ENERGY USE AND ITS RELATED EMISSIONS IN EUROPEAN UNION'S AGRICULTURE

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Abstract
The requirements of diminishing the energy use at European Union's level was highly emphasized when were adopted the 2020 targets in its development strategy. The economic, social and environmental implications represent the causes that were the basis for this decision. The agriculture represents an important sector in the EU's policies, because the member states must assure the food security and safety for the future in very uncertain conditions and with uncertain incomes for farmers. The main objective of this paper is to analyze the energy consumption and the emissions generated by it from agriculture at EU level. For better results, was made a comparative historical analysis for European Union on 11 years. The results show a reduction of EU's energy consumption from agriculture by 12.29% during 2000-2010 and the CO_2 emissions generated by the energy use in agriculture have decreased by 15.02% during the analyzed period of time, meaning that the sustainable policies for reducing the energy consumption and emissions in agriculture started to be effective.
Keywords Agriculture, comparative data analysis, energy use, European Union, greenhouse gas emissions

Introduction

By adopting the 2020 Europe Strategy, the European Union emphasized the need of reducing the energy use and the greenhouse gas (GHG) emissions in order to mitigate climate change. The GHG emissions have increased drastically after the industrial revolution due to the high use of fossil fuels that is why the policy makers have acknowledged the necessity of adopting concrete measures for diminishing the energy use and the GHG emissions in all sectors of economy. The structure of economy in each EU Member States is different, but nevertheless the agriculture represents an important source of pollution by emitting methane, ammonia and carbon dioxide from the use of fertilizers and pesticides, from the use of some pollutant types of crops, from the management practices of land resources, from livestock, from residues. Also, the agriculture represents an important cause of energy use that contributes to climate change by using more energy resources which generate a high amount of GHG emissions. In this context, are required analyses on the relation between agriculture and energy sector, as well as studies on the impact of the energy used in agriculture. This paper focuses on finding the evolution of energy use in agriculture and its related emissions during 2000-2010 for EU28. The analysis was made only for the 28 countries, with Croatia, although are not presented the agricultural characteristics for Croatia, because of the lack of data on agricultural indicators and structure in the analyzed period of time. The data used was provided from European Commission and FAOSTAT for using it at a comparative historical analysis for all EU

member states. The objectives of this research are: to establish some characteristics of EU member states regarding agriculture that could influence the energy use and the level of GHG emissions; to achieve a comparative historical analysis of the energy consumption in EU agriculture in order to determine the Member States that have critical energy consumption; to apply a comparative historical analysis of the GHG emissions generated by the energy used in the agriculture of Member States in order to determine its amount of pollution in total EU agriculture pollution. The results represent a starting point for improving the current energy and environmental policies.

1. Literature review

The relation between agriculture, energy and greenhouse gas emissions is highly explained and analyzed by specialists and policy makers, because a high use of energy in agriculture would lead to increases of GHG emissions, and, furthermore, would contribute to climate change whose negative effects will be reflected back on agriculture, and on human society and Earth. Thus, Zaharia and Antonescu (2014) present the relation between agriculture and climate change like a negative bidirectional relationship, because, from one hand, the agriculture generates GHG emissions and, on other hand, the climate change affects the good development of agricultural activities. Also, Pelletier et al. (2011) consider that food security could be achieved by a careful energy use due to the presence of a "complex relationship between energy use, food system productivity, and energy resource constraints and that the energy efficiency measures must not be restricted to technological means, but also must consider the roles of social, political, and economic contexts in shaping current and future food system trajectories". Other studies focus on determining improvements in the crop management for reducing energy use, like Alluvione et al. (2011) who demonstrate that the integrated farming techniques contribute to energy efficiency which ultimately produces the reduction of GHG emissions from agriculture. There are also studies which analyze the energy consumption and greenhouse gas emissions for crops, livestock, and mixed combination of those two. Mixed farms generate higher energy consumptions with few possibilities of reducing it, but are more flexible over time for system economic adjustment, and the GHG emissions could be diminished in the case of cattle by improving the feed management and genetics and adopting organic farming (Veysset et al., 2010). The greenhouse gas emissions from agriculture could be reduced if is acting on the way of "handling the manure and fertilisers, optimization of animal feeding, cropping practices, and land use changes with more organic farming, afforestation and energy crops" and it could be achieved a positive energy balance in agriculture by increasing bioenergy without affecting the food security (Dalgaard et al., 2011). In order to determine the most pollutant livestock were analyzed different types of livestock, because, around 2005, "it farming has an impact on global warming with about 10% of total GHG emissions from the EU-27 due to differences in animal production systems, feed types and nutrient use efficiencies" (Lesschen et al., 2011). Smith (2012) considers that in the past years have been developed many assessment models and methods and have been proposed mitigation measures for GHG emissions from agriculture considering the fact that population and its food needs are increasing. According to Harvey and Pilgrim (2011), in order to achieve a bio-economy and

a sustainable agriculture must be considered, as an integrated approach, all the influential factors, like energy and food demand, petro-chemical depletion, the various sources of anthropogenic climate change involved in land use, as well as, the new technologies generated by science and the innovation in the field.

