THE RELATIONSHIP BETWEEN NATURAL GAS AND RENEWABLE ENERGY

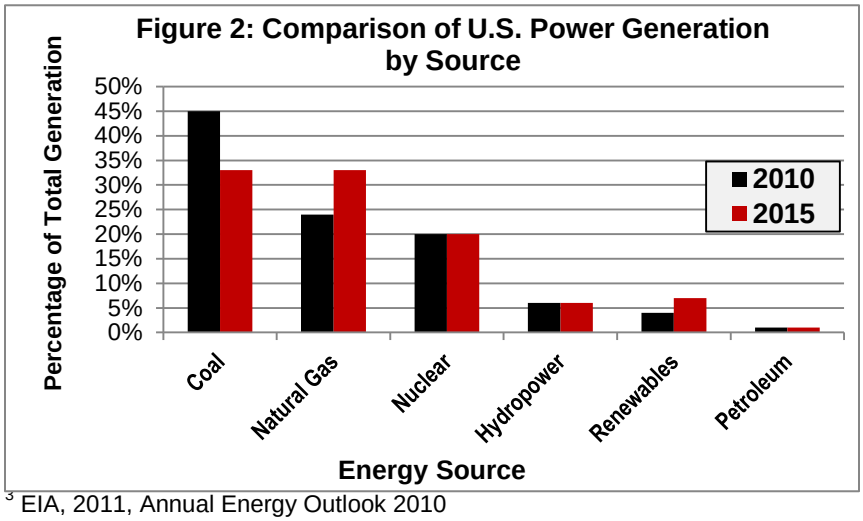
The United States relies on a diverse mix of resources to generate the electricity we need and meet growing demand reliably and affordably. In 2015, America generated the majority of its electricity from coal (33 percent), natural gas (33 percent) and nuclear (20 percent) energy sources (see figure 1 below).[1] In 2016, natural gas-fired generation is expected to supply 34 percent of electricity demand while coal will drop to 30 percent.[2]

This generation resource mix is constantly evolving as new technologies become more affordable, fuel resources become more or less available, and new regulations impact the construction of new power plants and the continued operation of existing power plants. Current power generation resources are drastically different than the resource mix just a few years ago. For example, in 2010, natural gas only accounted for 22 percent of all electricity generated- a full 11 percent less than in 2015 (see figure 2 below).[3]

Figure 1: U.S. Power Generation by Energy Source (2015)

Coal	33%
Natural Gas	33%
Nuclear	20%
Hydropower	6%
Renewables - Wind: 4.7% - Biomass: 1.6% - Solar: 0.6% - Geothermal: 0.4%	7%
Petroleum	1%

Source: *EIA, 2016, https://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3*



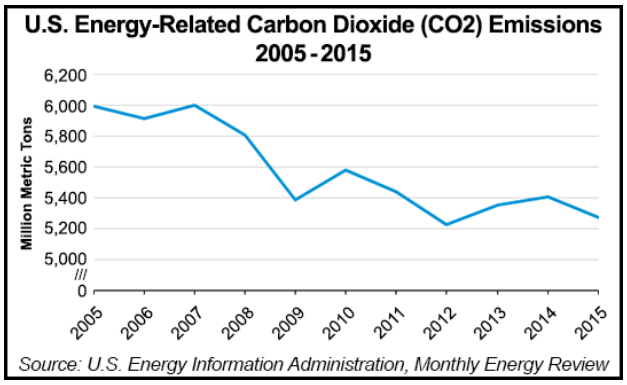
[3] EIA, 2011, Annual Energy Outlook 2010

The American power industry is facing numerous challenges. One is the ongoing retirement of older power plants (mainly coal and nuclear) as the costs of meeting new federal and state emissions regulations, together with lower natural gas prices, make them uncompetitive. In 2015 alone, nearly 18 gigawatts (GW) of electric generating capacity were retired in the United States, 80 percent of which was coal fired.[4] As power generators continue to retire older baseload coal and nuclear plants, they are constructing more and more dispatchable natural gas plants to fill the gap.

THE RISE OF NATURAL GAS

U.S. domestic natural gas production has experienced an unprecedented increase over the past decade largely due to developments in drilling technologies such as hydraulic fracturing and horizontal drilling. This increased supply of affordable and clean natural gas has led many power generators to shift away from coal and nuclear power generation.

