Applied Energy Symposium
MIT A+B
Co-organized with Harvard

Comprehensive Study of Major Methane Emissions Sources from Natural Gas System and Their Dependency to Throughput

Zahra Heydarzadeh[a], Michael Mac Kinnon[a], Clinton Thai[a], Jeff Reed[a], Jack Brouwer[a]

[a]Advanced Power and Energy Program, University of California, Irvine, CA, USA

OVERVIEW

Fig. 1 shows the distribution of each sector to the total methane emissions from the natural gas system for the year 2016 base year.

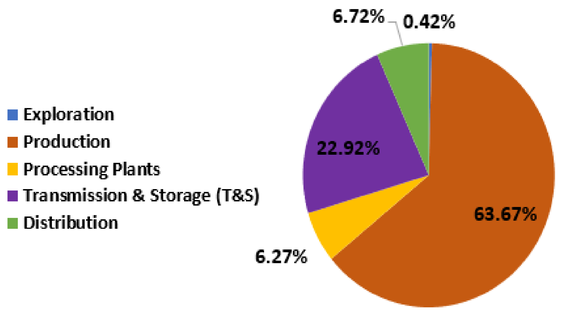

Fig. 1. U.S. Methane emissions from natural gas system in 2016 by EPA greenhouse gas inventory (Adapted from 2018 EPA/GHGI)

Goals

The goal of this study is to expand the characterization of components in the natural gas system. This is the first building block needed to determine the impact of changes in natural gas throughput on the total methane emissions.

Methodology

The first step in estimating marginal emissions of the natural gas infrastructure is to identify sources that have material impact on the emissions and for which enough component level data exists.

A 2018 EPA/GHGI report identifies 129 methane emissions sources from the U.S. natural gas system. Fig. 2 shows emissions percentages from each source. The "other" category in Fig. 2 represents sources in the natural gas system with methane emissions less than 3%.

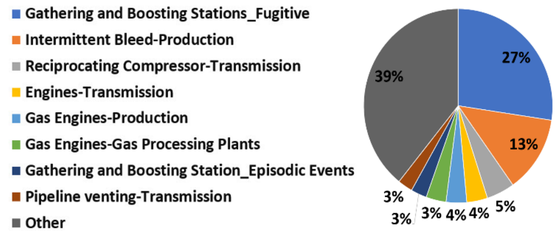

Fig. 2. The distribution of emissions percentage from each component of the natural gas system for the 2016 base year (data adapted from 2018 EPA/GHGI)

Emissions from each component of the natural gas system are attributed to several factors. These factors are then divided into three categories as suggested: Throughput-based, time-based, and event-based.

Equation below shows how the marginal approach calculates the total emissions for each individual emissions source in terms of its dependency upon time, event and/or throughput, where E_T, E_E, and E_{TP} are emissions rates driven by time, event, and throughput respectively, and a, b, and c are the marginal emissions coefficients of time, event, and throughput, respectively.

$$E = aE_T + bE_E + cE_{TP}$$

Results and Discussion

Comprehensive literature review is conducted to assess these marginal emission factor coefficients. The study of throughput, time, and event-based dependency of major emission sources is documented in order to determine each category percentage contribution. The final estimated coefficients for the investigated sources are presented in Table 1.

Some of the major contributors to the total methane emissions from the natural gas system are Pneumatic controllers. Pneumatic controllers are divided into two categories based on the type of emissions: intermittent vents, and continuous bleeding.

As shown in Fig. 3 emissions rate of intermittent controllers are highly dependent on frequency of opening and closing the valve, and therefore emissions rate for these types of devices are event based. When intermittent controllers process more gas flow, the actuation rate will increase, resulting in more venting to the atmosphere and as a result emissions rate is also partially dependent on throughput as shown in Table 1 (a=0%, b=80%, c=20%).

For continuous bleeding controllers, the temporary effect of opening and closing the valves on emissions rate canceled each other out (see Fig. 3), and therefore emissions rate for these type of controllers are time based (a=100%, b=0%, c=0%).

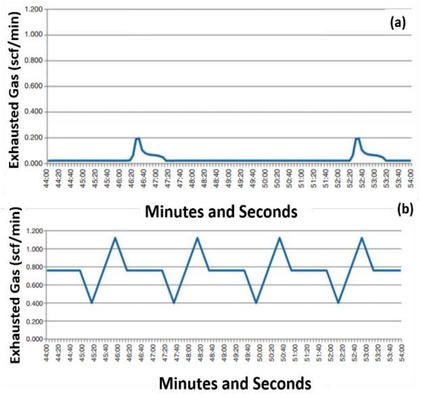

Fig. 3. Theoretical exhaust rate: (a) Intermittent-vent; (b) Continuous-vent (adopted from D. A. Simpson, *Society of Petroleum Engineers (SPE), Oil and Gas Facilities*, 2014)

Conclusions

The data in Table 1 shows that some methane emission sources may emit the same amount of gas regardless of their throughput and others show only partial dependence upon throughput. These coefficients (a, b, c) are then used to build a model using the marginal emission methodology to estimate the change in methane emissions of natural gas systems as system throughput changes.

Table 1. Marginal Emissions Assessment Coefficient

	Time Based *(a)*	Event Based *(b)*	Throughput Based *(c)*
Liquid Unloading	0%	80%	20%
Continuous Pneumatic	100%	0%	0%
Intermittent Pneumatic	0%	80%	20%
Dehydrator vents	0%	0%	100%
Blowdown vents	0%	80%	20%
Reciprocating compressors rod packing	90%	0%	10%
Centrifugal Compressors (Wet Seal)	20%	0%	80%
Centrifugal Compressors (Dry Seal)	90%	0%	10%
Storage tank	0%	10%	90%
Storage wellhead	30%	70%	0%
Gas engine	20%	0%	80%
Equipment leaks	90%	0%	10%

It is expected that this approach provides a more accurate method compared to the constant-emission-factor method to calculate the change in emissions of the natural gas system as throughput changes.