The Laboratory for Atmospheric Research

Washington State University
Department of Civil and Environmental Engineering

Faculty

Faculty	Position	Background	Are a of interest
Serena Chung	Associate Research Professor	Chemical Engineering	Regional modeling of atmospheric chemistry, aerosols and global change
Candis Claiborn	Professor, Dean	Chemical Engineering	Particulate matter and health
Tom Jobson	Professor	Chemistry	Atmospheric chemistry, VOC measurements
Brian Lamb	Regents Professor	Chemistry and Chemical Engineering	Greenhouse gas emissions, pollutant transport, regional modeling
Yunha Lee	Assistant Research Professor	Atmospheric Science	Global chemistry modeling, regional air quality modeling
Heping Liu	Associate Professor	Atmospheric Science	Biosphere atmosphere interaction, surface flux measurements
George Mount	Emeritus Professor	Atmospheric Physics	Remote sensing, satellite instrumentation
Shelley Pressley	Assistant Research Professor	Civil Engineering	Biosphere atmosphere interactions
Joe Vaughan	Associate Research Professor	Engineering Science	Regional air quality modeling
Von Walden	Professor	Atmospheric Science	Remote sensing of aerosols and clouds

Current Projects

AIRPACT air quality forecast system
Diesel emissions, chemistry, and health impacts
Formaldehyde and air toxics in LC Valley
Ozone and precursors in the Tri-cities (T-COPS)
JFSP—Black Carbon
JFSP—SOA from wildfires
JFSP—Regional wildfire modeling
Forest canopy modeling
REACCH climate change and agriculture
NARA air quality of the biojet supply chain
BioEarth regional earth system modeling
EPA Indoor Air Quality and Climate Change
EPA PM and Climate Change
ICECAPS - Atmospheric meas. in Greenland
N-ICE - Norwegian Young Sea Ice Experiment
Methane emissions from US natural gas systems
MARS methane tracer studies

My Background

- Idaho State University, BS Chemistry & almost a BA in English
- California Institute of Technology, PhD in Chemistry & Chemical Engineering
- Norwegian Institute for Air Research, postdoc for 14 months
- WSU, arrived in Jan, 1979, non-tenure track, soft-money position
- Eventually converted to tenure track: Assistant, Associate, Professor, Regents Professor
- Research: pollutant transport, biosphere-atmosphere interactons, regional air quality modeling, greenhouse gas emissions

My Typical Day: A daily mix

- Project management and oversight
  - Currently PI on ~ 10 projects
  - Project progess and status (weekly meetings)
  - Budgets (monthly, sort of)
  - Project meetings (external) and presentations (travel)
- Graduate student advising and mentoring
  - 3 PhD students
  - 2 MS students
  - Weekly meetings plus emails, etc
- Field Studies (travel) and Data analysis (the best part), but usually others are doing this
- Writing proposals (several each year, always a team effort)
  - Something magical about starting with a blank page and creating something new and exciting
- Writing papers—usually not me, but reviewing, helping grad students
- Service—
  - Journal and proposal reviews
  - University committees
  - Science advisory panels

What it takes

- A natural curiosity about how the world works
- An ability to write well and clearly
- An ability to work well with others—science today is mostly a team sport
- Some creativity
- Good organization and hard work

What it gives

- You are your own boss—work on what you want
- Lots of travel (good news/bad news)
- Lots of Job Satisfaction
  - In being part of a team
  - A chance to be creative
  - Helping address societal issues
- Flexible hours and decent salary

Some current research

EDF STUDIES BY SUPPLY CHAIN SEGMENT

(roughly 30 total papers)

PRODUCTION | GATHERING/PROCESSING | TRANSMISSION/STORAGE | LOCAL DISTRIBUTION | TRUCKS AND STATIONS

★ . NOAA Denver-Julesberg

★ 2. NOAA Barnett

★ 3. Coordinated Campaign (13 papers)

★ 4. UT Phase 1

5. UT Phase 2
★ Pneumatics
★ Liquid Unloadings

★ 6. HARC/EPA

7. CSU Study
★ Methods Paper
★ Measurement Paper
▲ Modeling Paper

8. CSU Study
★ Measurement Paper
★ Modeling Paper

★ 9. Methane Mapping

★ 10. Boston Study

★ 11. WSU Multi-City

✖ 12. Indianapolis Study

★ 13. WVU Study

★ 14. Pilot Projects

✖ 15. Gap Filling

✖ 16. Project Synthesis

★ Results public (green star)

★ Submitted, not yet public (blue star)

▲ Almost ready for submission

✖ Not yet submitted

EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

Decreasing Methane Emissions for Natural Gas Distribution Systems

Brian Lamb and Steven L. Edburg
Washington State University, Pullman, WA

Thomas W. Ferrara, Touché Howard, and Wesley Dyck
Conestoga-Rovers & Associates, Niagara Falls, NY

Matthew R. Harrison
URS Corporation, Austin, TX

Charles E. Kolb
Aerodyne Research, Inc., Billerica, MA

Amy Townsend-Small
University of Cincinnati, Cincinnati, OH

Antonio Possolo and James R. Whetstone
National Institute of Standards and Technology, Gaithersburg, MD

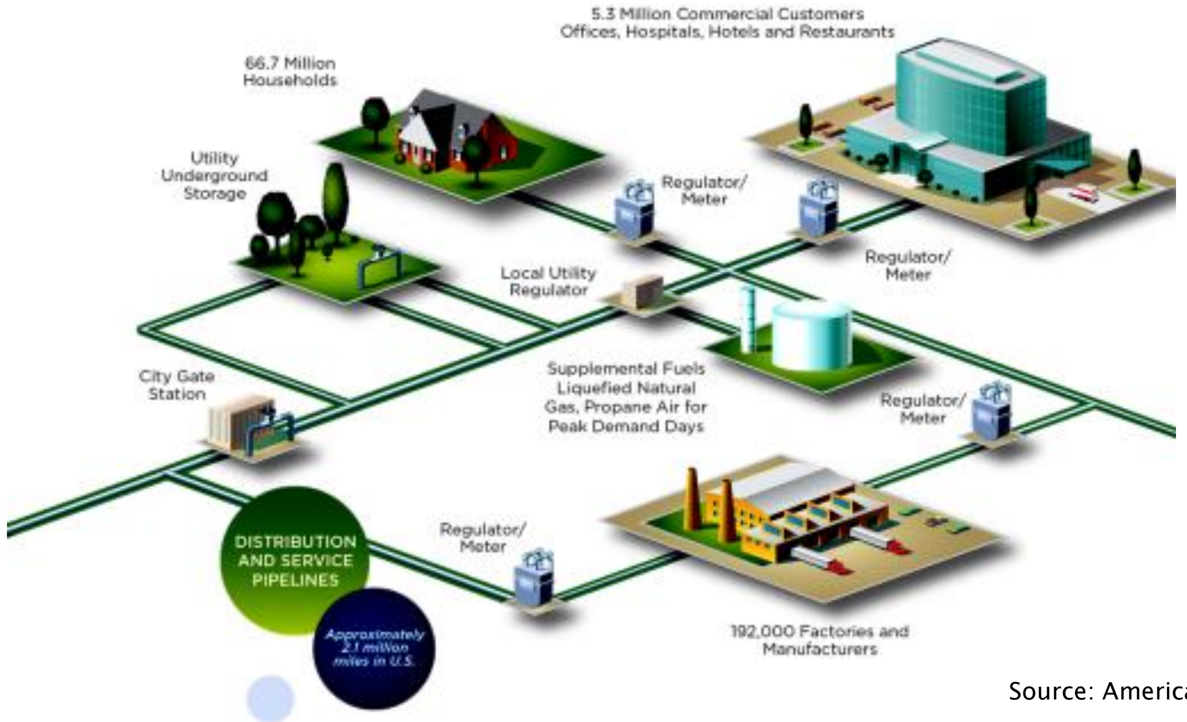
WASHINGTON STATE UNIVERSITY

CONESTOGA-ROVERS & ASSOCIATES

Why Study Natural Gas Distribution Systems?

