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Natural Gas as a Bridge Fuel

Measuring the Bridge

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Natural gas cannot play a long-term role in creating our desired carbon-constrained future, as its benefits are not enough to support our carbon reduction goals.

With the exception of a few bumps and starts, the nation's history with natural gas use has been one of constant growth. As far as fossil fuels go, natural gas is cheap, plentiful, versatile and comparatively clean. As a nation, when we have perceived the existence of plentiful natural gas supplies — as we do now — our policy has been simple: Let's use as much of it as we can, as quickly as possible.

Looking to the future, the growth in natural gas use appears to continue, unabated. Natural gas has a significant near-term role to play in helping us reduce reliance on coal-fired electricity and smooth the transition to intermittent renewable sources such as solar and wind. Yet, natural gas cannot play a long-term role in creating our desired carbon-constrained future, as its benefits are not enough to support our carbon reduction goals.

In recent years, there has been a surge of investment in natural gas facilities (power plants, pipelines, gathering equipment, wells, etc.). Investors in these facilities will want to maximize their investment return by sustaining natural gas markets as long as possible. The golden question is how will the pressure to allow for high returns on capital investment affect our ability to move away from the use of natural gas, as we must, to meet long-term greenhouse gas reduction goals?

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It is commonly understood that in order to stabilize climate change, we must achieve dramatic reductions in global greenhouse gas emissions. For years, the accepted target has been to reduce greenhouse gas emission to 80% below 1990 levels by the year 2050. To do this, we must eliminate almost all use of fossil fuels, including natural gas.

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When policies might constrain the domestic natural gas markets, investors will inevitably push back. And as domestic markets shrink, investors will act to develop offshore sales. In fact, investors are not even waiting for a reduction in U.S. demand for gas before looking to sell elsewhere. They are doing it now. All of these factors will contribute to pressures to keep developing and using natural gas long after it becomes a luxury we cannot afford.

Natural gas advocates characterize it as a bridge fuel. The implication is that we will use it now, to achieve short-term greenhouse gas reductions by replacing coal-fired power, then reduce or end reliance on natural gas over some time period to lock in long-term greenhouse gas reductions. But how long is the bridge? When should we stop developing new natural gas infrastructure? How do we make our use of natural gas beneficial without turning it into a long-term problem? There are several things policy makers can do.

1. Regulators can develop long-range plans to shape natural gas development and use. Both state and federal regulators make decisions every day that affect our reliance on natural gas without having a clear view of the big picture. Quantifying our current gas use and understanding trends is a first step. Then, regulators can develop scenarios that will support a reasoned retreat from natural gas use.

2. Lawmakers and regulators can set a final date beyond which no new natural gas power plants can be approved.

3. Policy makers can develop an explicit plan to phase out the use of natural gas for existing power plants and for other domestic uses.

4. The good news is that we don't have to wait for new technologies or better options before we reduce our dependence on natural gas. We have the tools to do it now. To maintain grid reliability, lawmakers and regulators must require the strategic selection of renewable power sources (both in terms of type and location), increase the range of demand response tools, act to increase the adoption of energy efficiency measures by focusing on the transformation of energy markets, increase reliance on regional power swings through the use of Energy Imbalance Markets, and require the retrofit of existing natural gas power plants to add flexibility in their operation.

Natural Gas Cannot Play a Major Long-term Role in Our Carbon-constrained Future

Meeting our ambitious long-term greenhouse reduction goals will require major changes across all sectors of energy use. This is perhaps most clearly demonstrated in a recent study produced by a number of authors affiliated with the Lawrence Berkeley National Laboratory, the Energy and Resources Group at the University of California at Berkeley, the Monterey Institute of International Studies and the Energy and Environmental Economics (E3) consulting group.[1]

The authors find that it is possible to achieve deep greenhouse gas reductions by 2050 with little change in life-style (although the potential for life-style change deserves further study). The logical sequence of deployment for the main components of this transformation is EE [energy efficiency] first, followed by decarbonization of generation, followed by electrification. This transformation will require electrification of most direct uses of oil and gas.[2]

Creating a virtually carbon-free supply of electricity becomes a critical part of the process. The authors looked at various ways to decarbonize the grid, including relying on a heavy dose of nuclear power, renewable energy or carbon capture and storage.[3] Regardless of the scenario adopted, the authors suggest that all nonelectric generation uses of fossil fuels must be eliminated and the use of fossil fuel for electric generation (including natural gas) must be almost entirely eliminated.

