Short Lived Climate Pollutants: Methane and Natural Gas

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Mobile Sources Technical Review Subcommittee

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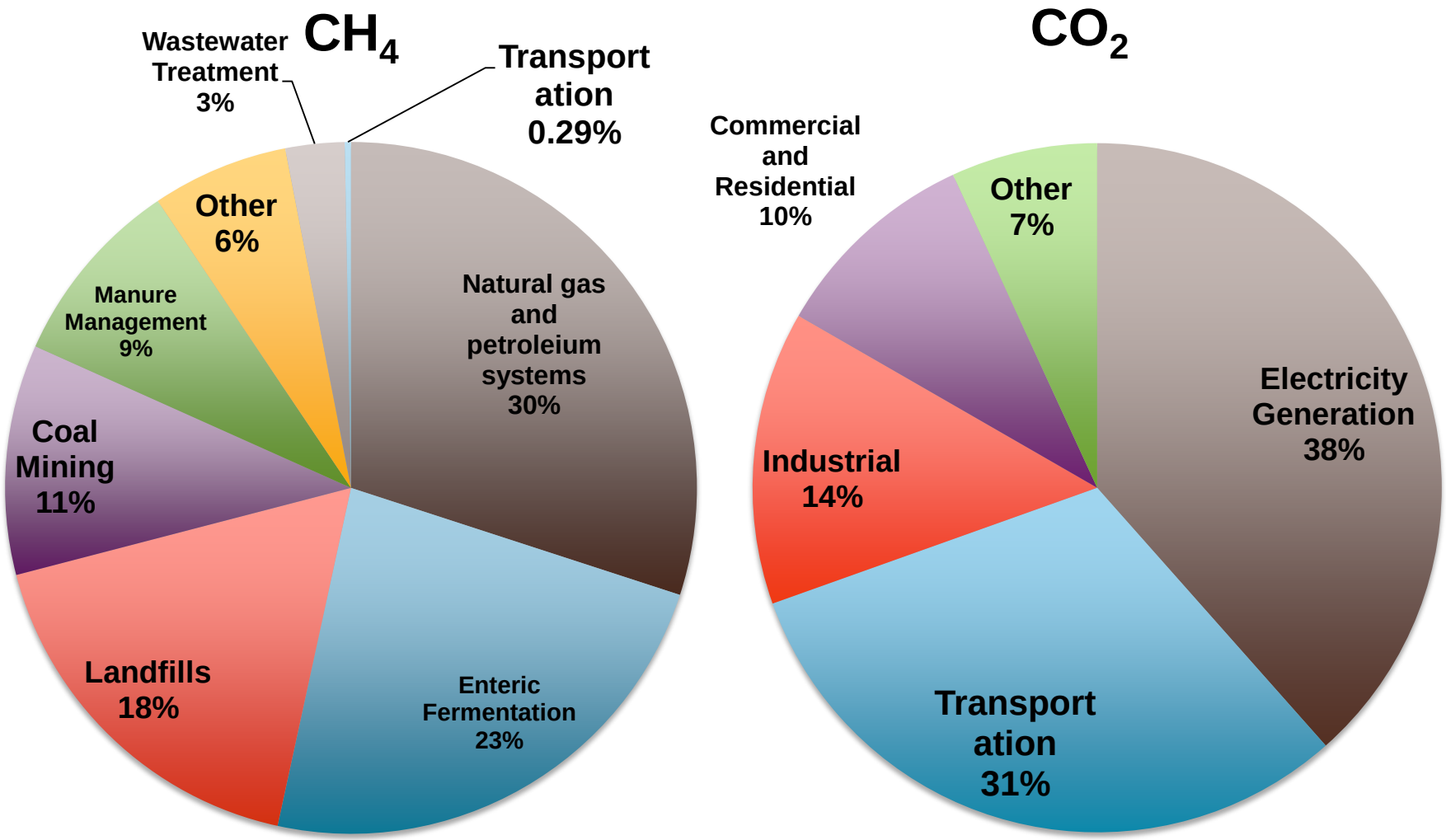
Introduction

