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# WILL NATURAL GAS DEMAND SOAR AS EMISSIONS REDUCTION INTENSIFIES?

By Iván Martén and Juan Vázquez

On December 12, 2015, at the United Nations' twenty-first Conference of the Parties (COP21) in Paris, negotiators from nearly 200 countries signed an ambitious agreement aimed at stemming global warming. Participating countries affirmed that they would seek to limit the global temperature increase to well below 2°C higher than preindustrial levels, by 2100. They also committed their best efforts to limiting warming to 1.5°C.

To achieve these aims, developed and developing countries must substantially reduce their greenhouse-gas emissions. Already, 147 countries have made specific commitments; these intended nationally determined contributions (INDCs) were submitted earlier in 2015 and formed the foundation for the COP21 agreement. Yet these initial commitments are likely to fall short. Indeed, emissions of carbon-dioxide equivalent during the year 2025 would have to be reduced by an additional 11 to 13 gigatons in order for the level of emissions to be consistent with meeting the 2°C objective.[1]

How might greater emphasis on emissions reduction affect demand for natural gas—a relatively clean-burning fossil fuel that is more economical than other fossil fuels in many sectors? Often called a "triple-A" resource because it is affordable, abundant, and available, natural gas is projected to see the strongest increase in demand among fossil fuels over the next decade, with global demand rising at an annual rate of 1.4%, versus 0.5% for coal.[2] But that estimate might be conservative if nations and industries turn more aggressively to natural gas to meet their emissions targets.

This article, the first in a planned series on the effects of COP21 on the energy sector, gauges the prospects for emissions-related growth in demand for natural gas over the next decade. We look at demand for natural gas in three key sectors: power generation, industry, and transportation.

## Power Generation

The burning of fossil fuels—mainly coal and gas—to produce electricity and heat is the single largest source of global greenhouse-gas emissions, accounting for more than 35% of emissions from fuel combustion.[3] Gas currently represents 30% of total fossil-fuel consumption in the power generation sector, while coal and oil products represent 62% and 7%, respectively.[4] In recognition of this pattern of usage, most of the INDCs include initiatives aimed at reducing emissions in the power generation sector. These initiatives focus primarily on efforts to expand capacity for renewable power generation, with particular emphasis on wind- and solar-based generation. Together, wind and solar technologies are expected to account for more than 40% of the anticipated global increase in total generation capacity between 2013 and 2025.[5]

An arguably underleveraged approach to reducing power-generation-related emissions, however, is to increase reliance on natural gas. Natural gas is a significantly cleaner-burning fuel than coal, emitting roughly half the $CO_2$ for the same amount of energy produced. Natural gas also emits lower levels of sulfur dioxide, nitrogen oxides, and particulate matter than does coal. Particle emissions are especially relevant for governments, as these emissions can cause health problems for local populations situated near generation plants.

Gas-fired generation also has substantial operational and cost advantages over renewable generation today. Combined-cycle gas turbine plants (CCGTs) are a programmable technology, which can translate into cost advantages for power systems. Current renewable generation sources, in contrast, are often not programmable. In addition, despite rapidly falling prices for many renewable generation sources as a result of technological advances and experience-curve benefits, natural gas generally remains less expensive than renewables. A recent study by the US Energy Information Administration (EIA) revealed that the levelized cost of energy for advanced CCGTs in the US is $75.20 per megawatt hour, well below the costs of solar thermal generation ($239.70) and solar photovoltaic generation ($125.30).[6] Per the EIA, the levelized cost of energy represents the per-kilowatt-hour cost (in real dollars) of building and operating a generation plant over an assumed financial life and duty cycle.

Is natural gas likely to assume a larger role in reducing emissions in power generation over the next decade, resulting in significantly increased demand for natural gas? The answer may hinge on the economics of gas versus coal, which can vary by country and region and for geopolitical reasons.