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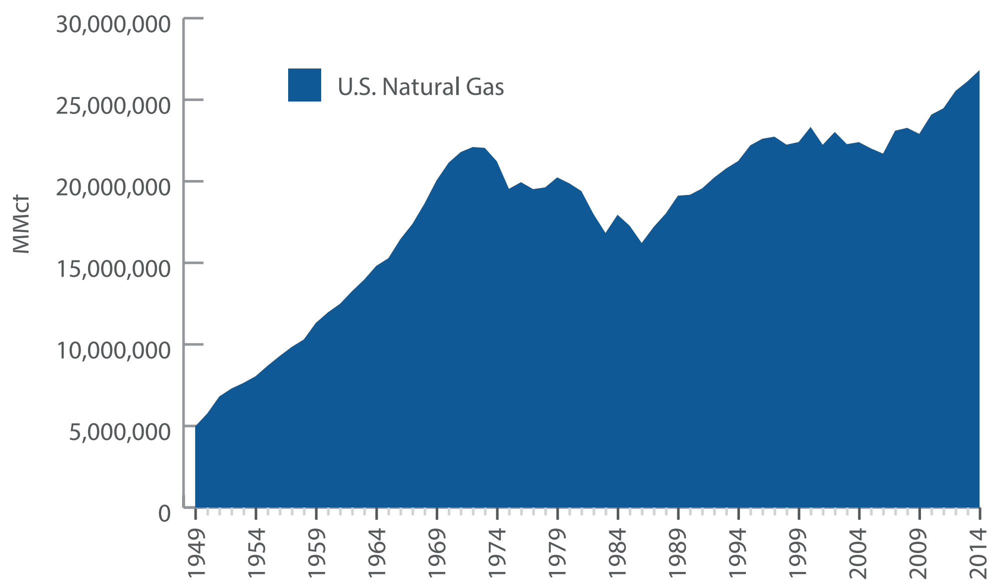
Domestic Use of Natural Gas Continues to Grow

The nation's history with natural gas use has been one of almost constant growth. In 2014, businesses and individuals in the United States used five times the amount of natural gas used 65 years earlier (see Figure 1).

Figure 1: U.S. Natural Gas Total Consumption (MMcf)



Data source: U.S. Energy Information Administration (EIA), 2015.

1 *Pathways to Deep Decarbonization in the United States*, James H. Williams, et al., (2015).
2 Ibid., p. xi.
3 Carbon capture and storage involves separating carbon dioxide and other greenhouse gases from a fossil fuel source either before or after combustion and permanently storing those gases – usually underground.

On average, natural gas consumption grew 2.78% for each year between 1950 and 2014, despite the fact that there was a period of reduced demand from 1973-1986 (driven by a temporary natural gas shortage and a growing reliance on nuclear and coal-fired electric generation). The current rate of growth (2.65% per year on average) is consistent with the historical average (see Table 1).

Table 1: Periods of Growth in U.S. Consumption of Natural Gas

Number of Years	Range of Years	Average Percentage of Natural Gas Increase
22	1950 to 1972	6.76%
14	1987 to 2000	2.66%
8	2007 to 2014	2.65%

Few have identified a time when the growth of domestic demand for natural gas will be reversed. The large-scale introduction of hydraulic fracturing in the United States has dramatically increased domestic supplies, contributed to low prices and encouraged greater consumption. In the eight years from 2005 to 2013, the total dry natural gas production in the U.S. increased by 35%, with natural gas's share of total U.S. energy consumption rising from 23% to 28%. In 2013 alone, dry natural gas accounted for 30% of total U.S. energy production.[4] The generation of electric power with natural gas has shown dramatic growth, as well (see Figure 2). The adoption of the U.S. Environmental Protection Agency's Clean Power Plan should, if anything, increase the pressure to build more natural gas-fired electric generating capacity, as substituting gas for coal is an option for compliance with the plan's requirements.

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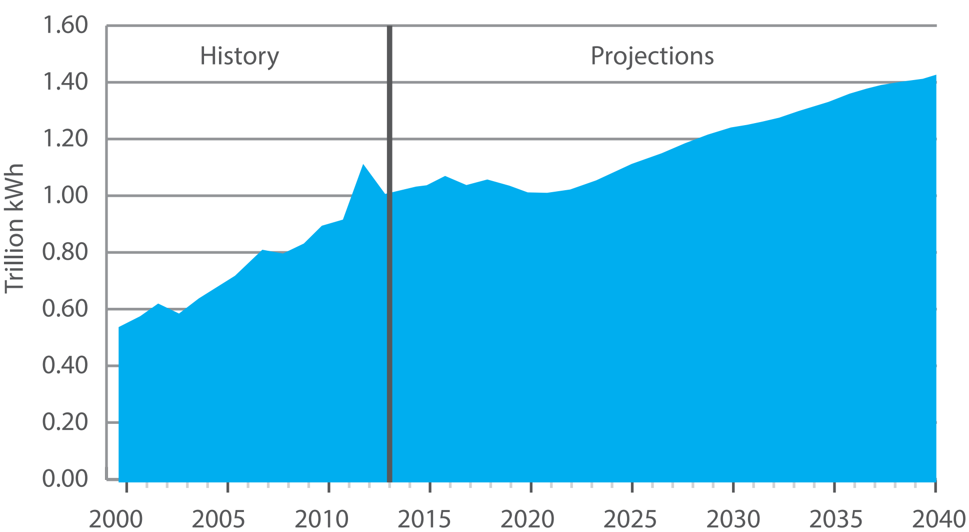
Figure 2: Natural Gas Electricity Generation: EIA AEO2015 Reference Case, 2000–2040



