CHAPTER 4: OIL AND NATURAL GAS SYSTEMS IN ECUADOR: AND ESTIMATE OF METHANE EMISSIONS

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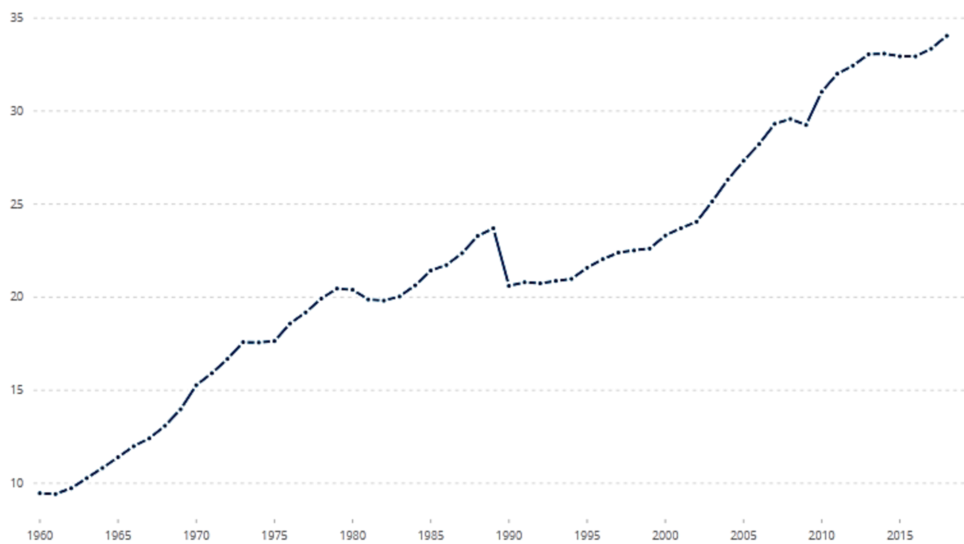
4.1. Introduction

The problem of global warming is caused by the greenhouse effect. Greenhouse gasses (GHG) are atmospheric gasses that retain most of the radiation emitted from the ground, retaining it in the atmosphere. In recent years, anthropogenic activities such as solid waste management, deforestation, burning of fossil fuels, livestock farming, waste generation, agriculture, among others, have increased global warming, causing a series of catastrophes evidenced by the increase in the average ocean and terrestrial atmosphere temperatures (Barboza Lizano, 2013). Studies show that global CO_2 emissions (see figure 8), far from stabilizing, have experienced significant growth in recent years (World Bank, 2021). It is known that 97% of the anthropogenic greenhouse effect is caused by six GHGs: Carbon Dioxide (CO_2), Water Vapor (H_2O), Methane (CH_4), Nitrogen Oxides (N_2O), Ozone (O_3) and Chlorofluorocarbons (CFCs). (León Aristizábal & Benavides Ballesteros, 2007).

Although we can identify all the gasses mentioned above, methane plays a debated role because it is the second most critical greenhouse gas and is estimated to have caused 25% of anthropogenic global warming. Studies show that it has a global warming potential (GWP) 28 to 34 times greater than CO_2 within a time period of one hundred years, and 84 to 87 times greater in a time period of twenty years.

Figure 8.

Global CO2 emissions.



The group of experts in charge of quantifying, evaluating and presenting annual reports regarding scientific, socioeconomic and technical knowledge on climate change, its causes, possible repercussions and response strategies, is the Intergovernmental Panel on Climate Change, known as IPCC, created in 1988. This support body established the methodologies to estimate GHG emissions and is periodically updating them in such a way that it allows us to know, in a global context, how much warming each country accounts for. In November 2014, the fifth AR5 evaluation report (Fifth Assessment Report) was completed and approved. It highlights, with certainty, that 95% of the main cause of global warming comes from human activities, and states that the risks will be greater if they are not controlled, which will have irreparable effects on the population and ecosystems (AR5 Synthesis Report, nd) (IPCC, 2015).

Different studies have been carried out to quantify methane in different sectors such as agriculture and livestock. However, few analyses have focused on the oil and natural gas sector.

