

PAPER • OPEN ACCESS

## Assessment CO<sub>2</sub> Emission Intensity of Crude Oil Production in Iraq

To cite this article: Jamal S. Abd al rukabie *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **928** 072048

View the [article online](#) for updates and enhancements.

You may also like

- [Relationships between economic development and resident environmental behavior and participation in areas with different economic and similar natural and cultural conditions](#)  
Junli Wu, Guijuan Gao, Bing Zhang et al.
- [Air quality model of Anhui Province based on the EKC fitting](#)  
Yueqin Shen
- [The nexus of carbon dioxide emissions, economic growth, and urbanization in Saudi Arabia](#)  
Naif Alajlan and Amirah Alreshaidi



**ECS**  
The  
Electrochemical  
Society  
Advancing solid state &  
electrochemical science & technology

**DISCOVER**  
how sustainability  
intersects with  
electrochemistry & solid  
state science research

## Assessment CO<sub>2</sub> Emission Intensity of Crude Oil Production in Iraq

**Jamal S. Abd al rukabie<sup>1</sup> , Ahmed S. Hassan<sup>2</sup> , Jasim H. Kadhum<sup>2</sup>**

<sup>1</sup>Department of Science, College of basic education , Sumer University, Iraq.

<sup>2</sup> Department of Atmospheric Sciences, College of Science, Mustansiriyah University, Iraq.

Corresponding Authors: [suheel77@yahoo.com](mailto:suheel77@yahoo.com)

### Abstract

Carbon Dioxide Emissions Intensity (CDEI) in Iraq correlated between carbon dioxide emission (kg CO<sub>2</sub>) and crude oil production (COP) (kg oil equivalent). This relationship is important for industry and energy sectors to the achievement of their economic and environmental goal, then to know a common pattern of emissions intensity. The sources of data set from Carbon Dioxide Information analysis center (CDIAC), contain: total CO<sub>2</sub> emission , COP from Iraqi Ministry of oil and Iraqi crude oil production increased over time and about (more than 80%) from Basra city. Environmental Kuznets Curve (EKC) was calculated.

CDEI was nonlinear behavior that high level in the 1970s then decreased to reach 1.707 kg co<sub>2</sub> / kg oil equivalent in 1997, and CDEI was more sensitive to COP than total CO<sub>2</sub> emissions. EKC maximum values present in early 1970s and in 2004 present highest value was (0.082 metric ton / current US\$ person). COP was unstable level, fluctuation between (1-3) mb/d, till reach 4.29 mb/d as average in 2019.

**Keywords:** Carbon dioxide emission intensity, Crude Oil production, EKC

### Introduction

Oil industry was united in their opposition to binding climate targets in the prelude to the 1992 United Nations Framework Convention on Climate Change (UNFCCC). All major oil companies took the view that action on global warming could damage their economic interests, as the oil industry earns its living from oil , gas and coal the main sources of greenhouse gas emissions. Ten years later many oil companies' positions have completely changed. Major European multinational oil companies such as BP (British Petroleum) and Shell endorse the Kyoto Protocol, set ambitious goals to reduce their own greenhouse gas (GHG) emissions and invest in renewable energy. [1]. The existence of convergence of some relevant ratios as Carbon Dioxide (CO<sub>2</sub>) emissions intensity, CO<sub>2</sub> emissions by fossil fuel consumption, fossil fuel intensity, energy intensity and economic structure, between industry and energy sectors in Portugal.[2] .



Better understanding of crude oil GHG emissions can help to quantify the benefits of renewable energy and identify the most cost-effective opportunities for oil-sector emissions reductions. There is a lack of comprehensive geographically rich datasets that would allow evaluation and monitoring of life-cycle emissions from oils. developed model well-to-refinery (CI) of all major active oil fields globally, and to identify major drivers of these emissions[3] .

Decadal of CO<sub>2</sub> emissions analyzed for three states of fossil fuel in Iraq , Co<sub>2</sub> emission concentration from fossil fuel gaseous and fossil fuel liquid consumption increased 10 time, 10.4 respectively[4] .

The CDEI is Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring , CDEI it's the ratio between carbon dioxide emission and crude oil production (Kg CO<sub>2</sub> per Kg oil equivalent ) [3].