- Methane, the primary constituent of natural gas, is 34 to 84 times more powerful as a greenhouse gas than carbon dioxide
- Several high profile news stories highlighted aging urban infrastructure as the source of a large number of distribution pipeline leaks
- The methane emission factors used in the current US EPA Greenhouse Gas emission inventory are based on studies completed in the 1990's
- Developing strategies for mitigating the impacts of these emissions requires an understanding of the sources and distribution of the emissions

The US Natural Gas Distribution System



Source: American Gas Association

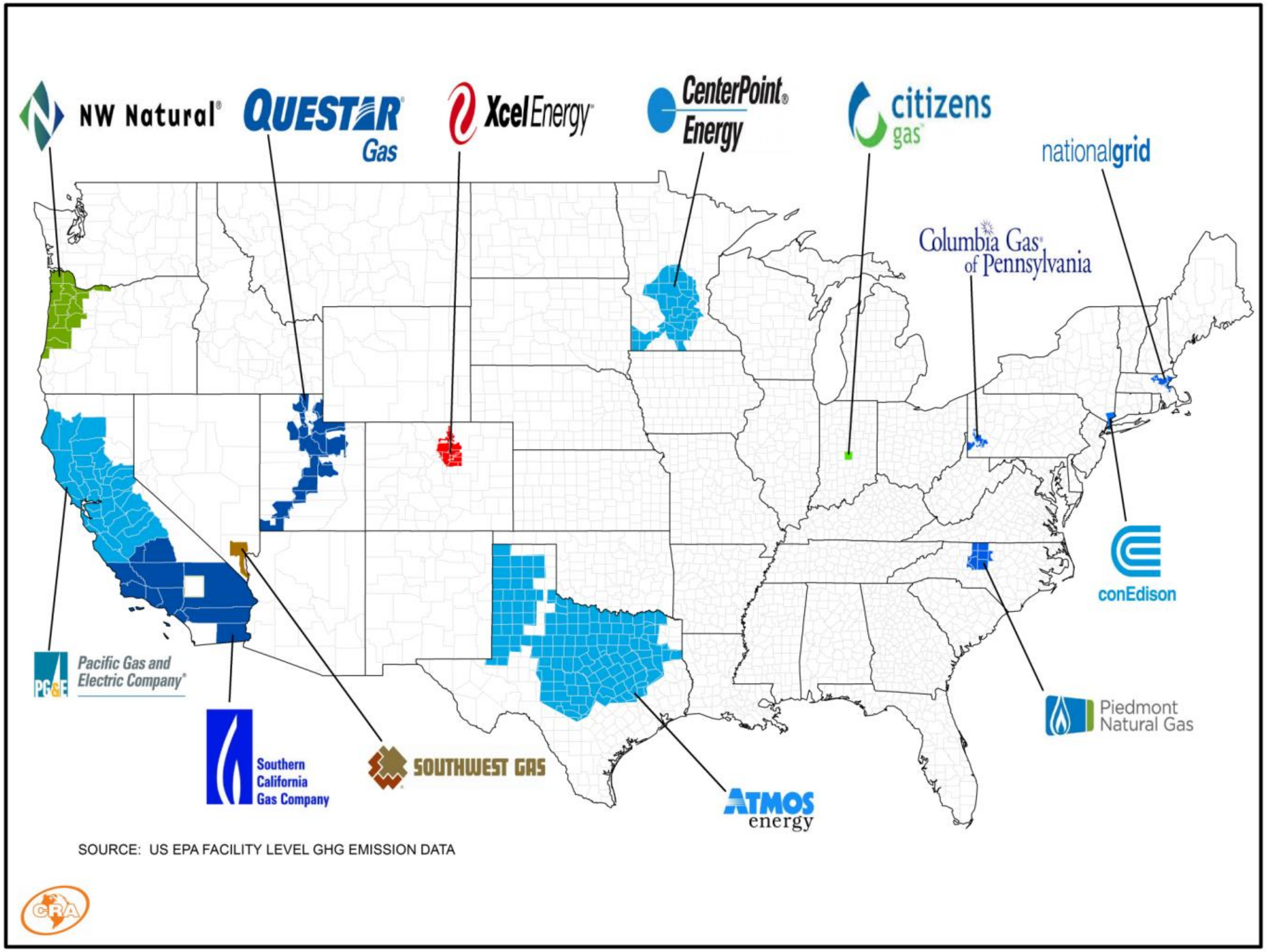
This study is focused on direct emission measurements of methane:

- Underground pipeline leaks
- Metering and Regulating (M&R) Stations

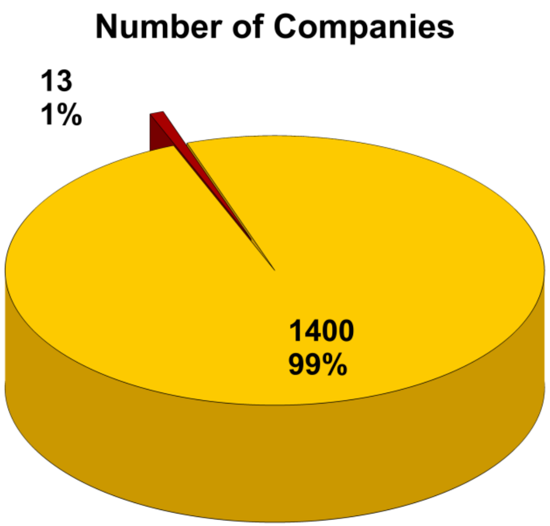
Project Overview

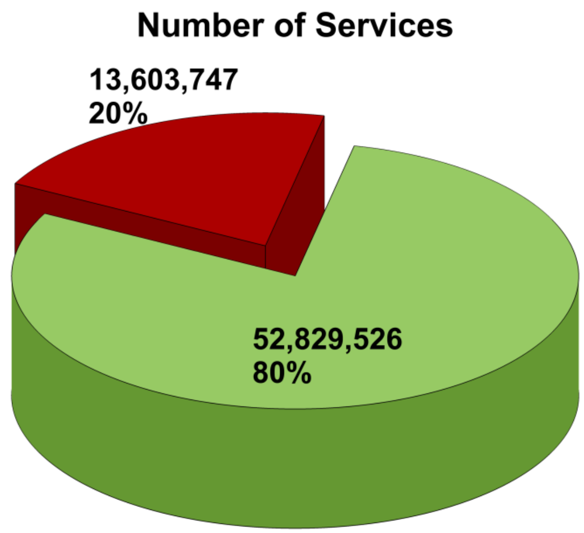
- A nationwide field study to better understand methane emissions associated with the distribution of natural gas.
- Fieldwork conducted in the summer and fall of 2013
- Over 400 new emission measurements for pipeline leaks and M&R stations
- Most comprehensive set of direct measurements yet of emissions from the distribution system.
- Funding provided by:
  - Environmental Defense Fund
  - Consolidated Edison of New York
  - National Grid
  - Pacific Gas & Electric
  - Southern California Gas Company
  - American Gas Association and associated utility companies

