# A CASE STUDY ON DRY SEAL VS. WET SEAL CENTRIFUGAL COMPRESSOR EMISSIONS

*Presented to:*

**The Rocky Mountain EHS Peer Group**

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*Presented by:*

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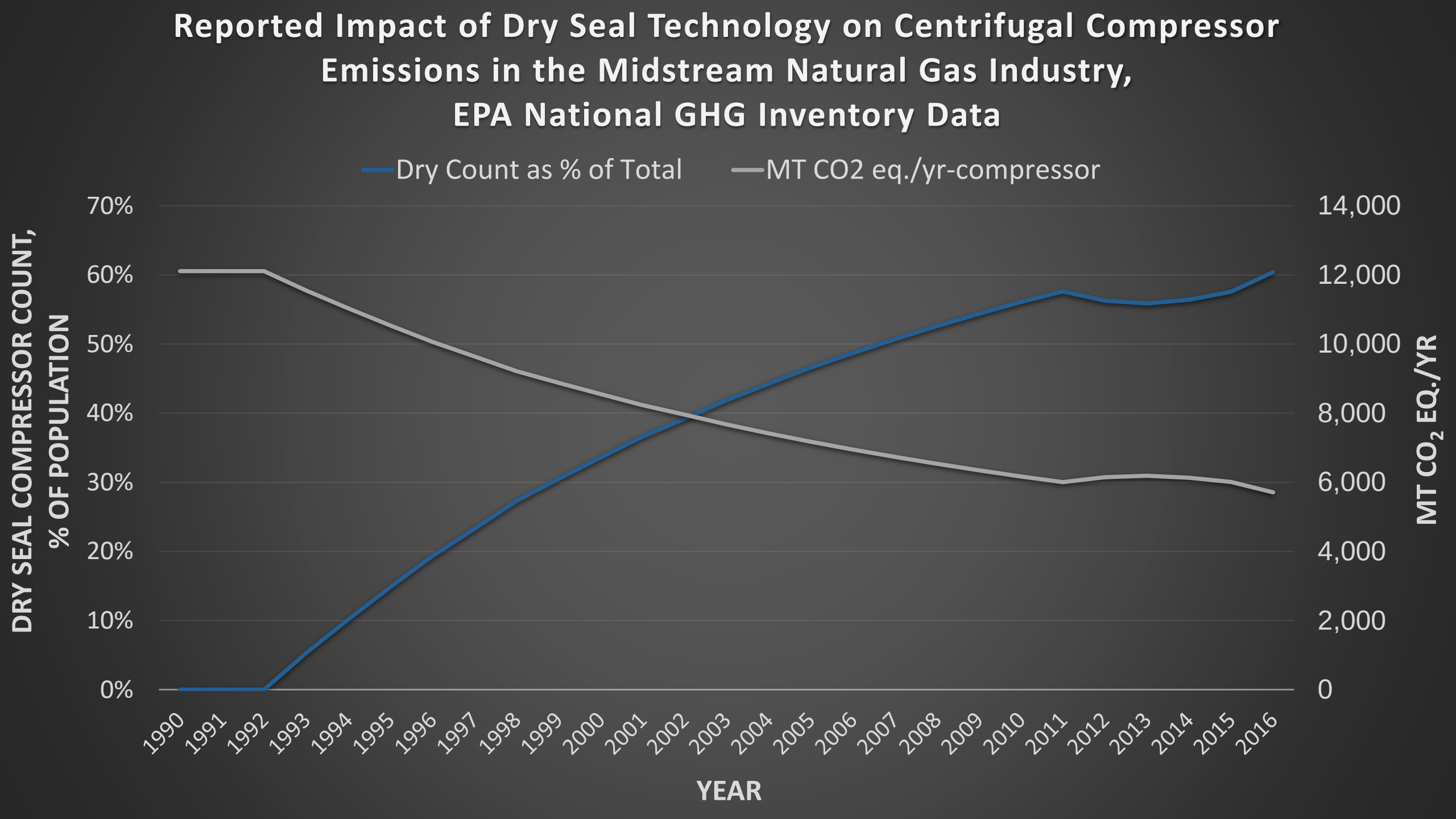
# Reported Impact of Dry Seal Technology on Centrifugal Compressor Emissions in the Midstream Natural Gas Industry, EPA National GHG Inventory Data