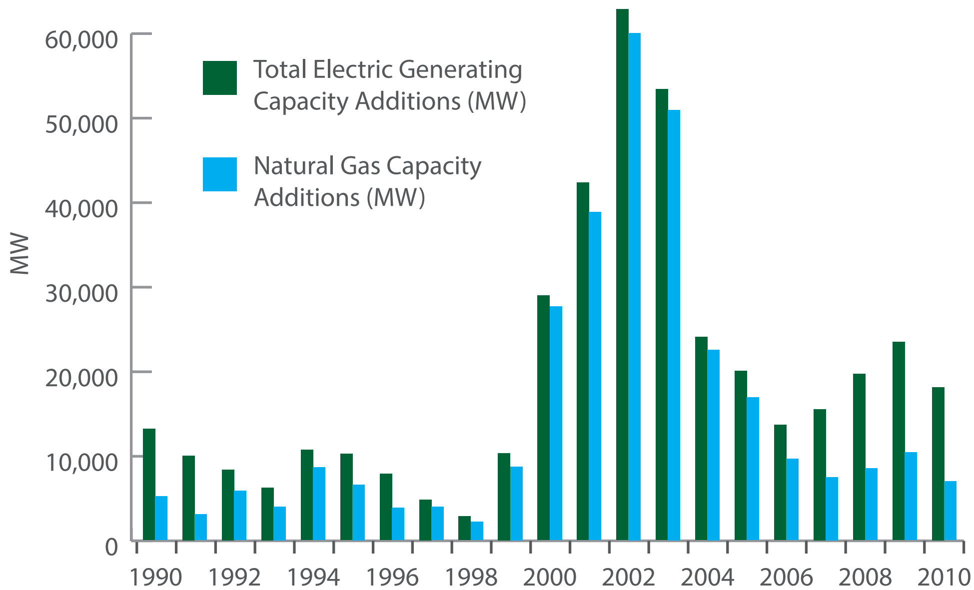
Data source: U.S. Energy Information Administration (EIA), 2015.

The growth in natural gas consumption is in step with the dominant role that new natural gas generation has played in recent years. The majority of the electric generating capacity additions from (2000 to 2010) were natural gas-fired. At the

4 *Annual Energy Outlook 2015* (AEO2015): **http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf**.

end of 2010, natural gas-fired generators constituted 39% of the nation's total electric generation capacity of 1,042 gigawatts (GW). Nearly 237 GW of natural gas-fired generation capacity was added between 2000 and 2010, representing 81% of total generation capacity additions over that period.[5] Figure 3 depicts this activity for the 1990 to 2010 period, over which natural gas capacity additions were a standard practice.

Figure 3: U.S. Power Plant Additions from 1990–2010



Data source: U.S. Energy Information Administration (EIA), **Most electric generating capacity additions in the last decade were natural gas-fired**, July 5, 2011.

Isn't Natural Gas Better Than Coal?

Natural gas is not always as clean as people wish it were. Due to methane leaks and energy required during extraction and production, the greenhouse gas savings are often much less than half of coal's emissions.

At the power plant, natural gas burns cleaner than coal, as it emits half the carbon dioxide emissions.[6] But natural gas is still a fossil fuel and it still emits carbon dioxide into the atmosphere, at a rate of about 117 lbs. of CO_2 per MMBtu.[7] And natural gas is not always as clean as people wish it were. Due to methane leaks and energy required during extraction and production, the greenhouse gas savings are often much less than half of coal's emissions.

Methane is the primary component of natural gas. During extraction, transportation, storage and use, natural gas often leaks. This is cause for concern as methane is a much more potent greenhouse gas than carbon dioxide. Methane has a shorter residence time in the atmosphere — only about 12 years[8] compared to about 100 years for carbon dioxide.[9] Nonetheless, over the long haul, methane is still at least 25 times as potent as carbon dioxide.[10]

5 U.S. Energy Information Administration (EIA), **Most electric generating capacity additions in the last decade were natural gas-fired**, July 5, 2011.
6 EPA 2013.
7 EIA 2015b.
8 EPA 2011.
9 The IPCC gives 5-200 years residence time in atmosphere, depending on different uptake rates, IPCC 2014.
10 EPA 2015a.