4.1.1. Methane leakage in the oil and natural gas industry

Most greenhouse gas emissions come from the use of fossil fuels such as coal, oil and natural gas. The growing and demanding extraction of these fossil fuels is exacerbating the problem of global warming due to the constant use of petroleum alloys and their derivatives in most elements of our daily lives. The oil and gas industry represents the largest industrial source of methane, with research indicating that 25% of current warming is due to man-made methane pollution. According to a study conducted by Mexico (Mario Molina Center, 2015), approximately 3.5 trillion cubic feet (98 billion cubic meters) of methane escaped from the global oil and gas supply chain in 2012. The study refers to emissions of unburned methane fugitives, which disappear when pipeline maintenance, leaking tanks or burners (in the oil industry) do not fully consume the gas and leak directly into the atmosphere. The problem is that methane leaks are more harmful and much more powerful greenhouse gasses, causing adverse environmental impacts.

According to the literature, the main sources of leaky methane emissions are found in energy production processes, from oil and natural gas systems, to coal mining (Global Methane Initiative, 2012). Methane, the main component of natural gas, is a much more powerful greenhouse gas when it leaks into the atmosphere. In addition, the use of natural gas (NG) is considered a "bridge fuel" in the transition to renewable energy and has been growing since the large-scale implementation of horizontal drilling and hydraulic fracturing technologies to tap shale resources.

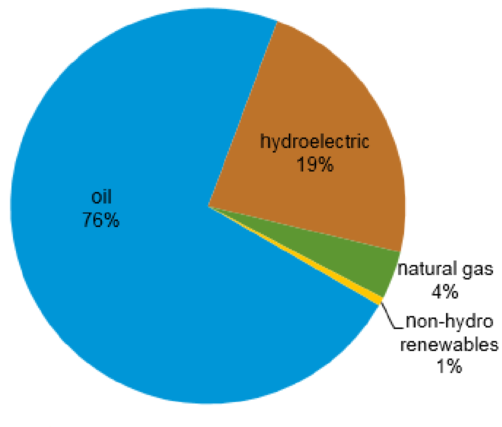
Based on a recent CH4 emissions extract from the well to the end user, (Alvarez et al., 2012) it is estimated that 2.3% of gross NG production in the United States is emitted to the atmosphere. CH4 emissions from the supply chain at this loss rate nearly double the immediate future climate impact of burning NG for energy.

Research also warns that global methane emissions from the oil and gas industry could increase by almost 20% by 2030, compared to a projected 10% increase in carbon dioxide emissions related to energy use (Dlugokencky et al., 2011). The extraction of oil and, to a lesser extent, natural gas, generate important income. However, studies observe that there are high geological risks involved in the exploration of oil and gas that involve the escape of methane. According to the reviewed literature on oil and gas emissions, many authors have focused on measuring emissions from emission sources, such as basins, facilities, abandoned wells (Singh et al., 2021; Waxman et al., 2020), but chain-wide studies of oil and natural gas systems are quite limited.

4.1.2. Main cñimate risk in Ecuador: Energy sector

Figure 9.

Ecuador´s energy sector.



Source: U.S. Energy Information Administration EIA

Ecuador is a mega-diverse country with a privileged location, but it is contemplative in the face of the environmental impacts and conflicts generated by climate change. Ecuador has the third largest oil reserves in South America and is the fifth largest oil producer in this region. In addition, Ecuador's energy mix is highly dependent on oil, which accounted for 76% of the country's total energy consumption in 2016. In October of the same year, Ecuador published its National Energy Agenda 2016-2040, which was designed for the transition of the Ecuadorian energy sector to a more diversified energy matrix (EIA. US. Energy Information Administration, 2021). However, this growth means intense exploitation of natural resources and climate risk (see figure 9).

According to official data from the Ministry of Energy and Non-Renewable Natural Resources (MERNNR, 2020), the country's population increased by 2.5 million people between 2010 and 2020, its GDP had an accumulated increase of 17.4% and energy consumption per capita, in the same period, showed an increase of 33.0%, going from 1,105 kWh per inhabitant to 1,470 kWh per inhabitant. This created a greater demand for energy production coming mainly from fossil sources in Ecuador, with oil being the most important primary energy source. Statistical data shows that, in 2018, the total production of primary energy considering oil exports was 216 million barrels of equivalent oil (BOE); of these figures, 87.5% was oil and only 7.8% was renewable sources.