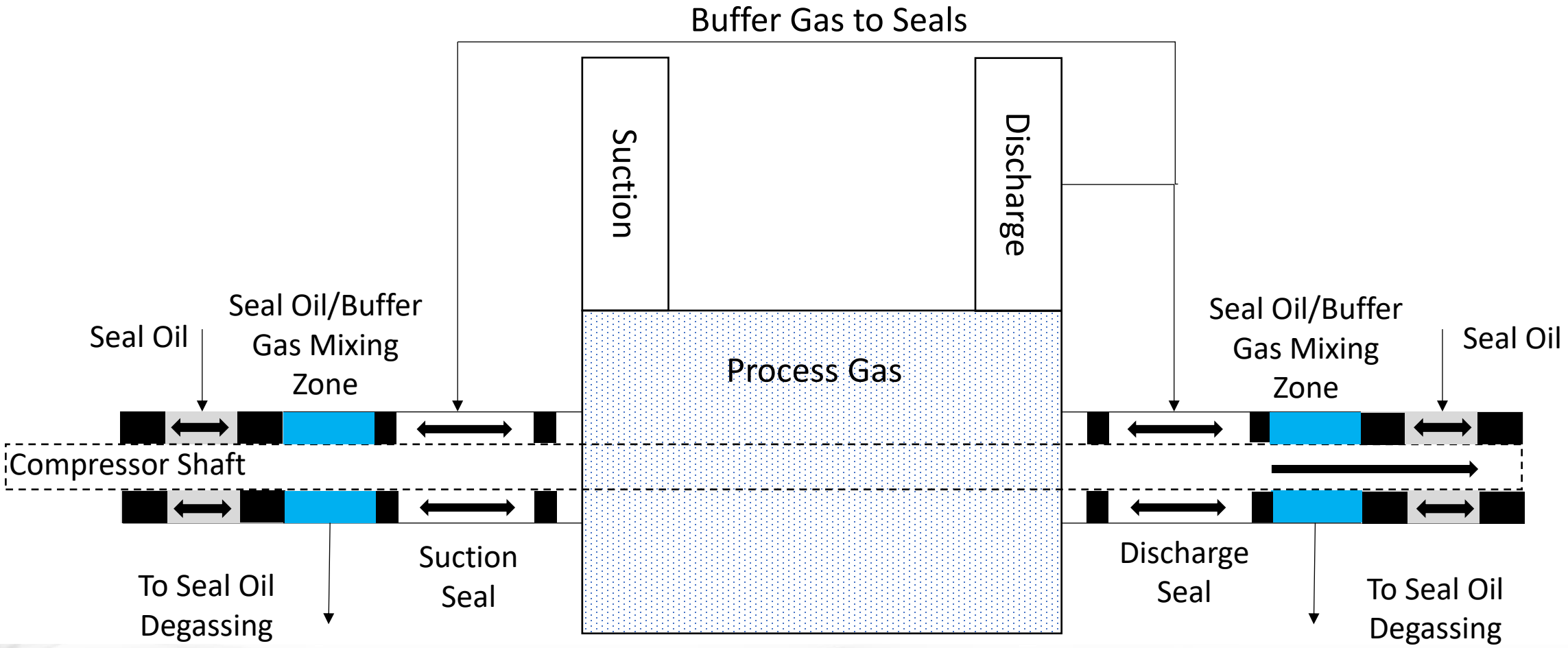


# Presentation Overview

- Centrifugal compressor seal design
- History of wet seal vs. dry seal regulation
- Emissions Measurement Study

# Centrifugal Compressor Seal Design

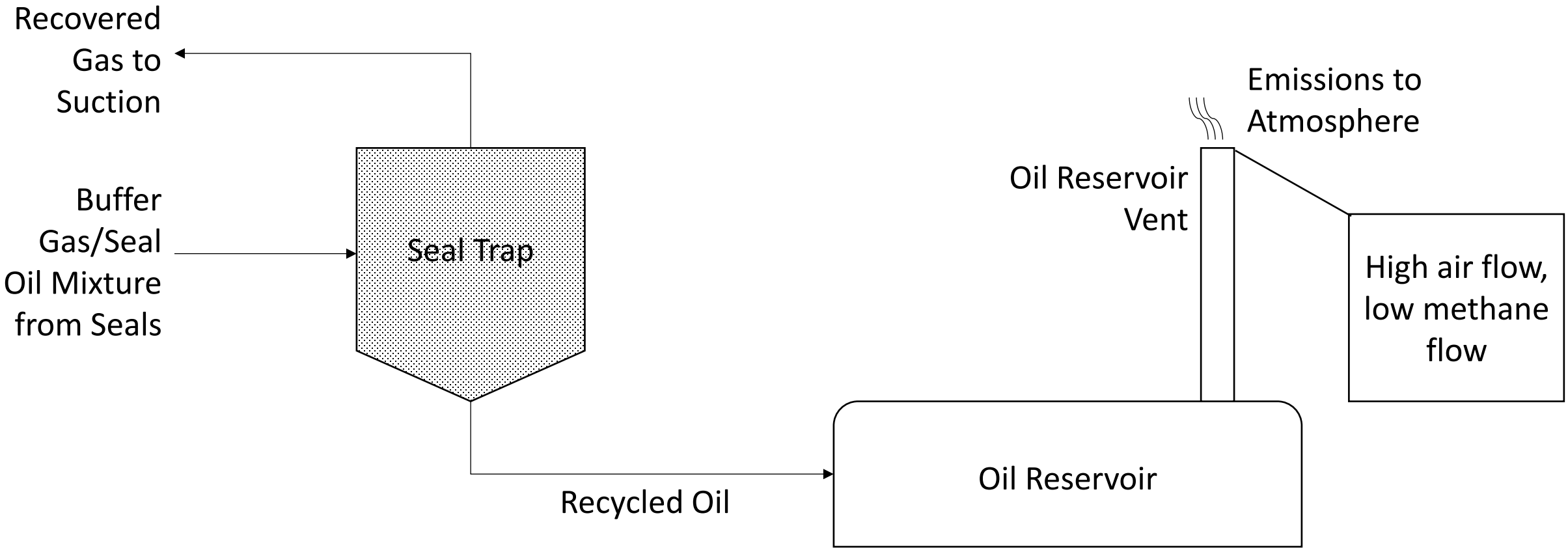
# Wet Seal Technology



# Solar Wet Seal Compressor Degassing System

- Solar turbine/wet seal compressor packages have always shipped **standard** with a system to recycle degassing emissions to suction.
- Solar centrifugal compressors account for 70% of the midstream natural gas market (Zimmerle, 2015; Solar, 2018).
- First-principles modeling performed by Solar in 2016 estimated:
  - >99% degassing emission recovery rate.
  - Natural gas emission to atmosphere between 0.03 – 0.4 scfm.