United States. The substitution of natural gas for coal in power generation is already increasing in the US, driven largely by the drop in natural-gas prices resulting from the shale-gas boom. From 2009 through 2013, coal-based power generation in the country fell by 180 terawatt hours (TWh), while gas-based generation rose by 210 TWh. The EIA projects that, in 2016, natural gas will surpass coal in the mix of fuel used for power generation in the US, with natural gas accounting for 33% of the total versus 32% for coal.

The decrease in US demand for coal has affected international coal prices, however, with per-ton prices falling from an average of $120 in 2011 to $45 at the end of 2015. This price drop has substantially altered the economics of substituting natural gas for coal in markets outside the US.

European Union. The European Union's power generation sector suffers from excess installed capacity, and as a result natural gas and coal compete largely on the basis of marginal costs. Natural gas's recent loss of competitiveness versus coal on this front is illustrated by changes over time in the relative economic advantage of the *clean spark spread* (the difference between the price obtained by a gas-fired plant for the electricity it produces and the plant's marginal cost of production, including the cost of $CO_2$ emissions certificates) versus the *clean dark spread* (the difference between the price obtained for the same amount of electricity produced by a coal-fired plant and that plant's marginal cost of production, including the cost of $CO_2$ emissions certificates). A positive value for this measure indicates that gas-fired plants are more economically efficient than coal-fired facilities in producing electricity; a negative value indicates the opposite. (See Exhibit 1.)

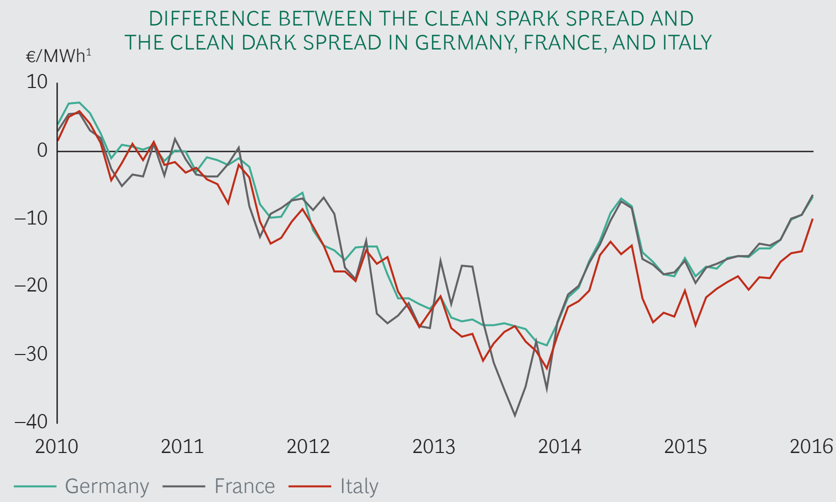
As the exhibit shows, the clean spark spread's advantage went from positive in 2010 to negative in 2011, meaning that natural gas had become less economical than coal. Natural gas became less and less competitive until the end of 2014, when it began to recover, reflecting a decline in natural-gas prices in Europe. But in Europe today, coal still holds an advantage over natural gas on this measure. This suggests that, to provide the impetus for any meaningful increase in the substitution of natural gas for coal in Europe, the price of natural gas relative to coal would need to fall further, or the cost of carbon emissions would need to rise, or some policy change altering the relative competitiveness of the respective technologies would have to occur.

**Developing Countries.** There are significant opportunities to increase the substitution of natural gas for coal in power generation in developing markets. In these markets, unlike in Europe, the power sector does not suffer from excess installed generation capacity. Rather, there is demand for more generation capacity, and natural gas competes with coal to satisfy that demand. In India, for example, demand for power has been growing by 6% annually since 1990 and is expected to continue to grow by 5% per annum until 2025. In China, demand for power has been growing by 10% per year since 1990 and is expected to continue to grow strongly until 2025.