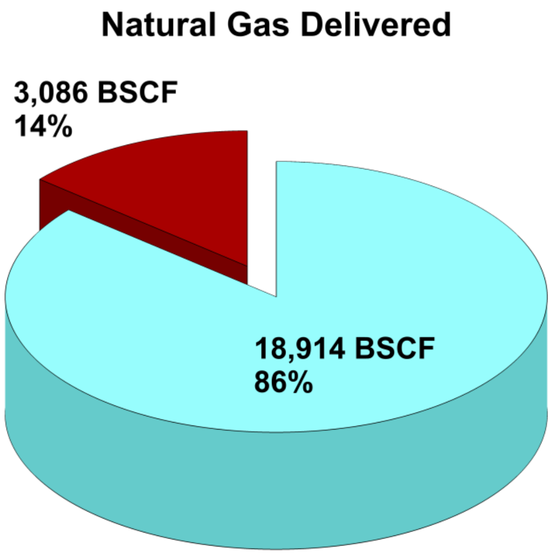
Participating Partners and Service Areas

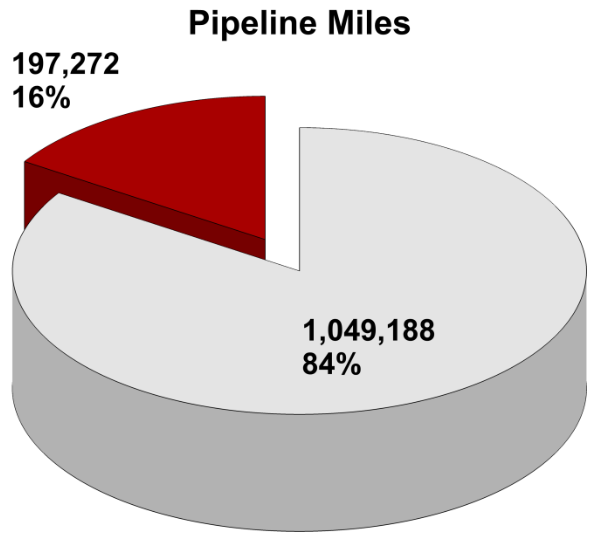


Study Partners Compared to All Distribution Companies

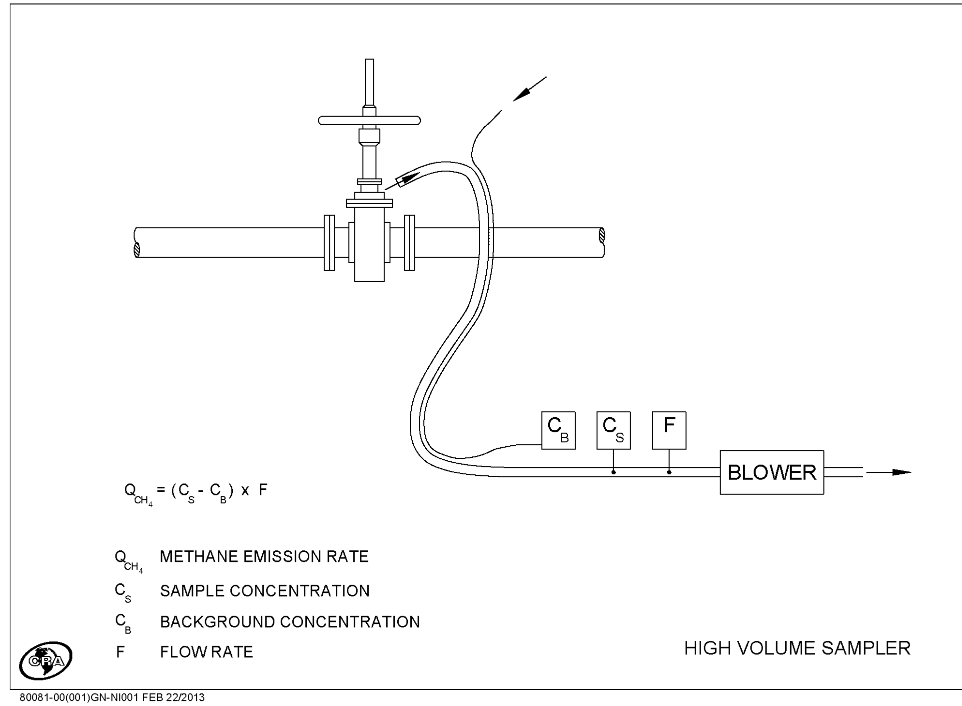








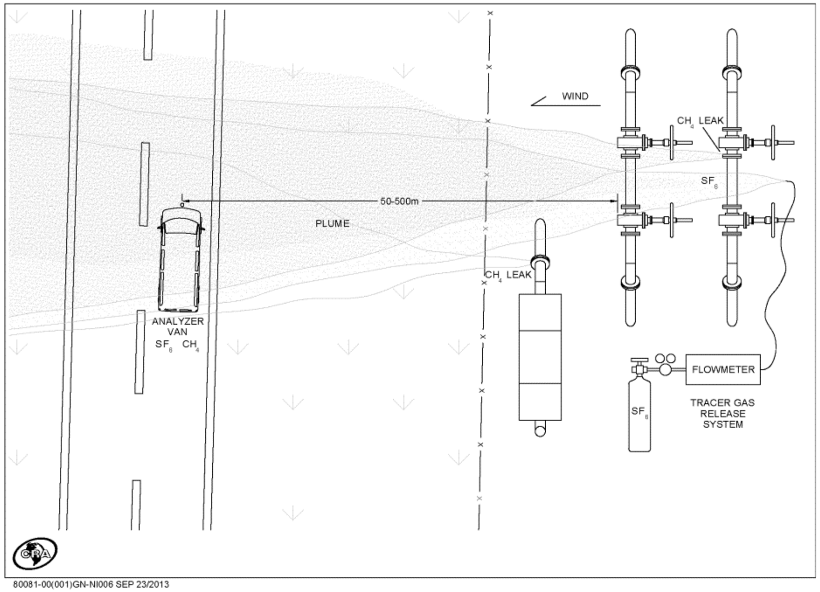
Measuring Emissions from M&R Facilities



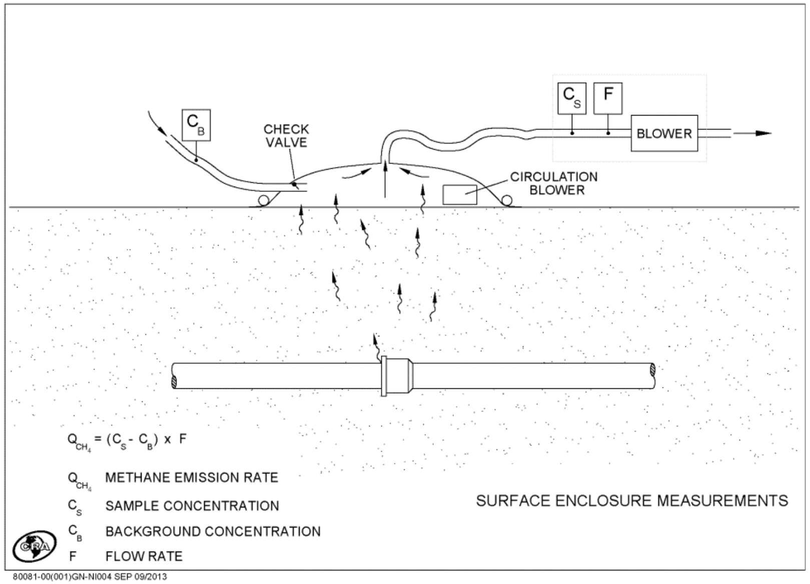
- Screen every component and device for leaks and emissions
- Measure component emissions with a high flow sampler
