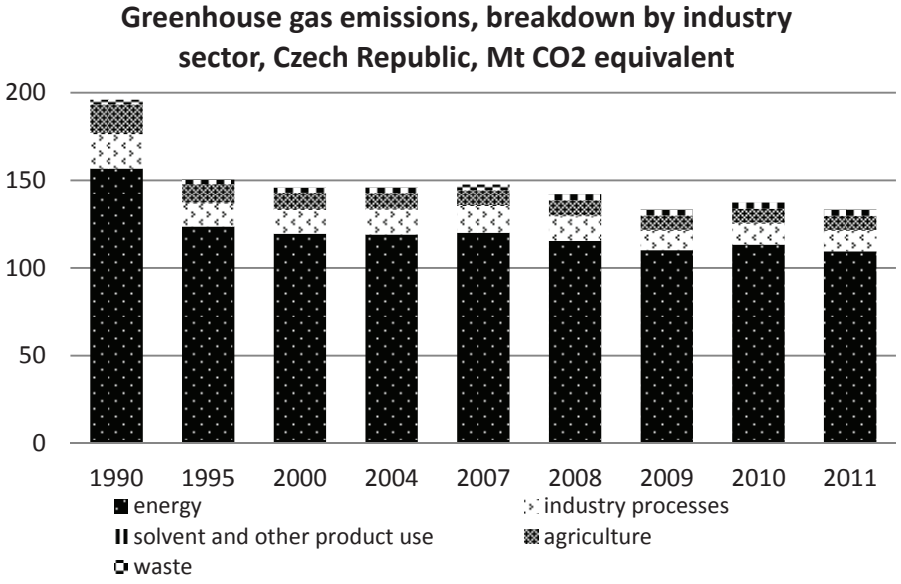
Carbon intensity of energy use presents how CO_2 intensive-energy use is in the country and energy intensity presents how much energy is required to produce a unit of economic output. Regarding the development of carbon intensity of the Czech Republic between 1995 and 2011 can be concluded the decreasing trend in amount of 15%, similarly as in EU28, i.e. that CO_2 emissions generated to meet the energy needs was by 15% lower in 2011 than in 1995. In 2011, the level of carbon intensity was 3.09 in contrast to EU28 average in the amount of 2.69. In the respect of energy intensity, the Czech Republic also reported the decreasing trend, however in the amount of 45%, similarly as in EU28, i.e. that in 2012 for the production of one unit of economic output was used half of energy than in 1995. For more details see Tab. II below.

The most important **source of greenhouse gas emissions** in the Czech Republic is energy industry including transport (average 122,702 Mt CO_2, 82%). That sector is followed by non-energy related industry, namely by industry processes (average 13,832 Mt CO_2, 8.83%), agriculture (average 9,817 Mt CO_2, 6.04%) waste (average 3,128 Mt CO_2, 2.73 %), solvent and other product use (average 573 Mt CO_2, 0.35%). In the respect of EU28 averages of emissions for those sectors, except solvent and other product use sector, all sectors do not exceed the EU28 averages. Moreover, the trend of all industries except of waste is decreasing; the relatively largest decline was reported in agriculture sector in the amount of 50.32%. In case of waste sector, in 2011 by 37% of CO_2 equivalent emissions were generated more than in 1995 in the Czech Republic. For more details see Fig. II and Tab. III below.

II: *Carbon intensity and Energy intensity at the Czech Republic and EU28*

	Carbon intensity					Energy intensity (EIa)				
	1995	2004	2008	2011	index, 1995 = 100	1995	2004	2008	2012	index, 1995 = 100
EU28	3.12	2.86	2.77	2.69	86.28	0.24	0.17	0.14	0.13	54.85
CZ	3.62	3.20	3.14	3.09	85.43	0.36	0.26	0.21	0.20	54.74

Source: Eurostat, online data code: nama_gdp_c, env_air_gge, nrg_100a, own calculation and processing



2: *Greenhouse gas emissions, breakdown by industry at the Czech Republic, 1990–2011*
Source: Eurostat, online data code: env_air_gge, own processing

III: *Greenhouse gas emissions breakdown by industry at the Czech Republic and EU28*

