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# Natural Gas and Climate Change

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Knowing how much methane is leaking from the natural gas system is essential to determining the potential climate benefits of expanded natural gas use. Climate Central's extensive review of the publicly available studies finds that a pervasive lack of measurements makes it nearly impossible to know with confidence what the average methane leak rate is for the U.S. More measurements, more reliable data, and better understanding of industry practices are needed.

It has been widely reported that shifting from coal to gas in electricity generation will provide a 50 percent reduction in greenhouse gas emissions. In reality, the extent of reduced global warming impact largely depends on three factors:

1. The methane leak rate from the natural gas system;
2. How much time has passed after switching from coal to gas, because the potency of methane as a greenhouse gas is 102 times that of carbon dioxide (on a pound-for-pound basis) when first released into the atmosphere and decays to 72 times $CO_2$ over 20 years and to 25 times $CO_2$ over 100 years, and;
3. The rate at which coal electricity is replaced by gas electricity.

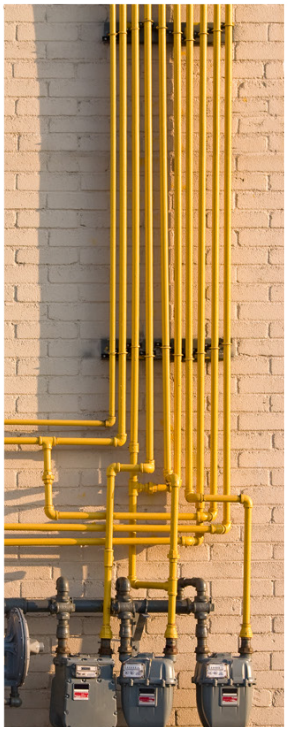
Climate Central has developed an interactive graphic incorporating all three factors. This makes it easy to visualize the greenhouse benefits of converting power generation from coal to natural gas for different assumptions of methane leak rates and coal-to-gas conversion rates while also considering methane's greenhouse potency over time.

Production

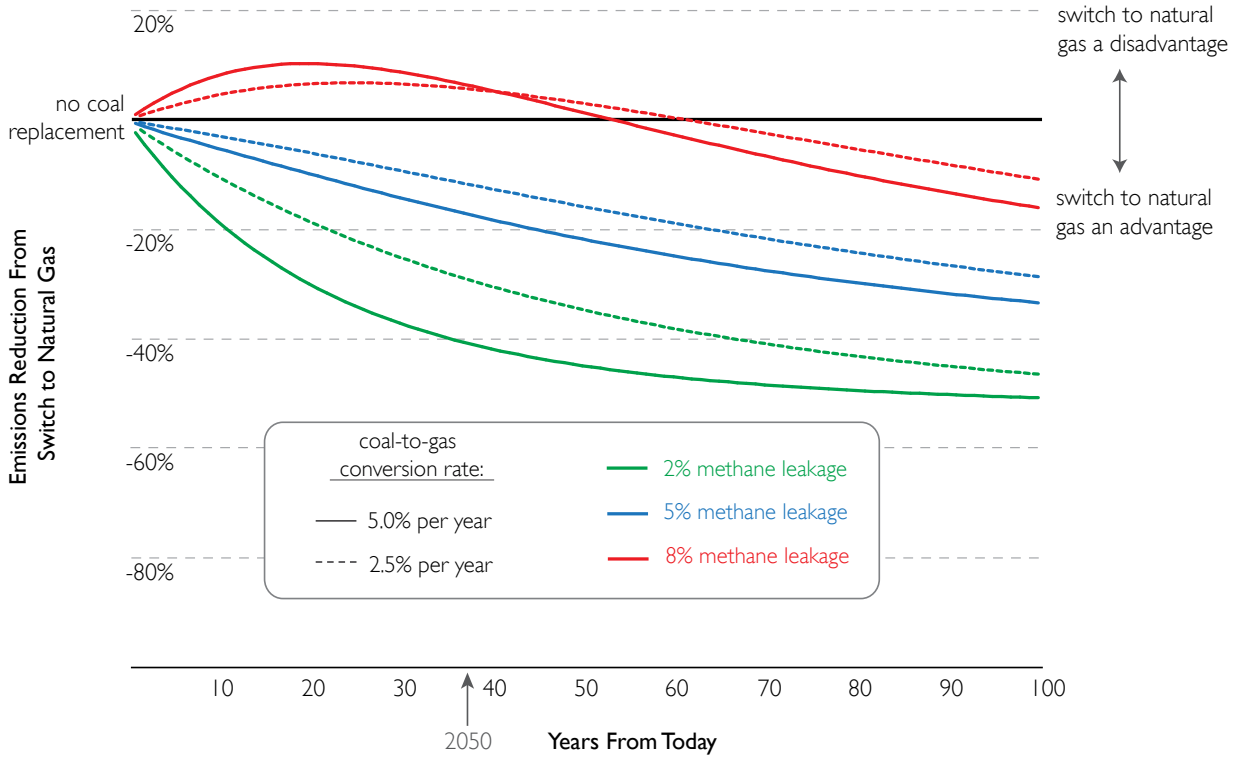
Processing

Transmission

Distribution



## It will be Decades Before Switching to Natural Gas From Coal Power Brings a 50 Percent Reduction in Emissions




The EPA recently estimated methane leaks in the natural gas system at 1.5 percent. A 1.5 percent leak rate would achieve an immediate 50 percent reduction in greenhouse gas (GHG) emissions, at the individual power plant level. However, EPA's estimate contains significant uncertainty, and like all estimates available in the peer-reviewed literature, lacks sufficient real-world measurements to guide decision-making at the national level. Climate Central found that the ongoing shift from coal to gas in power generation in the U.S. is unlikely to provide the 50 percent reduction in GHG emissions typically attributed to it over the next three to four decades, unless gas leakage is maintained at the lowest estimated rates (1 to 1.5 percent) and the coal replacement rate is maintained at recent high levels (greater than 5 percent per year).