The critical events caused in recent times by the oil and natural gas industry in the country have caused irreversible damage to both people and the environment. Studies show the correlation between the oil industry and social welfare, especially in areas of the Ecuadorian Amazon. There is evidence of health problems, quality of housing and poverty. Pollution and the propagation of conflicts in oil exploitation areas demonstrate poor environmental management in these sectors and create a hostile environment, generating latent and radical conflicts (Fontaine, 2005). CO_2 emissions are severely linked to the consumption of fossil fuels. Therefore, it is important for institutions to create energy policies to mitigate them.

This concern has been the subject of different studies related to the increase in energy consumption, CO_2 emissions and the policies implemented in recent years in Ecuador. The research of Arroyo & Miguel (2019) includes an analysis of Ecuador's CO_2 emissions and possible scenarios for 2030, and shows that Ecuador does not present an encouraging outlook in terms of economic projections and will not contribute to a decrease in CO_2 emissions, and require necessary policies to improve the quality of life in the country. In addition, the efficiency of the energy required to power a production unit in Ecuador is high, which increases the production of CO_2 emissions. Another study (Robalino-López et al., 2014) analyzes in detail how changes in the energy matrix and the Gross Domestic Product (GDP) would affect Ecuador's CO_2 emissions and underlines the importance of energy efficiency and the reduction of share of fossil energy. On the other hand, it is observed that the technologies used in the electrical matrix of Ecuador that consume locally produced fuels such as oil and natural gas, are inefficient from an environmental point of view, because they are technologies from the 70's (Oscullo & Haro, 2016), which creates great environmental impact.

The objective of this study is to estimate the methane generated during the supply chain of the oil and natural gas systems in Ecuador, within the category of fugitive emissions in the energy sector, to provide an improved general evaluation of the emissions of this supply chain. A national emissions inventory provides the perspective that countries have in terms of emission-capture by sources for the different economic sectors. This will allow identifying the areas of convenience to mitigate emissions by proposing the corresponding reduction measures and their contribution to the national inventory. For this study, historical data from 1990 to 2019 were considered.

4.2. Materials and methods

To learn the environmental impact caused by GHG emissions generated from anthropogenic activities, estimates are made, and it is currently an important practice that is done in most sectors of the industry and in many organizations. In this study, the methodology used to estimate methane (CH4) emissions is derived from the Revised IPCC Guidelines for National Greenhouse Gas Inventories, hereafter (IPCC, 2006).

Based on the Intergovernmental Panel on Climate Change (IPCC) classification, emission factors are divided into three levels, depending on the methodology used to quantify fugitive emissions from oil and natural gas systems (IPCC, 2006). The Tier 1 methodology for estimating emission values was selected for this study due to the limited availability of data on the values of the various parameters and emission factors required for oil and gas systems.

The economic sectors considered as emission sources are those defined by the IPCC in the 2006 guidelines (Vol.1, chap.8): Energy, Industrial Processes and Product Use, Waste and Agriculture, Forestry and Other Land Use. This work provides an improved overall assessment of CH4 emissions from the oil and gas supply chain, which we define to include operations associated with oil and gas exploration, production, processing and transportation, related to the energy sector in Ecuador.

Table 2.

Compilation of subacategories used dor emissions in oil and gas systems.

IPCC Code	Industry Name
1.B.2	Oil and Natural Gas
1.B.2.a	Petroleum
1.B.2.a.i	Exploration
1.B.2.a.ii	Production and Refining
1.B.2.a.iii	Transport
1.B.2.a.iv	Refinement
1.B.2.a.v	Distribution of petroleum products

1.B.2.b	Natural Gas
1.B.2.b.i	Exploration
1.B.2.b.ii	Production
1.B.2.b.iii	Prosecution
1.B.2.b.iv	Transmission and storage
1.B.2.b.v	Distribution

Oil and natural gas systems comprise all the infrastructure needed to produce, collect, process or refine, and bring natural gas and oil products to the market. The system begins at the wellhead, or the source of oil and gas, and ends at the final point of sale to the consumer (IPCC, 2006).