# Old Solar Degassing System Design



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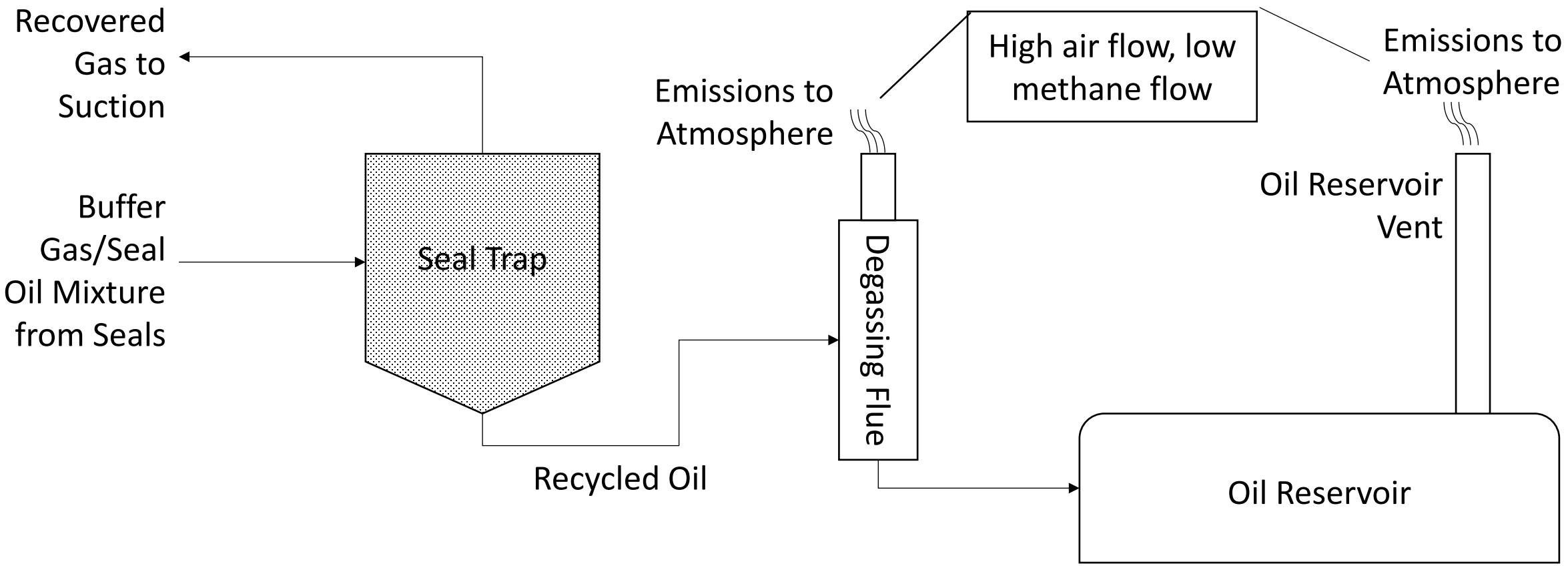
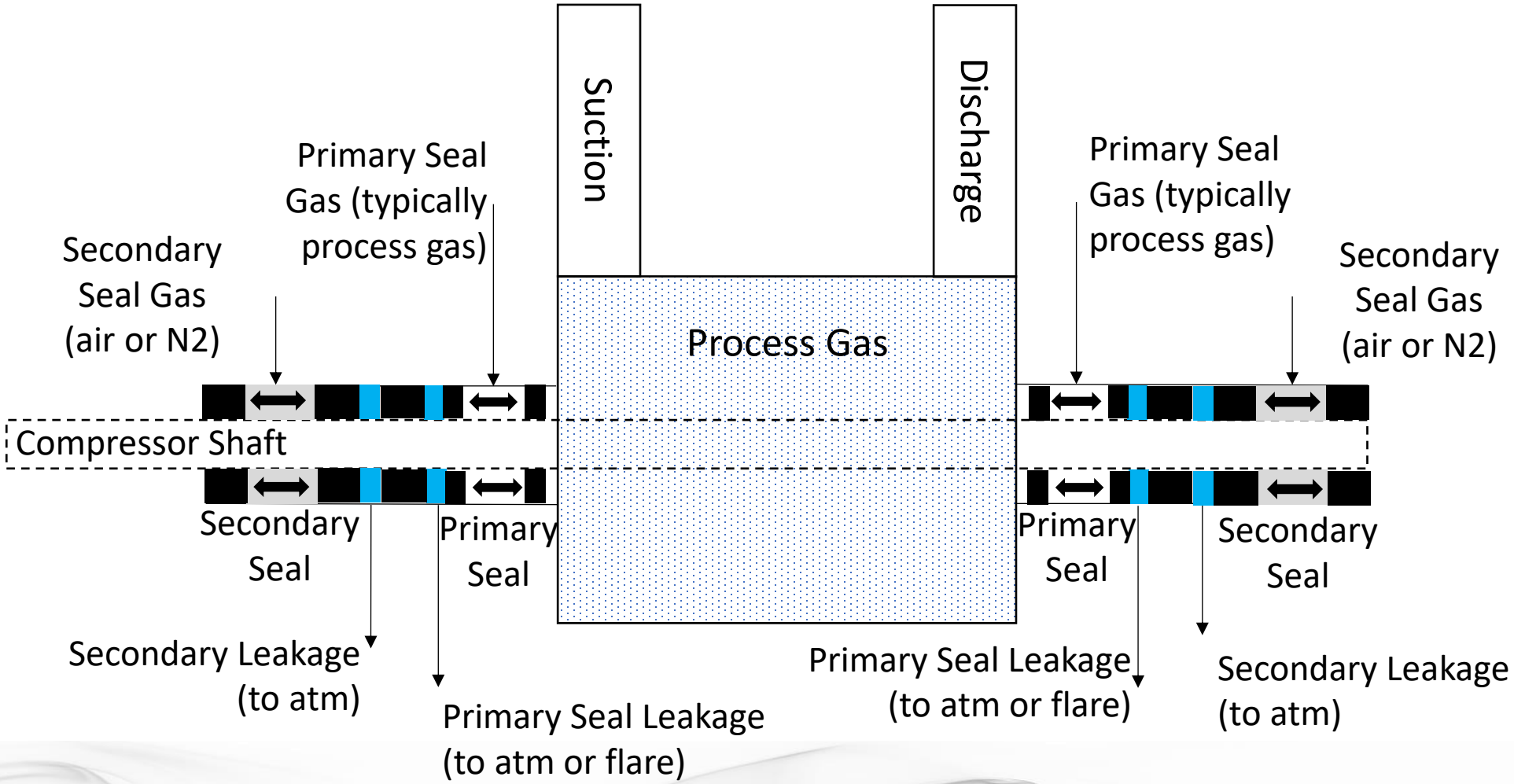


# Dry Seal Technology



# History of Wet Seal vs. Dry Seal Regulation

# Regulatory Background

- 2010 (Subpart W) – Wet seal vent emissions must be measured and reported. Dry seal vents exempt.
- 2011 (NSPS OOOO) – ≥95% VOC reduction for wet seal degassing in certain industry segments. Dry seal units exempt.
- 2015 (NSPS OOOOa) – ≥95% VOC and methane reduction for wet seal degassing in a larger portion of the industry. Dry seal units exempt.
- 2023 (NSPS OOOOb) – Both wet seal and dry seal units subject. TOO LATE??
- Various other State Regulations (final and draft), such as Colorado, California, Pennsylvania, New York, Maryland.