Extracting, transporting and refining crude oil on average accounts for about 18% of well-to-wheel greenhouse gas ( GHG ) emissions, the International Energy Agency ( IEA) predicts a 27% increase in global crude oil consumption over the next two decades from 83 million barrels per day (MMbbl / d) in 2009 to 105 MMbbl / d in 2030 [5].

Reducing emissions from petroleum production is particularly important, as current transportation fleets are almost entirely dependent on liquid petroleum products and many petroleum uses have limited prospects for short-term substituting (e.g. air travel). Better understanding of GHG emissions from crude oil can help to quantify the benefits of alternative fuels and identify the most cost-effective opportunities for oil-sector emissions reductions[3].

Carbon dioxide emission intensity is defined as the ratio between total carbon dioxide emissions and total crude oil production (CO<sub>2</sub> emissions per crude oil).Industrial processes release CO<sub>2</sub> in two ways; by burning fossil fuels and by physical or chemical transformation of materials. The vast majority (98 per cent) of CO<sub>2</sub> emissions from the processing of construction materials are caused by fossil fuel combustion occurring during the upstream (i.e. pre-use) life-cycle processes – the procurement, storage, manufacture and delivery of raw materials. Just a limited fraction of the overall building sector (2 per cent) is the outcome of upstream physical and chemical material transfer processes ( e.g. chemical reactions in cement production).[6].

The wide distribution of expected temperature increases in climate forecasts does not mainly derive from variability across climate models; rather, the wide variety of diverse

global socio-economic dynamics and the resulting oil demand result in strong uncertainty regarding possible climate change.. While the physical-science basis of models used in Intergovernmental Panel on Climate Change (IPCC 1990e2013)[7]. In Iraq crude oil production increase over time (In 1972 was nationalized) and it reached In 2019 to (4.290 mb/d average) .

The Kyoto Protocol came into effect in February 2005. Since the Protocol is an international negotiation related to the United Nations Framework Convention on Climate Change (UNFCCC), it has been ratified by several countries. There are several signatories who remain without a national greenhouse gas (GHG) emissions target, or have not made a commitment to reduce their GHG emissions by 2020. Besides, the post-Kyoto period is in line with many other changes and systems in national or regional climate policy (such as the EU ETS). An additional periodization after 2004 would have to consider not only those policies or systems,.[8].

Crude Oil Production GHG emissions are determined during the extraction process by interactions of eight major parameters: oil field age, gas-to-oil ratio, reservoir depth, density, viscosity, American Petroleum Institute (API) gravity (a measure of how “light” or “heavy” a crude is relative to water), type of feedstock (e.g., tar sands, conventional crude), and development type [onshore, offshore, surface mining, steam-assisted gravity drainage (SAGD)] . The ratio of the volume of gas in solution to the volume of crude oil at standard conditions is the gas-to-oil ratio (GOR). Higher values of GOR lead to higher production of natural gas.

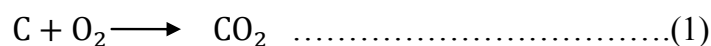
Flaring and drainage are an important source of GHG pollution from oil fields. Upon extraction of crude oil, gas dissolved in crude oil is released which can be used in extraction, captured and sold as a product, or flared and vented to meet energy needs. Flaring refers to the disposal by burning of the related gas produced during extraction. Venting means intentional releases of gas and the release of uncombusted gas in flaring (the combustion efficiency of flaring is not 100%, so some methane is left in the exhaust gas).[5].

Carbon dioxide (CO<sub>2</sub>) contributes the most to current climate change . The metal mining industry plays an important role in global CO<sub>2</sub> emissions due to the increasing demand for metallic minerals. In order to achieve the goal of reducing CO<sub>2</sub> emissions, CO<sub>2</sub> emissions charges, including carbon taxes and CO<sub>2</sub> emissions permit trading, are used as an effective way to reduce CO<sub>2</sub> emissions. Mitigation approach for CO<sub>2</sub> emissions' charges facilitate the movement from energy-intensive activities to the improvement of energy consumption efficiency, but its negative impact on economics has recently been

reported .It is necessary to analyze the impact of carbon prices on the profit, CO<sub>2</sub> emissions, and carbon intensity of metal mining projects, for reasonable carbon pricing. However, such analysis is still restricted due to Lack of either a sufficiently detailed inventory or a valid model for estimating CO<sub>2</sub> emissions for individual projects. Therefore, based on the Life Cycle Assessment ( LCA) method [9].