To determine fugitive emissions from oil and natural gas systems, a detailed sector disaggregation recommended in the IPCC guidelines is applied. The industry segments to be considered for the analysis are detailed in Table 1.

To estimate methane emissions by sector, we apply the basic IPCC default standard equations. For this study, total CH_4 emissions from the oil and gas industry in Ecuador are calculated as follows:

$$\text{Emission} = A * EF$$

Where:

Emission: Indicates the total CH_4 emissions from the oil and gas industry in the year of calculation.

A: Refers to activity data (Activity Data) and describes the magnitude of the activity that results in emissions or removals of greenhouse gasses, which takes place during the year of the period considered.

EF: Emission Factor. Coefficients that quantify gas emissions or absorptions by the unit of activity's data.

IPCC Guidelines provide a comprehensive set of default emission factors (EFs) for oil and natural gas activities. In this research, the IPCC guidelines most appropriate to national circumstances have been selected. In addition, the process to determine emission factors and emission estimates related to the use of the 2006 IPCC Guidelines is addressed, considering that they conform to and incorporate most of the 1996 IPCC Guidelines. After a detailed study, the appropriate parameters are selected for the calculation of the CH4 emission factor in each sector, summarized in tables 3 and 4:

Table 3.

CH4 emission factor (Oil)

Segment	Sub-segment	Value	Uncertainty (% of alue)	Units of measure
Oil exploration	Onshore Conventional	0.02	-30% to +30%	Tonnes/thousand cubic meters onshore conventional oil production
Oil Production	Onshore: Most activities occurring with higher-emitting technologies and practices	3.43	-30% to +30%	Tonnes/thousand cubic meters onshore oil production
Oil Transport	Pipelines	0.0054	±100%	Tonne/thousand cubic meters oil transported by pipeline
Oil Refining	All	0.03	-50% to +130%	Tonnes/thousand cubic meters oil refined
Oil Distribution	Other	NA	NA	Tonnes/thousand cubic meters product consumed

Note: Tier 1 emission factor used for fugitive CH4 emissions from oil operations.

Table 4.

CH4 emission factor (natural gas)

Segment	Sub-segment	Value	Uncertainty (% of value)	Units of measure
Gas Exploration	Onshore conventional Gas exploration	0.06	±20%	Tonnes/million cubic meters onshore conventional gas production
Gas Production	Onshore: Most activities occurring with higher-emitting technologies and practices	4.09	±20%	Tonnes/million cubic meters onshore gas production
	Gathering	3.2	±10%	Tonnes/million cubic meters onshore gas production
Gas Processing	Without LDAR, or with limited LDAR, or less than 50% of centrifugal compressors have dry seals	1.65	±10%	Tonnes/million cubic meters gas produced
Gas Transmission and Storage	Transmission: Limited LDAR or less than 50% of centrifugal compressors have dry seals	3.36	-20% to +30%	Tonnes/million cubic meter gas consumption
	Storage: Limited LDAR or most activities occurring with higher- emitting technologies and practices	0.67	-20% to +30%	Tonnes/ million cubic meter gas consumption
Gas Distribution	Less than 50% plastic pipelines, or limited or no leak detection and repair programsa	2.92	-20% to +120%	Tonnes/ million cubic meter gas consumption

Note: Tier 1 emission factor used for fugitive CH4 emissions from natural gas operations.

4.2.1. Study area

It is important to point out that Ecuador (officially the Republic of Ecuador) has an area of 283,560 km² and a population of more than 17 million (2021) (INEC, 2021). The Ecuadorian territory includes the Galapagos Islands, 1000 km from the west coast and has the densest biodiversity on the planet. To calculate methane emissions from the oil and natural gas sectors, a database of methane emissions organized in detail at the level of subcategories in the oil and natural gas sectors was developed using activity data from the database. data from the International Energy Agency (IEA, 2021), covering the years 1990-2019. In the literature reviewed, the IEA database is widely used as the basis for many methane-related analyses.