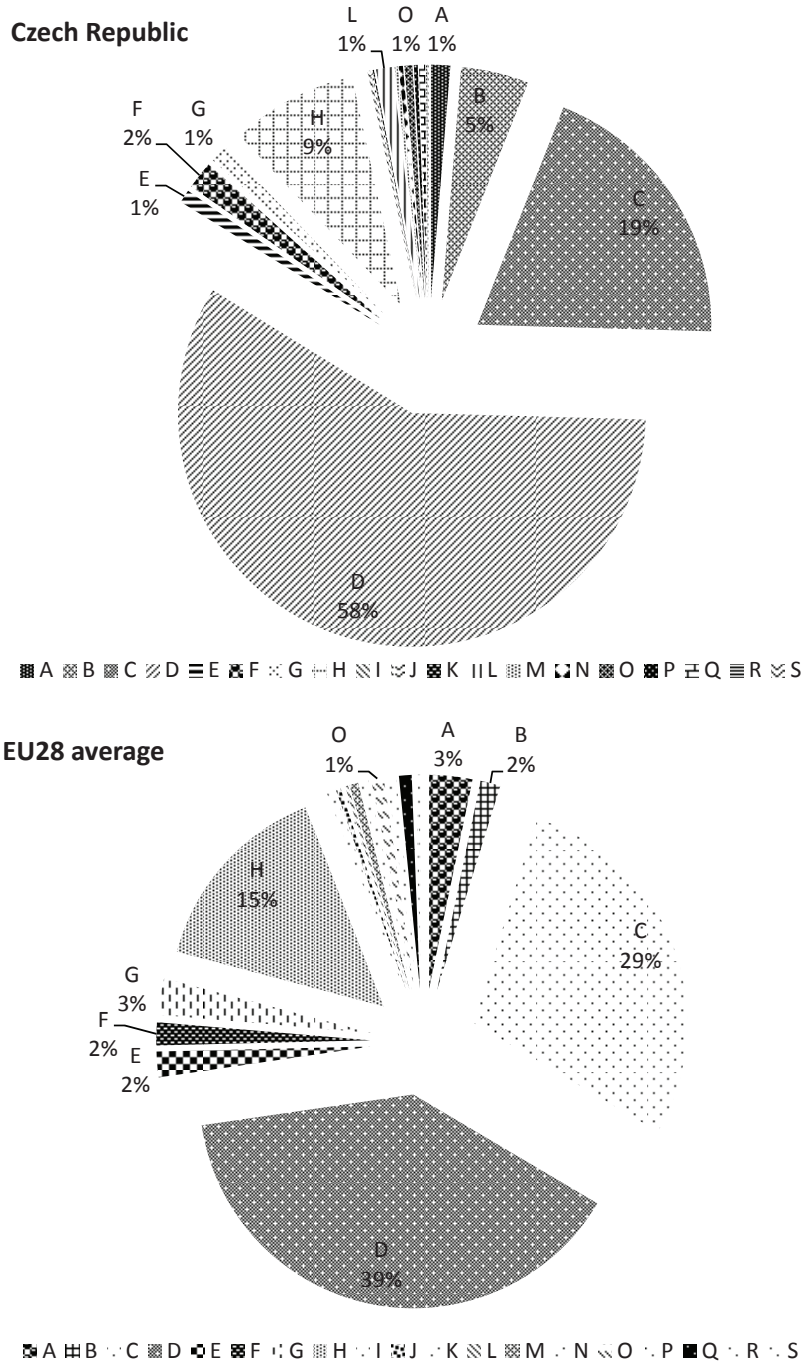
CO_2 equivalent (thousands of tonnes)	Czech Republic		EU28	
	Index 1990 = 100	Average 1990–2011	Index 1990 = 100	Average 1990–2011
energy	69.85	122,702	84.14	144,168
industry processes	60.14	13,832	72.52	14,295
solvent and other product use	61.30	573	60.61	470
agriculture	49.68	9,817	76.88	18,096
waste	136.77	3,128	65.90	5,712
Czech Republic total	**68.09**	-	**81.66**	-