2. Results and discussion

2.1 Some indicators of the EU's Member States agriculture

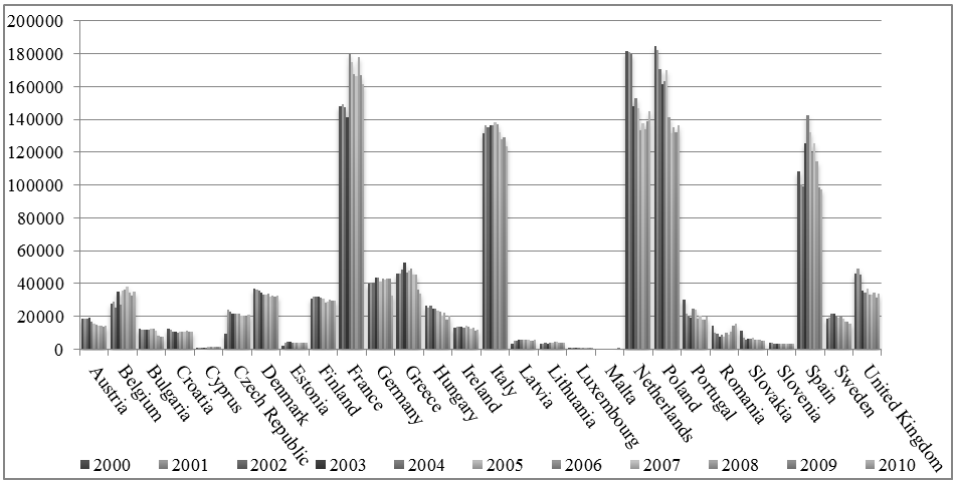
Each Member State presents some characteristics of agriculture and of economy structure that must be consider when analyzing the use of energy and the generated emissions. The agriculture sectors of Member States are different in what concerns the utilized agricultural area (UAA) per holding, the gross value-added, the structure of production, the net outcome generated, the technology use, and so on. We analyzed the share of agriculture in the GDP, the employed population in agriculture, the UAA per holding, and the gross added-value at basic prices from agriculture. According to European Commission (2011), the share of agriculture in the GDP of EU27, as well as EU15, represented 1.2% in 2010 while in 2000 the EU15 share of agriculture in the GDP was 1.7%. The percentage of rural population and the employed population in agriculture in the European Union differs from country to country and this differences influence the analysis of the energy use and its emissions from agriculture. According to European Commission, only five Member States (France, Poland, Germany, Italy, and Romania) summed up in 2010 a percentage of 60.4 of total EU rural population (European Commission, 2014), meaning that for these countries the development of rural areas is very important. An interesting fact is that, from those five countries, only Romania and Poland had the highest shares in the employed working population from EU of 19.1% and of 10.1% (European Commission, 2012), meaning that, for achieving social welfare, the agriculture sector is critical in Romania and Poland and for increasing its performance must be implemented effective policies. The EU27average population employed in agriculture represented in 2010 4.7% of total EU27 employed working population and this average was overachieved by 8 Member States. In 2000, 7 Member States of EU15 overachieved the EU15 average of employed working population in agriculture which represented 4.3% of total EU15 employed working population, the high average value of employed population in agriculture being caused mainly because of Greece (17%) and Portugal (12.5%), while the rest of the EU27 countries achieved an average of 10.6% because 5 countries of 12 had the value over 10%. In 2000, the average of employed working population in Romanian agriculture had been 45.2% of total employed population, meaning that during 2000-2010 Romania has reduced her share by more than half (European Commission, 2012). Even though in 2000 EU had only 15 Member States, we have calculated the average of the employed working population in agriculture for EU27 which represented 7.48% of total EU27 working population from 2000. This descending trend of the working population in agriculture represents a positive situation, because the effectiveness of agriculture activities, the use of technologies and the improvements of managerial practices is increasing. The EU27 UAA per holding had in 2007 12.6 ha, the largest area being in Czech Republic of 89.3 ha per holding and the smallest areas being in Malta of 0.9 ha per holding and in Romania with 3.5 ha per holding. Somehow, the small UAA per holding in Malta can be justify by the small area of the