The Greenhouse Gas Emissions Estimator (OPGEE) for Oil Production is an engineering based Life-cycle Assessment (LCA) tool estimating greenhouse gas (GHG) emissions from crude petroleum production, processing and transport. OPGEE 's system boundary runs from initial exploration to the refinery gate [10] .

Emission of co<sub>2</sub> is from burning oil, coal and gas for energy use. Burning wood and waste materials, and from industrial processes such as cement production. The carbon dioxide emissions of a country are only indicators of one greenhouse gas. For a more complete idea of how a country influences climate change and global warming, gases such as methane and nitrous oxide should be taken into account. This is especially important for the agricultural economies. Of considerable interest are the environmental effects of carbon dioxide. The largest share of greenhouse gases contributing to global warming and climate change is carbon dioxide. Let's look at the co<sub>2</sub> reaction specifically now. This reaction as follows:



There are many indicators to calculate co<sub>2</sub> emission intensity (CDEI) one of these depended on economic such as (united states and Europe ) , others depend on crude oil production (all oil countries ) this one of IPCC standards , china use the both.[11].

Carbon has an atomic weight of 12, oxygen weights 16 and CO<sub>2</sub> weights 44 (1 carbon atom [12] + 2 oxygen atoms [2 x 16 = 32] ) . Consequently, CO<sub>2</sub> is 3.67 times heavier than carbon (44 ÷ 12 = 3.67), which is how 1 L of gasoline, which contains about 0.63 kg of carbon, can produce about 2.3 kg of CO<sub>2</sub> (3.67 × 0.63 kg = 2.3 kg) .

There are many type of crude oil (light , heavy ....etc ) Barrels of crude oil equal (159 L ) and Burning (1 L ) of gasoline produces approximately (2.3 kg) of CO<sub>2</sub> that mean one Barrels of Gasoline produces (364.11 kg CO<sub>2</sub>)[12].



Figure 1: crude oil production and gas flaring in Iraq.

### Literature review

There are many papers have studied the CDEI, (Sirintip Juntueng et al. 2014) Study the intensities of carbon dioxide in Thailand's steel industry and propose greenhouse gas emission trends from 2011 to 2050.[13]. ( Jung-Hun Kima et al. 2019) Crude oil sludge(COS) thermolysis utilizing CO<sub>2</sub>[14]. ( Hongxu Li et al. 2020 ) Calculations of radiative intensity for co<sub>2</sub> media[15]. ( Kangjuan Lv<sup>1</sup>et al. 2020) study a crucial way to reduce energy related carbon dioxide intensities[16]. D .Nathan Meehan et al. 2018) Analysis of the carbon intensity (CI) of crude oil and gas output [17]. Wen Wen 2019) he is re-examining the implementation of provincial targets for the reduction of carbon dioxide emissions in China [18]. Liu Chen<sup>1</sup> et al. 2019) Carbon intensity and emission reduction potential in China[19]. (Jaehyeok Kim et al. 2020 ) he was study the relationship between income and carbon dioxide emission in Korea[20] . Eyup Dogan et al . (2020) Examine the role of the economic structure of European countries in the assessment of the Environmental Kuznets Curve ( EKC) hypothesis for European countries for the period 1980 to 2014[21]. Jamal al rukabie et al. (2020) In Iraq after year 2000 co<sub>2</sub> emission increased more than (5 time) [22].

### Methodology and Data Source

The data used in this paper are taken from (World Bank, 2018) from (1971 to 2014) (GDP per capita for Iraq, and CDEI.

The Total carbon dioxide emission it was taken from (Carbon Dioxide Information analysis center) (CDIAC) at oak ridge National Laboratory from (1960 to 2014).

The crude oil production of Iraq (1971 to 2019) we are taken it from the Iraqi oil ministry.

