Evaluation of CO\textsubscript{2} Emissions Due to Venting and Flaring of Natural Gas and Oil in Iraq Using IPCC Methods

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ABSTRACT

Fugitive emissions from venting and flaring the natural gas and oil are main source of CO\textsubscript{2} emissions and other pollutants. Intergovernmental Panel on Climate Changes (IPCC) carried out guidelines 2006, which provide methods to estimates CO\textsubscript{2} emissions and other greenhouse gases. The aim of this research is calculate CO\textsubscript{2} emissions due to OVF (Oil Venting and Flaring) and NGF (Natural Gas Flaring) in Iraq during (1970 – 2013) by IPCC methods. The results showed that the highest production of natural gas in Iraq in 2013 was (21.4 billion cubic meter/year - bcm/y), while the quantity of NGF of it was (12.4 bcm/y), by ratio reached to 58 %. CO\textsubscript{2} emissions due to OVF reached to highest values (10055 Gega grams - Gg) in 1979, while the lowest value (1479 Gg) in 1991. The percentage of share of CO\textsubscript{2} emissions from NGF and OVF decreased from 72 % in 1970 to 6 % in 1991; due to decrease of crude oil and natural gas production in Iraq result of First Gulf War events. Increased percentage of share of CO\textsubscript{2} emissions due to OVF and NGF reached to 6 % and 20 % respectively, because increased their production in 2013 in Iraq.

INTRODUCTION

The oil industry is all the processes that include the production, extraction, manufacturing, refining, transport and distribution of oil. Oil term applied to crude oil and its products. Crude oil is complex, naturally fluid mixture of petroleum hydrocarbons, also containing small amounts of oxygen (O\textsubscript{2}), nitrogen (N\textsubscript{2}), sulfur and other impurities. Crude oil is refined to products such as asphalt, gasoline, kerosene, jet fuel, naphtha, gasoil...etc. The global energy supply comes from oil is about 33 % [1]. Iraq was in the eighteenth ranking relative to the world in 2012 by (3031 thousand barrel/day – tb/y) is present 3.5 % of world total [2].

The first commercial well struck oil in Kirkuk of northeast Iraq in 1927. 90 % of Iraq's historical production has come from two super giant fields: Rumaila in the Basra and Kirkuk in the north. These fields still dominate today, making up over 80 % of Iraq's production capacity [3]. The burning of fossil fuel, mainly coal, oil and gas, has led to the warming up the environment through the emissions of carbon dioxide (CO\textsubscript{2}) as the main greenhouse gas [4]. Natural gas is a fossil fuel existing in deposits in the earth over wide regions of the globe. It is composed of hydrocarbons, which are molecules of hydrogen and carbon, lesser amounts of propane, ethane, butane and small quantities of non-hydrocarbon gases such as N\textsubscript{2} and helium. The methane (CH\textsubscript{4}) is the primary gas of natural gas that is formed 80-95 % of it. The combustion of natural gas releases CO\textsubscript{2} and nitrous oxide (N\textsubscript{2}O) [5]. Oil venting and flaring (OVF) is the release of gases directly to the atmosphere either intentionally to get rid of unwanted waste gases or unintentionally through equipment leaks and failures. Venting can occur from oil production, oil well drilling and transport [6]. Flaring is a high-temperature oxidation process used to burn combustible components, mostly hydrocarbons, of waste gases from industrial operations. Associated gas with crude oil
represents about 70% of the natural gas extracted in Iraq, a dissolved gas in the crude oil under the ground and must be separated from the oil when rising to the earth [7]. The highest production of natural gas in Iraq in 2013 was (21.4 billion cubic meter/year- bcm/y), while the value of NGF was (12.4 bcm/y), by ratio reached to 58% [8]. There are many studies deals with subject of gas flaring. [9] suggested in his study CO2 emission from gas flaring in oil production wells, refineries and chemical plants and it contributes to global warming. The result shown the largest flaring operations in 2004 occur in Nigeria by (24.1 bcm/y) from top 20 flaring countries in the world. Iraq was forth rank by (8.6 bcm/y). [10] studied on flaring of associated gas in Russia, Kazakhstan, Turkmenistan and Azerbaijan. The aim of the study was to review the flare situation and analyze appropriate technical solutions for the use of the associated petroleum gas. The four countries combined currently flare more than (20 bcm/y) per year, of which almost 85% by Russia. Some 400 flare sites were identified using satellite images from the National Oceanic and Atmospheric Administration (NOAA) and “on the ground data” from other data sources. Some 80% of the identified sites had relatively modest flare volumes (each less than 100 million cubic meter annually), while less than 10 sites was 2.5% flared more than one bcm.

The aim of this research is to calculate CO2 emissions due to OVF and NGF in Iraq during (1970 – 2013) by IPCC methods.