Source: Eurostat, online data code: env_air_gge, own calculation and processing

Another aspect of **greenhouse gas emission** analysis is breakdown **by economic activity**. In the Czech Republic the largest shares of greenhouse gas emissions on economic activity are generated in the NACE[8] sections D (Electricity, gas, steam and air conditioning supply, specifically 55.5 mil tCO_2, 58%), C (Manufacturing, 18.5 mil tCO_2, 19%), H (Transportation and storage, 8.3 mil tCO_2, 9%), as well as in EUR28. It is corresponding with the results of emissions breakdown by industry sector, have been mentioned above. Primary industries including Agriculture, forestry and fishing (NACE A, specifically 1.2 mil tCO_2) play a minor role, it reached 1% as well as NACE E, G, L and O, and they are below the EU28 average. Further, mining and quarrying activities (NACE B) have been still dominated in the Czech Republic, it generates 5% of emissions (4.4 mil tCO2) in contrast to 3% of the EU28 average. Activities of construction (NACE F) generate 2% of greenhouse gas emissions in the Czech Republic as well as in EU28. For more details see Fig. III and Tab. IV below.

Furthermore, based on the development of emissions during 2008 to 2011 can be concluded that emissions are declining mainly in the industry sector comparing to the service sector. In the Czech Republic, the relatively largest increasing of emissions was indicated in the NACE I (Accommodation and food service activities), specifically by 60% during 2008 to 2011. Further, it was followed by wholesale and retail trade (NACE G) and professional, scientific and technical activities (NACE H), which generate by 29% more emissions than in 2008. Other activities, namely NACE Q and S increased their emissions slightly. The rest of activities in service sector and industry sector produce lower amount of emissions than in 2008, the trend of emissions generated is declining. The relatively largest decreasing (by 29%) was indicated in the sector of manufacturing

8 Explanation of NACE codes is in note 5 above



3: *Greenhouse gas emissions, breakdown by economic activity, 2011 (tonnes of CO2 equivalent)*
Source: Eurostat, online data code: env_ac_ainah_r2, own processing

(NACE C), mainly because of large investments into more environmental friendly production processes and recession of economy due to the financial and economic crises. However as was mention above, activities generated the largest part of emissions are energy (NACE D), manufacturing (NACE C) and transport (NACE H) with emissions in the amount of 82.4 mil tCO_2 equivalents from the overall amount of 95.24 mil tCO_2 equivalents. For more details see Tab. IV below.

The last part of greenhouse gas emission analysis includes the **carbon productivity** of the economy of the Czech Republic, by NACE section. Based on the results in Tab. V below can be concluded that almost all economic activities except (NACE I, A, M and G) had higher carbon productivity in 2011 than in 2008, i. e. that each NACE section produced higher amount of gross value added in the respect of 1 tCO_2 generated through each NACE sections. However, in 2011 all NACE sections altogether

IV: *Greenhouse gas emissions breakdown by economic activity at the Czech Republic*

CO_2 equivalents in tonnes by economic activity, Czech Republic					
NACE/period	**2008**	**2009**	**2010**	**2011**	**Change 2011/2008 in %**
A	1,329,864	1,299,864	1,264,521	1,256,417	94.48
B	4,732,618	4,376,769	4,530,015	4,457,942	94.20
C	25,849,877	21,546,813	19,893,655	18,521,359	71.65
D	55,987,097	52,706,680	56,770,398	55,581,445	99.28
E	1,007,914	929,727	887,570	873,905	86.70
F	2,182,133	2 068 610	1 938 741	1,829,098	83.82
G	910,711	1,173,499	1,080,430	1,174,921	129.01
H	9,879,734	9,166,114	8,733,926	8,330,344	84.32
I	115,133	212,425	176,582	183,615	159.48
J	110,698	116,191	117,048	108,068	97.62
K	91,490	95,474	83,795	85,951	93.95
L	1,233,266	1,162,841	1,251,633	1,052,493	85.34
M	158,372	225,407	243,594	204,759	129.29
N	322,823	320,968	310,762	274,874	85.15
O	626,281	594,569	583,389	521,629	83.29
P	270,697	352,979	264,849	246,755	91.16
Q	406,927	429,181	434,742	408,441	100.37
R	79,185	75,453	75,605	69,116	87.28
S	61,045	66,047	69,545	64,905	106.32
Total	**105,355,867**	**96,919,610**	**98,710,800**	**95,246,037**	**90.40**

Source: Eurostat, online data code: env_ac_ainah_r2, own calculation and processing