# EPA Natural Gas Star Program

Methane emissions from wet seals typically range from 40 to 200 standard cubic feet per minute (scfm). Most of these emissions occur when the circulating oil is stripped of the gas it absorbs at the high-pressure seal face. Dry seals, which use high-pressure gas to seal the compressor, emit less natural gas (up to 6 scfm for a two seal system), have

*EPA, October 2006.*

According to previous measurements of seal oil degassing reported in Bylin, et al. (2009), emissions from degassing centrifugal compressor seal oil can be as high as 185 standard cubic feet per minute (scfm) (5.2 cubic meters ($m^3$) per minute) of gas per compressor, with an average value of 63 scfm (1.8 m3 per minute) of gas per compressor. Gas volume from degassing

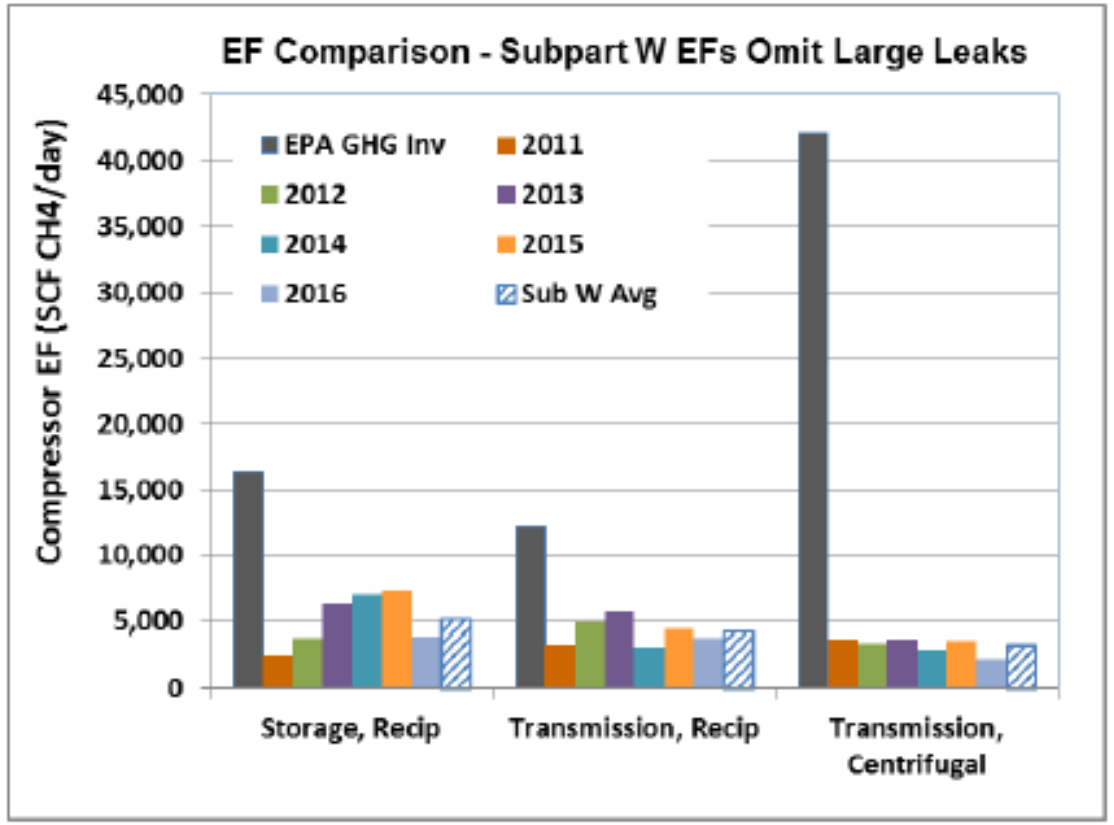
*EPA, 2014.*

group (15 compressors). The low emitters have an average emission rate of 26 thousand $m^3$ methane/year for a single compressor. The high emitters have an average emission rate of 934 thousand $m^3$ methane/year for a single compressor. Most measurements were conducted using anti-static calibrated vent bags, where a bag of a known volume was placed over the de-gassing vent stack

*Bylin, 2009.*

# EPA GHG Reporting Program *(40 CFR Part 98, Subpart W)*

- Wet seal vent emissions are measured and reported.
  - Measurements may be performed with calibrated vent bags & anemometers.
  - PRCI's analysis – EPA has **significantly** over-estimated emissions from wet seal degassing vents. (PRCI, 2018)
  - Average reported wet seal vent rent is 3 scfm, nowhere near the 40-200 scfm suggested by NG Star.
- Dry seal vent emissions were not historically not measured/reported. Now in May 2024.