MATERIALS AND METHODS

Intergovernmental Panel on Climate Change (IPCC) established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988 to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation [11]. IPCC guidelines 2006 provide method of work for a broad range of users to estimates GHGs emissions.

Fugitive emissions from fuel include all intentional and unintentional emissions from the extraction, processing, storage and transport of oil and gas systems (except contributions from fuel combustion) to the point of final use. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, venting and flaring. The option to release gas to the atmosphere by flaring and venting is an essential practice in oil and gas production, primarily for safety reasons. Flaring is the controlled burning of natural gas produced in association with oil in the course of routine production operations. Venting is the controlled release of gases into the atmosphere in the course of oil and gas production operations [12]. Eq. (1) used to calculate fugitive annual emissions from oil and gas industry segment [6]:

\[ E_{\text{gas,industry segment}} = A_{\text{industry segment}} \times EF_{\text{gas,industry segment}} \]  

(1)

where:

- \( E_{\text{gas,industry segment}} \) is the annual emissions (Gg)
- \( A_{\text{industry segment}} \) is the activity value (units of activity- oil venting and flaring)
- \( EF_{\text{gas,industry segment}} \) is the emission factor (Gg/unit of activity)

\( \text{CO}_2 \) emissions are expressed in Gega gram (Gg) equal to (1000 tonnes). Natural gas is expressed in terajoules (TJ). There are conversion factors for each fuel type to convert consumption fuel quantities from (Gg) to energy unit (TJ) for used it to estimate GHGs emissions [13]. Statistical method that used for determines the ratio of increase of \( \text{CO}_2 \) emissions follows the eq. (2) [14]:

\[ XR = \left( \frac{x_{\text{Max}}}{x_{\text{Min}}} - 1 \right) \times 100 \% \]  

(2)

where: \( XR \) = ratio of increase of \( \text{CO}_2 \) emissions (%)
\( x \) = maximum and minimum values of \( \text{CO}_2 \) emissions (Gg)

Data source used in this research is based on data from Organization of Arab Oil Export Countries (OAPEC) [8] for production of crude oil and natural gas in Iraq from (1970 – 2013).

RESULTS AND DISCUSSION

1- Natural Gas Flaring (NGF)

NGF is one of major environmental problem in Iraq, because of the emission of large amounts of various pollutants, especially oxides of carbon and nitrogen. Iraq produces large quantities of natural gas per year, but more than half of it is flaring in the air without exploitation, which represents a significant financial loss and big contamination of the environment. Most of production of natural gas in Iraq was flaring without any exploitation and control during previous years. \( \text{CO}_2 \) emissions (Gg) due to NGF by (bcm/y) in Iraq during this research shows in figure (1). The maximum of NGF was (16036 bcm/y) in 1979, combined with a maximum \( \text{CO}_2 \) emissions (32959 Gg) in the same year. The curves of \( \text{CO}_2 \) emissions and NGF in figure 1 were similar, because of the lack of suitable processing of natural gas extracted for export or manufacturing. According to the political and economic conditions, Iraq has strong decline in NGF and \( \text{CO}_2 \) emissions in years 1981 (2995 bcm/y and 6155 Gg) and 1991 (563 bcm/y and 1157 Gg), while was less decline in 2002 (3341 bcm/y and 6867 Gg) and 2007 (6968 bcm/y and 14322 Gg) respectively. But NGF and \( \text{CO}_2 \) emissions continued to rise after that supported by increase production of natural gas. For these reasons, correlation coefficient record very weak positive relationship (0.073).
Figure 1: CO\textsubscript{2} emissions (Gg) due to NGF by (bcm/y) in Iraq during (1970 – 2013)

CO\textsubscript{2} emissions reached a record level (25550 Gg) in 2013, but it never reach the historical level (32959 Gg) in 1979. XR of CO\textsubscript{2} emissions released by NGF shown in table 1. XR of CO\textsubscript{2} emissions has a continuous increase during first three time periods 117, 432 and 466 %, respectively.

Table 1: XR of CO\textsubscript{2} emissions due to NGF during (1970-2013)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>XR of CO\textsubscript{2} Emissions (%)</th>
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</thead>
<tbody>
<tr>
<td>1970-1980</td>
<td>117</td>
</tr>
<tr>
<td>1981-1991</td>
<td>432</td>
</tr>
<tr>
<td>1992-2002</td>
<td>466</td>
</tr>
<tr>
<td>2003-2013</td>
<td>193</td>
</tr>
</tbody>
</table>

As a result of interest in natural gas and benefit from it instead of flaring, XR of CO\textsubscript{2} emissions in the 4\textsuperscript{th} time period was decreased to 193 %, because of the growing demand for natural gas locally, especially for PEE and domestic purposes.