- Methane concentrations are higher than they have been in at least the last 800,000 years
- The rise in methane concentrations since the 1750s is predominantly due to human-related activities
- A 25 percent reduction in methane emissions by 2030 would reduce average surface warming by 0.2 degrees C around 2040.
- Methane vs CO_2
  - Global warming potential: $CH_4 > CO_2$
  - Lifetime in atmosphere: $CH_4 < CO_2$

US GHG Inventory: Sources of CH_4 and CO_2



Source: EPA: http://epa.gov/climatechange/ghgemissions/usinventoryreport.html, Inventory of U.S. Greenhouse Gas Emissions and Sinks:1990 – 2011

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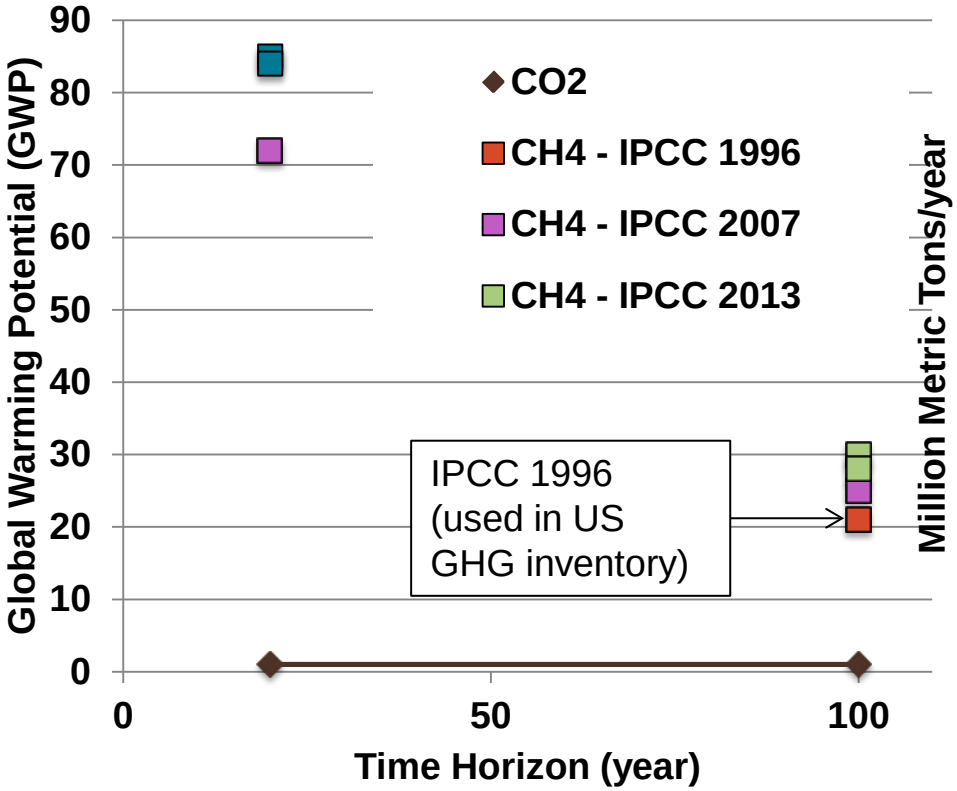
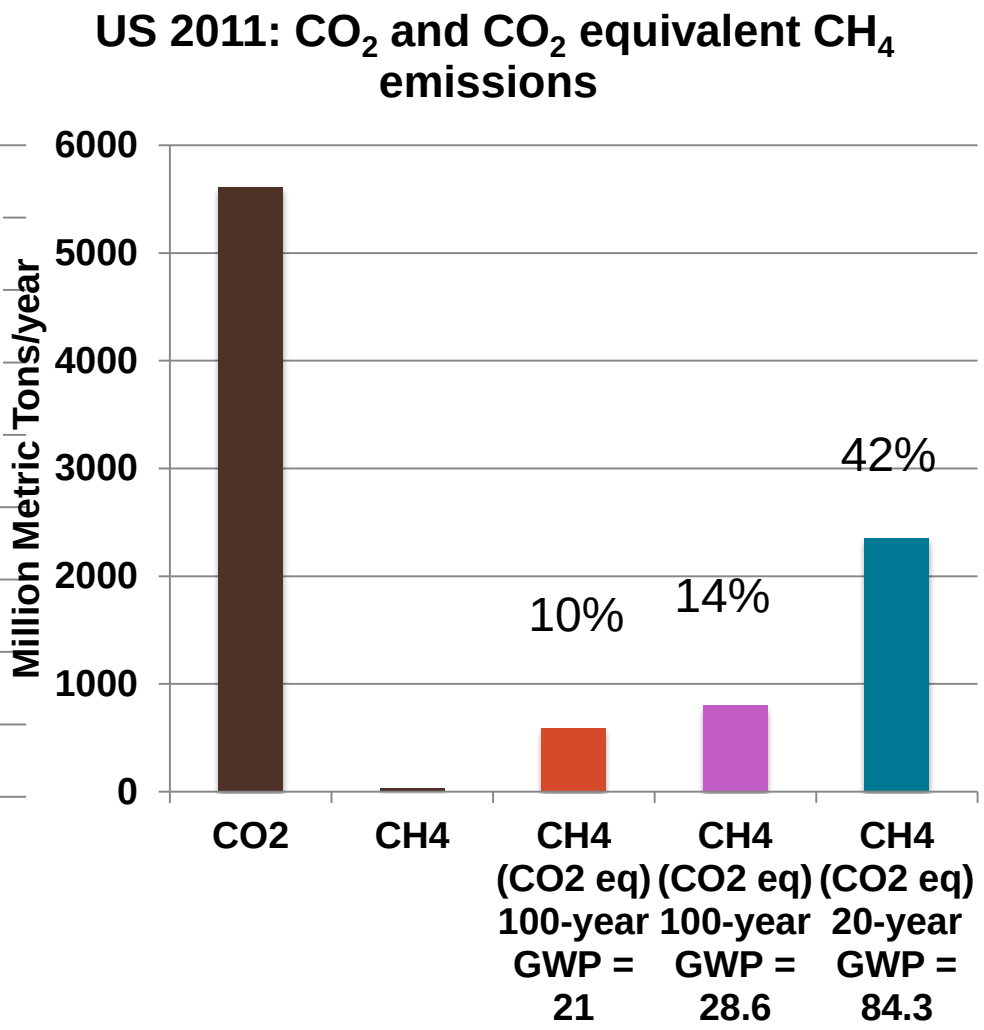
Methane's CO_2 equivalence?