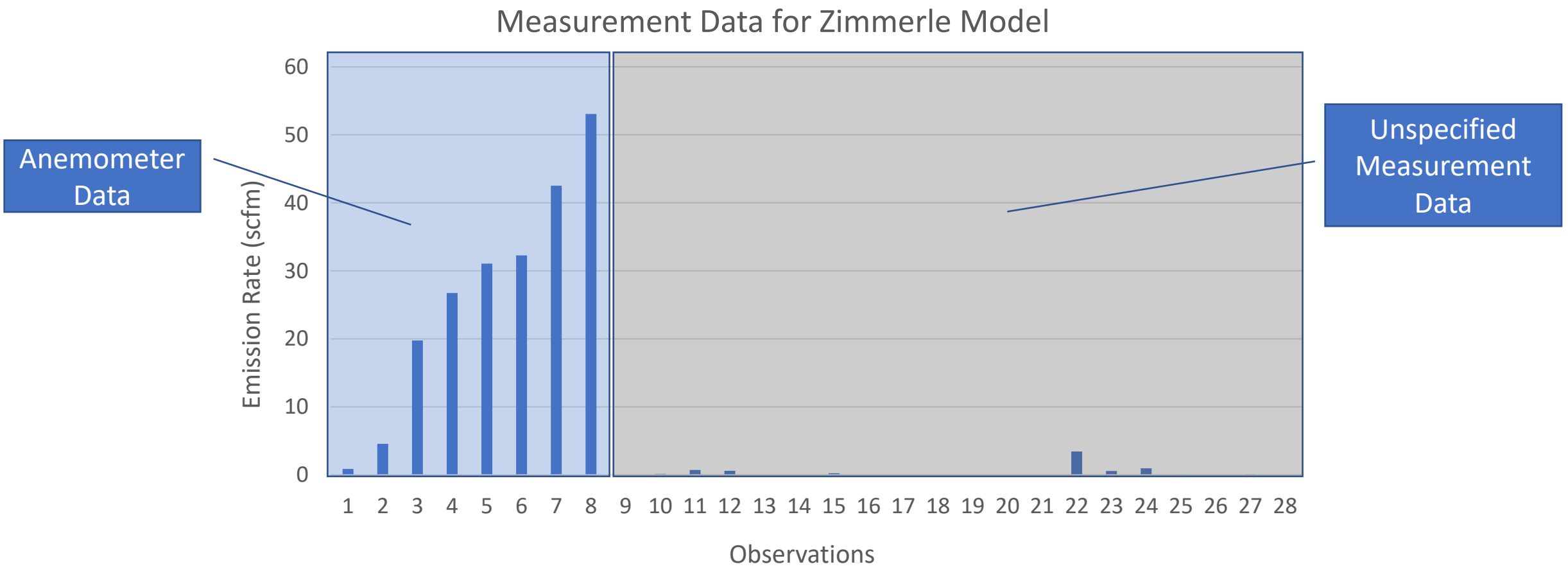

*Pipeline Research Council International (PRCI), 2018*

# Zimmerle Study

SCFM/compressor). While this study indicated similar emission rates for dry seals, emission rates for wet seals were significantly lower than utilized for the GHGI (SI, CDFMaster.xls). These results indicate that the emission advantages of dry seals may be overestimated in current literature and may warrant additional study. Annualized emissions are also

*Zimmerle, 2015*

# Zimmerle Study



# Emissions Measurement Study

# Study Background

- Tora performed an emissions measurement study in Q4 2018 for a confidential client.
- Measurements conducted using a Bacharach HiFlow Sampler, which measures methane flow rate.
- Study included 4 Solar wet seal centrifugal compressors and 11 dry seal centrifugal compressors (Solar and others).

