UNC INSTITUTE FOR THE ENVIRONMENT

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TECHNICAL MEMORANDUM:

3SAQS Methane Emission Inventory Recommendations

To: Tom Moore, Western Regional Air Partnership (WRAP) / WESTAR

From: Zac Adelman, University of North Carolina/Institute for the Environment

Subject: Recommendations for improving the 3SAQS methane emission inventory

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INTRODUCTION

Methane is both a precursor to photochemical smog and a strong greenhouse gas. It is a major source of ozone in the free-troposphere and influences background ozone levels throughout the tropospheric column, including at the surface. Global air pollution modeling research indicates that methane emissions controls can mitigate surface ozone concentrations through reductions in the global tropospheric ozone background[1,2]. These reductions occur both directly, by reducing an ozone precursor, and indirectly, through slowing the rate of temperature increase due to anthropogenic climate change. Because of its relatively long atmospheric lifetime, methane has typically been treated as a steady-state pollutant in regional photochemical modeling applications. Recent experiments by EPA and the University of North Carolina (UNC) show that activating methane emissions and chemistry in regional models adds value to the simulations by introducing a chemical tracer for key inventory sectors and by estimating the localized impacts of these emissions on ozone concentrations.

Figure 1 shows the results from a transient methane simulation built off of the WestJumpAQMS 2008 CMAQ simulations conducted by UNC. A transient methane simulation refers to the addition of active methane emissions and chemistry on top of the background steady state methane concentrations built into the model. These simulations used a steady state methane concentration of 1,850 ppb. Figure 1 shows

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[1] A.M. Fiore, D.J. Jacob, B.D. Field, D.G. Streets, S.D. Fernandes, and C. Jang (2002), *Linking ozone pollution and climate change: The case for controlling methane*, Geophys. Res. Lett., 29(19),1919,doi:10.1029/2002GL015601

[2] West, J.J., A.M. Fiore, and L.W. Horowitz (2012) *Scenarios of methane emission reductions to 2030: abatement costs and co-benefits to ozone air quality and human mortality,* Climatic Change, 114, 441-461, 10.1007/s10584-012-0426-4.

that on July 18, 2008 CMAQ predicted methane enhancements of over 4,000 ppb in at least one 12-km grid cell and widespread enhancements of over 200 ppb. Ozone concentrations increased slightly as a result of the active methane chemistry (< 0.5 ppb), particularly downwind of some major methane sources. As a tracer of oil and gas development and agricultural activity, the methane plot in Figure 1 shows the footprint, or spatial extent of influence, of these emissions sources on air quality.