Another complicating factor when evaluating natural gas's cleanliness is uncertainty about the actual methane leakage rates. In 2012, the EPA estimated a 1.3% leakage rate (methane emitted per unit of gas produced), using industry data. However, a recent report from the California Public Utilities Commission finds that estimates in peer-reviewed literature for downstream emission of methane from natural gas systems range from 0.07% to 10%.[11] These emissions are from transmission and distribution pipelines and do not include emissions at the wellhead or those occurring during the processing of the gas. A catastrophic release of natural gas, such as the major failure at California's Aliso Canyon gas storage facility, suggests that the day-to-day downstream emission rates only begin to tell the story. A new rule from the EPA will mandate that industries report all greenhouse gas emissions from hydraulic fracturing, compressor stations and pipelines, including methane emissions.[12] But these emissions will be self-reported, leading to the potential of continued underestimation of methane leaks. Most scientific papers that focus on the methane emissions of natural gas production conclude that there is a need for better data, more monitoring of leaks and more stringent regulations.[13]

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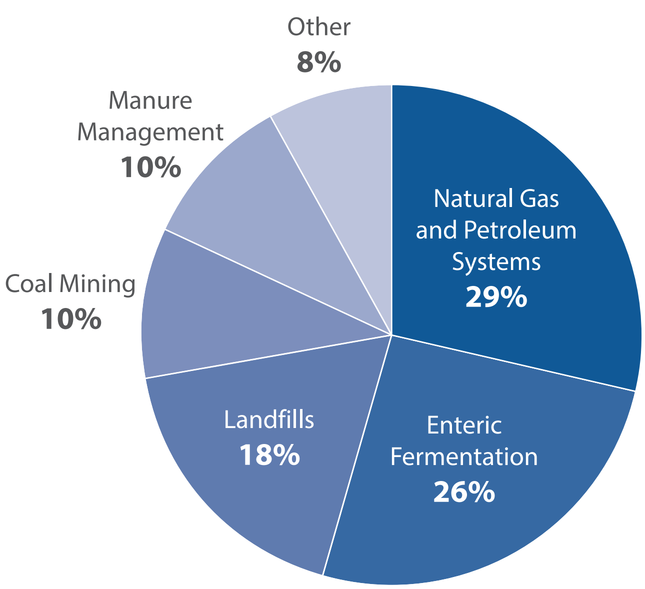
Natural gas system operators are likely incapable of entirely eliminating methane leaks, and the detection and elimination of minor or occasional leaks may seldom be cost-effective. But as part of its inventory of greenhouse gas emissions (for calendar year 2012, released in 2014, referred to as the EPA 2012 GHG NEI), the EPA estimates that more than 60,000 natural gas wells in the United States regularly vent methane into the atmosphere as part of what is referred to as liquid unloading. Altogether, oil and natural gas systems account for the largest share of methane emissions in the United States (see Figure 4).

Figure 4: Percentage of Total Estimated Methane Emissions



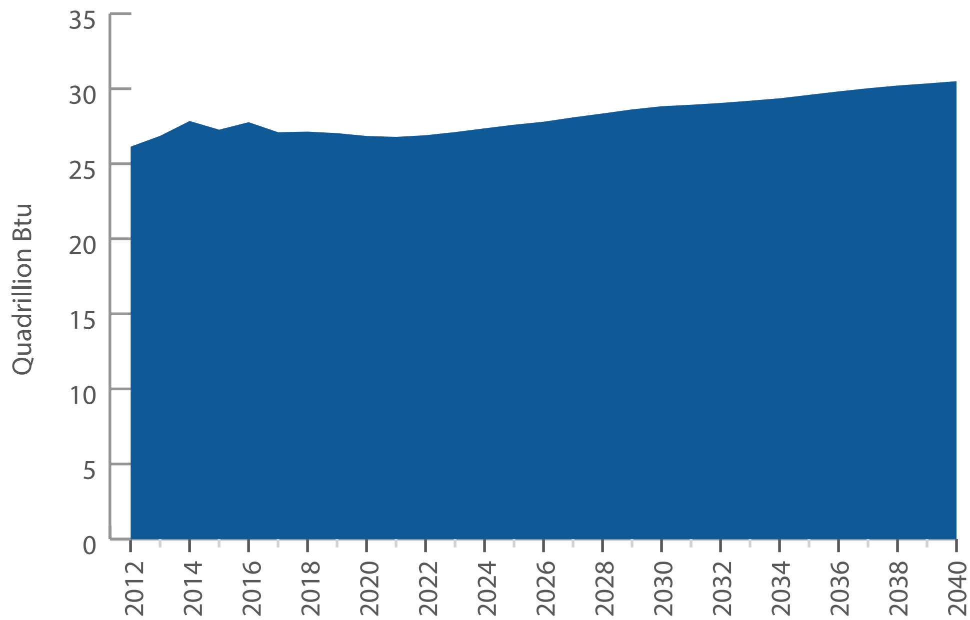
Data source: U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2013.