V: *Carbon productivity by economic activity at the Czech Republic*

Czech Republic Carbon productivity by NACE in EUR/t CO^2					
NACE/period	**2008**	**2009**	**2010**	**2011**	**Change 2011/2008 in %**
A	2,297.90	3,130.87	1,430.58	1,748.30	76.08
B	296.83	409.62	338.83	362.50	122.12
C	1,307.74	1,331.82	1,631.78	1,821.12	139.26
D	88.62	102.63	102.49	98.21	110.81
E	1,327.10	1,898.19	1,267.62	1,781.09	134.21
F	3,678.79	4,497.37	4,977.25	5,141.22	139.75
G	14,833.14	13,280.02	13,396.24	13,802.80	93.05
H	808.60	931.62	958.97	1,001.02	123.80
I	21,178.92	10,907.40	13,451.57	14,410.05	68.04
J	57,517.53	59,402.16	57,763.38	62,630.10	108.89
K	51,506.20	63,418.41	65,822.42	77,099.51	149.69
L	6,354.83	8,252.55	8,149.75	9,510.75	149.66
M	37,286.90	28,465.44	27,106.58	33,183.34	88.99
N	7,911.46	8,037.88	7,815.94	9,429.79	119.19
O	13,039.20	15,856.36	15,592.68	17,636.47	135.26
P	17,822.12	15,642.31	20,778.67	22,949.45	128.77
Q	10,625.73	12,395.95	12,353.99	13,762.35	129.52
R	16,285.83	19,643.97	20,537.07	23,256.40	142.80
S	21,535.11	22,860.89	22,598.24	25,632.96	119.03
Total	-	-	-	**1,446.82**	

Source: Eurostat, online data code: nama_nace21_k, env_ac_ainah_r2, own calculation and processing

VI: *Gross value added by economic activity at the Czech Republic*

Czech Republic Gross Value Added by NACE in Mil EUR					
NACE section/ period	**2008**	**2009**	**2010**	**2011**	**Change 2011/2008 in %**
A	3,055.9	4,069.7	1,809.0	2,196.6	71.88
B	1,404.8	1,792.8	1,534.9	1,616.0	115.03
C	33,804.9	28,696.4	32,462.0	33,729.6	99.78
D	4,961.7	5,409.2	5,818.2	5,458.4	110.01
E	1,337.6	1,764.8	1,125.1	1,556.5	116.37
F	8,027.6	9,303.3	9,649.6	9,403.8	117.14
G	13,508.7	15,584.1	14,473.7	16,217.2	120.05
H	7,988.8	8,539.3	8,375.6	8,338.8	104.38
I	2,438.4	2,317.0	2,375.3	2,645.9	108.51
J	6,367.1	6,902.0	6,761.1	6,768.3	106.30
K	4,712.3	6,054.8	5,515.6	6,626.8	140.63
L	7,837.2	9,596.4	10,200.5	10,010.0	127.72
M	5,905.2	6,416.3	6,603.0	6,794.6	115.06
N	2,554.0	2,579.9	2,428.9	2,592.0	101.49
O	8,166.2	9,427.7	9,096.6	9,199.7	112.66
P	4,824.4	5,521.4	5,503.2	5,662.9	117.38
Q	4,323.9	5,320.1	5,370.8	5,621.1	130.00
R	1,289.6	1,482.2	1,552.7	1,607.4	124.64
S	1,314.6	1,509.9	1,571.6	1,663.7	126.56
Total	**123,822.9**	**132,287.3**	**132,227.4**	**137,709.3**	**111.21**

Source: Eurostat, online data code: nama_nace21_k, own processing

generated lower carbon productivity at the amount of 1,446.82 EUR/tCO_2 in comparison with 2,348.57 EUR/tCO_2 for EU28. Further, in 2011, the highest carbon productivities were generated by NACE K and J, due to lowest emissions and higher gross value added, specifically in the amount of 77,099 EUR/tCO_2 and 62,630 EUR tCO_2. The highest improvement of carbon productivities were observed mainly by section[9] K and L (by 50%), R (by 42%), F and C (by 39%), O (by 35%) and E (by 34%). Improvements of carbon productivity were caused due to both decreasing of emissions (see Tab. IV above) and increasing of gross value added (see Tab. VI above) generated by individual sections. Comparing with the 4 exceptions, where a situation was different. In NACE G, I and M, the reduction of carbon productivity was caused due to increasing of emissions in individual sectors, e.g. the relatively largest increasing of emissions was in NACE I by almost 60% with impact on the reduction of the carbon productivity in the amount of 32% (for more details see Tabs. IV and V). However in case of NACE A the reduction of carbon productivity was cause by both factors – decreasing of emissions and gross value added, therefore there was indicated the relatively largest reduction in carbon productivity by 34%. For more detail see Tabs. IV, V and VI.