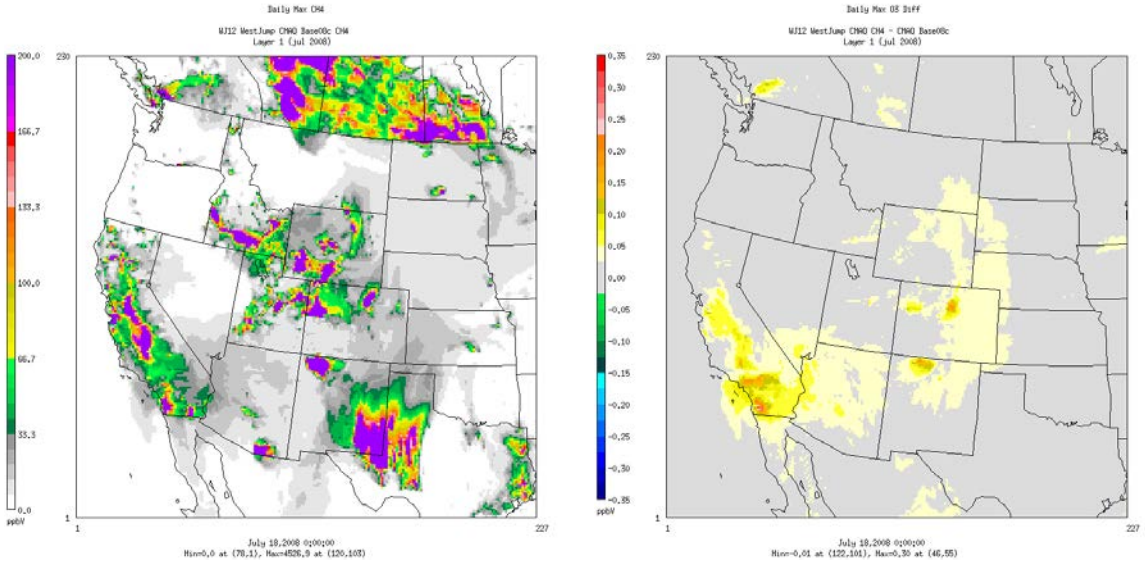

Figure 1. July 18, 2008 daily maximum transient methane concentrations (l) and the resulting change in daily maximum ozone concentrations from the addition of reactive methane (r).

We plan to activate methane for the **3SAQS 2011 base year and future year simulations**. The additional insight provided by the transient methane simulations, particularly for the air quality impacts from oil and gas sources, will aid in the evaluation of the emission inventories and the model results. Recent ambient measurements of methane and methane-based VOC ratios near oil and gas development sites can be compared to the air quality model results to evaluate the quality of the emission inventories input to the model. Before we conduct transient methane simulations for the 3SAQS, we must ensure that we capture as many of the known regional methane sources as possible.

METHANE INVENTORY NEEDS

As methane has typically not been a required input to regional air quality model applications, the methane emissions inventories are not as well developed as for the criteria pollutants. Methane can either be inventoried directly or as a component of total organic gases. For the 3SAQS it is being estimated from the criteria pollutant VOC inventories through a process where the non-methane reactive organic gas (ROG)

inventory is converted to a total organic gas (TOG) estimate using source-specific multipliers. Sources with large methane and ethane contributions have large "ROG-to-TOG" multipliers. Chemical speciation of the TOG during emissions processing results in methane emission estimates, but regional air quality models ignore these emissions. Analysis of the emissions estimated for the 3SAQS 2008 base year CAMx simulations shows that we are missing some significant methane sources in the 3-state region.

Figure 2 shows the major sources of global atmospheric methane. With the exception of rice cultivation, all of the major anthropogenic methane sources exist in the 3-state region. Figure 3 is a plot of the 2008 3SAQS methane sources in Colorado, Utah, and Wyoming. It shows that oil and gas (AROG and PTOG) is the major methane source in the region. The nonpoint sector, which includes agricultural sources and waste disposal/treatment, is the next largest source, followed by non-CEM point. Non-CEM point also includes waste disposal (landfills) sources.

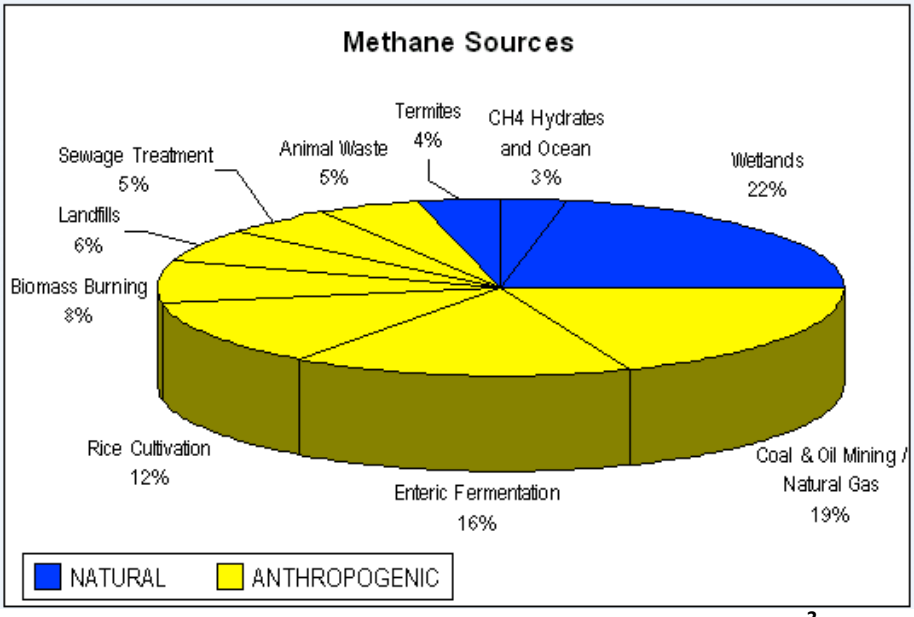

Figure 2. Global sources for methane from NASA GISS[3]