The value of CDEI and EKC values can calculated by methods fellow:

$$EKC = \frac{\text{Total carbn dioxide emission}}{GDP \text{ per capita}} \dots\dots\dots(2)$$

$$CDEI = \frac{\text{Total carbn dioxide emission}}{\text{crude oil quantites}} \dots\dots\dots(3)$$

CDEI measured by (kg CO<sub>2</sub> / kg oil eq.) and EKC value measured by (metric ton / current US\$ person) .

## Results and Discussions

The CDEI in Iraq was studied for period (1971 – 2014), to explain the relationship between carbon dioxide emissions that exponential increased and crude oil production in Iraq which had many fluctuations through studies period. Moreover other relationship between total carbon dioxide emission and GDP per capita that named EKC model values, interactive with CDEI, as shown in the equation (3). The results show that high level of was in the early of study's period, while ratio was in 1.707 kg CO<sub>2</sub>/ kg oil equivalent) in 1997, yield increased slowly in the end of time's study as shown in Fig. 2. The variance of CDEI leads to think that COP was more sensitivity than total CO<sub>2</sub> emissions depend on them changes.

The relationship between CDEI and COP was inversely proportional , but in 2004 and 2007 the relationship was identically because of increased the total carbon dioxide emission. In 1991 and 2003 the (CDEI) was increased because decrease the crude oil production., in 1990 EKC was low value (0.011 metric ton / current US\$ person) because increased the GDP per capita in this year .

In 2004 the value of EKC was high because increased the total carbon dioxide emission. Crude oil production (COP) increased over time, the most quantity of production from Basra city (more 80% of total production of Iraq).

The lowest value was in 1991 because of the first Gulf war, the height value was in 2019 it equal (4.290 mb/d) average. after the events of the geopolitics effect on the economic growth (GDP per capita) and crude oil production in Iraq and unstable state for example in 1972 oil industry nationalized , 1980 -1988 Iran – Iraq war , 1990 – 2003 sanctions ends with second Gulf war and 2009 first licensing round .

The total carbon dioxide emission increased over time in Iraq because increased the crude oil production .In 2018 was reached more than (180 mt /years ).

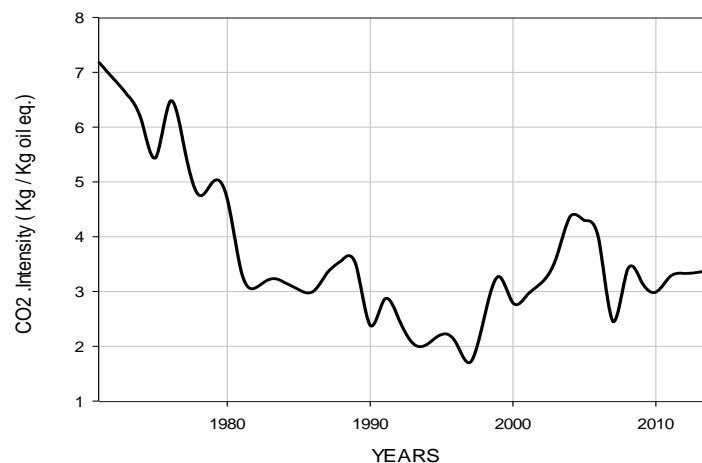


Figure 2: CO<sub>2</sub> emission Intensity over Time (1971 -2014) for Iraq.

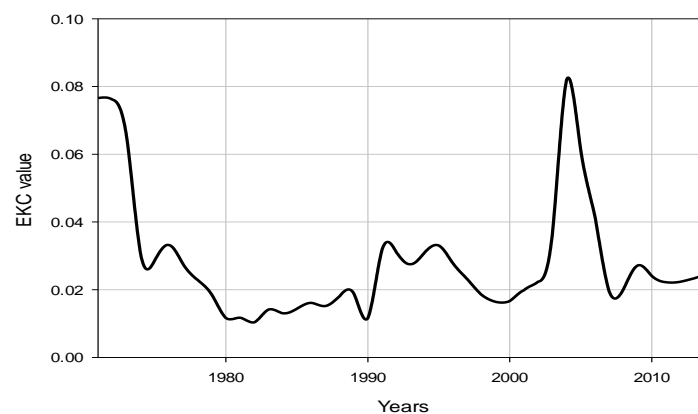


Figure 3: Time series of EKC values over Time (1971 -2014) for Iraq.