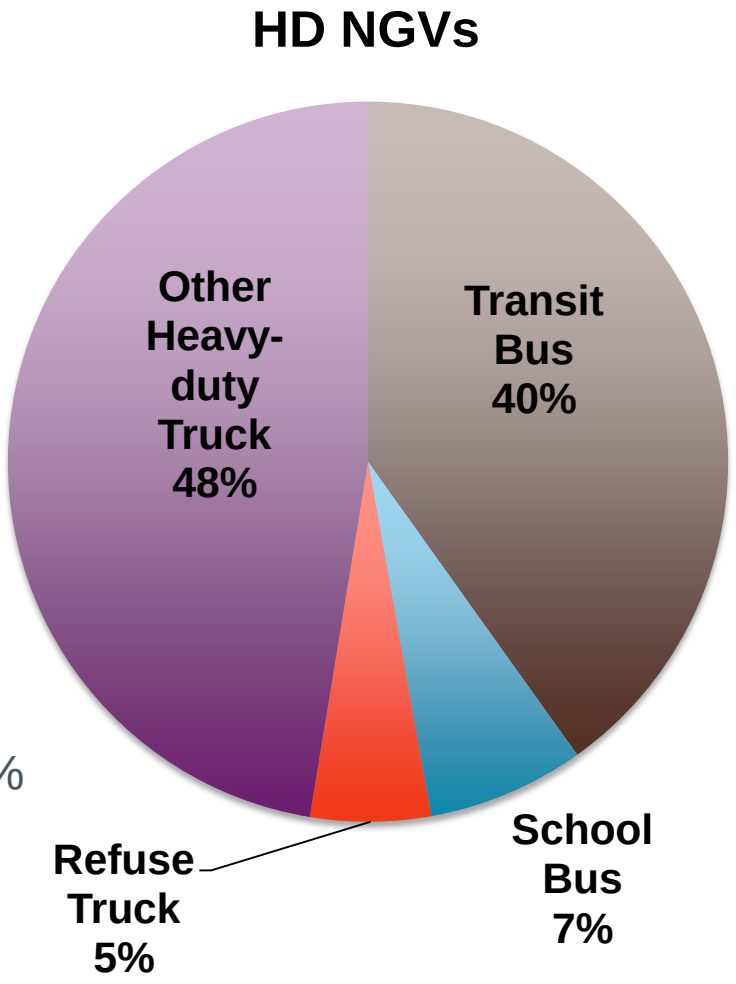




Source: IPCC

US: Natural Gas for Transport - Today

- Vehicles
  - ~135,000 NGVs (0.05% of total vehicles)
  - HDVs: ~25,000 (0.4% of total HDVs)
  - LDVs: ~110,000 (0.05% of total LDVs)
- Infrastructure
  - Natural Gas infrastructure has been growing ~11%/year (2009-2012).
  - Number of stations ~1500 (~1.2% of total fueling stations).