Additionally, several new regulations and rules, including the recent Environmental Protection Agency (EPA) Mercury and Air Toxics Standards (MATS), have increased interest in phasing-out older coal-fired plants, leading many power generators to increase the use of natural gas in existing plants and to develop new gas-fired plants as a cleaner and affordable alternative. A July 2016 report from the Energy Information Administration (EIA) found that natural gas-fired electricity generation is expected to reach record levels in 2016, providing an average of 3.8 million megawatt hours (MWh) per day.[5] And this trend is likely to continue. For example, within the PJM transmission grid, which reaches from Maryland to Illinois, about 20,000 megawatts (MW) of gas-fired power plants are projected to come on-line by mid-2019, generating enough electricity for approximately 20 million homes.[6]



[4] EIA, 2016, http://www.eia.gov/todayinenergy/detail.cfm?id=25272
[5] EIA, 2016, https://www.eia.gov/todayinenergy/detail.cfm?id=27072
[6] Chicago Tribune, 2016, http://www.chicagotribune.com/news/sns-wp-blm-energy-8659a826-3ead-11e6-9e16-4cf01a41decb-20160704-story.html

This switch from coal-fired to natural gas-fired electricity generation has provided numerous environmental benefits. When burned, natural gas emits approximately half as much carbon dioxide (CO_2), one-fifth as much carbon monoxide (CO) compared to coal, and virtually no sulfur dioxide, particulate matter or mercury.[7] These lowered emissions from natural gas-fired plants have contributed significantly to the recent dramatic drop in CO_2 emissions nationwide. For example, CO_2 emissions from electricity generation in 2015 were at their lowest rate since 1993, and 21 percent below their 2005 levels.[8] This decrease was attributed to a "shift in the electricity generation mix, with generation from natural gas and renewables displacing coal-fired power."[9]

Additionally, natural gas-fired power generation is currently the lowest-cost dispatchable[10] and non-site specific[11] form of power generation available for new power plants.[12] On a "Levelized Cost of Electricity" (LCOE) basis,[13] natural gas (conventional combined cycle) power costs an average of $75.20 per MWh, while conventional coal plants cost $95.10 per MWh, and advanced nuclear plants cost $95.20 per MWh.[14] Combined-cycle natural gas plants, which combine natural gas-fired combustion turbines (basically jet engines) with steam turbines that recover and use waste heat from the combustion turbine, are very efficient. In addition, they can start up in about 10 to 15 minutes to meet surges in electricity demand, such as on a hot summer day when more people turn on their air conditioning. This high efficiency and rapid startup make them ideal power generators.[15]

"Lowered emissions from natural gas-fired plants have contributed significantly to the recent dramatic drop in CO2 emissions nationwide."

President Obama's "Clean Power Plan", which seeks to cut U.S. carbon emissions 32 percent below 2005 levels by 2030, acknowledges the need for natural gas in pursuing a clean energy future, stating "all low-carbon electricity generation technologies, including renewables, energy

[7] EIA, 2015, http://epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html
[8] EIA, 2016, http://www.eia.gov/todayinenergy/detail.cfm?id=26232
[9] Ibid.
[10] "Dispatchable" meaning it can be turned on and off to increase or decrease the amount of power it provides.
[11] "Non-Site Specific" meaning it can be built pretty much anywhere, as opposed to hydroelectric power which requires a dam and body of water
[12] EIA, 2016, https://www.eia.gov/forecasts/aeo/electricity_generation.cfm
[13] Levelized Cost of Electricity (LCOE) is the per-kilowatt hour cost of power, taking into account capital costs, fuel costs, O&M costs, financial costs and assumed utilization rates.
[14] EIA, 2016, https://www.eia.gov/forecasts/aeo/electricity_generation.cfm
[15] Forbes, 2016, http://www.forbes.com/sites/michaelkrancer/2016/03/14/experts-final-clean-power-plan-is-a-trojan-horse-for-american-natural-gas/#7a56237f6af7

efficiency, natural gas, nuclear and carbon capture and storage, can play a role in state plans."[16][17]

WHAT ABOUT RENEWABLES?