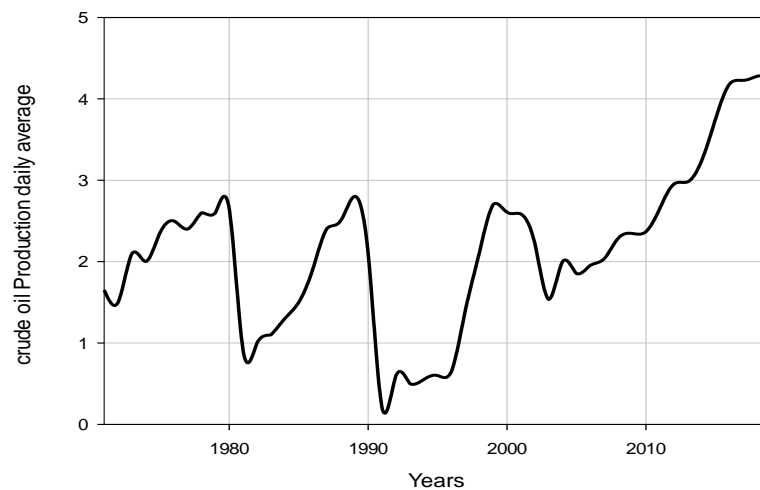


Figure 4: Time series of crude oil Production Daily Average over Time (1971 -2019) for Iraq.

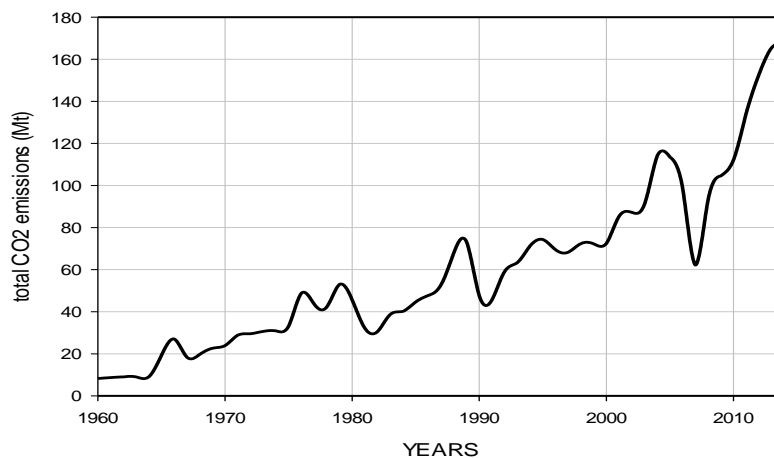


Figure 5: Time series of total CO<sub>2</sub> emissions over time (1960 - 2014) for Iraq

## Conclusions

The significant results shown the sensitivity of COP toward CDEI, that found out decreased values to reach minimum value in 1997. many indicators effect on calculated Carbon dioxide emission intensity such as crude oil production (this one of IPCC standards ) , it decreased over time ,carbon dioxide emission (mt) increased in last decadal because increasing in crude oil production .relationship between carbon dioxide emission

intensity and crude oil production was inverse . Values of (CDEI) were highest comparing with neighboring countries because Iraq burning associated gases with crude oil production. EKC values unstable because Iraq (oil country).

