

## MEMORANDUM

Date: **December 30, 2021**

To: **Tom Moore, Western States Air Resources Council - Western Regional Air Partnership**

From: **John Grant, Rajashi Parikh, Anthony Gerigk and Amnon Bar-Ilan**

Subject: **Review of Western Regional Air Partnership Region Input Factors Implementation in the 2020 Nonpoint Oil and Gas Emission Estimation Tool**

EPA uses the Nonpoint Oil and Gas Emission Estimation Tool (O&G Tool) to estimate nationwide nonpoint source oil and gas (O&G) emission inventories for use in the National Emission Inventory (NEI) and modeling platforms. EPA has incorporated Western Regional Air Partnership (WRAP) Oil and Gas Workgroup (OGWG) survey results into the 2020 O&G Tool for those geographic areas covered by the survey.

Ramboll reviewed the 2020 O&G Tool to ensure that WRAP OGWG survey inputs were applied correctly in the 2020 O&G Tool. Ramboll review consisted of checks and comparisons below.

- Comparison of WRAP OGWG survey input factors to those implemented in the 2020 O&G Tool.
- Comparison of WRAP OGWG weight- and mole-based gas composition profiles to weight fractions implemented in the 2020 O&G Tool.
- Hand calculation of emissions based on 2020 O&G Tool inputs (including those inputs that were updated based on WRAP OGWG survey data) to ensure that county-level emissions are being estimated accurately and consistently with 2020 O&G Tool inputs.

The review documented herein relied on the data sources below.

- WRAP OGWG survey input factors<sup>1</sup>
- WRAP OGWG gas composition<sup>2</sup>
- 2020 O&G Tool memo<sup>3</sup>
- Table of EPA O&G Tool inputs for source categories that were updated based on WRAP OGWG survey data<sup>4</sup>
- Activity data applied in the tool for each affected source category<sup>4</sup>
- O&G Tool output emission inventory estimates for affected source categories<sup>4</sup>
- Documentation of emission estimation methodology for affected source categories<sup>4</sup>

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<sup>1</sup> Grant, J., R. Parikh, A. Bar-Ilan, 2019. "Revised Final Report: Circa-2014 Baseline Oil and Gas Emission Inventory for the WESTAR-WRAP Region". Ramboll. Prepared for the Western Regional Air Partnership Oil and Gas Workgroup.

[https://www.wrapair2.org/pdf/WRAP\\_OGWG\\_2028\\_OTB\\_RevFinalReport\\_05March2020.pdf](https://www.wrapair2.org/pdf/WRAP_OGWG_2028_OTB_RevFinalReport_05March2020.pdf)

<sup>2</sup> Ramboll, 2020. Memorandum: Gas Composition Profiles Developed by the Western Regional Air Partnership Oil and Gas Working Group and Potential Data Sources Available to Develop Additional Gas Composition Profiles. [https://www.wrapair2.org/pdf/OG\\_Speciation\\_Development\\_24Nov2020.pdf](https://www.wrapair2.org/pdf/OG_Speciation_Development_24Nov2020.pdf)

<sup>3</sup> ERG, 2021. Memorandum: Analysis of WRAP Gas Composition and Basin Factor Data for use in the 2020 NEI Nonpoint Oil and Gas Emission Estimation Tool.

<sup>4</sup> 2020 O&G Tool Input Factors as transmitted by Email from EPA (Jeffrey Vukovich) to Ramboll (John Grant), December 7, 2021.

**1. Input Factors Comparison**

Ramboll compared 2020 O&G Tool input factors to WRAP OGWG survey-based emission inventory inputs to confirm implementation of the WRAP OGWG survey-based emission inventory inputs into the 2020 O&G Tool. Table 1 below summarizes findings and recommendations of the comparison.