2- Oil Venting and Flaring (OVF)

The Production of Crude Oil (PCO) is back bone of Iraq economy. The PCO by (million barrel/year - mb/y) and CO\textsubscript{2} emissions (Gg) result from OVF in Iraq shown in figure 2. The correlation coefficient between CO\textsubscript{2} emissions and PCO was very weak (0.14), due to the fluctuations in PCO that affected on the amount of CO\textsubscript{2} emissions from it. CO\textsubscript{2} emissions due to OVF have been associated clearly with PCO and were characterized by high emissions and sharp decline accordingly. The highest value of PCO in Iraq in this research was (1301 mb/y) in 1979, while the lowest value of it recorded (191 mb/y) in 1991 because First Gulf War. Table 2 showed XR of CO\textsubscript{2} emissions during (1970-2013). CO\textsubscript{2} emissions due to OVF can be divided into two parts, first part since (1970-1991). During the 1\textsuperscript{st} time period, CO\textsubscript{2} emissions were increased ascending (except in 1972) to reach the historic level in 1979 (10055 Gg), then decreased in the following year 1980 (7586 Gg), due to the start of the Iraq-Iran War and

decreases of PCO (982 mb/y) for the same reason in 1980. XR of CO\textsubscript{2} emissions was recorded 70 % in the 1\textsuperscript{st} time period. CO\textsubscript{2} emissions has increased from 2\textsuperscript{nd} time period, along with PCO gradually, to reach the highest level (8359 Gg and 1082 mb/y), respectively in 1989, and then fall sharply in 1991(1479 Gg), due to the First Gulf War. Accordingly, XR of CO\textsubscript{2} emissions were recorded 104 %. The second part of CO\textsubscript{2} emissions due to OVF in Iraq began from (1992-2013). During the 90s, despite of the economic conditions, PCO and CO\textsubscript{2} emissions rise gradually again during the 3\textsuperscript{rd} time period, to reach the peak in 2000 by (986 mb/y and 7617 Gg). XR of CO\textsubscript{2} emissions in this time period was recorded 102 %. In spite of decreased in PCO and CO\textsubscript{2} emissions in 2003 (503 mb/y and 3887 Gg) respectively, but the start up gradually from 2005 to reach the highest value in 2013 (1088 mb/y and 8407 Gg), due to production increased and development of infrastructure facilities in the fields of Basra (Rumaila and west Qurna). XR of CO\textsubscript{2} emissions in 4\textsuperscript{th} time period reached to 116 %.

Figure 2: The PCO by (mb/y) and CO\textsubscript{2} emissions (Gg) result from OVF in Iraq during (1970-2013)

Table 2: XR of CO\textsubscript{2} emissions from OVF during (1970-2013)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>XR of CO\textsubscript{2} Emissions (%)</th>
</tr>
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<tbody>
<tr>
<td>1970-1980</td>
<td>70</td>
</tr>
<tr>
<td>1981-1991</td>
<td>104</td>
</tr>
<tr>
<td>1992-2002</td>
<td>102</td>
</tr>
<tr>
<td>2003-2013</td>
<td>116</td>
</tr>
</tbody>
</table>

The percentage of share of CO\textsubscript{2} emissions due to NGF and OVF in 1970, 1991 and 2013 showed in figure 3. NGF was the highest percentage in 1970 is 51 %, followed by OVF 21 %. The situation has changed much in 1991 to be NGF and OVF are 6 % of all. The decline of NGF and OVF in 1991 compared to 1980 due to decrease of crude oil and natural gas production in Iraq result of First Gulf War events. Increase percentage of
share of CO\textsubscript{2} emissions in 2013 due to OVF and NGF to reach 6 % and 20 % respectively.

Figure 3: The percentage of share of CO\textsubscript{2} emissions due to OVF and NGF in Iraq in (1970, 1991 and 2013)

CONCLUSIONS

1. The results showed that Iraq produces large quantities of natural gas per year, but more than half of it is flaring in the air without exploitation, which represents a significant financial loss and big contamination of the environment.

2. There are many fluctuations in production of natural gas and crude oil in Iraq after 1979, because the wars, economic retributions and internal conflicts that began from 1980.

3. The results shown CO\textsubscript{2} emissions due to OVF have been associated clearly with PCO and were characterized by high emissions and sharp decline accordingly.

4. The percentage of share of CO\textsubscript{2} emissions due to OVF and NGF in Iraq decreased from 1970-2013, because growth of CO\textsubscript{2} emissions due to production of electrical energy and transportation.

5. Reduction of NGF and OVF by using modern techniques in processing and investment of extracted natural gas or associated to the crude oil in production of electrical energy and petrochemical industries. As well as to maintain of the environment from pollution.

REFERENCES

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