One obvious issue with the 3-state methane inventory is the magnitude of the nonpoint emissions in Colorado and Wyoming. Although it's difficult to see in Figure 3, these states do have methane emissions in the nonpoint inventory, these emissions are just very small relative to Utah. Figure 4 shows the distribution of the largest nonpoint inventory methane sources in each of the three states. Utah stands out with over 75% of the inventory contributed by livestock animal waste. Wyoming also stands out with trona mining as a large methane source.

[3] http://icp.giss.nasa.gov/education/methane/intro/cycle.html

Neither Colorado nor Wyoming have agricultural methane emissions because these two states do not include VOC in their livestock inventories. For comparison, Figure 5 shows the 2008 livestock ammonia emissions in the three states. As a proxy to livestock activity, this figure indicates that both Colorado and Wyoming have significant agricultural emissions sources and these sources should also include methane emissions from livestock waste.

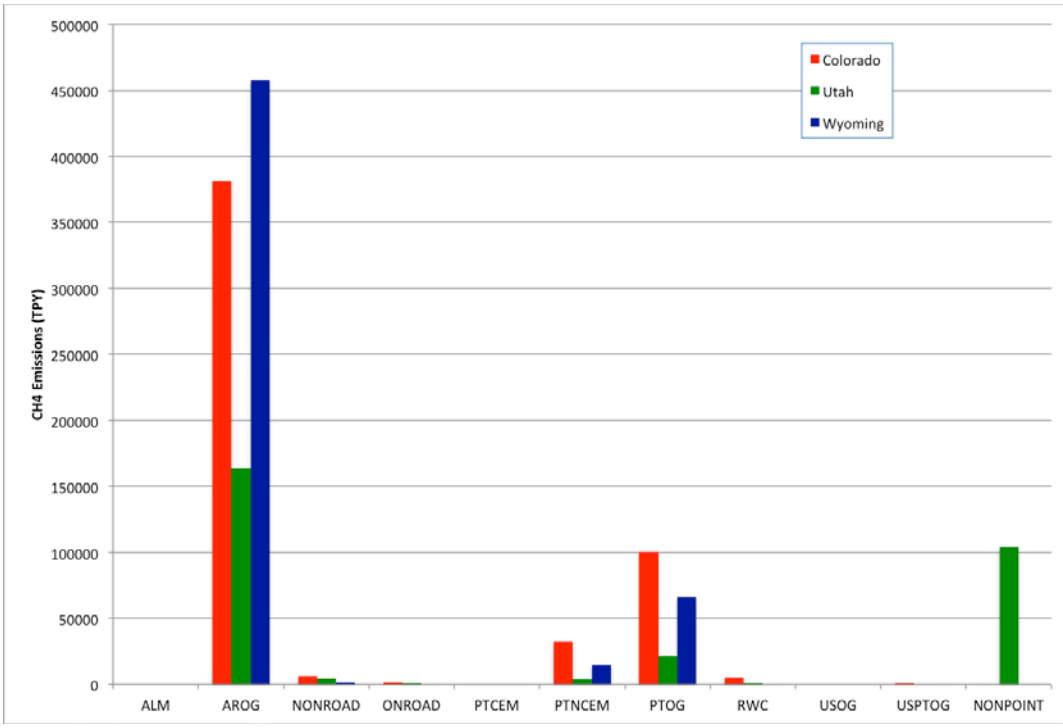

Figure 3. 3SAQS 2008 methane emissions in the 3-states by inventory sector

Another major source of methane that is missing in the 3SAQS modeling is enteric fermentation. Figure 1 estimates that enteric fermentation accounts for over 22% of the global anthropogenic sources of methane. While important for methane emissions, enteric fermentation is not included in the NEI; the AP-42 for Livestock & Poultry Feed Operations contains guidance only for ammonia. A 2001 EPA draft report[4] does provide emissions factors for other agricultural pollutants including VOC and methane. A 2004 report by the National Resource Council[5] points out that although enteric fermentation accounts for 19% of the U.S. national methane emissions, it is not considered in the 2001 EPA draft report.