Source: NGVA Europe statistics from June 2012

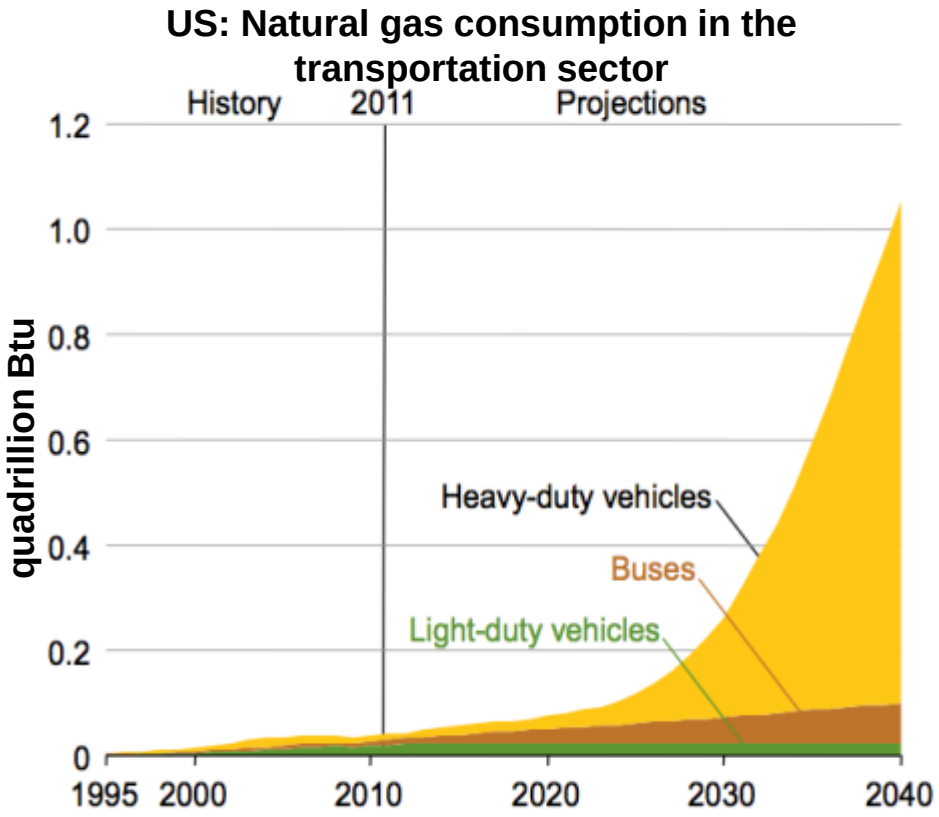
Heavy-Duty Engine Technology: Options

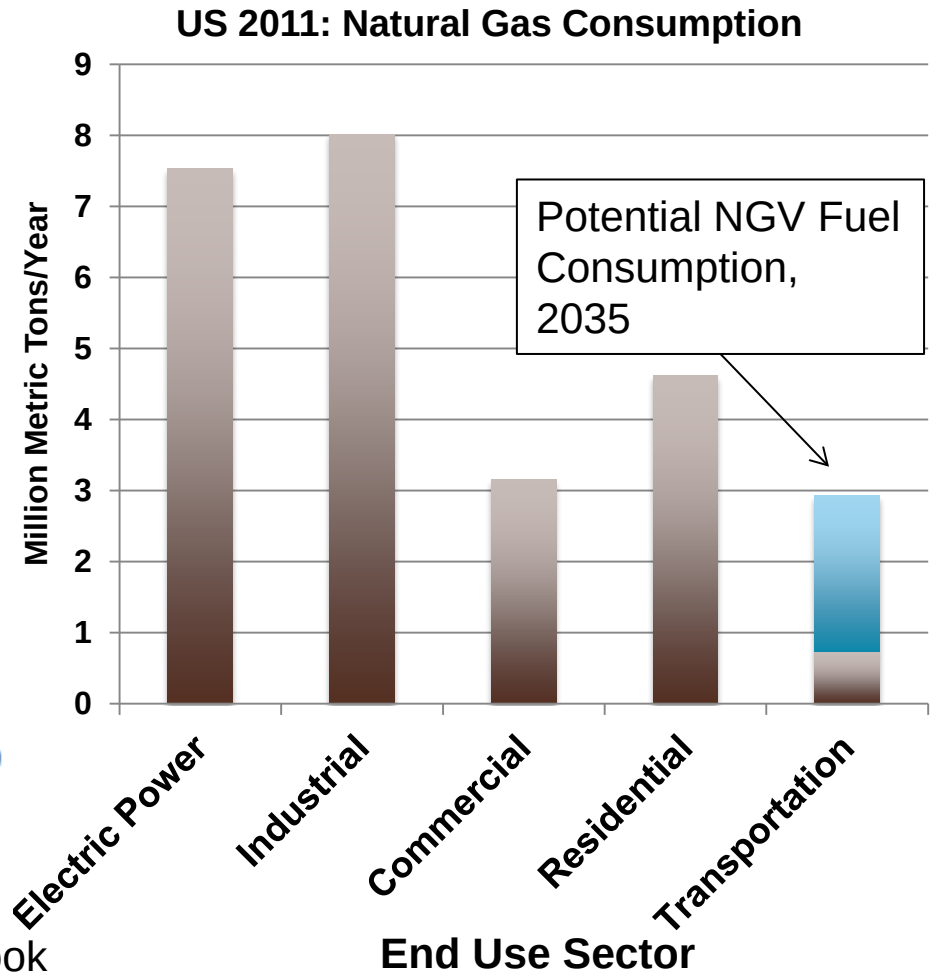
- Spark-ignited, throttled engines
  - Stoichiometric with three-way catalyst
  - Turbocharged with EGR
  - LNG or CNG
- High Pressure Direct Injection
  - Westport system
  - Diesel pilot with gas spray
  - LNG
- Dual fuel (diesel / natural gas)
  - Can operate as diesel-only
  - Diesel provides ignition source
  - Retrofit technology
  - LNG or CNG
- **Methane tailpipe emissions**
  - Low with stoichiometric burn
  - High with lean operation