Figure 10.

Representative graph of natural gas production in Ecuador.

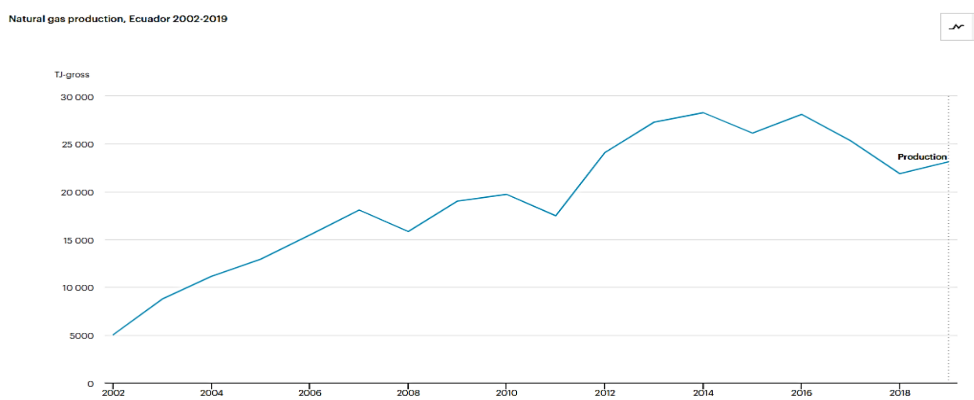
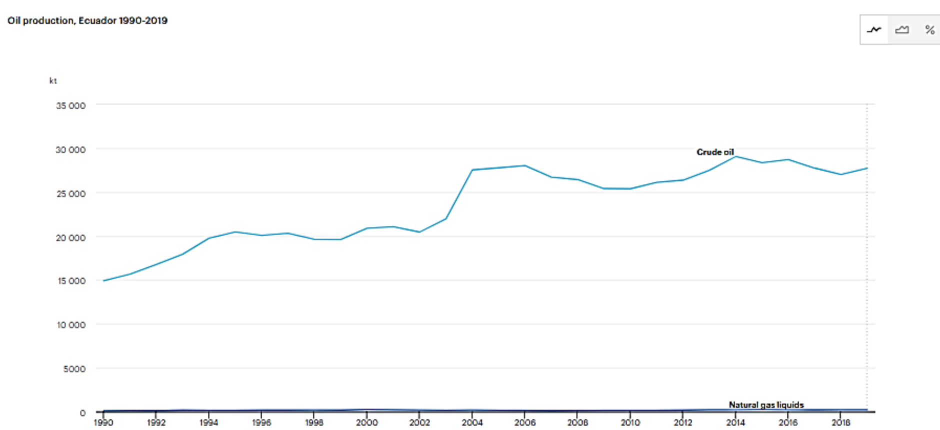


Figure 11.

Representative graph of oil production in Ecuador.



4.3. Results

4.3.1. Oil industry

According to reference materials, methane emissions in the oil industry are calculated from exploration, production, transportation, refining, and distribution, with no emission factor at the distribution stage. Based on currently available data, activity for the oil industry in Ecuador includes production, consumption and consumption of refined oil products; by some accounts, these areas should still be dominated by conventional oil and gas.

Table 5.

Estimates of methane emissions from the activities' categories-Oil.