**Table 1. Summary of finding and recommendations for the inputs in the 2020 O&G Tool.**

Source	Applicable Basins	Findings	Recommendations
<b>Survey Input Data</b>			
All applicable survey sources	Williston (SD <sup>5</sup> )	<b>SD (Williston) Input Factors:</b> WRAP survey input data for Williston (ND) have been assumed for Williston (SD).	<b>No update recommended:</b> WRAP survey data for Williston (ND) are applied to Williston (SD). This is appropriate in absence of SD specific inputs.
		<b>Well type:</b> For drill rigs, WRAP survey data is for oil wells only. The 2020 O&G Tool updates presume that the survey data applies to all well types.	<b>No update recommended:</b> A vast majority of wells in these basins are oil wells and hence the use of oil well survey inputs is appropriate.
		<b>Electrification:</b> Per the WRAP survey, 23% of engines in the Williston (ND) basin are electrified. It appears that this isn't being taken into account in the 2020 O&G Tool.	<b>Update recommended (#1):</b> Account for 23% engine electrification as indicated in the WRAP survey.
Drill Rigs	Permian (NM <sup>5</sup> ), Williston (ND <sup>5</sup> ), Williston (MT <sup>5</sup> )	<b>Engine Tier:</b> WRAP survey engine tier inputs are not incorporated into 2020 O&G Tool emission factors.	<b>No update recommended:</b> MOVES emission factors used in the 2020 O&G Tool are similar to survey-based emission factors; updates to emission rates are not warranted.
		<b>Well type:</b> For this source category, WRAP survey data is for oil wells only. The 2020 O&G Tool updates presume that the survey data applies to all well types.	<b>No update recommended:</b> A vast majority of wells in these basins are oil wells and hence the use of oil well survey inputs is appropriate.
		<b>Spud type:</b> For this source category, WRAP survey data is specific to the horizontal spud type. The 2020 O&G Tool applies these data to all spud types.	<b>No update recommended:</b> A vast majority of spuds in these basins are horizontal spuds and hence the use of horizontal spud survey inputs is appropriate.
Hydraulic Fracturing	Permian (NM), Williston (ND)	<b>Engine Type and Electrification:</b> WRAP survey data for the Permian (NM) Basin is for two engine configurations (internal combustion engines and turbines). 95% of activity is estimated to be performed by internal combustion engines and 5% by turbines. The 2020 O&G Tool includes only the diesel engine configuration. Additionally, in the Permian (NM) Basin diesel engine configuration, 5% of engines are electrified.	<b>Update recommended (#2):</b> It is reasonable to exclude the turbine configuration from the 2020 O&G Tool. If feasible, 5% electrification should be accounted for in the 2020 O&G Tool.

<sup>5</sup> South Dakota (SD); New Mexico (NM); North Dakota (ND); Montana (MT)

Source	Applicable Basins	Findings	Recommendations
Hydraulic Fracturing	Permian (NM), Williston (ND)	<b>Engine Tier:</b> Engine tier inputs are not incorporated into the 2020 O&G Tool emission factors.	<b>No update recommended:</b> MOVES emission factors used in the 2020 O&G Tool are similar to survey-based emission factors; updates to emission rates are not warranted.
Crude Oil Tanks	Central Montana Uplift (MT), Permian (NM), Powder River Basin (MT), Sweetgrass Arch (MT), Williston Basin (MT), Williston (ND)	<b>Control:</b> 2020 O&G Tool percent of tanks that are controlled is not based on WRAP survey data.	<b>No update recommended:</b> GHGRP data has been used in the 2020 O&G Tool.
		<b>Gas venting rate:</b> 2020 O&G Tool gas venting rate (mcf gas/bbl <sup>6</sup> crude oil) is not based on WRAP survey data.	<b>Update recommended (#3):</b> Gas venting rate should be updated based on WRAP survey data in the 2020 O&G Tool.
Condensate Tank	Sweetgrass Arch (MT), Williston Basin (MT), Williston (ND)	<b>Control:</b> 2020 O&G Tool percent of tanks that are controlled is not based on WRAP survey data.	<b>No update recommended:</b> GHGRP data has been used in the 2020 O&G Tool.
		<b>Gas venting rate:</b> 2020 O&G Tool gas venting rate (mcf gas/bbl condensate) is not based on WRAP survey data.	<b>Update recommended (#4):</b> Gas venting rate should be updated based on WRAP survey data in the 2020 O&G Tool.
Well-head Engines	Sweetgrass Arch (MT)	<b>Spud Type:</b> The 2020 O&G tool assumes that the WRAP survey data for vertical spud types is applicable to horizontal spud type.	<b>No update recommended:</b> Due to limited data availability, it is reasonable to assume vertical spud type survey input factors for both horizontal and vertical spud types.
Lateral Compressor Engines	Big Horn Basin (MT), Central Montana Uplift (MT)	<b>Spud Type:</b> The 2020 O&G tool assumes that the WRAP survey data for vertical spud types is applicable to horizontal spud type.	<b>No update recommended:</b> Due to limited data availability, it is reasonable to assume vertical spud type survey input factors for both horizontal and vertical spud types.