- Perform tracer ratio tests at selected stations for QA purposes

Tracer Ratio Method

- Used for comparison to high-flow measurements.
- Mobile van used to measure methane and tracer levels downwind of select facilities or pipeline leaks.

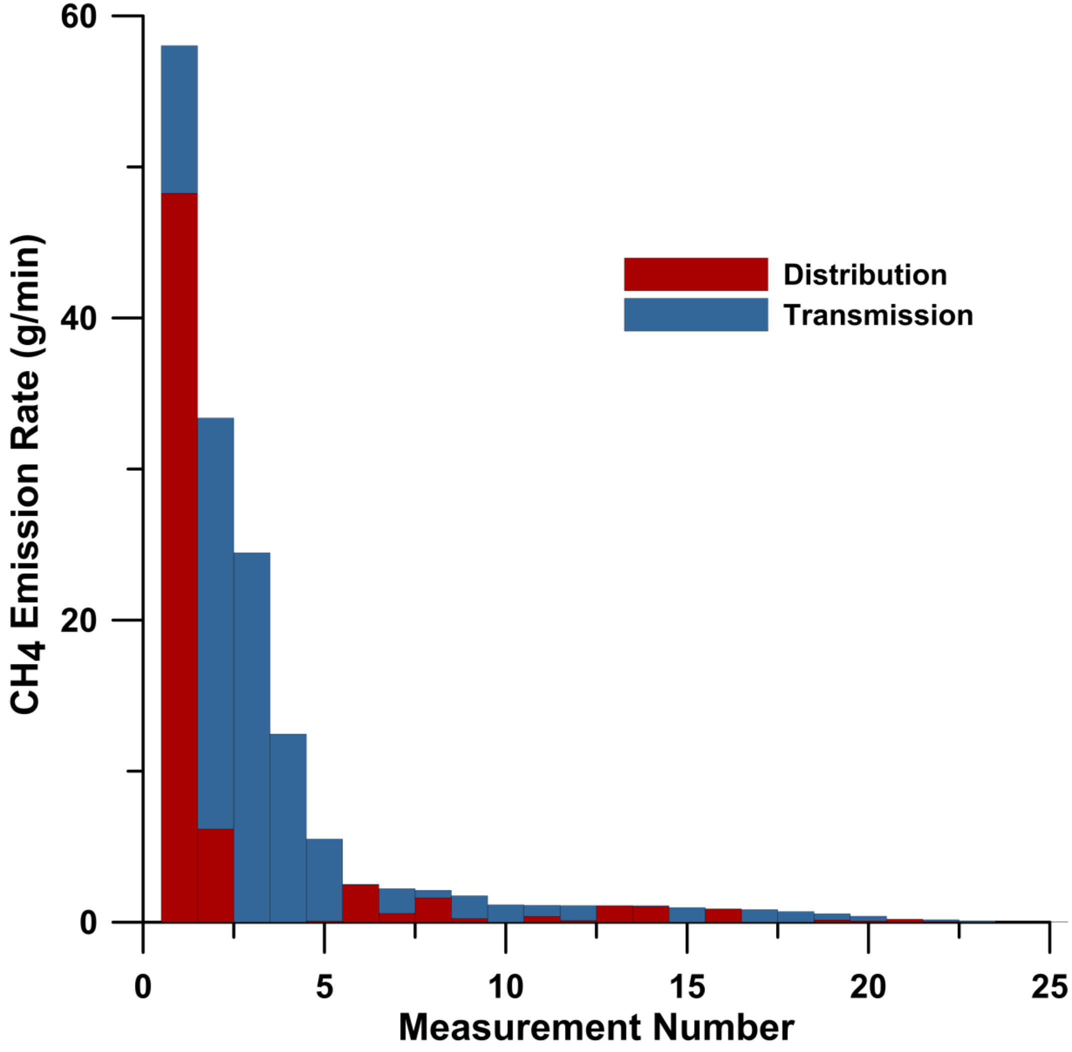


Measurements of Pipeline Leaks

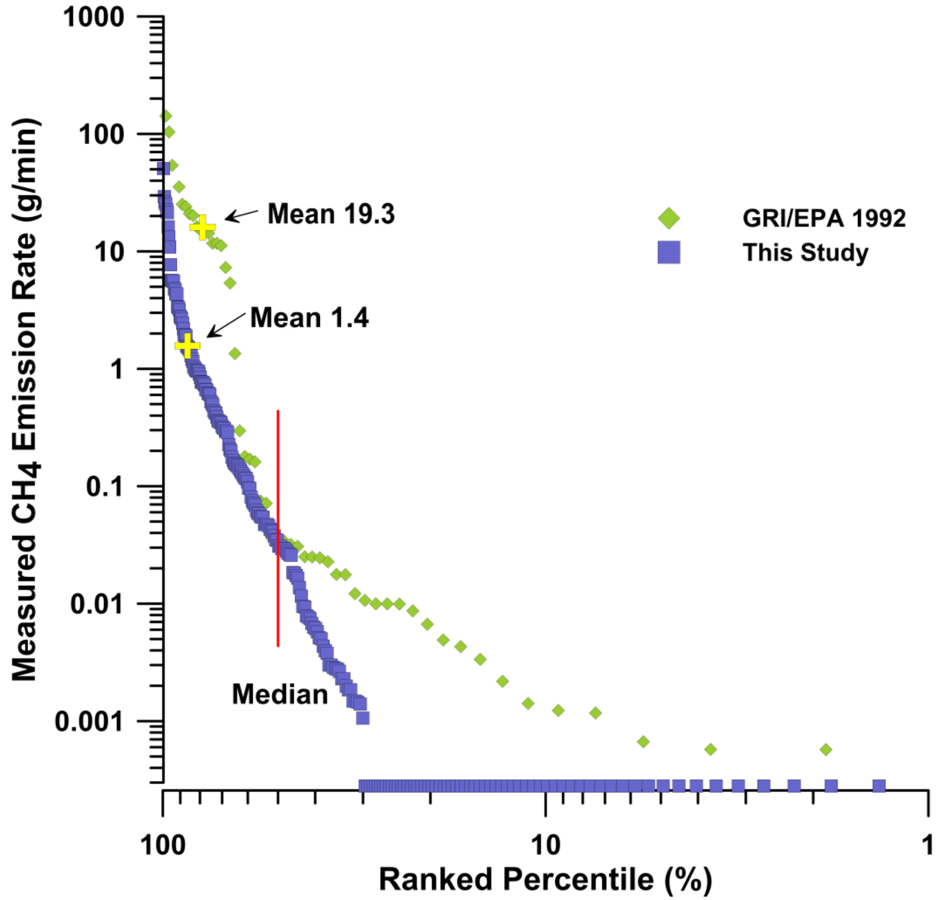


- Map the surface area of the leak using a portable sniffer
- Use a flexible surface enclosure to capture the leak
- Measure the emissions using the high-flow sampler