US Fleets and Shippers: Trends

- January 18, 2012: “Waste Management plans to convert its entire fleet of 18,000 collection vehicles to CNG.”
- October 8, 2013: “UPS plans to invest approximately $50 million to build an additional nine liquefied natural gas (LNG) fueling stations, bringing the total number of stations to 13 to support the operation of approximately 1,000 UPS LNG tractors.”
- October 17, 2013: “Lowe’s working with carriers to transition all regional distribution center dedicated fleets to natural gas by end of 2017.”
- June 27, 2013: “P&G to Convert 20 Percent of Its For-Hire Truck Loads to Natural Gas. P&G Invests in Growth of Natural Gas Industry by Awarding Loads to Eight Natural Gas Transportation Carriers.”

US: Natural Gas for Transport – Tomorrow?





Source: EIA: Annual Energy Outlook 2013 and Tiax/ANGA: Natural Gas Vehicle Industry Overview

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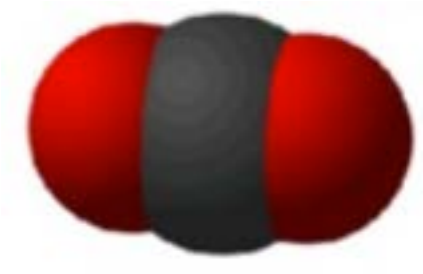
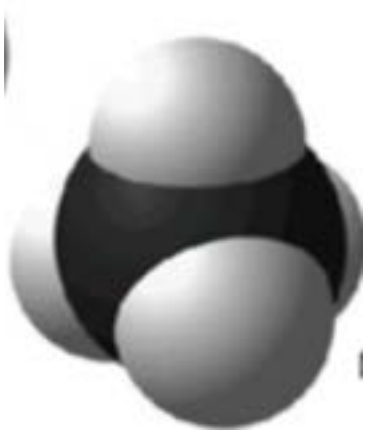
NGV Market Penetration: Impact on GHG Emissions

- CO_2 transport emissions go down
  - Less CO_2 from combustion
  - C:H Ratio of methane lower than diesel (and gasoline)
  - Efficiency of NGVs range depending on engine technology
  - Decrease CO_2 from combustion ~10-25% (per vehicle)
- CH_4 emissions from NG systems and transportation go up
  - From leakage and increased volume in NG system
  - Leakage/venting from fueling stations, vehicles and tailpipe emissions
- **Question: How much increase in CH_4 emissions will offset CO_2 savings?**