The climate benefits of natural gas are very sensitive to small increases in leak rates. Assuming that natural gas replaces 2.5 percent of coal-fired power each year (the average over the past decade) even a relatively low overall leak rate of 2 percent would not achieve a 50 percent reduction in GHG emissions compared to the current fleet of coal-fired power plants, for over 100 years. If the leak rate were as high as 8 percent, there would be no climate benefit at all from switching to natural gas for more than 60 years.

To compute these estimates, we analyzed first the potential GHG benefits from replacing the electricity generated by a single coal power plant with electricity from natural gas instead. For an individual power plant, if the leak rate were 2 percent it would take 55 years to reach a 50 percent reduction in greenhouse impacts compared to continued coal use. If the leak rate is more than 6 percent of methane production, switching to natural gas provides zero global warming benefit for the first 5 years compared to continuing with coal. The switch achieves a modest 17 percent reduction in GHG emissions after 37 years (or by 2050, if the switch occurs in 2013). An 8 percent leak rate increases GHG emissions until 2050 compared with continued coal use, and produces only about 20 percent less climate pollution than continued coal use after 100 years of operation.

But unlike converting a single power plant from coal to natural gas, the U.S. cannot switch its entire fleet of coal-fired power plants to natural gas all at once. When substitution is analyzed across the entire fleet of coal-fired plants, the rate of adoption of natural gas is a critical factor in achieving greenhouse benefits. The rate of adoption is analyzed together with the powerful but declining potency of methane emissions over time. Each year, as a certain percentage

of coal plants are converted to natural gas, a new wave of highly potent methane leaks into the atmosphere and then decreases in potency over the 100 years analyzed.

When the rate of adoption is included, the GHG benefits of switching to natural gas can be even more elusive. With a 2 percent methane leak rate, and an average annual conversion rate of electricity from coal to gas of 2.5 percent (a rate that would be supportable with new gas production projected by the U.S. Department of Energy) the reductions would be 29 percent by 2050 and 16 percent by 2030. If methane leakage is 5 percent of production, by 2050 we would reduce the global warming impact of the US fleet of coal fired power plants by 12 percent. By 2030, the reductions would be just 5 percent. With an 8 percent leak rate, GHG emissions would be greater than with coal for more than 50 years before a benefit begins to be realized.

What is the natural gas leak rate in the U.S.? There are large differences among published estimates of leakage from the natural gas supply system, from less than 1 percent of methane production to as much as 8 percent. At the basin level, studies have reported methane leak rates as high as 17 percent. The EPA's 2012 annual greenhouse gas emissions inventory estimate was 2.2 percent. Its 2013 inventory estimate made a large adjustment that reduced the estimate to 1.5 percent. The degree of methane leakage is uncertain, but it is likely to be reduced in the future since it also represents lost profits for gas companies. Nevertheless, our analysis indicates that the ongoing shift from coal to gas in power generation in the U.S. over the next three to four decades is unlikely to provide the 50 percent benefit that is typically attributed to such a shift.

Determining methane leakage is complicated by various uncertainties:

- Large variability and uncertainty in industry practices at wellheads, including:
    - Whether methane that accompanies flowback of hydraulic fracking fluid during completion of shale gas wells is captured for sale, flared, or vented at the wellhead. Industry practices appear to vary widely.
    - Liquids unloading, which must be done multiple times per year at most conventional gas wells and at some shale gas wells. Gas entrained with the liquids may be vented to the atmosphere. There have been relatively few measurements of vented gas volumes, and estimating an average amount of methane emitted per unloading is difficult due to intrinsic variations from well to well.
- Lack of sufficient production experience with shale gas wells:
    - There are orders of magnitude in variability of estimates of how much gas will ultimately be recovered from any given shale well. This makes it difficult to define an average production volume per well, which introduces uncertainty in estimating the percentage of gas leaked over the life of an average well.
    - The frequency with which a shale gas well must be re-fractured to maintain gas flow. This process, known as a well workover, can result in methane emissions. The quantity of emissions per workover is an additional uncertainty, as it depends on how workover gas flow is handled.
- The leak integrity of the large and diverse gas distribution infrastructure:
    - Leakage measurements are challenging due to the large extent of the distribution system, including more than a million miles of distribution mains, more than 60 million service line connections, and thousands of metering and regulating stations operating under varying gas pressures and other conditions.
    - Recent measurements of elevated methane concentrations in the air above streets in Boston, San Francisco and Los Angeles strongly suggest distribution system leakages. Additional measurements are needed to estimate leak rates based on such measurements.

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