As was mentioned above, gross value added was increasing during 2008 to 2011 in almost all sectors, except of NACE A and C. However, sector C has been still generated the highest gross value added, at the amount of 33,729 mil EUR, compared with others. The second highest value of gross value added is generated through sector G – wholesale and retail trade, repair of motor vehicles and motorcycles – at the amount of 16,217 mil EUR. The relatively largest growth of gross value added was observed in NACE K by 40%. For more details see Tab. VI above. All those improvements had positive impact on carbon productivity (see above).

In addition, in the respect of energy intensity (EIb) i.e. the amount of energy required to produce a unit of gross value added, was observed that each NACE section had lower energy intensity in 2011 compared to 2008. However, in comparison with EU28 result in the amount of 150.19 TOE per mil EUR, the Czech Republic has had still higher energy intensity, specifically at the amount of 178.11 TOE per mil EUR, despite of the fact that the trend is declining by 14% compared to 2008. Further, the relatively largest reduction of energy intensity was indicated in NACE

9 Note 5 above include an explanation of NACE section

VII: *Energy intensity by economic activity at the Czech Republic*

Czech Republic Energy Intensity (EIb) by NACE in TOE / Mil EUR					
NACE/period	**2008**	**2009**	**2010**	**2011**	**Change 2011/2008 in %**
A	8,384.53	599.76	1,404.48	1,116.79	13.32
B	18,239.11	13,614.79	16,552.94	15,180.32	83.23
C	757.95	850.58	782.67	727.30	95.96
D	5,164.02	4,512.42	4,366.83	4,494.25	87.03
E	19,155.43	13,830.80	22,582.08	15,760.62	82.28
F	3,191.78	2,623.65	2,632.97	2,608.67	81.73
G	1,896.73	1,566.25	1,755.40	1,512.68	79.75
H	3,207.28	2,858.38	3,033.47	2,941.84	91.72
I	10,507.83	10,534.57	10,696.38	9,271.48	88.23
J	4,024.17	3,536.45	3,757.84	3,624.46	90.07
K	5,437.32	4,031.28	4,606.41	3,701.85	68.08
L	3,269.32	2,543.52	2,490.77	2,450.69	74.96
M	4,338.94	3,804.16	3,847.81	3,610.43	83.21
N	10,032.22	9,461.06	10,460.33	9,464.27	94.34
O	3,137.60	2,589.03	2,793.03	2,666.54	84.99
P	5,310.98	4,420.73	4,616.79	4,331.95	81.57
Q	5,925.74	4,588.00	4,730.60	4,364.16	73.65
R	19,868.41	16,467.82	16,363.17	15,261.54	76.81
S	19,490.57	16,165.71	16,166.39	14,745.09	75.65
Total	**206.90**	**184.48**	**192.12**	**178.11**	**86.06**

Source: Eurostat, online data code: nrg_100a, nama_nace21_k, own calculation and processing

A (agriculture), in the amount of 87%. The lowest energy intensity was observed in NACE C, it is mainly caused by the highest amount of gross value added generated through that sector in comparison with others. Contrary to other sectors, sectors B, E, R and S that generated the lowest gross value added, report the highest energy intensity. For details see Tab. VII and Tab. VI above.

4. DISCUSSION

Regarding the Kyoto targets, the Czech Republic is deeply below the 8% reduction's target, as well as 20% reduction's target. However its overall greenhouse gas emission per capita (12.73 tCO_2) is above of EU28 average (9.07 tCO_2 per capita). As regard as the energy intensity to GDP, it was observed a decreasing trend, specifically in the amount of 45% compared to 1995 in 2012. It is positive because for the production of one unit of economic output is used half of energy than in 1995. Moreover, similar positive trend in the amount of 15% was observed in case of the carbon intensity that presents lower emissions generated to meet the energy needs compared to 1995.

