Updated Vented, Flaring, and Fugitive Greenhouse Gas Emissions for Crude Oil Production in the GREET™ Model

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1. Background

In 2013, the U.S. total crude oil production reached 7.5 million barrels per day, while shale oil production from Eagle Ford and Bakken plays reached 1.5 million barrels per day, representing about 20% of the total U.S. crude production (U.S. Energy Information Administration, 2015a). Vented, fugitive, and flaring (VFF) CH_4 and CO_2 emissions can be released to the atmosphere during crude oil production processes (U.S. Environmental Protection Agency, 2015). VFF CH_4 and CO_2 emissions can vary among the oil wells as a result of varying crude production operations and the emission control and flaring reduction practices at the well level. VFF CH_4 and CO_2 emissions can be an important greenhouse gas (GHG) emission source for crude production, and require careful examination for the purpose of evaluating the well-to-wheels GHG emissions of petroleum fuel production pathways. Here, we looked at the VFF CH_4 and CO_2 emissions of crude oil production in the U.S. in 2013 based on the latest GHG emission inventory report by the United States Environmental Protection Agency (EPA) (U.S. Environmental Protection Agency, 2015). The aim of this analysis is to update our estimation of the VFF CH_4 and CO_2 emissions per mmBtu of crude oil production that we estimated and incorporated in the Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET™) model in 2015. This analysis focuses on the VFF CH_4 and CO_2 emissions associated with U.S. crude oil production. In particular, the VFF CH_4 and CO_2 emissions from two major shale oil production plays, i.e. the Bakken and Eagle Ford shale plays, are analyzed and reported elsewhere for incorporation into the GREET 2015 model.

2. Data and methodology

The 2015 EPA methodology for estimating VFF CH_4 and CO_2 emissions in 2013 remained the same as it was in the 2014 EPA methodology, which was summarized in our previous analysis (Cai et al., 2014). For this update, we applied the same approach to process the EPA VFF CH_4 and CO_2 emissions in 2013 to estimate the VFF CH_4 and CO_2 emission factors in grams per mmBtu of crude oil production.

3. Results

With the information on the U.S. crude oil production in 2013, which was 2720.8 million barrels (U.S. Energy Information Administration, 2015b), we estimated the VFF CH_4 and CO_2 emission factors from U.S. crude oil production, as shown in Tables 1 and 2.

Table 1. VFF CH_4 emission factors for various activities and equipment operations for crude oil production in 2013

Activity/Equipment	**Emissions, Gg**	**Emission factors, g/mmBtu**
Vented Emissions	**795.1**	**53.7**
Oil Tanks	317.5	21.4
Pneumatic controllers	220.6	14.9
Chemical Injection Pumps	54.1	3.7
Vessel Blowdowns	0.3	0.02
Compressor Blowdowns	0.2	0.01
Compressor Starts	0.5	0.03
Stripper wells	14.2	1.0
Well Completion Venting	0.2	0.01
Well Workovers	0.1	0.01
Offshore Platforms, Shallow water Oil, fugitive, vented and combusted	168.1	11.3
Offshore Platforms, Deepwater oil, fugitive, vented and combusted	19.3	1.3
Fugitive Emissions	**94.4**	**6.4**
Oil Wellheads	59.5	4.0
Separators	10.7	0.7
Heater/Treaters	11.4	0.8
Headers	5.3	0.4
Floating Roof Tanks	0.2	0.01
Compressors	2	0.1
Sales Areas	1.8	0.1
Battery Pumps	0.4	0.03
Pressure Relief Valves	0.2	0.01
Well Blowouts Onshore	2.8	0.2
Voluntary Reductions	**-284.6**	**-19.2**
Total Net Emissions	**604.9**	**40.8**

Table 2. VFF CO_2 emission factors for various activities and equipment operations for crude oil production in 2013

Activity/Equipment	Emissions, Gg	Emission factors, g/mmBtu
Vented Emissions	**455.2**	**30.7**
Oil Tanks	416.5	28.1
Pneumatic controllers, High Bleed	20.4	1.4
Pneumatic controllers, Low Bleed	6	0.4
Chemical Injection Pumps	3	0.2
Stripper wells	0.8	0.1
Offshore Platforms, Shallow water Oil, fugitive, vented and combusted	7.7	0.5
Offshore Platforms, Deepwater oil, fugitive, vented and combusted	0.6	0.0
Fugitive Emissions	**5.4**	**0.4**
Oil Wellheads (light crude)	3.3	0.2
Separators	0.6	0.04
Heater/Treaters	0.5	0.03
Headers (light crude)	0.3	0.02
Compressors	0.1	0.01
Sales Areas	0.3	0.02
Battery Pumps	0.1	0.01
Well Blowouts Onshore	0.2	0.01
Total	**460.6**	**31.1**

We estimated a flaring CH_4 and CO_2 emission factor of about 0.01 and 1.6 g/mmBtu of the U.S. crude oil produced, respectively, based on the volume of the associated gas flared, which was about 0.01 billion cubic meters (U.S. Environmental Protection Agency, 2015), at a flaring efficiency of 98%, and on the physical properties of the associated gas we assumed before (Cai et al., 2014). Table 3 summarizes the VFF CH_4 and CO_2 emission factors based on the 2015 EPA GHG Emission Inventory. We applied these VFF emission factors to U.S. conventional crude production other than shale oil production, as these emission factors were based on the EPA estimation of the VFF emissions that used process- and activity-specific emission factors that were developed in the 1990s, representing much better the emission characteristics of the U.S. conventional crude production than shale oil production that started to boom only around 2006.

Table 3. Vented, flaring, and fugitive CH_4 and CO_2 emission factors from U.S. crude oil production

	CH_4, g/mmBtu of crude	**CO_2, g/mmBtu of crude**
Venting	53.7	30.7
Flaring	0.01	1.6
Fugitive	6.4	0.4
Voluntary Reductions	-19.2	
Total VFF	**40.8**	**32.7**

The small emission factors for flaring are primarily due to the small portion of the flaring volume of associated gas from oil and gas production in the U.S. that the EPA allocated to crude oil production, which is disproportional to the relative ratio of the oil and gas production by energy. Better clarification on the EPA data and methodology to draw the boundary between oil and gas production is warranted to shed light on a more accurate allocation of the flares between crude oil production and natural gas production, which is very important to improve the understanding of the flaring emissions associated with oil and gas production in the U.S.

References:

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