11 *What Gets Measured: A Summary of Recent Policies, Studies and Pilot Projects Related to Methane Emissions From California's Natural Gas Transmission and Distribution System*, Martin Kurtovich, **http://www.cpuc.ca.gov/NR/rdonlyres/B4CE3B9A-7291-4A7F-9672-9C09C99A7456/0/PPDIntrotoMethaneemissionmeasurements.pdf** at p. 7, citing other studies.
12 EPA Federal Registrar 2014.
13 Alvarez et al., 2012.

At a time when we should be dramatically reducing our use of all fossil fuels, EIA has found that business as usual supports continued growth in the use of natural gas.

The U.S. Energy Information Administration (EIA) currently projects that a continuation of existing policies will result in natural gas demand of 20.88 quadrillion Btu by 2040, representing 10% growth in gas consumption between 2015 and 2040 (see Figure 5). At a time when we should be dramatically reducing our use of all fossil fuels, EIA has found that business as usual supports continued growth in the use of natural gas.

Figure 5: Total Natural Gas Consumption (in quadrillion Btu), 2012–2040

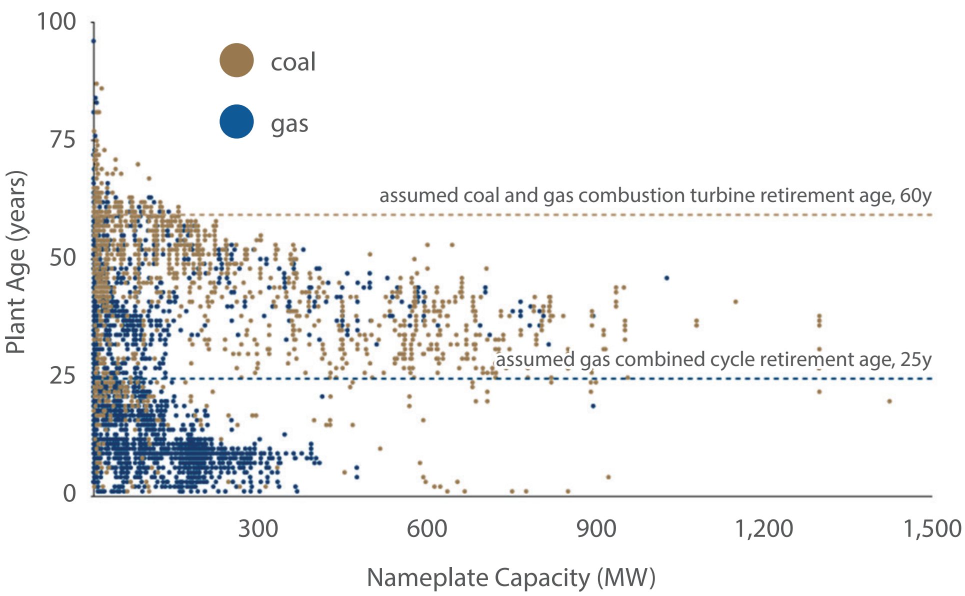


Data source: U.S. Energy Information Administration (EIA), 2015.

Natural Gas Facilities Can Remain Useful for 30-60 Years

Natural gas power plants can continue to produce revenue 60 years after initial commercial operation (see, for instance, Figure 6 in which the Rocky Mountain Institute plots the natural gas plants in operation in fall 2011).

Figure 6: Age and Capacity of Operating U.S. Coal and Gas-fired Generators, Fall 2011



Source: Rocky Mountain Institute © 2011. For more information see www.RMI.org/ReinventingFire.

By way of example, the average age of retired natural gas power plants in California is about 35 years,[14] longer than the usual 30-year predicted lifespan. And in California, 14 natural gas-fired power plants still in operation were built in the 1950s.[15] In the United States, a total of 111,360.2 MW of natural gas capacity, or 27% of all natural gas capacity, is more than 30 years old.[16] Other natural gas infrastructure can live a long, revenue-producing life. For instance, natural gas pipeline can continue to operate for at least 50 years.[17]

A Power Plant on the Drawing Boards Today Could Still Be Operational in 2050 and Well Beyond