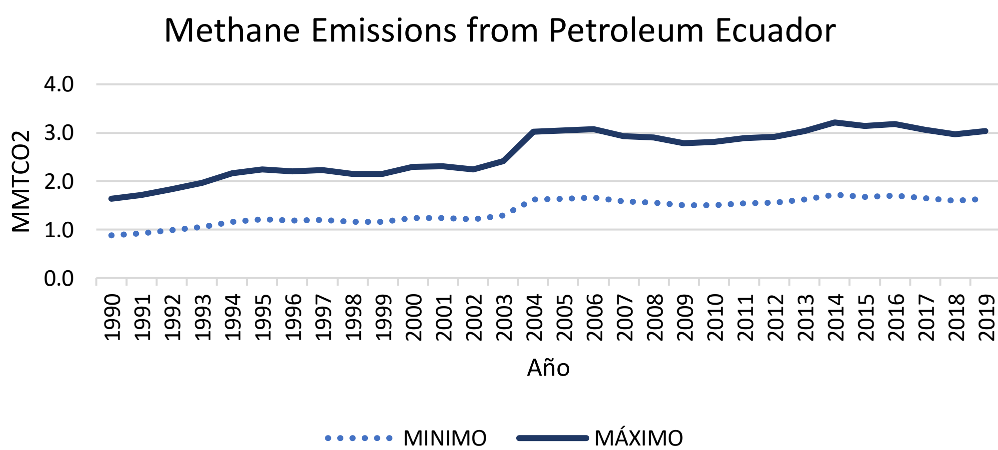
	1.B.2.a.i		1.B.2.a.ii		1.B.2.a.iii		1.B.2.a.iv	
	EXPLORATION		**PRODUCTION**		**TRANSPORT**		**REFINEMENT**	
AÑO	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1990	0.00511	0.00949	0.87617	1.62718	0.00000	0.00112	0.00000	0.00000
1991	0.00536	0.00996	0.91964	1.70790	0.00000	0.00115	0.00000	0.00000
1992	0.00574	0.01066	0.98426	1.82790	0.00000	0.00112	0.00000	0.00000
1993	0.00614	0.01140	1.05310	1.95576	0.00000	0.00111	0.00000	0.00000
1994	0.00676	0.01256	1.16012	2.15452	0.00000	0.00119	0.00000	0.00000
1995	0.00701	0.01301	1.20183	2.23197	0.00000	0.00116	0.00000	0.00000
1996	0.00688	0.01277	1.17963	2.19073	0.00000	0.00136	0.00000	0.00000
1997	0.00695	0.01292	1.19267	2.21495	0.00000	0.00142	0.00000	0.00000
1998	0.00672	0.01248	1.15290	2.14110	0.00000	0.00138	0.00000	0.00000
1999	0.00671	0.01246	1.15078	2.13717	0.00000	0.00126	0.00000	0.00000
2000	0.00715	0.01328	1.22668	2.27811	0.00000	0.00128	0.00000	0.00000

2001	0.00721	0.01339	1.23696	2.29721	0.00000	0.00141	0.00000	0.00000
2002	0.00700	0.01301	1.20113	2.23066	0.00000	0.00141	0.00000	0.00000
2003	0.00752	0.01397	1.28971	2.39517	0.00000	0.00147	0.00000	0.00000
2004	0.00943	0.01751	1.61671	3.00247	0.00000	0.00154	0.00000	0.00000
2005	0.00951	0.01766	1.63093	3.02887	0.00000	0.00162	0.00000	0.00000
2006	0.00960	0.01782	1.64597	3.05680	0.00000	0.00167	0.00000	0.00000
2007	0.00914	0.01698	1.56802	2.91203	0.00000	0.00168	0.00000	0.00000
2008	0.00905	0.01681	1.55216	2.88258	0.00000	0.00180	0.00000	0.00000
2009	0.00870	0.01616	1.49201	2.77087	0.00000	0.00194	0.00000	0.00000
2010	0.00869	0.01614	1.49054	2.76814	0.00000	0.00203	0.00426	0.01961
2011	0.00894	0.01661	1.53401	2.84887	0.00000	0.00218	0.00427	0.01966
2012	0.00903	0.01677	1.54828	2.87538	0.00000	0.00226	0.00436	0.02007
2013	0.00941	0.01748	1.61378	2.99701	0.00000	0.00238	0.00457	0.02100
2014	0.00995	0.01848	1.70647	3.16916	0.00000	0.00249	0.00493	0.02267
2015	0.00971	0.01803	1.66512	3.09236	0.00000	0.00245	0.00503	0.02315
2016	0.00983	0.01826	1.68597	3.13108	0.00000	0.00240	0.00474	0.02182
2017	0.00950	0.01764	1.62899	3.02527	0.00000	0.00251	0.00472	0.02169
2018	0.00925	0.01717	1.58582	2.94509	0.00000	0.00262	0.00000	0.00000
2019	0.00949	0.01763	1.62787	3.02320	0.00000	0.00000	0.00000	0.00000