country, but, in the case of Romania, this justification cannot be applied because the UAA of the country is big, so it could be concluded that Romania should increase its UAA per holding for achieving a better agricultural performance in the future. A way of doing that is association. Another important indicator relevant for the energy use in agriculture is the gross value-added. The total EU27 gross value-added at basic prices of agriculture in 2010 was 143,810 million euro, the highest net outcome contribution being brought by France (27,172 million euro) and the lowest being brought by Malta (57 million euro), while the total EU27 gross value-added at basic prices of agriculture in 2001 would have been 170,362 million euro, the highest net outcome contribution being brought by France (32,205 million euro) and the lowest one being brought by Malta (88 million euro). In 2010, Romania was situated on 8th regarding the agricultural net outcome contribution, with 6,456 million euro, while, in 2001, Romania would have been situated on 9th regarding the agricultural net outcome contribution for EU27, with 5,709 million euro, if it had been part of EU in 2001 (European Commission, 2001 and 2011). These analysed agricultural indicators must be the starting point in presenting the evolution of energy use and of emissions from agriculture, because without them could not be explained the different uses of energy and the Member States could not be properly compared among them.

2.2 The energy consumption of Member States in agriculture: a comparative historical analysis

One of the European Union's objectives in the energy sector is to increase the energy efficiency in order to diminish the use of fossil fuels which contribute to GHG emissions and eventually to climate change. As the population's needs are increasing and the non-renewable resources are decreasing or the capacity of the renewable ones is shrinking, than food security is very important all over the world, including in EU. The percentage of the energy used in agriculture and forestry has decreased in EU28 by 0.25% during 2000-2009. From 28 Member States, 10 countries have registered an increase of this percentage and the rest 18 a decrease. The energy use in Poland agriculture and forestry registered the highest decrease from EU28, by 2.43% of total energy use between 2000 and 2009, while in Cyprus the energy use in agriculture and forestry has registered the highest increase at EU28 level, by 1.57%. According to FAOSTAT (2014a), in 2009 the highest share of agriculture and forestry energy use of total energy use has been registered in Poland (5.51%), in Netherlands (5.41%) and in Denmark (4.98%) while in 2000 the highest share of agriculture and forestry energy use of total energy use has been registered in Poland (7.94%), in Netherlands (6.84%) and in Greece (6.01%). Also, in 2009 the lowest share of agriculture and forestry energy use of total energy use has been recorded in Malta (0.31%), Germany (0.45%), UK (0.64%), and Luxemburg (0.79%) while in 2000 the lowest share of agriculture and forestry energy use of total energy use has been recorded in Germany (0.4%), Luxemburg (0.56%), Cyprus (0.57%) and UK (0.76 %). So, some EU countries have reduced their percentage of energy use from agriculture and forestry a lot more than others and some EU states have increased their percentage. The increases of the percentage of energy use from agriculture and forestry could be due both to increases of energy use because of a bad management of farms and to decreases of energy use from other sectors of economy. The total energy consumption in EU28 agriculture has decreased during 2000-

2010 by 12.29%. This decrease could be due to the adaptation of EU strategy for sustainable development since 2001 (European Council, 2001). Figure 1 illustrates the comparative analyses of the total energy consumption in EU28 over the 11 analyzed years.



Source: FAOSTAT, 2014

Fig. 1 Total energy consumption in agriculture in EU28, between 2000 and 2010

It could be easily seen that in 2010 the highest energy consumptions over European Union has been recorded in France, Netherlands, Poland, Italy and Spain with more than 97,000 Terajoule each of consumed energy in agriculture, all these countries summing up 664,014.42 Terajoule, while in 2000 Poland, Netherlands, France, Italy and Spain consumed in agriculture more than 108,000 Terajoule of energy each state, all these countries summing up 754,786.91 Terajoule of consumed energy in agriculture, meaning that more than 65% of EU28 energy was consumed in agriculture by only 5 Member States. In the following, the performed analysis will highlight these five states. There are 9 Member States, among which is also Romania, which registered increases in the total energy consumption in agriculture during the analyzed period of time, Cyprus and Czech Republic having the highest increases, by 352.79% and 116.11%. The evolution of Malta cannot be analyzed due to the lack of data. During 2000-2010, the highest decreases of energy consumption in agriculture have been recorded in Slovakia and Bulgaria, by 51.58% and 41.41%. As can be observed in table 1, 4 of the 5 critical Member States presented above (France, Netherlands, Poland, Italy and Spain) have decreased their total energy consumption in agriculture and France, the member state with the highest energy consumption in agriculture in 2010, has increased its consumption during 2000-2010 by 8.86%.