Achieving long-term greenhouse gas emission reduction goals not only requires eliminating virtually all natural gas use by 2050, it would necessitate phasing out natural gas use (as well as the use of coal and oil) over the years between now and then. This will become increasingly difficult as the nation encourages more and more investment in natural gas development and infrastructure. Consider, for instance, the amount of time it takes to seek and achieve a permit to build a new natural gas power plant, construct the power plant and bring it into commercial operation. This is a multiyear process. Once the plant comes online, it begins a useful operating life which is (on average) 35 years. A plant that goes online in 2016 could easily still be in operation in 2050. One that begins the permitting process in 2016 would extend several years beyond 2050. The further out from 2016 the nation continues to license new gas-fired power plants, the longer beyond 2050 investors will seek to

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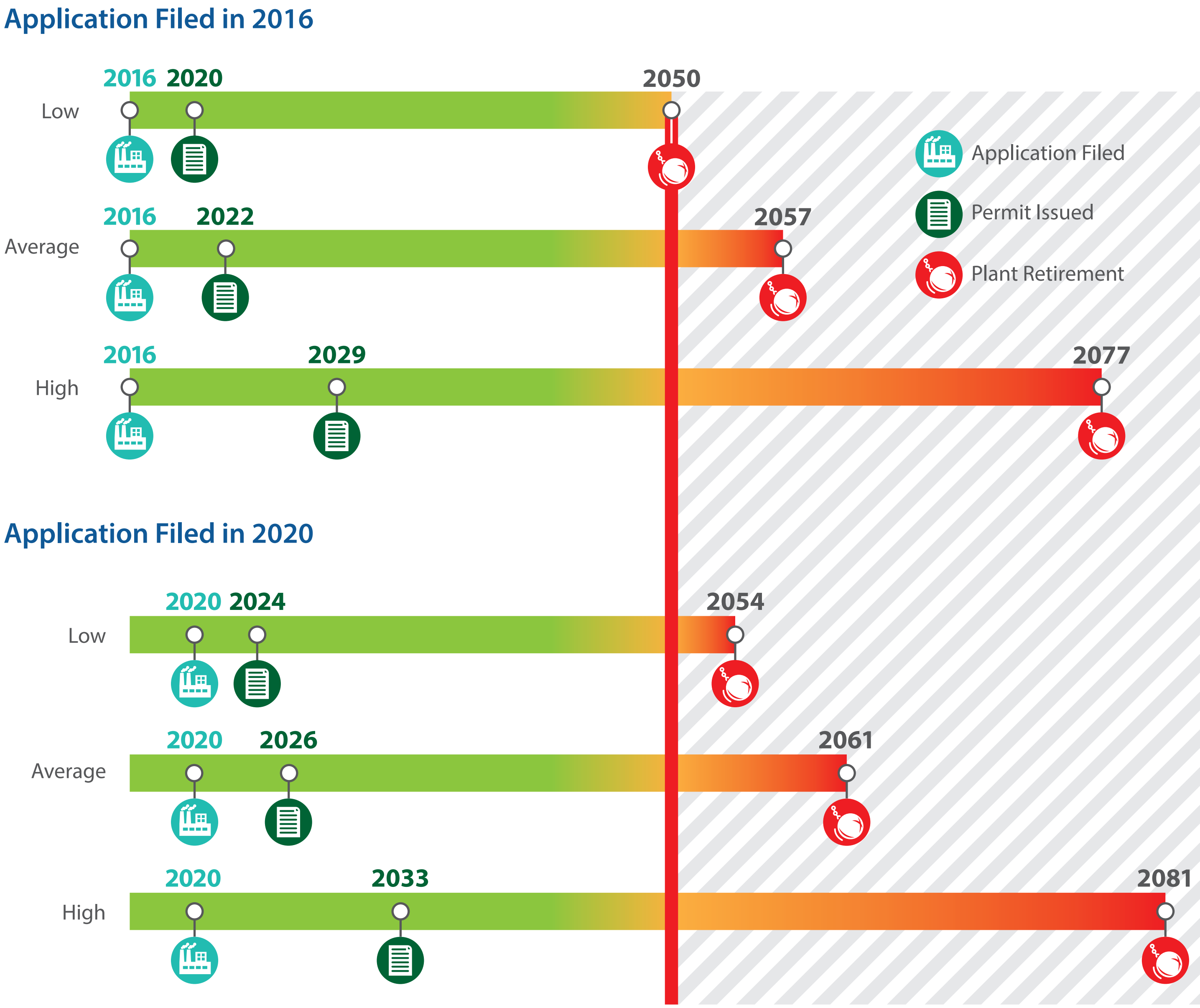
14 State of California, Energy Almanac 2008.
15 State of California, Energy Almanac 2015.
16 EIA 2011.
17 See, for instance, the website of the Interstate Natural Gas Association of America, **http://www.ingaa.org/file.aspx?id=10929**.

keep plants in operation. An analysis of short, average and long time frames for these milestones indicates the challenge that policymakers will face in phasing out natural gas usage as more and more power plants are approved for construction.