<sup>6</sup> Million cubic feet per barrel

Source	Applicable Basins	Findings	Recommendations
Artificial Lift Engines	Permian (NM), Williston (ND), Williston (MT)	<b>Spud Type:</b> The 2020 O&G Tool input factors are based exclusively on vertical or horizontal spud types for basins in which a single spud type's input factors are available in the WRAP survey. For basins in which WRAP survey data are available for both vertical and horizontal spud types, an average of vertical and horizontal spud types is assumed for the 2020 O&G Tool input factors.	<b>Update recommended (#5):</b> For basins where horizontal and vertical survey inputs are available, we recommend estimating weighted average input factors based on the oil production by spud type.
		<b>Rich-/Lean-Burn:</b> The 2020 O&G Tool input factors have not been updated to reflect WRAP survey estimates of the fraction of lean-burn and rich-burn engines.	<b>Update recommended (#6):</b> Update 2020 O&G Tool based on WRAP survey estimates of lean-burn and rich-burn engine fractions.
		<b>New Source Performance Standard (NSPS) Compliance:</b> Emission rates for Permian (NM) Basin engines in the 2020 O&G Tool are based on uncontrolled AP-42 emission factors. However, WRAP survey indicates that 99% of engines meet NSPS JJJJ criteria.	<b>Update recommended (#7):</b> Revise 2020 O&G Tool emission rates to be consistent with 99% of engines meeting NSPS JJJJ for the Permian (NM) basin.
Casinghead Gas Venting and Flaring	Williston (ND), Williston (MT), Williston (SD)	<b>Input factors:</b> The 2020 O&G Tool input factors to estimate venting and flaring emissions are: * Gas Venting Rate (MCF/bbl): 0.0282 based on the WRAP 2011 emission inventory <sup>7</sup> * Fraction of Gas Vented: 0.84 based on GHGRP Subpart W data for 2020	<b>Update recommended (#8):</b> Revise venting and flaring volume inputs consistent with WRAP study Section 2.3.2 <sup>1</sup> : <b>Combined volume of gas flared and vented:</b> EIA publishes combined gas flared and vented volume estimates for each year <sup>8</sup> , including 2020, for North Dakota and Montana. The Tool input factors should be adjusted so that venting and flaring volumes are consistent with EIA estimates. <b>Vented and flared split.</b> Apply the 2011 Williston Basin emission inventory <sup>7</sup> estimate of 99.7% flared and 0.3% vented.

<sup>7</sup> Grant, J., R. Parikh, A. Bar-Ilan, 2014. "Development of Baseline 2011 and Future Year 2015 Emissions from Oil and Gas Activity in the Williston Basin". Prepared for Bureau of Land Management Montana/Dakotas State Office and the Western States Air Resources Council.

[https://www.wrapair2.org/pdf/2011\\_2015\\_Williston\\_Basin\\_14Aug2014.pdf](https://www.wrapair2.org/pdf/2011_2015_Williston_Basin_14Aug2014.pdf)

<sup>8</sup> [https://www.eia.gov/dnav/ng/ng\\_prod\\_sum\\_a\\_EPG0\\_VGV\\_mmcfa.htm](https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGV_mmcfa.htm)

**2. Gas Composition-based Inputs Comparison**

Ramboll compared 2020 O&G Tool input factors that were derived from WRAP OGWG survey-based gas composition profiles. Table 2 below summarizes findings and recommendations of the comparison.

**Table 2. Summary of findings and recommendations for the gas composition profiles-based inputs to the 2020 O&G Tool.**

Source	Applicable Basins	Findings	Recommendations
<b>Gas Composition Data</b>			
Oil Well Gas Actuated Pumps	Williston (ND), Williston (MT)	<b>Weight fraction:</b> "2020 NEI Tool ACT_OIL_WT_FRACTION_TOLUENE_VOC" <sup>4</sup> (column AR) was not populated correctly.	<b>Update recommended (#9):</b> Revise the toluene to volatile organic compound (VOC) weight fractions in Column AR.
Gas Well Pneumatic Devices, Gas Well Mud Degassing, Gas well Gas Actuated Pumps, Gas Well Fugitives, Gas Well Dehydrators, Gas Well Produced Water	Central Montana Uplift (MT)	<b>Weight fraction:</b> Produced gas composition analysis data were not updated for this basin.	<b>Update recommended (#10):</b> Revise the gas composition data for all applicable sources in this basin based on the WRAP OGWG gas composition for this basin.

**3. Emission Calculation Checks**

Ramboll performed hand emission inventory calculations of county-based emissions for categories with 2020 O&G Tool updates based on WRAP OGWG survey inputs. Hand calculations relied on 2020 O&G Tool emission calculation methodology. Hand calculation results were compared to 2020 O&G Tool emission inventory output. Table 3 below summarizes findings and recommendations.