Skewed Distribution of Emission Rates for City Gates (TDTS sites)

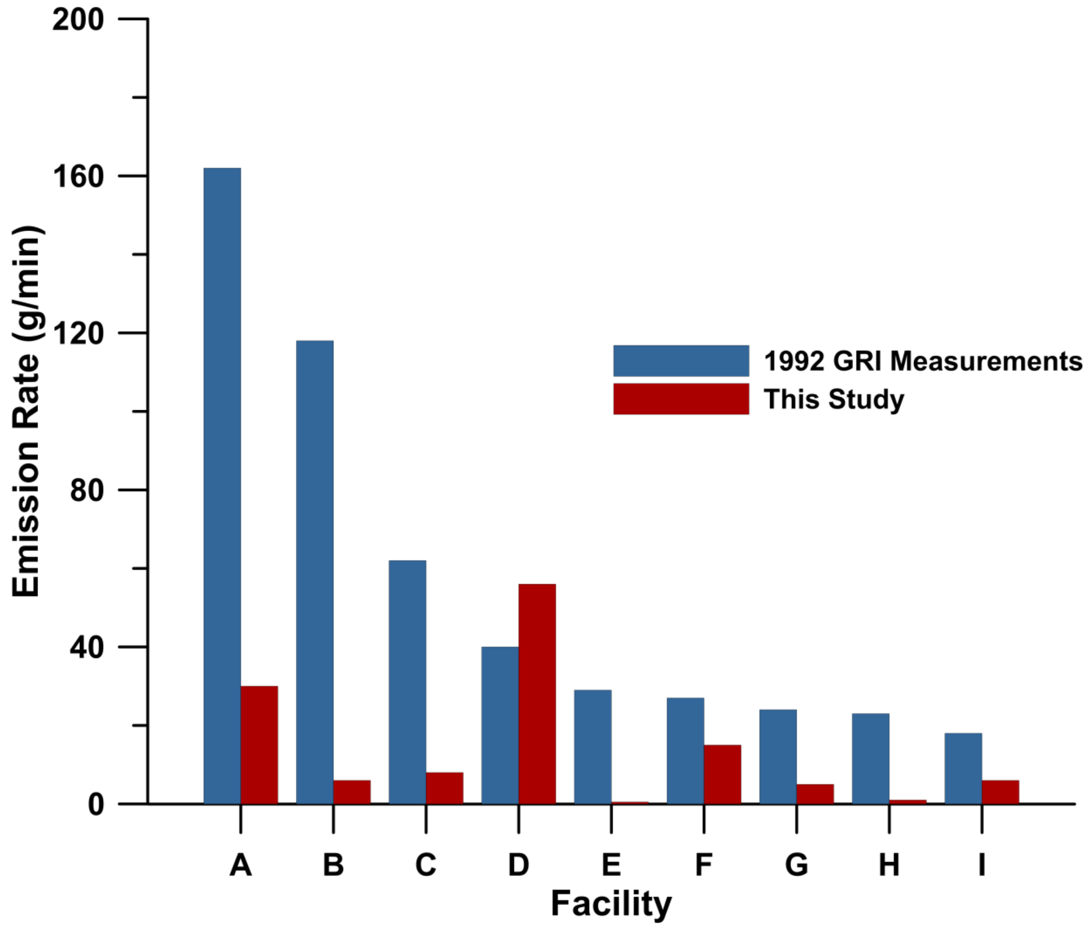


Emissions from M&R Facilities



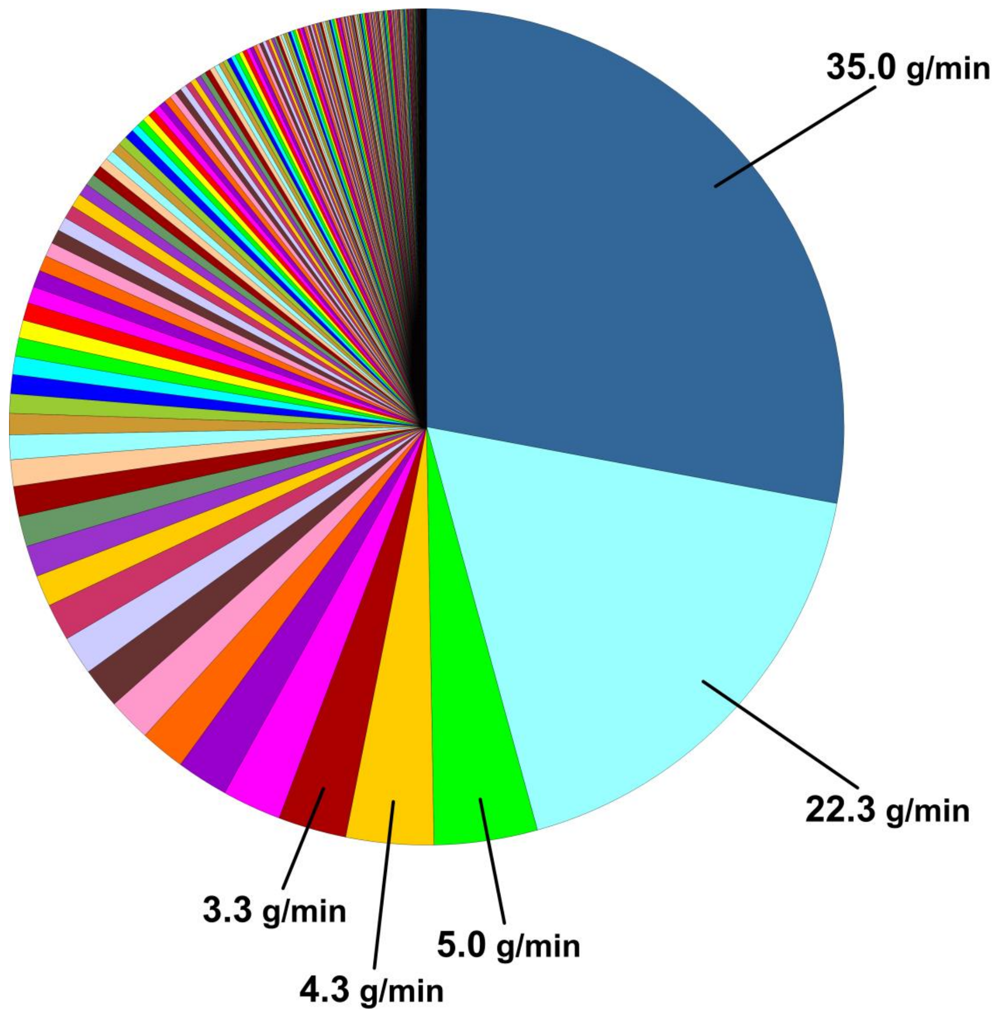
- Emissions at higher emission sites were much higher from the 1992 GRI/EPA study compared to our study
- Median values are quite similar in both studies
- Overall new emission factors are 4 to 13 times smaller than from the 1992 GRI/EPA study