Although renewable energy sources such as wind and solar power are increasing their share of the electricity mix each year, they currently make up less than 7 percent of total electricity generation in the United States.[18] A major barrier to greater utilization of wind and solar power to replace the power generated by retiring units as well as to satisfy growing power demand is their low capacity factor, or the amount of time they are able to generate electricity at full capacity. Wind and solar power facilities are intermittent, meaning they can't generate electricity when the wind isn't blowing or the sun isn't shining. The average capacity factors for onshore wind and solar power generation are just 36 percent and 25 percent respectively; compared to 85 percent for new, fully-dispatched conventional coal-fired power plants, 87 percent for new, fully-dispatched combined cycle natural gas-fired plants, and 90 percent for advanced nuclear plants.[19] This means wind turbines are only providing electricity at their full capacity just 36 percent of the time. They sit idle or produce minimal power the remainder of the time. This puts renewable energy at a major disadvantage to fossil fuel and nuclear-fueled power generation plants because power grid operators value dispatchable, non-intermittent generation sources.

On average, wind turbines are only providing electricity at their full capacity just 36% of the time, compared to 87% for combined cycle natural gas-fired power plants.

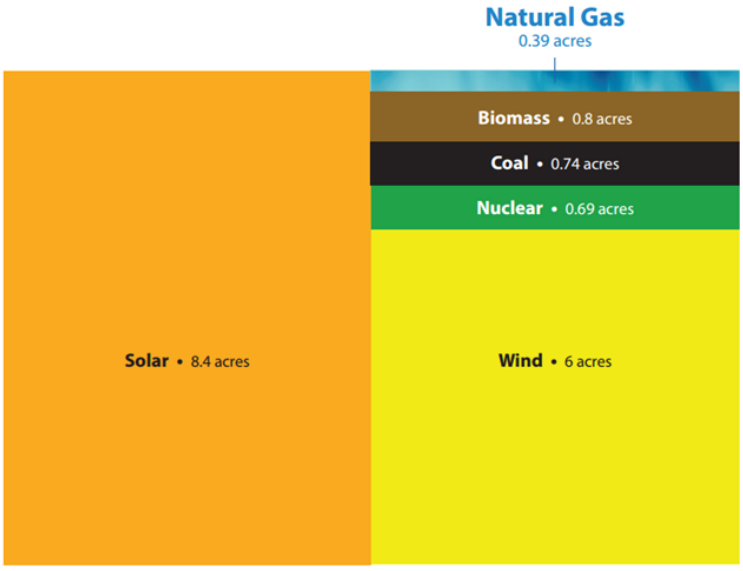
Battery storage is widely touted as an environmentally benign technology for backing up intermittent wind and solar generation. The intermittency of renewable power sources could be mitigated by storing

[16] White House, 2015, https://www.whitehouse.gov/the-press-office/2015/08/03/fact-sheet-president-obama-announce-historic-carbon-pollution-standards
[17] EPA, 2015, https://www.epa.gov/cleanpowerplan/fact-sheet-clean-power-plan-keeping-energy-affordable-and-reliable
[18] EIA, 2016, https://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3
[19] EIA, 2015, https://www.eia.gov/forecasts/aeo/electricity_generation.cfm

energy in batteries when it is not needed, and using it when demand spikes. However, large scale battery facilities using current battery technology are not able to provide the storage capacity and power output required at a reasonable cost. They also require large land areas, and their manufacture and operation have significant environmental impacts. Kinder Morgan's engineers have estimated that it would take more than one billion Tesla Powerwall batteries at a cost of more than $3 trillion dollars to store the equivalent amount of energy in one of KM's larger natural gas storage fields. Therefore, intermittent power sources such as wind and solar must be complemented by dispatchable generation that can be ramped up and down quickly, which in most cases means natural gas-fired generation.

Another problem facing renewable energy is land use. Solar and wind turbines need more open space than natural gas, coal or nuclear power plants. The amount of land required to produce enough electricity for 1,000 households per year at a natural gas power plant would be just 0.39 acres, including the land required both for the power plant itself and for the production and transportation facilities to supply natural gas to the plant.[20] By comparison, it would take 6 acres to produce that much electricity with wind power and 8.4 acres to produce the same amount of electricity with solar power (see figure below).