**Table 3. Summary of findings and recommendations of sample emissions calculations.**

Source	Sample Basin	Findings	Recommendations
Drill Rigs	Williston (ND)	<b>Emissions do not match:</b> Per the WRAP survey, 23% of engines in the Williston (ND) basin are electrified. It appears that this isn't being taken into account in the 2020 O&G Tool emissions calculation.	<b>Update recommended (#11):</b> Account for 23% engine electrification as indicated in the WRAP survey.
Hydraulic Fracturing	Permian (NM)	<b>Emissions do not match:</b> WRAP survey data for the Permian (NM) Basin is for two engine configurations (diesel engines and turbines). 95% of activity is estimated to be performed by diesel engines and 5% by turbines. The 2020 O&G Tool includes only the diesel engine configuration. Additionally, in the Permian (NM) Basin diesel engine configuration, 5% of engines are electrified.	<b>Update recommended (#12):</b> It is recommended that electrified activity fractions available from the WRAP OGWG survey be accounted for in 2020 O&G Tool emissions calculations.
Crude Oil Tanks	Power River (MT)	<b>Emissions match.</b>	-
Condensate Tanks	Williston Basin (MT)	<b>Emissions match.</b>	-
Artificial Lift Engines	Permian Basin (NM)	<b>Emissions do not match:</b> In the 2020 O&G Tool, emission factors are based on AP-42 uncontrolled emission rates. However, WRAP survey data indicates that 99% of engines meet NSPS JJJJ standards.	<b>Update recommended (#13):</b> Revise emission factor to be consistent with the fraction of engines meeting NSPS JJJJ as indicated in WRAP OGWG survey results.
Well-head compressor engines	Sweetgrass Arch (MT)	<b>Emissions match.</b>	-
Lateral compressor engines	Central Montana Uplift (NM)	<b>Emissions do not match:</b> Unable to replicate emissions for rich-burn engines. See example below.	<b>Update recommended (#14):</b> Review and confirm 2020 O&G Tool calculations.

**Lateral compressor engines emissions:** As noted in the table above, we were unable to match lateral compressor engine emissions with the emissions provided in the output spreadsheet. We performed sample calculation for the oxides of nitrogen (NOx) based on the equation below with the inputs shown in Table 4.

$$E_{engine,rich} = \frac{EF_i \times HP \times LF \times t_{annual}}{907,185} \times (1 - F_{controlled} \times CF_i) \times F_{rich} \times W_{gas} \times F_{compression} \times \frac{1}{N_{lateral}}$$

where:

- $E_{engine,rich}$  are emissions from rich-burn compressor engine in a county [ton/yr]
- $EF_i$  is the emissions factor of pollutant  $i$  [g/hp-hr]
- $HP$  is the rated horsepower of the engine [hp]
- $LF$  is the load factor
- $t_{annual}$  is the annual number of hours the engine is used [hr/yr]
- $F_{controlled}$  is the fraction of lateral compressors that are controlled
- $CF_i$  is the control factor for controlled engines for pollutant  $i$
- $F_{rich}$  is the fraction of rich-burn lateral compressors in the county amongst all lateral compressors
- $W_{gas}$  is the total gas well count in a county
- $N_{lateral}$  is the number of gas wells served by a lateral compressor engine
- $F_{compression}$  is the fraction of natural gas wells in the county needing compression
- 907,185 is the unit conversion factor g/ton

**Table 4. 2020 O&G Tool sample input factors and emissions for the rich-burn lateral compressor engines.**

Parameter	Input
STATE_ABBR	MT
BASIN	Central Montana Uplift
County	Blaine
SOURCE_CATEGORY	LATERAL/GATHERING COMPRESSOR ENGINES
SCC	2310021351
SCC_SHORTENED	On-Shore Gas Production/Lateral Compressors 4 Cycle Rich Burn
POLLUTANT_CODE	NOx
Emission Factor (g/bhp-hr)	8.237
HP	277
Fraction rich-burn	0.890
LF	0.8303
Hours (hours-yr)	4,576
Number of Gas Wells per Single Lateral Compressor	28
County-Level Natural Gas Well Counts	599
Fraction of natural gas wells in the county needing compression	0.07124434
Hand Calculated NOx emissions (tons/yr)	12.96
2020 O&G Tool NOx emissions (tons/yr)	33.34

#### 4. Recommendations

For each update identified above, we have assigned priority and summarized the recommendation below.

- “High priority” was assigned to recommended revisions for a WRAP region basin(s) that are expected to result in substantive changes to the O&G emission inventory.
- “Low priority” was assigned to recommended revisions for a WRAP region basin(s) that are expected to result in relatively small changes to the O&G emission inventory.
- “General Comments on Tool Inputs/Functionality” was assigned to recommended revisions applicable broadly across basins in the Tool (i.e., not limited to WRAP region O&G basins).