For this report, we examined California's recent history related to permitting and constructing new, large gas-fired generating facilities (500 megawatts or larger).[18] The average length of time from permit application to commercial generation was six years. The shortest was four years, while the longest period was 13 years. Considering low, medium and high estimates for permitting, construction and commercial operation, we looked at the potential years of operation for plants for which applications might be filed in 2016 or 2020. The results are included in Figure 7.

Figure 7: Typical Timelines for Natural Gas Power Plants



18 See California Energy Commission, Status of All Projects http://www.energy.ca.gov/sitingcases/all_projects.html.

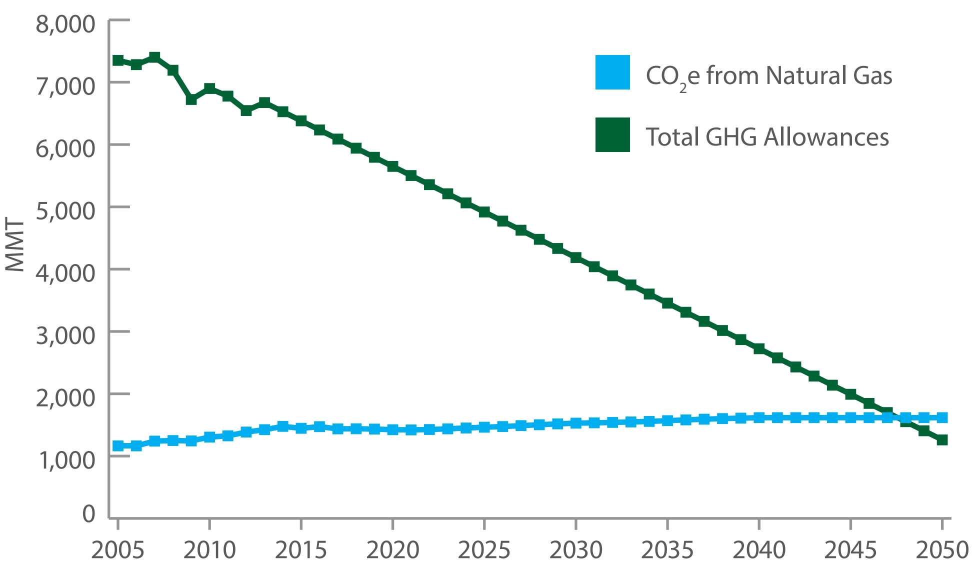
The numbers continue to grow. A permit application in 2025 could lead to a plant still in operation in 2086. An application in 2030 could lead to a plant in operation in 2091. As more people and institutions invest in natural gas, political pressure to sustain its use grows. It will become more and more difficult to achieve long-range greenhouse gas reduction goals.

The U.S. Cannot Accommodate Business-as-Usual Natural Gas Use and Meet Long-term Greenhouse Gas Reduction Goals

Policymakers and advocates have long suggested that, in order to stabilize climate change, the world must reduce its greenhouse gas emissions 80% below 1990 levels by the year 2050. If the U.S. were to adopt this standard and if natural gas use throughout society remained at the EIA's projected 2040 levels, natural gas emissions would more than exhaust the country's entire greenhouse gas allotment by 2050 (See Figures 8 and 9). That means that unless the U.S. adopts and enacts policies to reduce reliance on natural gas over the next 35 years, the country would fail to meet the target, even if it eliminated 100% of all other greenhouse gas emissions. As researchers cited earlier concluded, almost any remaining use of natural gas in 2050 threatens the country's ability to achieve such long-term goals.[19]

Unless the U.S. adopts and enacts policies to reduce reliance on natural gas over the next 35 years, the country would fail to meet the target, even if it eliminated 100% of all other greenhouse gas emissions.

