1 Questions & Answers

The text below responds to concerns and questions raised regarding both the Subramanian et al. (2015) and Zimmerle et al. (2015) papers studying emissions from the transmission & storage sector. Questions are in italics and response in regular text.

2 Questions about input data sets

Q 1. Subramanian et al. Table S2 lists Site 20 and 43 as "storage" (without specifying injecting or quiescent) and "transmission" (but specifying quiescent state) respectively.

a. Both sites are storage sites. Site 20 was initially in quiescent mode, but started injecting in the afternoon, when all the tracer flux data were collected. These sites were correctly labeled in other the SI tables.

b. Resolution: Site 20 should be described as "quiescent/injecting", while the description for Site 43 should be corrected to read "storage" instead of "transmission."

Q 2. A few measurements were reported as Hi-Flow measurements, but were higher than the upper limit of the Hi-Flow (10.5 SCFM)

a. Measurement #10: Site 3 lists 11.9 SCFM for transmission tank emissions, but these are actually two separate emissions (8.1 SCFM and 3.8 SCFM) that were both within the range of the Hi-Flow. One of the emissions was labeled as "transmission tank vent" in the onsite measurements.

b. Measurement #51, #92, #185 – likely field-mislabeled measurement method: These values were reported by the onsite survey team as taken with a Hi-Flow, but reported emissions are 27.7 SCFM (Site 12 non-compressor OEL), 75.4 SCFM (Site 44, compressor OEL but actually a "blowdown vent with meter"), and 26.5 SCFM (Site 10, compressor connector.) We reported the measurement method as recorded by the onsite team; however, when the emission was found to be higher than the Hi-Flow, the onsite team substituted a different measurement method, for example a turbine meter, anemometer, or a bag with a timer, and occasionally did not update the log sheets to reflect the substitution. Therefore, the onsite logs do not always reflect the final measurement method actually used. Since this study was not intended to evaluate measurement methods, data QA/QC did not screen for this type of logging error. However, due to issues with VPAC accuracy noted in the SI, the modeling study did not use VPAC measurements. These measurements were identified in field and partner data sets and were not utilized in the modeling study (Zimmerle, et. al.), and are not shown in the CDFMaster.xlsx.

   Excluding these 3 measurements, the remaining 1,100+ Hi-Flow measurements reported in this study were all below the Hi-Flow upper limit (10.5 SCFM), with one value of 10.4 SCFM and the remaining at 9 SCFM or lower. After an extensive review of field records, the team believes all measurements were within the flow limits of the method utilized.

Q 3. *"As I understand it, the data in "CDFMaster" has both the field measurements made by your teams (designated "Field") as well as additional measurements contributed by the participating companies ("Partner"). However, I can't get the number and sum of the "Field" measurements in "CDFMaster" to match the Table S10 in the Subramanian SI. For some categories they match, for others the sum is the same but the number of measurements is different, or both are different, and it seems to be both higher and lower. For example, the reciprocating isolation valve category in Table S10 lists 47 measurements for a total of 13.5 scfm and a factor of 0.3 scfm, and lists how many were at each site, which does total to 47. However, the RecipIsolation_NOD tab lists only 7 "Field" measurements, although the sum is the same (13.5 scfm), resulting in a much higher factor of 1.93. So if you could help me understand how those numbers work, that would be helpful."*

a. The survey teams often used a VPAC to detect leaks at isolation valves; if no leak was detected, the measurement was reported as zero. In the measurement paper (which included VPAC data in the analysis), Table S10 includes counts of isolation valves where the onsite team did not detect a leak (usually with a VPAC.) Hence, there are 47 measurement counts (1 isolation valve per NOD reciprocating compressor), with 7 non-zero measurements totaling 13.5 SCFM. So the measurement paper "study factor," calculated following the protocol for "company reporter factors," is 0.3 SCFM (13.5/47.) A similar approach is used for other columns in these tables of the measurement paper.
b. As noted earlier, CDFMaster.xlsx uses only field or partner measurements made following the study protocol and *not* using VPAC. Therefore, the "zero" VPAC measurements shown in the measurement paper are not utilized in CDFMaster.xlsx. These valves are treated *as if they had not been measured. Therefore,* the resulting distribution (which combines field and partner data, including many zeros from the partner data made via other methods) does not include these additional 40 "field" zeros.

Q 4. *" In the spreadsheet "CDFMaster", one measurement method is listed as "Combined". I'm guessing that since that's associated with several measurements that are exactly the same, that it was a measurement out of a common stack that was then divided equally among the components that went into that stack. Is that correct?"*

Correct – "Combined" refers to units that manifold into a single stack. Any measured emission was averaged and attributed back to the units on the single stack. As with the notes above, every attempt was made to note the measurement method, but this was not a focus of QA/QC for the study

3 Questions regarding modeling methodologies

Q 5. *Clarification of the "reclassification" utilized in post-analysis of field measurements.*

An important issue for developing a GHGRP Estimate is source classification. The GHGRP is governed by rules in Subpart W that require measurements of some emissions sources, while emissions from certain other source types are reported using emission factors and not direct measurements. Some operating modes are not reportable to the GHGRP. If emissions exist from one of these sources during a GHGRP survey, ambiguity exists on how these emissions should be recorded. For example consider reciprocating compressor rod packing. Rod packing is measured and reported when the compressor is in operating pressurized mode (OP), but is not reported in non-operating pressurized mode (NOP). Therefore, from the point-of-view of the GHGRP, an emitting rod packing vent is classified as a rod packing vent in one operating mode, but in another operating mode, it may be classified as a "compressor open-ended line" or could be omitted from reporting altogether, depending upon the company's interpretation of the reporting rules. The difference in classification may materially impact reported emissions, since a compressor OEL is reported as a leak count and emission factor, which may be significantly different from actual emissions.