The AP-42 guidance for greenhouse gases (GHGs) from biogenic sources does include a chapter on enteric fermentation[6]. This document includes regional emissions factors to

[4] http://www.epa.gov/ttn/chief/ap42/ch09/draft/draftanimalfeed.pdf

[5] http://www.epa.gov/ttn/chief/ap42/ch09/related/nrcanimalfeed_dec2002.pdf

[6] http://www.epa.gov/ttn/chief/ap42/ch14/final/c14s04.pdf

calculate methane from several different livestock species. Although this guidance was used to calculate a GHG inventory for the U.S., it is not followed for the criteria pollutant NEI. The U.S. GHG inventory is not readily available in a form that is applicable to regional modeling, otherwise we could consider directly augmenting the 3SAQS inventory with methane emissions from the GHG inventory.

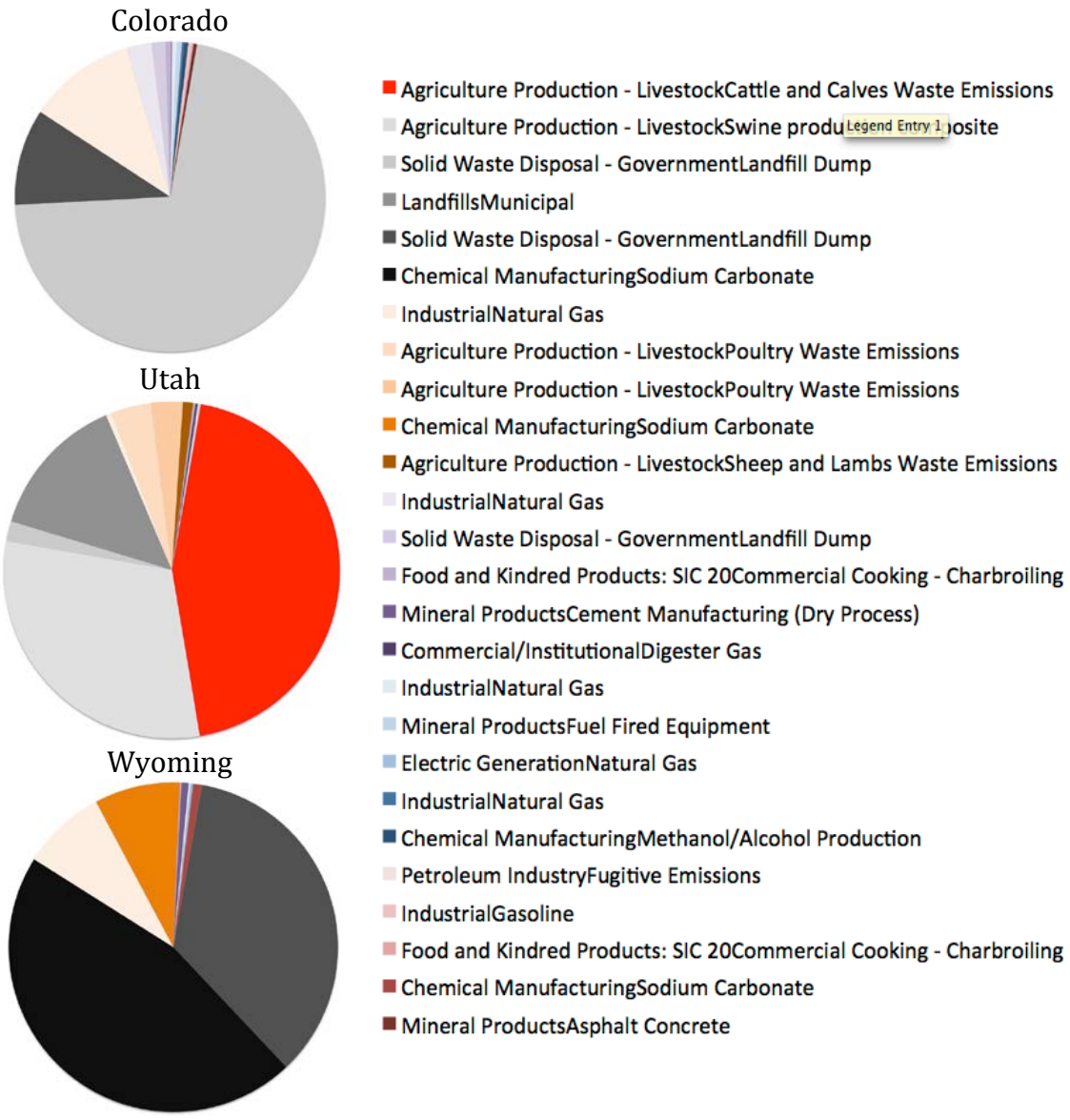

Figure 4. non-CEM Point and Nonpoint Methane Emissions Sources

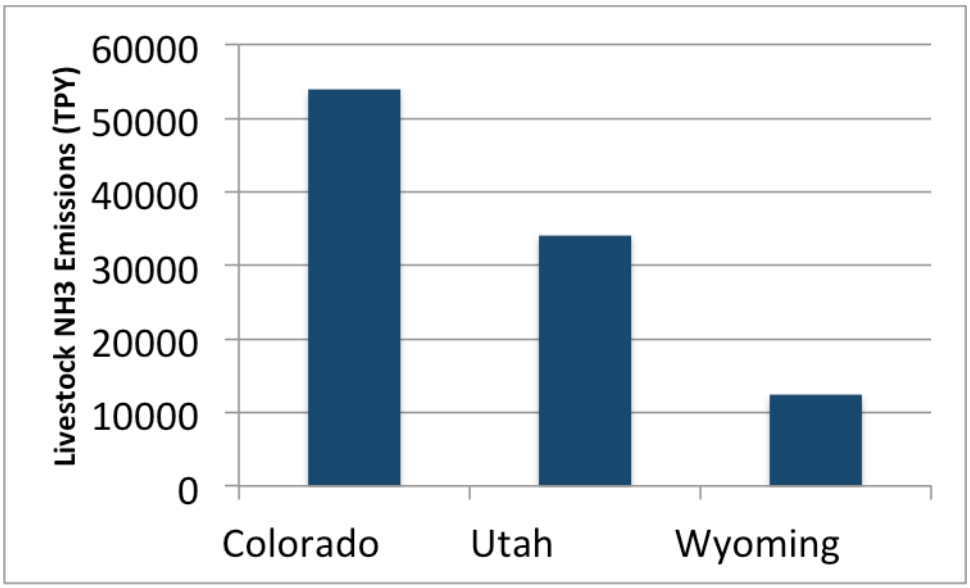

Figure 5. 3SAQS 2008 livestock NH3 emissions

The landfill methane inventory for the three states looks reasonable. Figure 6 shows the 2008 statewide landfill methane inventory and 2008 state total population. The landfill emissions scale roughly proportionally to the states total population.