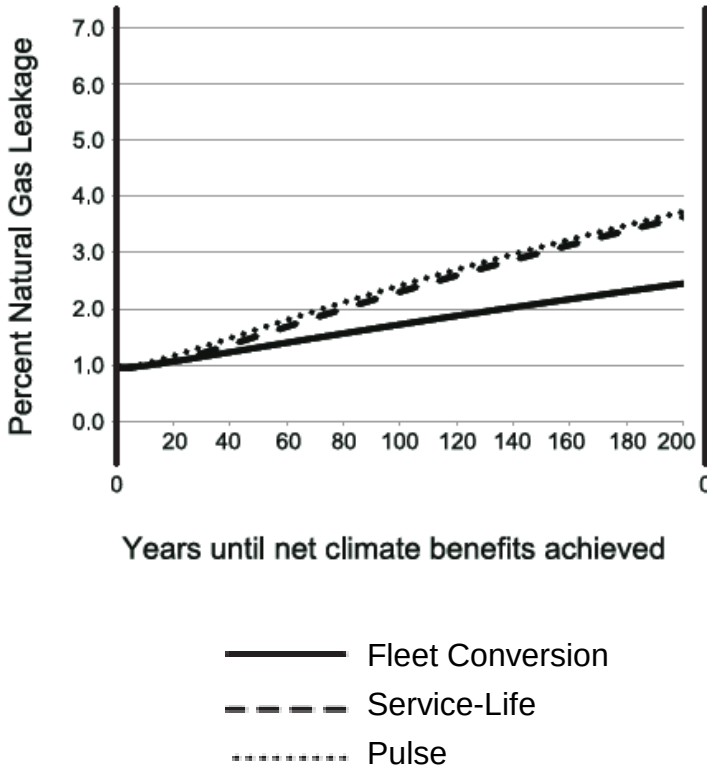




Maximum Methane Leakage to Deliver Benefits

- EDF conducted a study to determine maximum Well-to-Wheels methane leakage that would still allow for climate benefits from NGVs <u>today</u>
  - **1%** - to replace diesel vehicles
  - **1.6%** - to replace gasoline vehicles

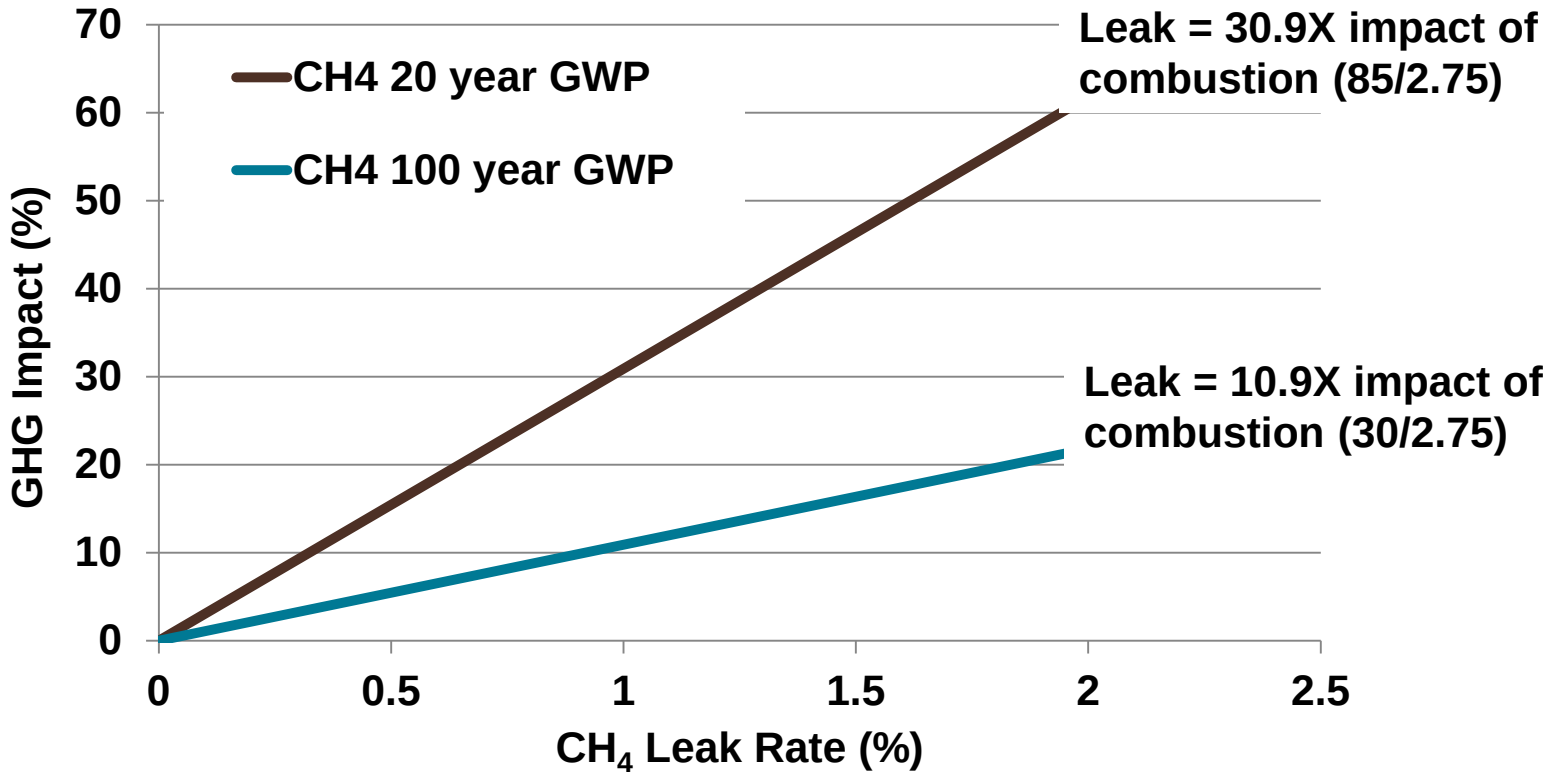
Caveat: Calculated using lower GWPs (IPCC 2007)