Recommended revisions to the 2020 O&G Tool are listed below.

- **High Priority**

- **Artificial Lift Engine Emission Rates (recommended updates #6, #7, and #13):** Artificial lift engines emission rates for the Permian Basin (NM) should be updated to account for NSPS compliance and lean-burn engines. The current emissions are overestimated because uncontrolled rich-burn AP-42 emission rates are applied.
- **Casinghead Gas Venting and Flaring (recommended update #8):** For casinghead gas venting and flaring, the inputs that are used to estimate the volume of gas flared and vented should be updated consistent with WRAP methodology<sup>1</sup>. 2020 volume of gas vented and flared is available from EIA<sup>8</sup> to estimate year specific volumes.
- **Drill Rig and Hydraulic Fracturing Electrification (recommended updates #1, #2, #11, and #12):** The fraction of engines that are electrified should be updated for basins in which the percent of electrified activity is known. Currently drill rig and hydraulic fracturing emissions are overestimated because electrified activity is not accounted for in applicable basins.
- **Oil Well Gas Actuated Pumps Toluene to VOC Weight Ratio (recommended update #9):** Gas composition in 2020 O&G Tool data provided by EPA<sup>4</sup> includes an incorrect toluene to VOC weight ratio for the Williston (ND) and Williston (MT) basins.
- **Produced Gas Composition for the Central Montana Uplift (MT) Basin (recommended update #10):** A produced gas composition analysis for gas wells in the Central Montana Uplift (MT) Basin is available from the WRAP OGWG and should be implemented in the 2020 O&G Tool.
- **Condensate Tanks and Crude Oil Tanks Gas Venting Rate (recommended updates #3 and #4):** The gas venting rate for condensate tanks and crude oil tanks should be updated with WRAP survey input factors. The gas venting rate impacts emissions associated with tank flaring.



- **Low Priority**
  - **Spud Specific Equipment Activity (recommended updates #5):** For artificial lift engines, we recommended calculating weighted average input factors based on oil production by spud type. This is a low priority update because emission changes that would result from this update are expected to be small.
- **General Comments on Tool Inputs/Functionality**
  - **NSPS Compliance Rate Effect on Well-head Engine Emission Rates:** The 2020 O&G Tool uses uncontrolled AP-42 emission rates and the fraction of engines that are controlled to estimate emission rates for artificial lift and compressor engines. Given that NSPS JJJJ has been in effect for over a decade, there should be an option in the Tool to default to NSPS JJJJ emission factors rather than estimating emission factors based on uncontrolled AP-42 emission factors and the fraction of engines that are controlled.
  - **GHGRP Subpart W-based Input Factors:** As part of WRAP OGWG efforts to improve emission inventories in the WRAP region, Ramboll carefully documented the fraction of activity represented by survey respondents<sup>1</sup> to support the basis for emission inventory estimates. Several 2020 O&G Tool input factors were updated based on data reported under GHGRP Subpart W. EPA should include the fraction of activity represented by reporting companies to support the basis for the 2020 O&G Tool emission inventory estimates.
  - **Associated Gas Venting and Flaring:** EPA should consider using state-level EIA volume of gas vented and flared<sup>1</sup> to confirm that 2020 O&G Tool estimates of the volume of gas vented and flared are reasonable.
  - **Rich- and Lean-Burn Specification Capability for Artificial Engines:** The 2020 O&G Tool does not have an option to account for the fraction of artificial engines that are lean-burn and rich-burn. The 2020 O&G Tool estimates emissions for artificial lift engines based on rich-burn engine emission rates. The WRAP survey indicated that a substantial fraction of artificial lift engines were lean-burn engines (26% to 76% depending on basin and spud type). Updating the Tool to allow for specification of rich-burn and lean-burn engine fractions could result in more accurate emission estimates for basins in which rich-burn and lean-burn engine fractions are available.
  - **Accounting for Differences in Input Factor for Horizontal and Vertical Wells:** The 2020 O&G Tool does not provide flexibility to estimate different emission regimes for vertical and horizontal spuds, with the exception of drill rigs. In basins where there are substantial legacy vertical wells and newer horizontal wells, distinguishing between emission regimes for each could result in more accurate emissions. However, we understand that this update only makes sense if there are basins for which data to distinguish vertical and horizontal well input factors are readily available.
  - **Lateral Compressor Engines (Rich-burn, #14):** EPA should verify that the 2020 O&G Tool is calculating rich-burn, lateral compressor engine emissions correctly.