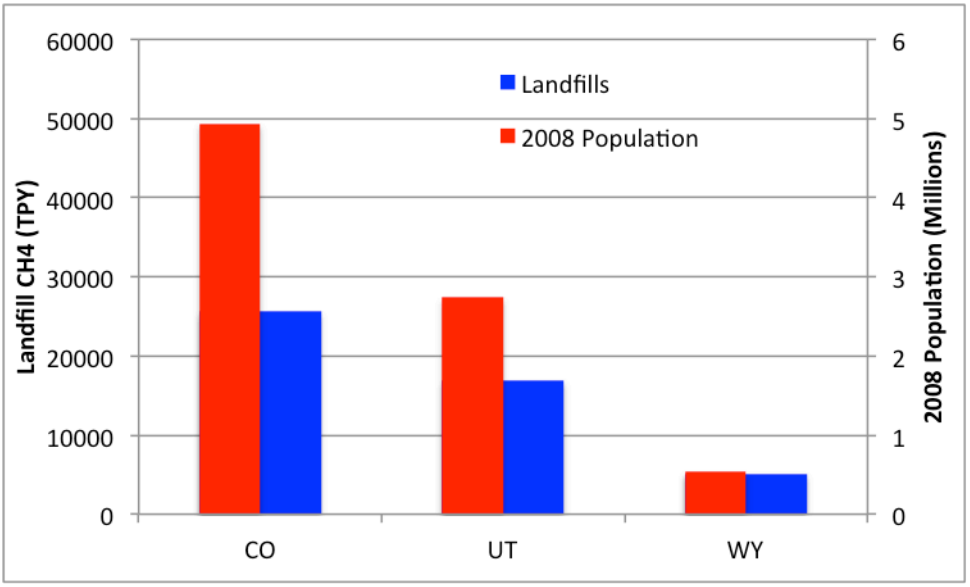

Figure 6. 3SAQS 2008 landfill CH4 emissions and 2008 state population

Emissions data for wastewater treatment plants are not being processed correctly for simulating methane. The NEI includes VOC emissions factors for these sources and the AP-42 chapter on wastewater[7] has an explicit section on methane. The AP-42 guidance appears to distinguish the VOC (criteria) and methane (GHG) emissions separately and

[7] http://www.epa.gov/ttnchie1/ap42/ch04/final/c4s03.pdf

as a result methane is not part of the NEI for these sources. In fact, the speciation profiles used to convert the NEI wastewater TOG to model species are not only missing methane but they allocate 50-74% of the TOG to "unidentified" or "unknown". It's clear that most or all of this unknown mass is methane.

Another large source of methane is biomass burning. The 3SAQS modeling is using a speciation profile that splits 17% of the fire TOG to methane.

The largest anthropogenic source of methane in the three states is the oil and gas industry. Figure 7 shows the largest sources of methane emissions in each state from the 3SAQS point and area oil and gas inventory. Colorado is dominated by venting from initial completions, which account for almost 50% of the state total methane inventory. With the addition of pneumatic devices and gas well fugitives, these three sources account for 75% of the Colorado methane inventory. Like Colorado, about 25% of Utah's methane inventory is from pneumatic devices. The contribution from initial completions is small while natural gas and CBM dehydrators are large sources in Utah. Wyoming has the largest relative contribution from pneumatic devices of all three states with an almost equal contribution from natural gas fugitives. Secondary methane sources in Wyoming include natural gas and CBM dehydrators.

METHANE INVENTORY NEEDS

The following steps should be taken to satisfy our objective of building as complete a methane inventory as possible for the three states.

- Livestock Waste
  - Build a county-level VOC inventory for livestock waste in Colorado and Wyoming. Look to Utah for guidance on how they calculated livestock waste VOC and apply this approach to Colorado and Wyoming. UNC can estimate methane from the VOC inventory using the speciation factors (ROG->TOG->CH4)
  - Assignment: Colorado and Wyoming
- Enteric Fermentation
  - Build a county-level draft methane inventory for enteric fermentation for all three states. Use the AP-42 biogenic GHG guidance[6] to build a bottom up inventory using animal population estimates. We need to recognize that per the recommendations of the NRC[5] the correct way to estimate these emissions is to use a process-based model, similar to what is used for ammonia emissions modeling, that considers local variations in animal populations, feed, and handling practices. As a first cut, a draft inventory for these sources can be developed using the AP-42 emission factor approach and possibly refined later.

    - An alternative approach is to ask the EPA GHG inventory group if they have county/SCC-level estimates for these sources that they used to derive the national estimates
    - Assignment: UNC to contact EPA about the existing GHG inventory to see if it's in a form that we can use for regional modeling
    - Assignment: Colorado, Utah, Wyoming to build a bottom up inventory using AP-42
- Wastewater Treatment
    - Revise the speciation profiles being applied to sewage/wastewater treatment sources to include methane; update the ROG->TOG conversion factor to consider that methane is up to 70% of the emissions from these sources
    - Assignment: UNC
- Oil and Gas
    - Review the relative contributions of the sources of methane to see if they make sense
    - Assignment: Colorado, Utah, Wyoming

NEXT STEPS

After receiving these updated inventories, UNC will prepare the data for input to a version of CAMx that is configured for a transient methane simulation. We will conduct these transient simulations for the 2011-based 3SAQS modeling platform.