Re-Visited 1992 GRI/EPA Higher Emitting Sites



Study surveys showed that companies have made substantial upgrades and rebuilds of M&R stations during the past 20 years

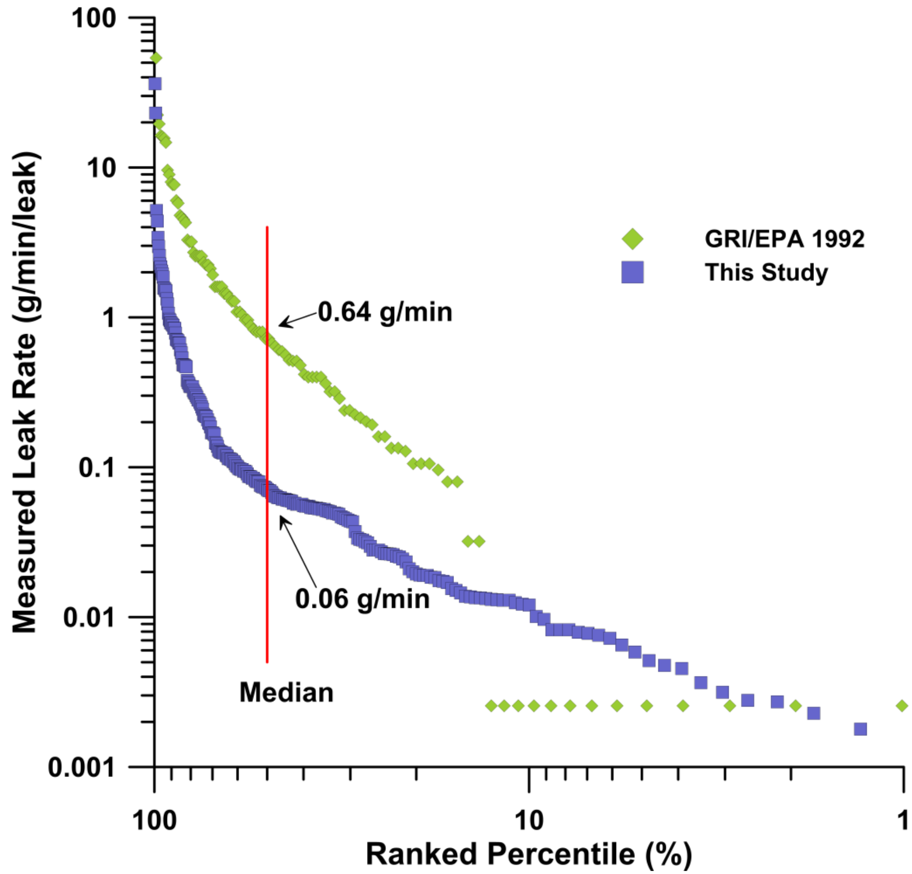
Skewed Distribution of Pipeline Leak Rates: a few leaks account for most of the emissions



- Largest three leaks account for 50% of total emissions from measured leaks
- Median is much less than the mean

Calculated emission factors (EF) and 95% upper confidence limits were based on statistical treatment of skewed distributions

Pipeline Leak Rates Compared to GRI/EPA 1992 Study

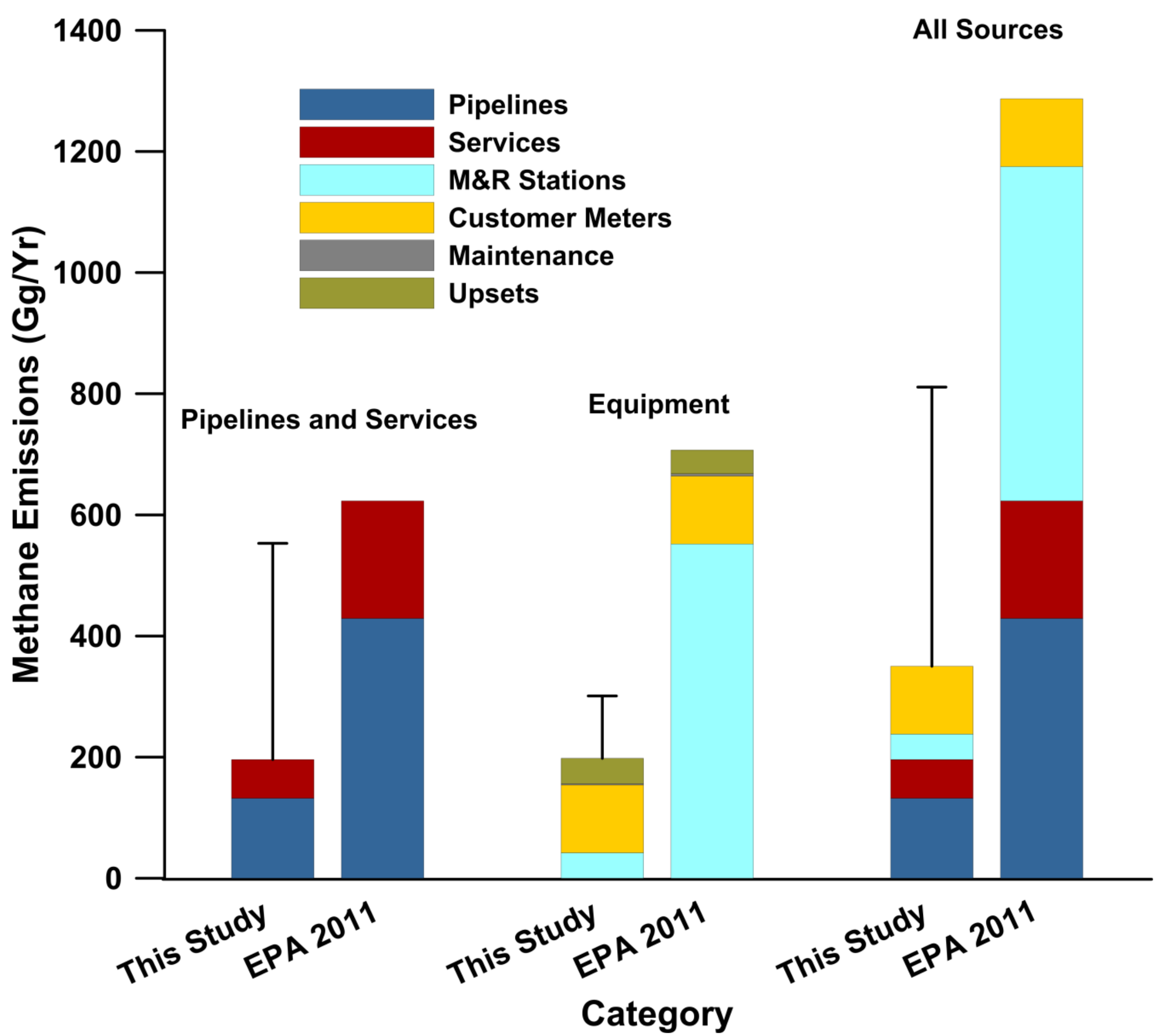


- Twice as many leaks measured
- Similar maximum leak rates > 32 g/min
- Factor of 10 less for the median leak rate