Table 1 Indices of energy consumption in the EU Member States during 2000-2010 *

EU / Member State	Total energy consumption	Gas-diesel oils	Gasoline	Natural gas	Liquefied petroleum gas	Residual fuel oil	Hard coal	Electricity	Energy for power irrigation
	%								
Austria	-24.33	-9.50	-	-3.15	-20	-69.23	-	-35.20	-
Belgium	25.73	-12.66	-	1534.37	-	-94.70	-	221.40	-

EU / Member State	Total energy consumption	Gas-diesel oils	Gasoline	Natural gas	Liquefied petroleum gas	Residual fuel oil	Hard coal	Electricity	Energy for power irrigation
	%								
				**					
Bulgaria	-41.41	-51.02	-	90	200	-100	-20	29.14	-
Croatia	-15.50	-15.97	-33.33	52.27	50	-71.43	-	0.00	-
Cyprus	352.79	-14.81**	-	-	-	-	-	61.05	0.00
Czech Republic	116.11	31700	-	-6.31	-77.78	-91.89	-77.78	-8.97	-
Denmark	-11.90	-11.51	-50	-19.78	-40.00	-68.18	31.71	-1.64	-
Estonia	75.01	142.31	-100	219.33	-	-50.00	-100	-13.24	0.00
Finland	-5.01	-11.44	-33.33	-21.94	0.00**	54.35	40	9.76	-
France	8.86	22.47	-	-30.49	-35.75	-50.00	-	29.16	-
Germany	-18.95	-	-	-100	-	-	-100	19.87	-
Greece	-27.19	-32.76	-50	-	-	33.33	-	-8.42	-
Hungary	-24.67	-15.36	-	-36.80	28.57	-88.24	-	-20.42	-
Ireland	-12.73	-14.67	-	-	-	-	-	-2.11	-
Italy	-6.25	-9.44	-78.85	21.44	-11.43	-	-	14.33	-
Latvia	84.34	169.23	-100	26.56	-	-100	0.00	-11.46	-
Lithuania	12.76	28.13	-80	25.41	0.00	-50	0.00	-0.53	-
Luxembourg	44.16	50.00	-	100	-	-	-	14.71	-
Malta	-	-	-	-	-	-	-	-	-
Netherlands	-20.10	-28.35	-	-29.33	4.35	-	-	93.83	-
Poland	-25.91	-34.87	-96.77	177.48	25	-83.57	17.26	-65.98	-
Portugal	-35.45	-46.26	-	2950	-30	220**	-	43.50	-
Romania	8.24	-20.25	-66.67	245.01	2200	-	-	9.82	-
Slovakia	-51.58	-54.23	-100	-33.17	-33.33	-	-100	-53.65	-
Slovenia	-12.34	0.00	-20.00	-	-	-	-	-	-
Spain	-10.48	-14.64	-	10.06	-46.48	-73.02	-	18.89	-
Sweden	-16.55	-25.61	-	10.24	0.00	-44.44	-	5.71	-
United Kingdom	-26.16	-73.70	-	29.38	5537900	10.00	-85.71	-7.55	-
EU28	**-12.29**	**-14.07**	**-66.84**	**-19.87**	**-6.17**	**-64.54**	**14.38**	**7.67**	**0.00**

Source: own calculations using FAOSTAT data, 2014

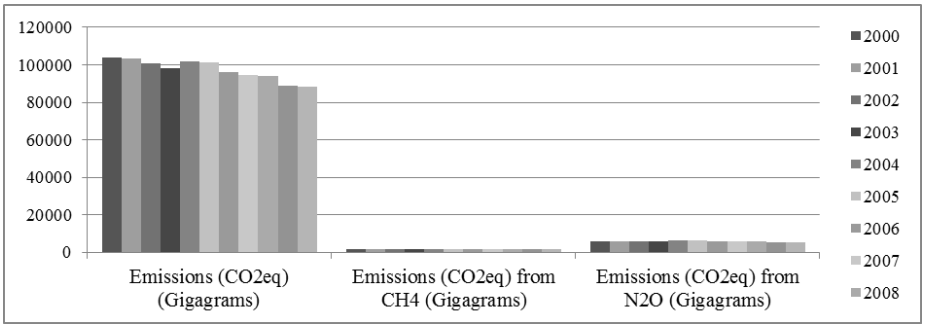
*Formula: %=(value of 2010-value of 2000)/ value of 2000 * 100