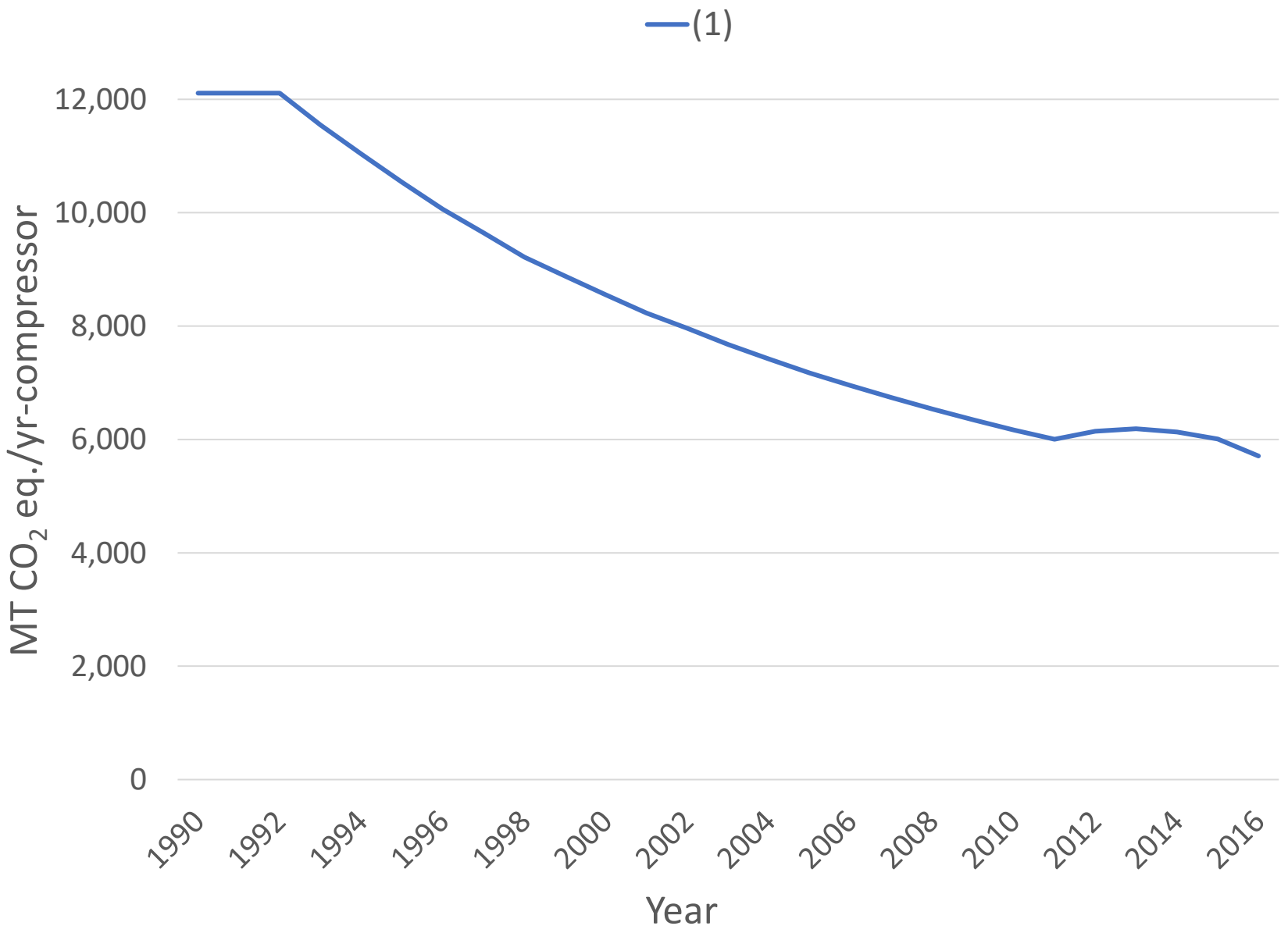
# Study Results

- Wet Seal Units:
  - Range: 0.025 – 0.11 scfm
  - Average: **0.08 scfm**
- Dry Seal Units:
  - Range: 2.68 – 6.55 scfm
  - Average: **3.78 scfm**
- Results generally align with the 2015 Zimmerle study (ignoring the wet seal measurement data collected with an anemometer).

# Revising Historic Emissions Estimates

(1) EPA NGHGI Data:

- Avg. Wet Seal Vent Rate: 48 scfm
- Avg. Dry Seal Vent Rate: 6 scfm



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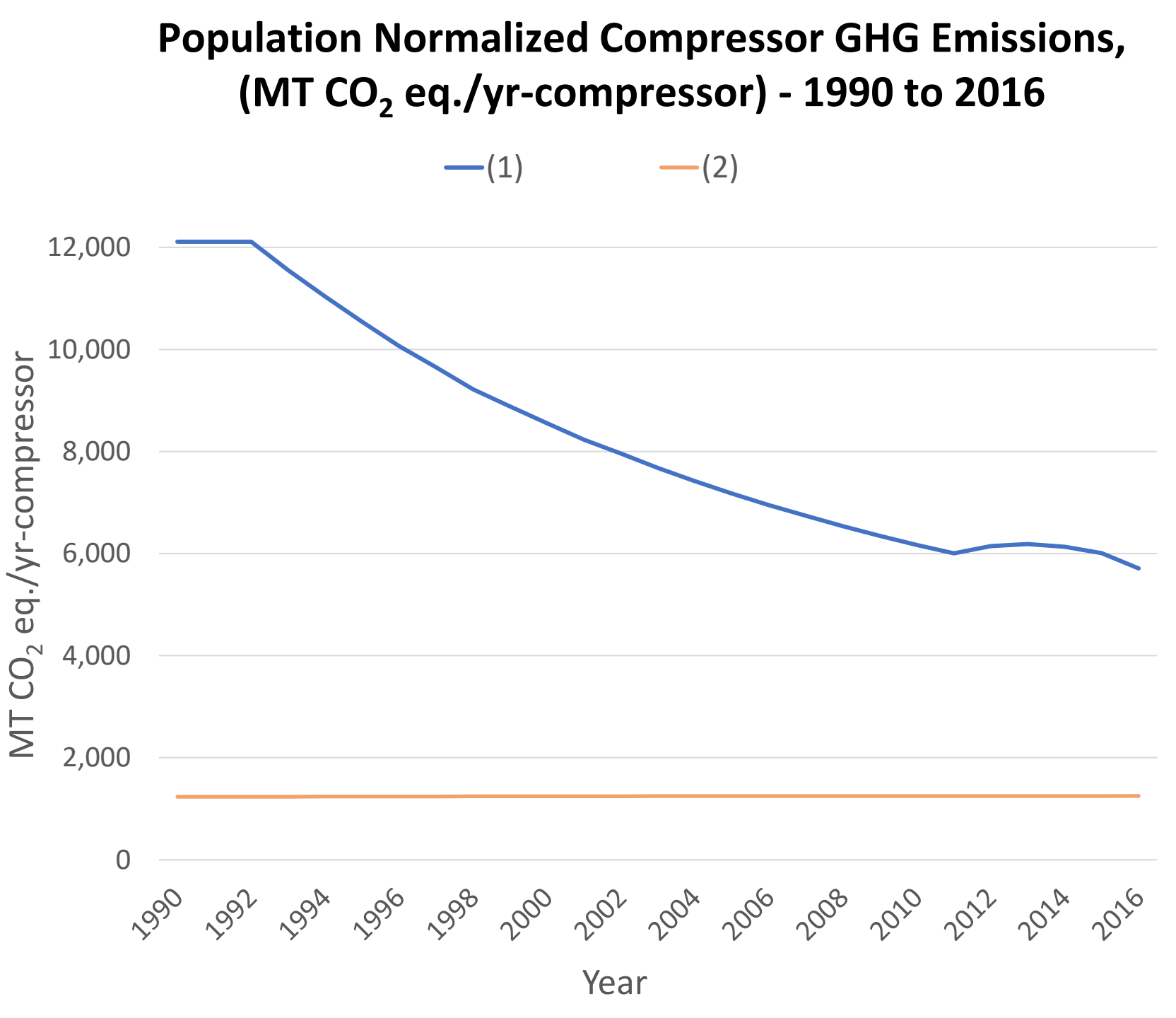
- Avg. Solar Wet Seal Vent Rate: 0.08 scfm (Tora Study, 2018)
- Avg. Non-Solar Wet Seal Vent Rate: 16 scfm (Zimmerle, 2015)
- Avg. Dry Seal Vent Rate: 5 scfm (Zimmerle, 2015)