In this study, comprehensive surveys were performed, including measurements of all identified sources in all operating modes. However, one objective of the study was to compare study results with emissions that would be reported to the GHGRP. Therefore, to use the example above, when calculating emissions *as they would have been reported*, an emitting rod packing vent would be classified as a rod packing vent or compressor OEL, depending upon the compressor operating mode, if emissions were detected and reported.

In addition, survey teams may occasionally mis-identify compressor equipment (isolation or blowdown valves, rod packing vents or centrifugal compressor seals) as "components," typically as compressor or non-compressor OELs.

For example, at Site #10, a reciprocating blowdown valve (measured emission 51 SCFM) was classified as a compressor component OEL (emission factor 0.3 SCFM) in the original report from the third-party contractor. Similar misclassifications were identified at 9 of the 47 study sites after careful review by the study team in consultation with the Partner companies. Before reclassification, the aggregate GHGRP Estimate at these sites was 44% of the aggregate SOE; after reclassification, the aggregate GHGRP Estimate was 55% of the aggregate SOE.

The impact of such misclassifications can be reduced through application of additional QA/QC procedures, such as those done in Subramanian et al. However, to accurately compare as-reported GHGRP data to the nationwide modeled emissions (SME in Zimmerle et al.), it is important to note that mis-identification occurs, and so the

classification reported by the survey team was used (i.e. the GHGRP data was not reclassified.)

Q 6. *Can the team provide the equivalent table to the modeling paper's SI Table 17-1 for the alternate station count?*

Table is provided Figure 3-1:

Emission Category	Activity Factor Comparison				Emissions Comparison					
	GHGI Activity Estimate	SME Mean Activity Estimate		Activity Units	GHGI Net Emissions (Gg)[4]	SME Mean Emissions (Gg)		GHGI Emission Factor	SME Emission Factor	Emission Factor Units
Transmission Stations Fugitives	*1,799*						+64%/-40%	*599*		
Station[2]	1,799	1,587	+36%/-24%	stations	95	102	+49%/-29%	53	64	Mg/station
Reciprocating Compressor[6]	7,235	4,518	+28%/-19%	units	773	295	+31%/-21%	107	65	Mg/compressor
Centrifugal Compressor (wet seals)[6]	659	767	+34%/-21%	units	198	52	+40%/-27%	301	68	Mg/compressor
Centrifugal Compressor (dry seals)[6]	66	1113	+28%/-20%	units	13	49	+40%/-28%	193	44	Mg/compressor
Uncategorized / Super-Emitter[1]		1587	+36%/-24%	stations	0	320	+108%/-65%		202	Mg/station
Storage Stations Fugitives	*344*						+69%/-42%	*573*		
Station[2]	344	381	+10%/-9%	stations	44	27	+38%/-26%	129	71	Mg/station
Compressors[3,6]	1,111	1512	+13%/-11%	units	153	106	+18%/-16%	137	70	Mg/compressor
Uncategorized / Super-Emitter[1]		381	+10%/-9%	stations	0	77	+150%/-83%		201	Mg/station
Compressor Exhaust	*69*			10	*133*		+14%/-10%	1.9		
Engines (Transmission)	51	27	+15%/-10%	10^9 hp-hr	121	99	+14%/-10%	2.4	3.7	g/hp-hr
Turbines (Transmission)	12	35	+13%/-10%	10^9 hp-hr	1.1	1.1	+21%/-18%	0.094	0.031	g/hp-hr
Electric (Transmission)	N/A	7.2	+47%/-32%	10^9 hp-hr		0			0	g/hp-hr
Engines (Storage)	4.4	6.0	+10%/-10%	10^9 hp-hr	10	22	+11%/-10%	2.4	3.6	g/hp-hr
Turbines (Storage)	1.5	1.8	+48%/-38%	10^9 hp-hr	0.14	0.056	+106%/-58%	0.094	0.031	g/hp-hr
Electric (Storage)	N/A	1.4	+52%/-44%	10^9 hp-hr		0			0	g/hp-hr
Pneumatic Devices	*84*			10	*243*		+30%/-24%	*2.9*		Mg/device
Transmission Stations	71	41	+47%/-34%	10^3 devices	207	43	+49%/-34%	2.9	1.0	Mg/device
Storage Stations[5]	14	32	+16%/-14%	10^3 devices	36	67	+19%/-17%	2.7	2.1	Mg/device
Station Venting	*2,143*			stations	*153*		+26%/-18%	*72*		Mg/Station
						86	+22%/-15%	72	54	Mg/station
Storage Stations[1]	344	381	+10%/-9%	stations	25	16	+45%/-32%	72	43	Mg/station
Total for Categories included in Study (Gg)					**1,805**	**1,362**	**+39%/-24%**	**Ratio: 75% [58% to 105%]**		
Total including 266 Gg of emissions from categories not included in SME (Gg)					**2,071**	**1,628**	**+32%/-20%**	**Ratio: 79% [63% to 104%]**		
Transmission All Categories	1,799	1,587	+36%/-24%	stations	1,537	1,047	+55%/-35%	854	660	Mg/station
Storage All Categories	344	381	+10%/-9%	stations	268	315	+53%/-34%	780	825	Mg/station

Figure 3-1: Comparison to GHGI for Alternate Station Count. This table parallels the table provided in the SI, Table 17-1 comparing the SME to the GHGI. The only change between Table 17-1 and this table is an increase in non-reported, non-partner facilities (Lane 5), modeled as indicated in the SI.