Acreage requirements to make electricity for 1,000 households per year



Source: NGSA, 2013, http://www.ngsa.org/analyses-studies/beck-data-rev/

[20] NGSA, 2013, http://www.ngsa.org/analyses-studies/beck-data-rev/

Currently, the largest wind power plant in America is the Alta Wind Energy Center in the Mojave Desert in California, with an installed capacity of approximately 1,550 MW, consisting of 600 windmills over 3,200 acres (5 square miles).[21] However, assuming its average capacity factor is the same as the national average (36%), it generates approximately 13,400 mega watt hours (MWh) (1,550 MW x 24 hours x 36%) during an average day. By comparison, the largest natural gas power plant in the United States is the West County Energy Center (WCEC) in Palm Beach County, Florida, which has a nameplate capacity of 3,657 MW and sits on 220-acres.[22] Assuming the WCEC runs at the 87 percent average capacity factor for a new, fully-dispatched natural gas combined cycle power plant, it generates approximately 76,400 MWh (3,657 MW x 24 hours x 87%) during an average day. The WCEC is able to generate over five times the power on one-fourteenth of the land compared to the Alta facility.

NATURAL GAS: A KEY COMPONENT OF OUR ENERGY FUTURE

Natural gas power generation serves as an excellent complement to renewable energy sources because, among other reasons, natural gas provides the reliability and flexibility renewable energy lacks. A report by the National Renewable Energy Laboratory (NREL) found that the availability of wind and solar power generation varies wildly minute-to-minute and day-to-day. Natural gas serves as a perfect "firming" backup source due to its ability to be dispatched flexibly, allowing for system reliability.[23]

Due to the current low price and abundance of natural gas, and low environmental impact, many power generators are building new natural gas-fired power plants to back up renewable energy sources in order to reliably deliver power to their customers. Essentially, in order for wind and solar energy sources to continue their expansion, they need to be complemented by a simultaneous expansion of reliable backup energy sources such as natural gas-fueled power plants.

A study by the National Bureau of Economic Research found that "renewable and fast-reacting fossil technologies appear as highly complementary and should be jointly installed to meet the goals of cutting emissions and ensuring a stable supply."

[21] Power Technology, 2015, http://www.power-technology.com/projects/alta-wind-energy-center-awec-california/
[22] Florida Power & Light, 2016, https://www.fpl.com/clean-energy/natural-gas/west-county.html
[23] NREL, 2012, http://www.nrel.gov/docs/fy13osti/56324.pdf

A working paper released by the National Bureau of Economic Research in July 2016 analyzed the adoption of wind and solar energy in 26 developed countries between 1990 and 2013 and found that on average, a 1% increase in the share of "fast-reacting fossil generation capacity" (FRF, e.g., natural gas-fired power plants), is associated with a 0.88% increase in renewable energy sources over the long-term.[24]

The authors are not asserting that equivalent amounts of FRF and renewables are required for system optimization, but rather that it describes "the historic relationship between renewable energy integration and the presence of fossil-based generation technologies which are used as back-up capacity."[25]

The study concludes that increased natural gas capacity allows a larger expansion of renewable energy sources: "(T)he successful integration of renewable was possible (and higher) partly due to the availability of fast-reacting fossil-based units."[26] It also notes "the fact that renewables and fast-reacting fossil technologies appear as highly complementary and that they should be jointly installed to meet the goals of cutting emissions and ensuring a stable supply."[27] Fossil fuel generation, therefore, should not be seen as an opponent of renewable energy development, but rather as a key ally.

MORE INFRASTRUCTURE IS NEEDED

Natural gas and renewables are not mutually exclusive solutions to a greener energy future; they are both necessary pieces of the U.S. energy mix. In order to continue to expand natural gas power plants to replace the nation's aging coal and nuclear power plants as well as backup renewable energy sources, additional pipelines will be needed.

Many companies, including Kinder Morgan, are meeting the need for additional natural gas supply. Kinder Morgan is the nation's largest owner of natural gas transportation and storage infrastructure and approximately 38 percent of all natural gas consumed in the country moves on Kinder Morgan pipelines, giving us a key role to play in the renewable energy future. Kinder Morgan takes its commitment to the

[24] NBER, 2016, http://www.nber.org/papers/w22454?utm_campaign=ntw&utm_medium=email&utm_source=ntw
[25] Ibid. at 7
[26] Ibid.
[27] Ibid. at 26

environment very seriously and is proud to be contributing to the advances in infrastructure development needed to help our country reach this future.