For the calculation of the emission factor, the active data unit was unified. The activity data ton/million equivalent tons of oil was multiplied by the corresponding coefficient to convert it to cubic meters, and then multiplied by the emission factor to obtain the methane emission in tons. The conversion of units is preceded again to convert these values to millions of tons of carbon dioxide equivalent according to the guidelines. Table 5 presents the summary of the results obtained in this study for the period 1990-2019 for the oil subcategory corresponding to the category of fugitive emissions from the energy sector. The results indicate that CH4 emissions increase annually. The oil production segment is the one that generates the highest methane emissions, followed by the exploration segment. It can be seen that methane emissions are increasing in the different segments. For example, in 2018 the maximum CH4 emissions of the transport category were approximately 0.00245 MMtCO 2 eq, an increase of 31.30% compared to 0.00180 MMtCO 2 eq in 2008. The main driving force behind this change is the increase in activity data and the trend is also consistent with the trend of change in activity data.

Figure 12.

Summary of methane emissions from the Oil industry within the category of fugutive emissions.



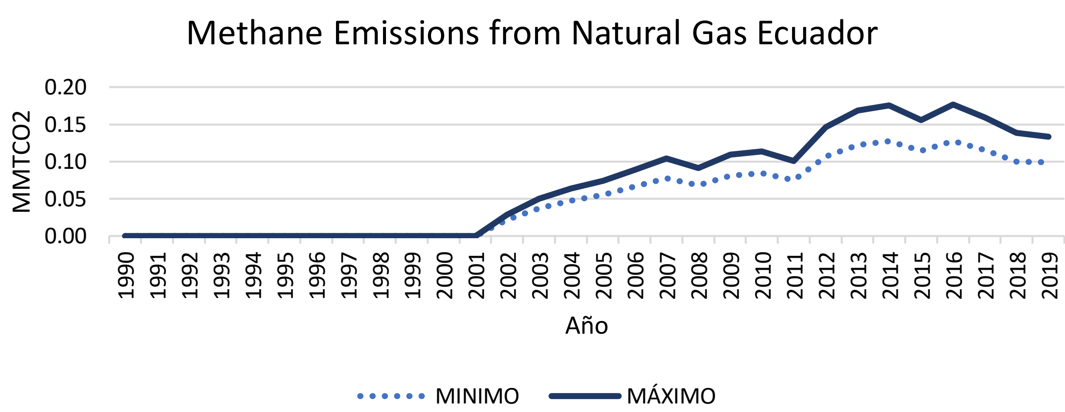
4.3.2. Natural Gas Industry

The calculation of methane emissions in the natural gas industry starts from exploration, production, treatment, storage, transportation and distribution. According to the available data on natural gas, the activity data is also related only to production and consumption. For the calculation requirements, the corresponding emission factor was considered. The basic steps of the calculation can be summarized as follows: first, the activity data unit is unified, then multiplied by the emission factor, and finally converted to millions of tons of carbon dioxide equivalent. The specific results for the study period between 1990 and 2019 of the natural gas supply chain are shown in Table 6.

It can be seen that the segment with the highest proportion of methane emissions was production. In 2019, the maximum CH4 emissions from the production category were approximately 0.0108625 MMtCO2 eq, an increase of 17.82% compared to 0.089268 MMCO 2 eq in 2009.

Figure 13.

Summary of methane emissions from the Oil industry within the category of fugitive emissions.



Figures 12 and 13 show the annual fugitive emissions of CH4 from Oil and Natural Gas, an average annual growth rate (ACT) of approximately 2.16% was observed during the period 1990-2019, in relation to the projected global 15%.

Table 6.