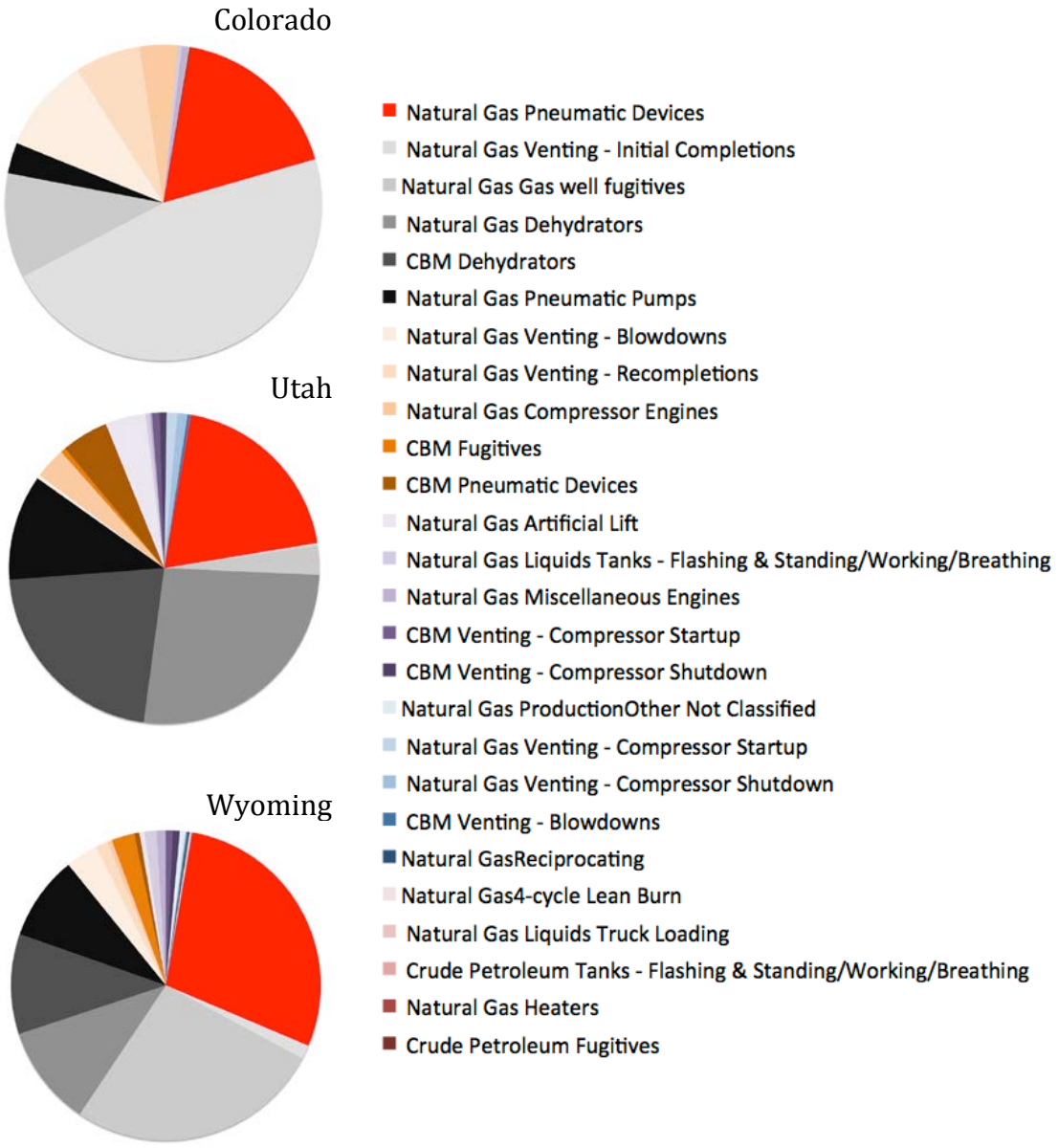

Figure 7. Oil and gas methane emission sources