## References

- [1] T. Skodvin et al. , *Climate change and the oil industry*. Manchester: Manchester University Press. pp.246 ,2003 .
- [2] V. Moutinho, M. Robaina-Alves, and J. Mota, “Carbon dioxide emissions intensity of Portuguese industry and energy sectors: A convergence analysis and econometric approach,” *Renew. Sustain. Energy Rev.*, vol. 40, pp. 438–449, 2014, doi: 10.1016/j.rser.2014.07.169.
- [3] B. M. S. Masnadi *et al.*, “Global carbon intensity of crude oil production,” no. August, pp. 10–13, 2018, doi: 10.1126/science.aar6859.
- [4] A. S. Hassan and K. N. Zaki, “Decadal analysis of carbon dioxide emissions from different state of fossil fuels in Iraq,” *Indian J. Public Heal. Res. Dev.*, vol. 9, no. 12, pp. 865–868, 2018, doi: 10.5958/0976-5506.2018.01956.3.
- [5] E. Summary, “Carbon Intensity of Crude Oil in Europe.” ,pp.20 ,2010 .
- [6] R. Macmath, “CARBON DIOXIDE INTENSITY RATIOS : A Method of Evaluating the Upstream Global Warming Impact of Long-Life Building Materials,” 2012.
- [7] F. Pretis and M. Roser, “Carbon dioxide emission-intensity in climate projections : Comparing the observational record to socio-economic scenarios,” *Energy*, vol. 135, pp. 718–725, 2017, doi: 10.1016/j.energy.2017.06.119.
- [8] S. Acar and M. Lindmark, “Periods of converging carbon dioxide emissions from oil combustion in a pre-Kyoto context,” *Environ. Dev.*, pp. 1–9, 2016, doi: 10.1016/j.envdev.2016.06.005.
- [9] Y. Liu, F. Ren, and H. Ding, “Impact analysis of carbon prices on metal mining projects by block-based estimation model : Implications for cleaner production,” *J. Clean. Prod.*, vol. 229, pp. 695–705, 2019, doi: 10.1016/j.jclepro.2019.05.052.
- [10] A. R. Brandt *et al.*, “Oil Production Greenhouse Gas Emissions Estimator,” vol. 1, no. 650, 2017.
- [11] T. Services, “Carbon Dioxide Intensity Indicators,” no. May, 2007.
- [12] N. R. Canada, “Automart,” vol. 2, pp. 1–2.
- [13] S. Juntueng, S. Towprayoon, and S. Chiarakorn, “Resources , Conservation and

Recycling Energy and carbon dioxide intensity of Thailand ' s steel industry and greenhouse gas emission projection toward the year 2050," *Resources, Conserv. Recycl.*, vol. 87, pp. 46–56, 2014, doi: 10.1016/j.resconrec.2014.03.014.

- [14] J. Kim, J. Oh, K. Baek, Y. Park, M. Zhang, and J. Lee, "Thermolysis of crude oil sludge using CO<sub>2</sub> as reactive gas medium," *Energy Convers. Manag.*, vol. 186, no. December 2018, pp. 393–400, 2019, doi: 10.1016/j.enconman.2019.02.070.
- [15] H. Li, J. Zhang, Y. Cheng, and Z. Huang, "Journal of Quantitative Spectroscopy & Radiative Transfer Calculations of radiative intensity in one-dimensional gaseous media with black boundaries using the statistical narrow band model," *J. Quant. Spectrosc. Radiat. Transf.*, vol. 240, p. 106691, 2020, doi: 10.1016/j.jqsrt.2019.106691.
- [16] K. Lv, Y. Cheng, and Y. Wang, "Does regional innovation system efficiency facilitate energy - related carbon dioxide intensity reduction in China?," *Environ. Dev. Sustain.*, no. 0123456789, 2020, doi: 10.1007/s10668-020-00609-0.
- [17] D. N. Meehan, H. M. El-houjeiri, A. S. Company, and S. Jeffrey, "SPE-192166-MS Carbon Intensity : Comparing Carbon Impacts of Middle East and US Shale Oils," 2018.
- [18] W. Wen and Q. Wang, "Re-examining the realization of provincial carbon dioxide emission intensity reduction targets in China from a consumption-based accounting," *J. Clean. Prod.*, p. 118488, 2019, doi: 10.1016/j.jclepro.2019.118488.
- [19] L. Chen, X. Li, S. Xue, L. Qu, and M. Wang, "Carbon intensity and emission reduction potential in China : spatial measuring method," *J. Econ. Struct.*, no. 2019, 2020, doi: 10.1186/s40008-019-0142-6.
- [20] J. Kim, H. Lim, and H. Jo, "Do Aging and Low Fertility Reduce Carbon Emissions in Korea ? Evidence from IPAT Augmented EKC Analysis," 2020.
- [21] E. Dogan and R. Inglesi-lotz, "The impact of economic structure to the environmental Kuznets curve ( EKC ) hypothesis : evidence from European countries," 2020.
- [22] J. S. A. Al Rukabie, A. S. Hassan, and J. H. Kadhum, "Empirical analysis of CO<sub>2</sub> emission using EKC model in Iraq," *Int. J. Adv. Sci. Technol.*, vol. 29, no. 3 Special Issue, pp. 557–564, 2020.