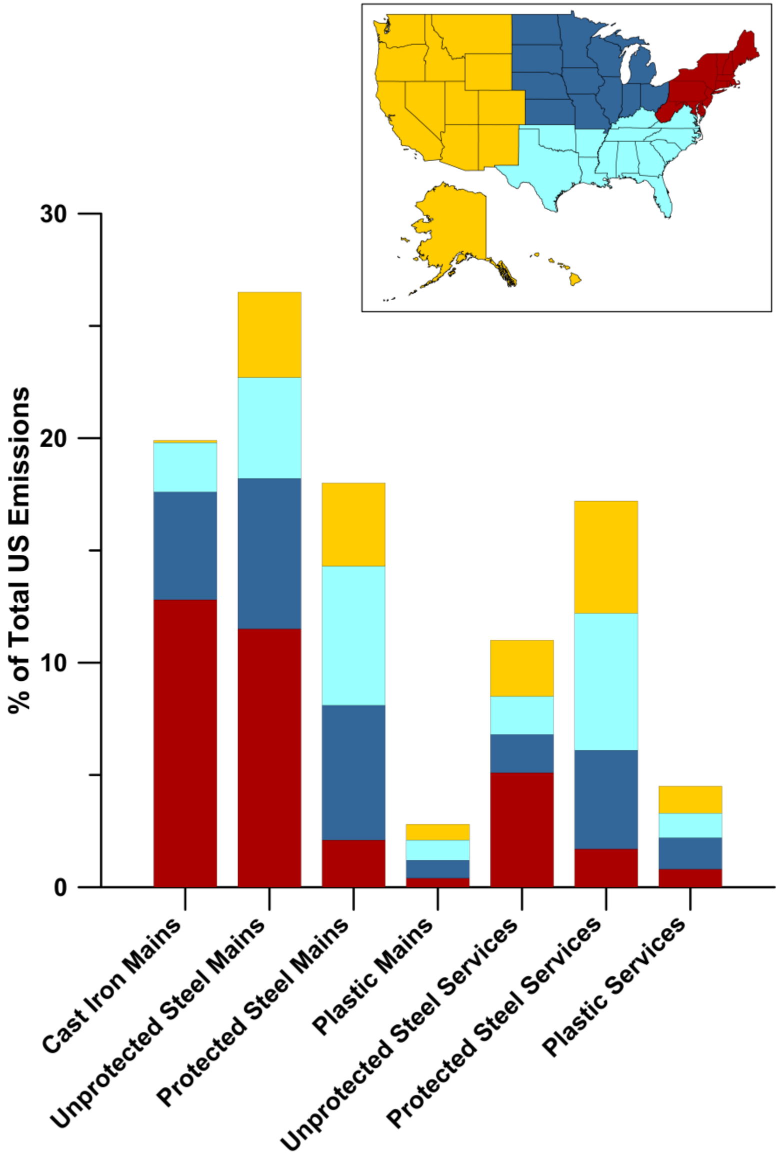
We used completely different methods compared to the 1992 study

- GRI/EPA used pipe isolation/pressurization method
- GRI/EPA sampled pipelines scheduled for replacement
- GRI/EPA used empirical estimates of soil oxidation

Updated US Inventory for Local Distribution Systems



Regional Extrapolation of Pipeline Leak Emissions



- The eastern region accounts for 35% of the total U.S. methane from pipeline leaks
- The western region contributes 17% of the total US emissions.
- Leaks from cast iron and unprotected steel pipeline mains account for 70% of the eastern emissions and almost half of total U.S. emissions.
- Plastic and protected steel account for 92% of US pipeline mains by mileage, but leaks from these pipelines contribute approximately 20% of total US emissions
- Services account for 33% of US emissions

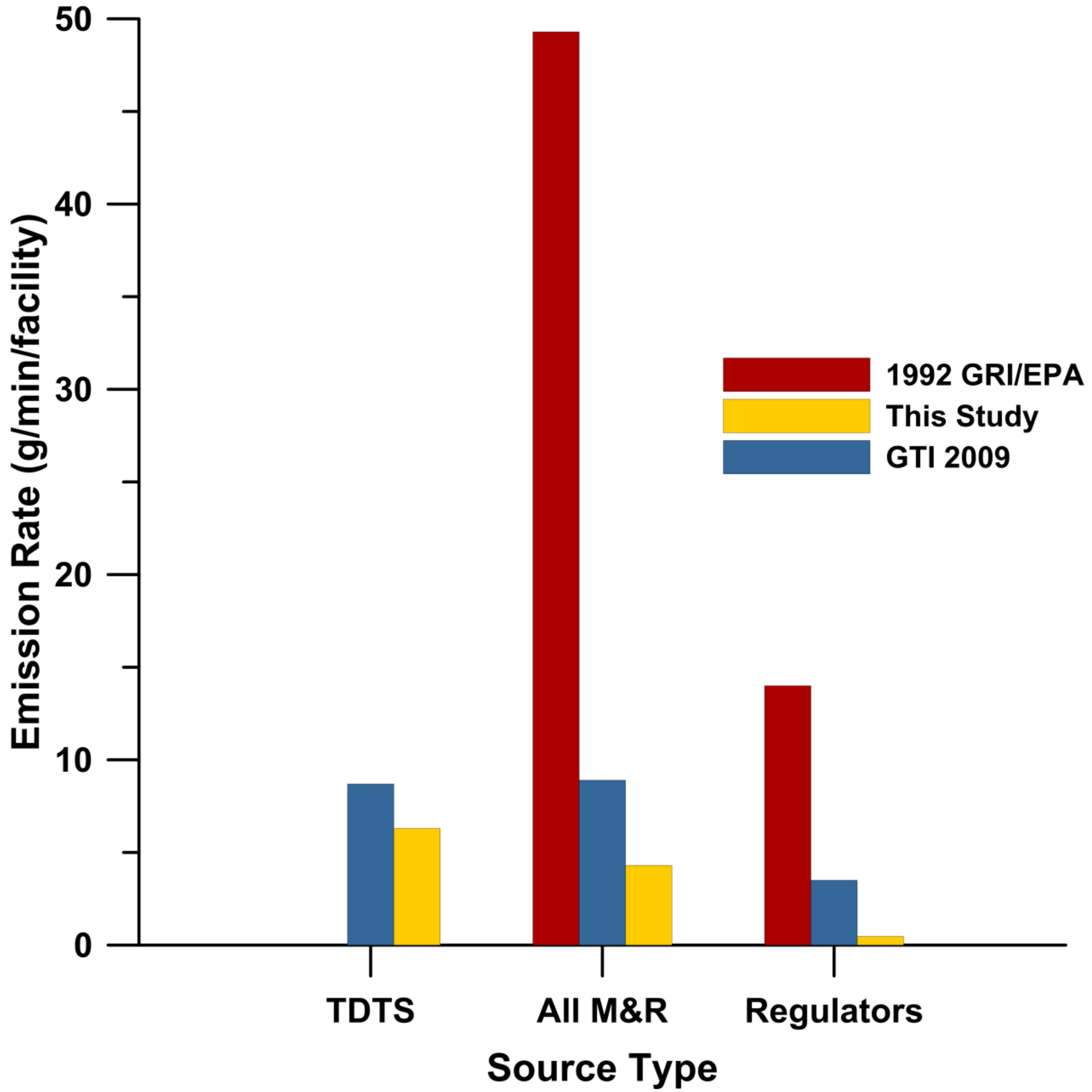
Overall Program Summary

- National emission inventory estimates are 36% to 70% less than the current EPA inventory estimate, due to new updated emission factors
- Significant upgrades to M&R stations have resulted in substantially lower emission factors
- Pipelines leak emission factors are lower than previous estimates
  - Improved leak screening methods by companies
  - Differences in sampling methods between GRI/EPA 1992 study and this study
- Because of differences in pipeline types, there are large variations in emissions on a regional basis