Estimates of methane emissions from the categories' activities - Natural Gas

	1.B.2.b.i		1.B.2.b.ii		1.B.2.b.iii		1.B.2.b.iv		1.B.2.b.v	
	EXPLORATION		**PRODUCTION**		**TREATMENT**		**TRANSMISSION AND STORAGE**		**DISTRIBUTION**	
AÑO	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1990	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1991	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1992	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1993	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

1994	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1995	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1996	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1997	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1998	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1999	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2002	0.000135	0.000202	0.017239	0.023617	0.004161	0.005086	0.000000	0.000000	0.000000	0.000000
2003	0.000235	0.000352	0.030083	0.041213	0.007262	0.008875	0.000000	0.000000	0.000000	0.000000
2004	0.000298	0.000447	0.038190	0.052319	0.009219	0.011267	0.000000	0.000000	0.000000	0.000000
2005	0.000346	0.000519	0.044353	0.060763	0.010706	0.013085	0.000000	0.000000	0.000000	0.000000
2006	0.000414	0.000621	0.053026	0.072644	0.012800	0.015644	0.000000	0.000000	0.000000	0.000000
2007	0.000484	0.000725	0.061980	0.084910	0.014961	0.018286	0.000000	0.000000	0.000000	0.000000
2008	0.000423	0.000635	0.054233	0.074297	0.013091	0.016000	0.000000	0.000000	0.000000	0.000000
2009	0.000508	0.000763	0.065161	0.089268	0.015729	0.019224	0.000000	0.000000	0.000000	0.000000
2010	0.000527	0.000791	0.067595	0.092602	0.016316	0.019942	0.000000	0.000000	0.000000	0.000000
2011	0.000467	0.000701	0.059892	0.082050	0.014457	0.017670	0.000117	0.000190	0.000085	0.000233
2012	0.000644	0.000967	0.082592	0.113147	0.019936	0.024367	0.002210	0.003591	0.001601	0.004403
2013	0.000729	0.001094	0.093485	0.128071	0.022566	0.027581	0.003268	0.005310	0.002368	0.006511
2014	0.000756	0.001134	0.096889	0.132735	0.023388	0.028585	0.003663	0.005952	0.002654	0.007298
2015	0.000699	0.001048	0.089574	0.122713	0.021622	0.026427	0.001480	0.002405	0.001073	0.002949
2016	0.000751	0.001127	0.096286	0.131908	0.023242	0.028407	0.004184	0.006799	0.003031	0.008337
2017	0.000677	0.001016	0.086798	0.118909	0.020952	0.025608	0.003832	0.006227	0.002776	0.007635
2018	0.000585	0.000878	0.074992	0.102736	0.018102	0.022125	0.003569	0.005800	0.002586	0.007112
2019	0.000619	0.000928	0.079291	0.108625	0.019140	0.023393	0.000000	0.000000	0.000000	0.000000

4.4. Conclusions and recommendations

The estimate made allows us to obtain direct methane emissions (CH4) for the period 1990-2019, disaggregated for the activities concerning the oil and natural gas systems in Ecuador, leading the way for more in-depth studies of emissions from fossil sources in Ecuador. the country.

Methane (CH4) fugitive emissions are increasing by 2.16% annually in proportion to the activity data, with the exploration and production segments as the greatest increase values. In relation to the global 15% projected, we see a significant problem. Under this scenario, the reduction of the consumption of petroleum derivatives should be considered through a change in the electrical matrix in Ecuador using renewable energies, allowing for a reduction in CO2 emissions with the diversification of the electrical matrix.

More attention needs to be paid to oil and gas systems in order to mitigate the spread of methane emissions. The existence of inefficient units from the environmental point of view contributes to the propagation of this GHG, due to the fact that deplorable or quite old technology is used, which makes it necessary, beyond expanding the system, to require a complete technological uphaul in the industry segments and the national electricity matrix.

Another problem we can see has to do with the insufficient levels of investment and financing in both sectors: public and private, in specific programs and projects for mitigation and adaptation to climate change.

The economic wealth of Ecuador is another important issue that influences the emission of these polluting gasses. Although the country has shown a growing trend in national GDP per capita, its economy remains poor, which prevents it from investing in equipment with better energy efficiency technology such as electric or hybrid vehicles, or more environmentally friendly technologies. The technologies used increase the consumption of fossil fuels and the spread of methane emissions.

4.5. References

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