** Base year in formula*: 2005

The indices which indicate the value 0.00 represent the maintenance of a steady trend and the ones which have the value -100 show a decrease of energy consumption up to 0. The majority of the developed countries have increased their electricity consumption in agriculture and have decreased their use of gas-diesel oils. All 12 EU countries, for which we have been able to calculate the indices, have reduced their gasoline consumption in agriculture. At EU28 level, the sources of energy which have recorded increases in their use during 2000-2010 were the energy consumption from hard coal by 14.38% and the energy consumption from electricity by 7.67%, meaning that the policy makers should propose more intensive measures for diminishing the energy consumption in agriculture by supporting green investments, green technologies, green agricultural practices, and by adopting programmes of education for all the farmers and landowners.

2.3 Emissions generated by energy use in EU agriculture: a comparative historical analysis

Another EU objective in the energy sector is the reduction of GHG emissions in order to mitigate climate change and because of the diminution of non-renewable energy resources. The EU28 agriculture generates about 10% of the total GHG emissions and of about 1.11% of worldwide GHG emissions and the trend of the emissions generated from agriculture is descending over time (Zaharia and Antonescu, 2014). In agriculture, the emissions derived from bad manure management, enteric fermentation, rice cultivation, use of synthetic fertilizers, bad crop management, cultivating organic soils, burning crop residues and savannah and from energy use. In figure 2 is illustrated the GHG emissions from energy use in agriculture during 2000-2010 and could be observed the high share of CO_2 emissions.



Source: FAOSTAT, 2014

Fig. 2 Total EU28 emissions from energy use in agriculture between 2000 and 2010, by type

The emissions generated by the energy use in agriculture have overall decreased during 2000-2010, but the emissions from CH_4 have increased by 6.4% while the CO_2 emissions and the N_2O emissions have decreased by 15.02% and by 13.76% in the analyzed period of time. 8 countries from 28 have not decreased their CO_2 emissions from energy use in agriculture, among which is situated also France, which increased its emissions by 10.51%, an obvious thing considering the fact that only France – from the 5 critical Member States – has increased its total energy consumption in agriculture by 8.86% while its share in the total EU28 quantity of energy use emissions in agriculture represented in 2010 13.96%. In 2010 and in 2000, Poland, France, Netherlands, Italy, and Spain, have had the highest quantity of emitted CO_2 emissions from EU28 agriculture while the smallest CO_2 emitted emissions have been recorded in Malta, Luxemburg, Cyprus, Slovenia, Lithuania, and

Latvia. 15 EU countries from 28 have increased their CH_4 energy use emissions in agriculture during 2000-2010 and in 2010 Poland, Germany, Netherlands, Spain, and Italy, had the highest amounts of emitted CH_4 energy use emissions in agriculture while Malta, Slovenia, Luxemburg, Croatia, Cyprus, and Latvia, emitted the smallest quantity of CH_4 energy use emissions in agriculture. Only one of the five critical member States regarding the highest amount of CH_4 energy use emissions generated in agriculture – Poland – has decreased its CH_4 energy use emissions in agriculture by 8.95%, considering that its share in total EU CH_4 energy use emissions in agriculture was in 2010 22.01% and that has decreased its total energy consumption in agriculture by 25.91%, while the rest four countries, namely, Netherlands, Spain, Germany, and Italy have increased their CH_4 energy use emissions in agriculture by 61.54%, 16.55%, 14.72%, and 10.14% even though their total CH_4 energy consumption in agriculture have decreased by 20.10%, 10.48%, 18.96%, and 6.25%; all this four countries represented in 2010 43.14% of total EU CH_4 energy use emissions in agriculture. In what concerns the N_2O emissions from energy use in agriculture, in 2010, France, Italy, Poland, Spain, and Greece had the highest shares of the total EU N_2O emissions from energy use in agriculture, of about 66.16%, while the lowest shares was in the case of Malta, Luxembourg, Cyprus, Lithuania, and Germany, with about 0.98% of total EU N_2O emissions from energy use in agriculture. One of the five critical Member States regarding the highest amount of N_2O energy use emissions generated in agriculture – France – has increased its N_2O energy use emissions in agriculture by 22.27%, considering that its share in total EU N_2O energy use emissions in agriculture was in 2010 21.39% and that has increased its total energy consumption in agriculture by 8.86% during 2000-2010, while the rest four countries, namely, Italy, Poland, Spain, and Greece, have decreased their N_2O energy use emissions in agriculture by 9.26%, 34.18%, 14.20%, and 32.35%, also because their total N_2O energy consumption in agriculture have decreased by 6.25%, 25.91%, 10.48%, and 27.19%. The analyzed situation shows that the countries which are the highest polluters have the highest impact on environment that is why they should promote more the sustainable policies and practices in agriculture, especially France, who is an important actor on the international market in what concerns agriculture. In table 2 were calculated the percentages of energy use emissions from agriculture in total agriculture emissions in order to understand the high importance of energy use management at EU level.