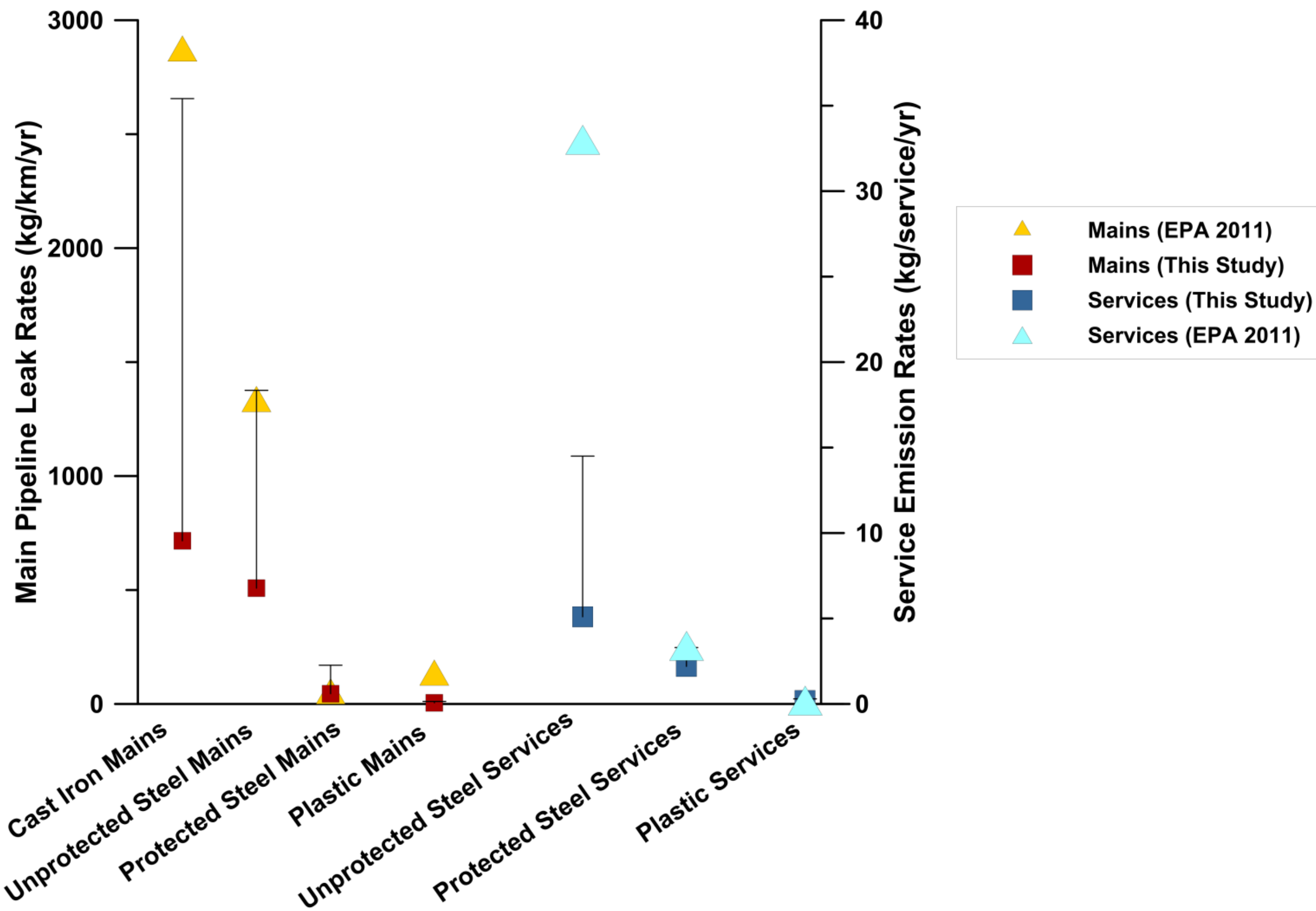
Questions & Discussion

Extra Slides

Comparison of M&R Results to Previous Studies



Pipeline Leak Summary



Measured pipeline leak rates are lower than previous measurements.
This may be the result of:
1) differences in measurement methods
2) changes in leak survey methods since 1992

Current Estimates of Methane Emissions from Natural Gas Distribution Systems

- Emissions from different categories
  - Underground pipelines and services
  - Metering and regulating (M&R) stations
  - Customer meters
  - Mishaps (dig-ins) and maintenance
- For each category
  - Emissions = Emission Factor x Activity Factor = EF x AF
  - The emissions from each category are summed for the total distribution system emissions
  - Current EPA Greenhouse Gas inventory uses EFs from a 1992 GRI/EPA national study of the natural gas system

Next Steps

Top-down vs. bottom-up comparisons of emissions show a large gap for urban areas

- We need better treatment of all urban sources
  - End-use emissions (residential, commercial and industrial customers)
  - LNG storage
  - CNG vehicles and re-fueling stations
  - Complete accounting for landfills, wastewater treatment, and other biogenic sources
- We need better leak surveys to capture the super-emitter leaks and facilities
  - Process for identification and repair of super-emitters
  - Mobile mapping may not yet be mature enough for quantitative surveys
- Seasonal effects on methane emission factors need to be addressed

Developing a Representative Database by Random Selection of Test Sites

- In each distribution service area, we selected one city or region for measurements
- For this target area, we used partner company survey data to randomly select pipeline leaks and M & R facilities to measure.
- In each selected area, we collected approximately 10-20 pipeline leak measurements and emissions data for 10-20 M&R stations.

Key Findings

- Methane emissions from local natural gas distribution systems in cities and towns throughout the U.S. have decreased in the past 20 years with significant variation by region.
- Upgrades in M&R stations, changes in pipeline materials, better leak detection, and new regulations have led to this decrease.
- For both M&R stations and pipeline leaks, the distribution of measured emission rates is highly skewed where a few sites contribute a large fraction of the total measured emissions
- M&R stations have undergone significant upgrades and our emission factors were substantially less than those from the 1992 GRI/EPA study
  - These changes were confirmed by re-visiting 9 sites from the GRI/EPA study where we found more than a factor of 10 smaller emissions
- Vented devices at M&R stations often are the largest emission source within a facility
- For pipeline leaks, our emission factors were less than in the 1992 study, but it is not clear why these differences exist
  - Changes in safety regulations and in company survey and repair methods
  - Differences in the study methods