Source: Alvarez, R. A., S. W. Pacala, J. J. Winebrake, W. L. Chameides, and S. P. Hamburg. **"Greater Focus Needed on Methane Leakage from Natural Gas Infrastructure."** *Proceedings of the National Academy of Sciences* 109, no. 17 (2012): 6435–6440.

GHG Impact from Methane Leaks

- Compare the GHG impact of CH_4 combustion (to CO_2) vs direct release into the environment
  - Combustion: 1g CH_4 → 2.75 g CO_2
- Methane leak has a substantially greater impact than methane undergoing combustion



Sources of Methane Emissions Throughout the Natural Gas Value Chain

- Well-to-pump
  - Production
  - Processing
  - Transmission and Storage
  - Local Distribution

- Range from Studies: 1.1-6.9%
- EPA (2011): 2.55%
- EPA (2013): 1.55%

- Pump-to-wheels
  - Fueling stations
  - Fueling events
  - Vehicle
    - Fueling system (venting and leakage)
    - Tailpipe

- Very little data available
- EDF Estimate: 0.6%

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Fugitive Methane Emissions Study

- EDF is leading a series of collaborative studies to determine leakage from NG value chain
  - Production
  - Gathering & Processing
  - Transmission and Storage
  - Local Distribution
  - Transportation (Pump-to-Wheels)

Project Objective: Quantify methane emissions that would be associated with increased use of natural gas as a transportation fuel in the heavy-duty vehicle sector

Source: http://www.edf.org/methaneleakage

Mitigation: Technology and Strategies are Available

- Mitigation strategy for fueling stations and vehicles

Fugutive Emission Type		Mitigation Strategy
Unintentional	**Leaks (Continuous or Intermittent)**	**Improved materials and components. Pressure checks. Inspection and maintenance**
Unintentional	**Failure/Disaster**	**Shut off valves. Safety systems**
Unintentional	**Refueling**	**Recapture**
Unintentional	**Tailpipe Emissions**	**Emissions control/catalyst**
Unintentional	**Vehicle (fueling system, crankcase, etc)**	**Capture, recirculate to engine**
Intentional	**LNG boil-off/Pressure relief**	**Recapture. Improved tank insulation. Flare**
Intentional	**Discharge**	**Operational strategies**

Policies – Upstream

- New Source Performance Standards
  - Key feature: will require companies to capture natural gas that escapes when hydraulically fractured gas wells are prepared for production (“Green Completions”)
- Greenhouse Gas Reporting Program
  - Mandatory GHG reporting for large sources and suppliers

Policies - Downstream

- Greenhouse Gas Emissions Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 1
  - HD Engine Tailpipe Standard: 0.1 g/hp-hr
  - Option to use CO_2 credits (using conversion factor of 25)
  - No vehicle level standards
- Phase 2
  - Being worked on now…

Future

- A small amount of CH_4 can have a large impact on climate
- Concerns for the future
  - Full vehicle
  - Fueling station/fueling event
  - Consider upstream
  - Fixing leakage from the pump and vehicle is not enough!
- US: NGV incentives in LD CAFE rule – uncertain what will happen for HD Phase 2