During 2000-2010, the shares of energy use emissions from agriculture in total agriculture emissions have decreased by 1.2% in the case of CO_2 emissions and by 0.2% in the case of N_2O emissions while in the case of CH_4 emissions, the share have increased by 0.11%. The CO_2 emissions form energy uses in agriculture have the largest share in the total CO_2 emissions generated by agriculture. All these aspects impose the diminution of CO_2 emissions from energy use in agriculture by adopting sustainable strategies for those agricultural activities that consumes and pollute heavily due to the high use of energy.

Table 2 Percentage of energy use emissions from agriculture in total agriculture emissions -%-

Share of EU28 emissions	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2010-2000
CO_2 emissions	18.88	19.10	18.90	18.53	19.16	19.39	18.71	18.36	18.42	17.86	17.68	-1.20
CH_4 emissions	0.67	0.70	0.67	0.66	0.69	0.71	0.74	0.73	0.77	0.76	0.77	0.11
N_2O emissions	2.87	2.84	2.84	2.84	3.01	3.10	2.89	2.76	2.81	2.77	2.67	-0.20

Source: own calculations using FAOSTAT data, 2014

Always, must be remembered that the fossil fuels are limited, the reserves started to reduce a lot in the past century, so the human society, which is dependent on energy, should be more careful with the ways of using the energy resources in the future. Also, for now, without energy resources, the objectives of Common Agriculture Policy, especially food security, could not be achieved, and all the efforts in this regard made so far would be in vain.

Conclusions

This research shows the positive or negative situation of EU Member States in what concerns the agriculture energy consumption and the emissions generated by energy use in agriculture. The EU strategy for sustainable development proposes the presence of equilibrium between the economic, social and environmental pillars, this means that the natural resources must be exploited and use in a more environmental-friendlier manner for achieving eventually the social welfare. During 2000-2010, the percentage of energy use from agriculture and forestry has slowly decreased, because were countries which registered increases that could have been due both to increases of energy use because of a bad management of farms and to decreases of energy use from other sectors of economy. Also, the total energy consumption in EU28 agriculture has decreased by 12.29% during the analyzed period of time; this positive situation generating lowest GHG emissions into atmospheres from agriculture. Overall, the energy use GHG emissions from agriculture have decreased during 2000-2010, but the CH_4 emissions from energy use in agriculture have increased by 6.4% and the CO_2 emissions and the N_2O emissions have decreased by 15.02% and by 13.76% in the analyzed period of time. The CO_2 emissions form energy uses in agriculture have the largest share in the total CO_2 emissions generated by agriculture, around 18%, so it is imperious to act on these emissions and on the agricultural activities which generates them. The shares of energy use emissions from agriculture in total agriculture emissions have decreased by 1.2% in the case of CO_2 emissions and by 0.2% in the case of N_2O emissions and, in the case of CH_4 emissions, the share have increased by 0.11%. The highest impact on environment generated by energy consumption and its GHG emissions in agriculture is caused by the countries which are the highest polluters, like France, who is an important actor on the international market in what concerns agriculture, that is why they should promote more the sustainable policies and practices in agriculture. So, as the needs of the population are increasing, the food security and safety must be met, the non-renewable resources are decreasing, the capacity of the renewable ones is shrinking, and the sustainable development requires the protection of environment and human health in the economic activities, than the use of energy sources must be carefully managed in agriculture. It is not enough to treat the bad management practices, but also t is required to prevent the high uses of energy and the generation of high quantities of GHG emissions, in order to achieve the economic, social and environmental equilibrium and to achieve social welfare.

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