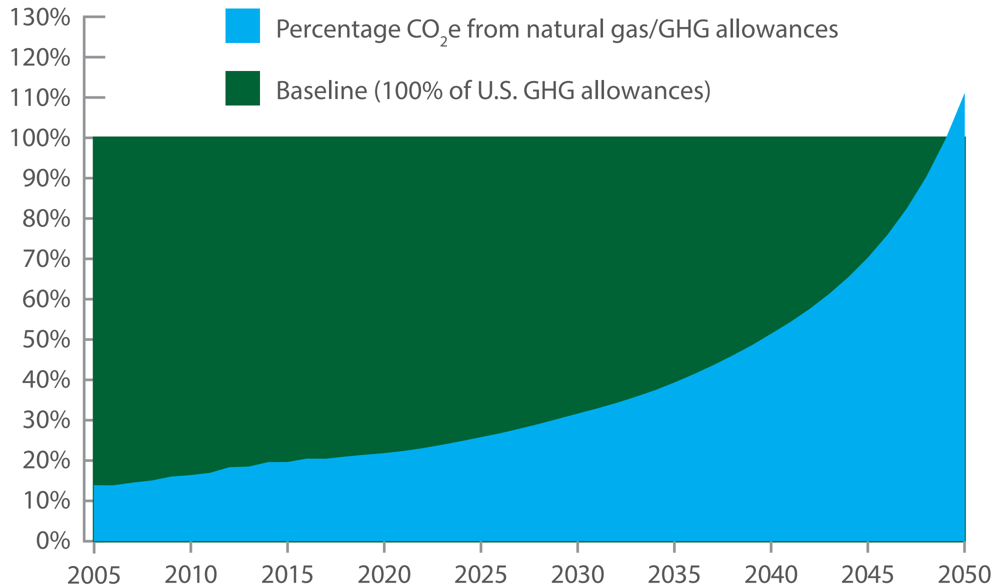
Figure 8: CO_2e from Natural Gas vs. Total Greenhouse Gas Allowances*



*The total natural gas consumption rate (CO_2e) is derived from EIA data for National Energy Consumption by Sector and Source. The conversion factor used to determine MMT is 0.1 mmBtu/1 therm × 14.46 kg C/mmBtu × 44 kg CO_2/12 kg C × 1 metric ton/1,000 kg = 0.005302 metric tons CO_2/therm. The excel data is provided by the EIA Annual Energy Outlook 2015: Website access: http://www.eia.gov/forecasts/aeo/.

19 See Footnote 1.

Figure 9: **GHG Emissions Reductions Allowances***



*The data to express the greenhouse gas emissions reductions allowances was derived from the EPA's Greenhouse Gas Inventory Data Explorer. Barring other factors, the data projection assumes the national goal of achieving 80% below 1990 levels greenhouse gas emissions reductions by 2050 (1990 levels were 6,301.05 MMT CO_2e). This implies the need to arrive at approximately 1260 MMT by 2050. The excel data is provided at the following link. Website access: **http://www3.epa.gov/climatechange/ghgemissions/inventoryexplorer/#allsectors/allgas/gas/all**.

Solutions

One of the key roles played by natural gas is to hasten the retirement or reduced use of coal-fired power plants. It is evident that strategies built around this premise have met with some success, and the trend should continue with the enactment of the U.S. EPA's mercury rule (after it is reaffirmed) and Clean Power Plan. The need to eliminate the combustion of coal remains critical. However, an increased reliance on natural gas can only be an interim solution. Nonetheless, in most if not all jurisdictions, the length and character of that interim phase is ill-defined and the unraveling of the growing natural gas dependence is unplanned. There are several steps that legislators and regulators can take to improve the likelihood that we can break this dependence when we need to.

Quantifying our current gas use and understanding trends is a first step. Then, regulators can develop scenarios that will support a reasoned retreat from natural gas use.

1. Make Plans

Regulators can adopt long-range plans to shape natural gas development and use. Both state and federal regulators make decisions every day that affect our reliance on natural gas without having a clear assessment of long-term implications. Quantifying our current gas use and understanding trends is a first step. Then, regulators can develop scenarios that will support a reasoned retreat from natural gas use.

2. Create Deadlines

With the benefit of well-developed plans, lawmakers and regulators can set a final date beyond which no new natural gas power plants can be approved.

3. Schedule a Phaseout of Natural Gas Use

Policymakers can develop an explicit plan to phase out the use of natural gas for existing power plants and for other domestic uses.

4. Use Other Tools

The good news is that we don't have to wait for new technologies or better options before we reduce our dependence on natural gas. We have the tools to do it now. To maintain grid reliability, lawmakers and regulators must require the strategic selection of renewable power sources (both in terms of type and location), increase the range of demand response tools, act to increase the adoption of energy efficiency measures by focusing on the transformation of energy markets, increase reliance on regional power swings through the use of Energy Imbalance Markets, and require the retrofit of existing natural gas power plants to add flexibility in their operation.

These are examples of the steps legislators and regulators can take to ensure that our natural gas use serves as a bridge, rather than a new, permanent pathway. The most critical step is to change the public conversation. We must acknowledge that our use of all fossil fuels, including natural gas, must have limits. Those limits are unlikely to be achieved, within any acceptable time frame, without careful planning and consideration of all proposed interim actions in the context of adopted plans.

Lawmakers and regulators can still do much to reduce the need for new natural gas plants, now and in the future, by expanding and modifying existing programs.

For more information on this report, visit **www.energycenter.org/policy** or contact **policy@energycenter.org**.

Center for Sustainable Energy

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