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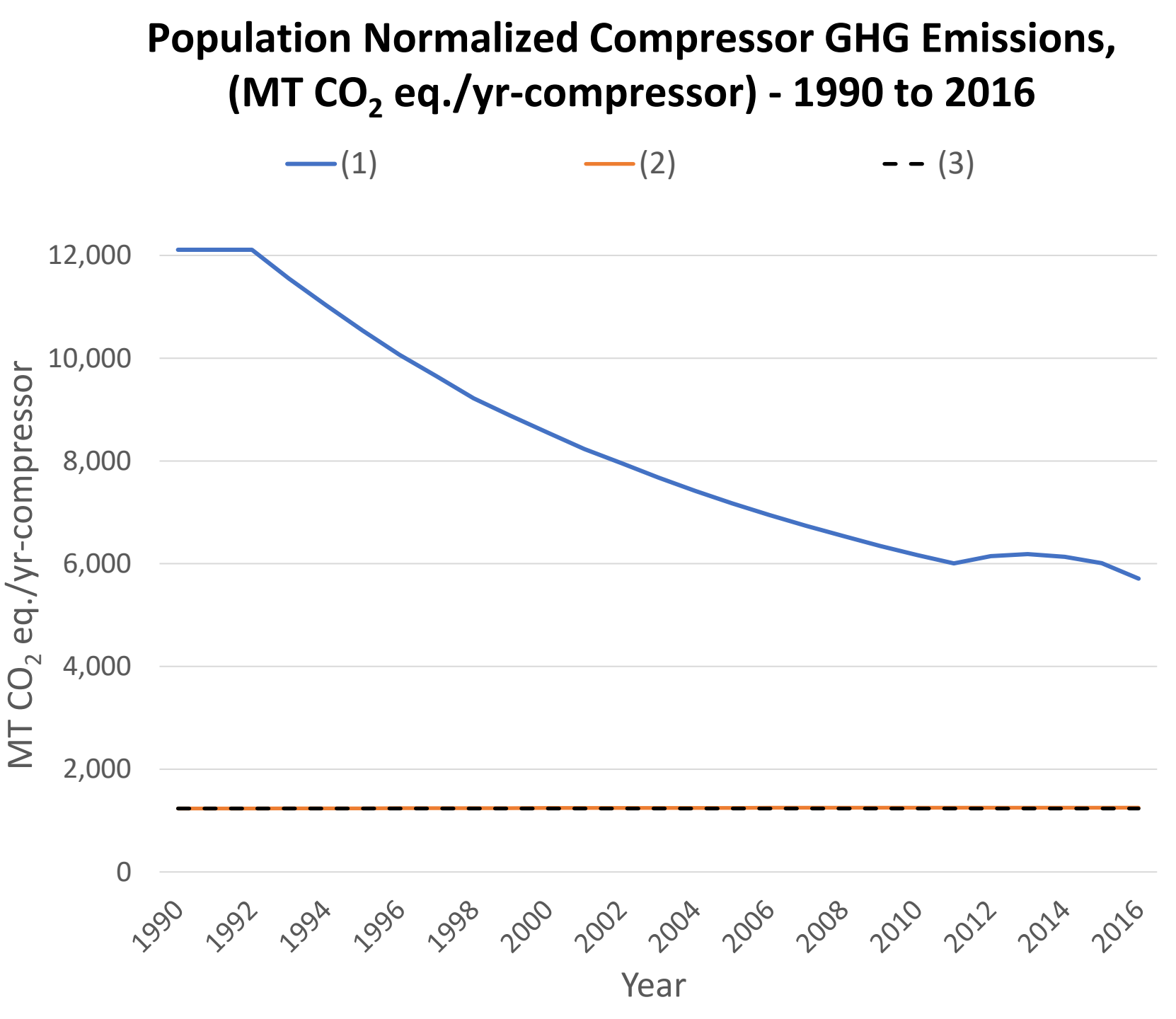

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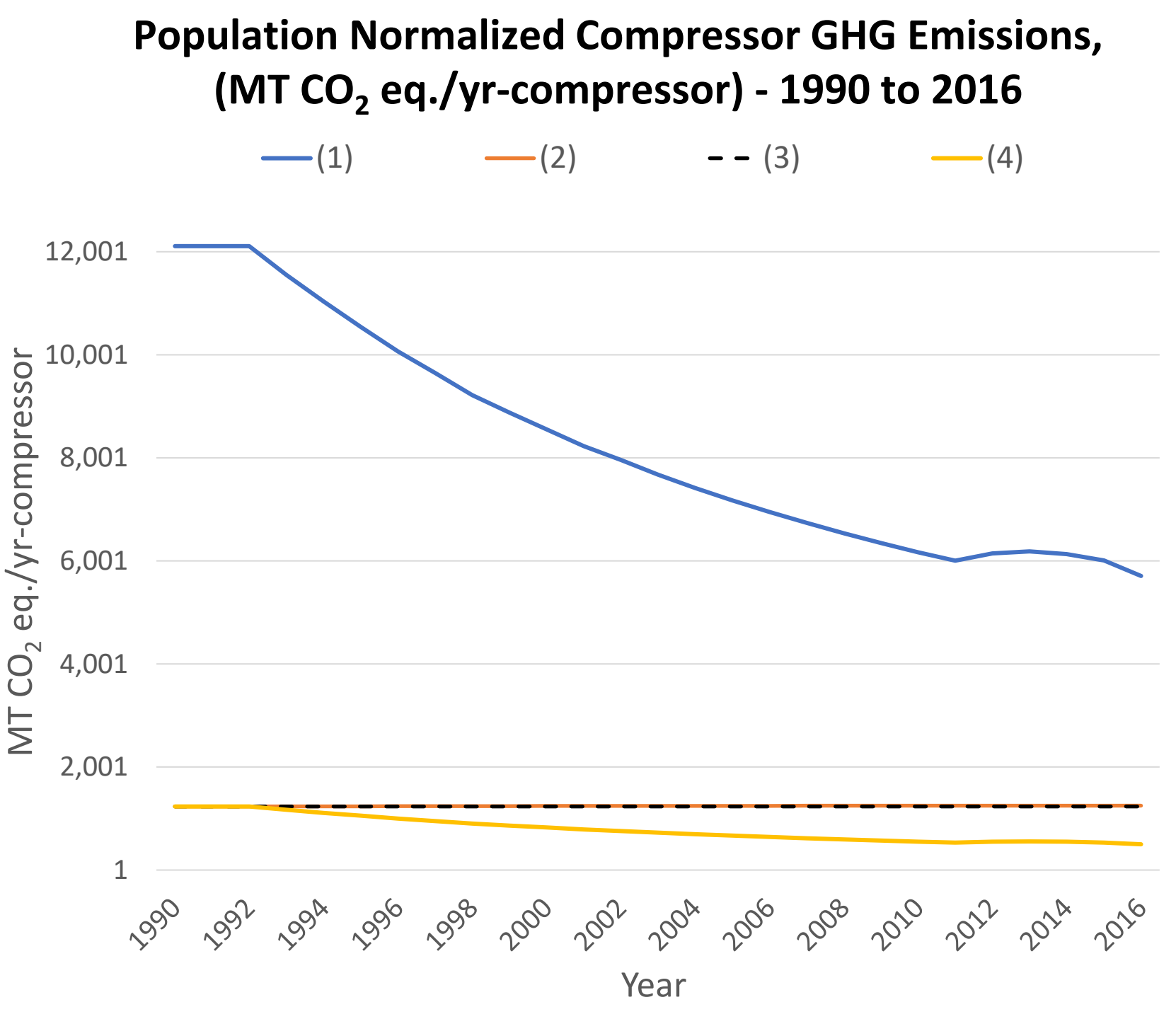
- 70% would have recovery systems, 30% would not