Regarding the source of greenhouse gas emissions in the Czech Republic, as the most important source was observed the energy industry including transport, which covers 82% of overall emissions and reaches average in the amount of 122,702 Mt CO_2. Further, the largest decline was reported in agriculture sector in the amount of 50.32% (average 9,817 Mt CO_2). The decreasing trend was also observed in other sectors, although in case of waste sector the increasing trend by 37% was detected. However, in the respect of EU28 average of emissions, except solvent and other product use sector, all sectors do not exceed the EU28 average.

Based on the detailed analysis (breakdown by economic activity), the primary industries including agriculture, forestry and fishing play a minor role in the Czech Republic, it generates 1% of overall emissions, although mining and quarrying industries are still dominated with 5% share on emissions. There is still visible fact that the Czech Republic has been focused on heavy industries. The largest shares of greenhouse gas emissions on economic activity were indicated in energy (NACE D, 58% of emissions), followed by manufacturing (NACE C, 19% of emissions) and transport (NACE H, 9% of emissions), as well as in EU28 and generate emissions in the amount of 82.4 mil tCO_2 from the overall amount of 95.24 mil tCO_2. Further, it is positive that almost all sector of economy produce lower amount of emissions than in 2008. The relatively largest decreasing by 29% was observed in the sector

VIII: *Overall evaluation of the development of GHE and other aspects at the Czech Republic*

Country	GHE[1,2] (2011)	Kyoto target (2008–2012/2013–2020)[1]	GHE per capita (2011)	Energy intensity[3] EIa (2012)	Carbon intensity[3] (2011)	Carbon productivity[4] (2011)	Energy intensity[4] EIb (2011)
	in tCO_2			in 1000 TOE per GDP	in tCO_2 per TOE	in EUR/t CO_2	in TOE per Mil EUR
EU28	83.07	-/80	9.07	0.13 (54.85)	2.69 (86.28)	2,348.57	150.19
CZ	68	92/80	12.73	0.20 (54.74)	3.09 (85.43)	1,446.82	178.11

(1) indexed to 1990
(2) greenhouse gas emissions
(3) indexed to 1995, result in brackets
(4) total for all NACE
Source: Eurostat/EEA, own calculation and processing

of manufacturing, mainly because of large investments into more environmental friendly production processes during last decade and also mainly recession of economy due to financial and economic crises, which reduced economic activities and production.

Furthermore, based on the carbon productivity of the individual areas of the economy can be concluded that almost all economic activities except (NACE I, A, M and G) had higher carbon productivity in 2011 than in 2008, i.e. higher amount of gross value added was generated in the respect of 1 tCO_2. Improvements of carbon productivity were caused due to both decreasing of emissions and increasing of gross value added generated by individual sectors. However, in case of agriculture (NACE A) was observed the relatively largest decline of carbon productivity in the amount of 34% due to decreasing of emissions and gross value added generated by that sector. The highest carbon productivity is generated by NACE K and J with contrast to the lowest carbon productivity in NACE D. In addition, it was indicated the increasing trend of gross value added in all sectors of economy except of agriculture and manufacturing sectors. Although the sector of manufacturing is still generated the highest gross value added in the amount of 33,729 mil EUR.

Regarding the energy required to produce a unit of gross value added i.e. energy intensity, was observed that each NACE sectors has lower energy intensity than in 2008. The relatively largest reduction of energy intensity was indicated in NACE A, in the amount of 87%. Further, sectors B, E, R and S have the highest energy intensity in the amount around 15 tis. TOE per mil EUR in contrast with the lowest in case of manufacturing (NACE C).

Finally, if all factors were evaluated altogether (for details see Tab. VIII below), it can be concluded that although the Czech Republic is deeply below Kyoto targets, there are other aspects of emissions and areas where is place for improvements, e.g. in case of both energy intensities, as well as in case of carbon intensity and carbon productivity, where the Czech Republic reaches worse results than the EU28.

Based on the results can be recommended to decrease greenhouse gas emission and increase gross value added generated by each NACE sector. Both those factors will impact on improvement of energy intensity, carbon productivity as well as greenhouse gas emissions per capita.

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