(4) Simulation Case II – What if EPA would have required wet seal recovery systems rather than pushing dry seal technology?



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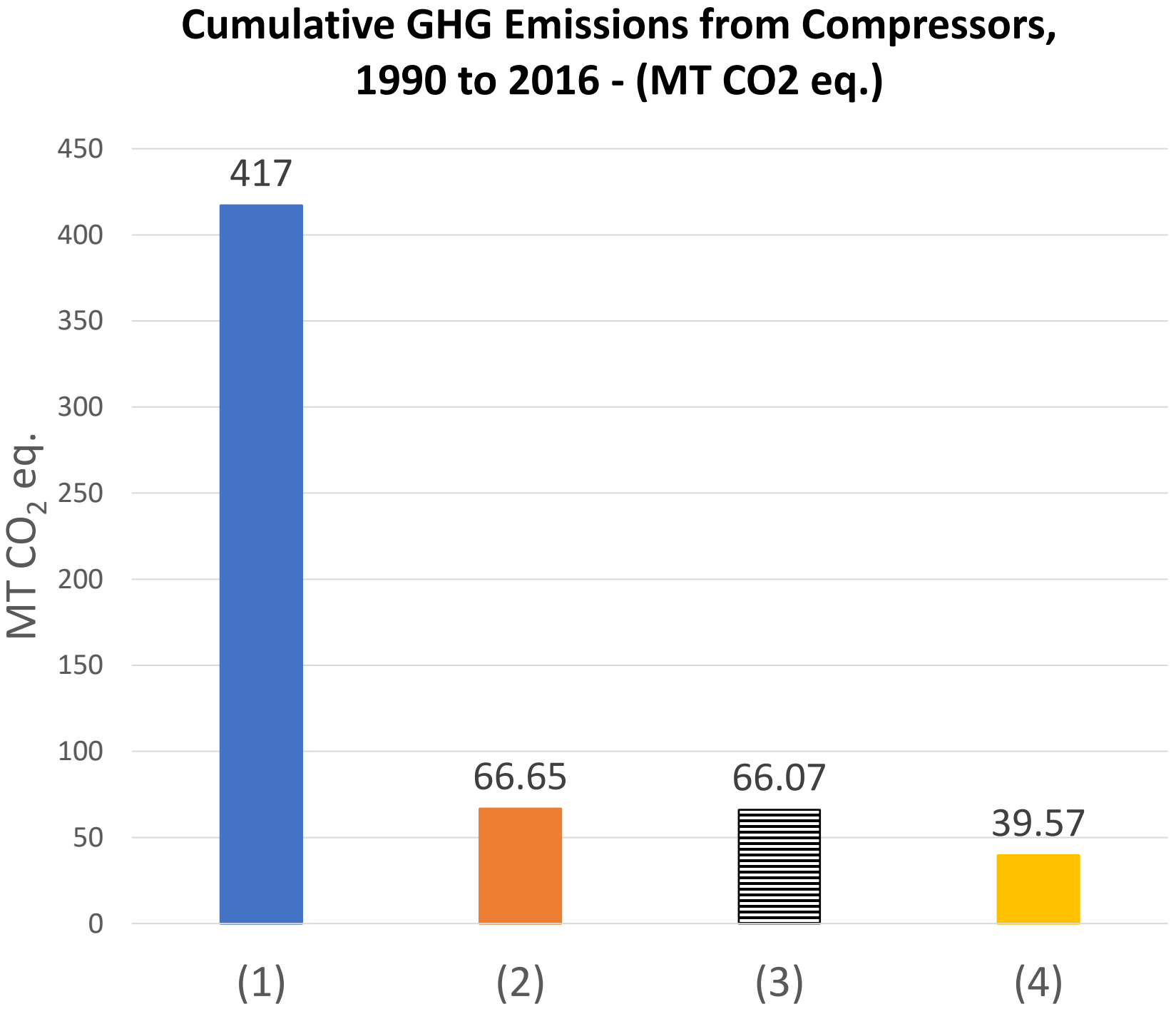

# Conclusions

- Actual emissions are significantly less than historic estimates.
- Historic emission reduction claims are overstated, emissions may have actually increased.
- Replacement of remaining Solar wet seal units would increase emissions ~550,000 metric tons of CO2e per year.
- Industry could benefit from corrected wet seal degassing emissions estimates.
- The damage is mostly done (lesson learned for the future).

# References


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Zimmerle, Daniel J., et al, “Methane Emissions from the Natural Gas Transmission and Storage System in the United States”, Environmental Science & Technology, 49, 9374-9383. 2015.

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