At the moment, coal is more competitive than natural gas in many of these markets, and coal-fired plants continue to be these countries' preferred means of adding capacity. In China, for example, from 2009 to 2013, coal-fired generation increased by about 1,200 TWh while gas-fired generation increased by only 50 TWh.

These countries' heavy reliance on coal for power generation, however, poses growing health and environmental challenges, largely driven by emissions of particulate matter. Pollution from particulate emissions has become a serious concern in China, India, and several other markets, and policymakers are being compelled to take remedial steps, including the promulgation of regulations promoting the use of natural gas over coal. China's Action Plan on Prevention and Control of Air Pollution, launched by the Chinese Ministry of Environmental Protection in September 2013, is one example.[7] China took the further step of announcing in 2014 that it would cap its use of coal for power generation in 2020.

**EXHIBIT 1 | Coal Remains More Competitive Than Natural Gas in Europe in Power Generation**




**Source:** Bloomberg.
[1]MWh = megawatt hours.

It remains to be seen over the next decade how developing markets will collectively react as the harmful effects of large-scale coal use for power generation become more evident, and what role natural gas will play in their strategies. If non-OECD countries were to move aggressively toward natural gas and were to reach the same fossil-fuel generation mix as that of OECD countries today, global greenhouse-gas emissions over the next decade would be reduced by 1 gigaton per annum and natural-gas demand would rise by about 400 bcma (billion cubic meters per annum).

A major turn toward natural gas by the power generation sector worldwide could have a substantial beneficial effect on global emissions. If, for example, countries collectively were to substitute natural gas for 100% of their current coal use in power generation, global emissions would fall by approximately 5 gigatons of $CO_2$ equivalent, a reduction amounting to about 10% of current emissions.

## Industry

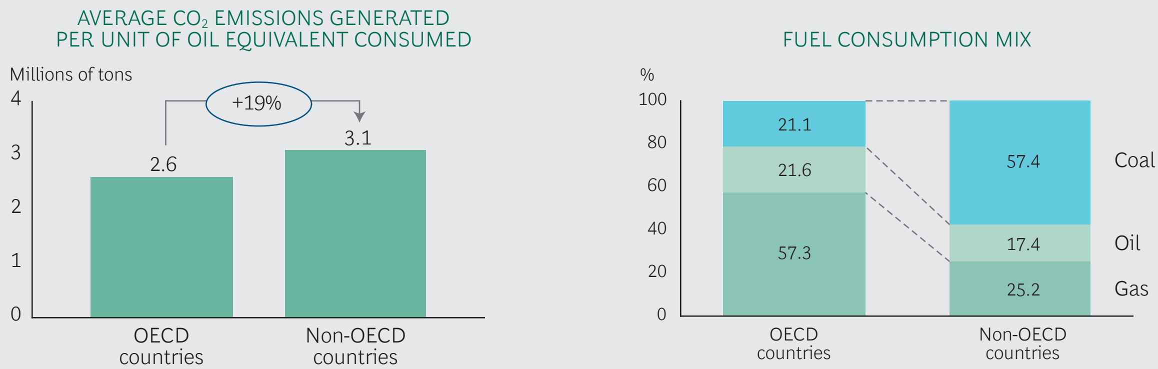
Emissions from the use of fossil fuels in the industrial sector represent about 19% of total global greenhouse-gas emissions.[8] Emissions in this sector result mainly from the combustion of fossil fuels in industrial boilers for steam generation and heating processes. Natural gas represents about 34% of the fossil fuels consumed by the sector globally; coal and oil represent about 47% and 19%, respectively.

Increased substitution of natural gas for coal and oil products in this sector could meaningfully reduce global emissions—an efficient natural-gas industrial boiler emits approximately 40% less $CO_2$ than a coal industrial boiler, for example. Already, natural gas accounts for about 60% of fossil-fuel consumption in OECD countries. This largely reflects tightening environmental standards regarding the emission of sulfur compounds and nitrogen oxides that are present in coal and oil products.[9] In fact, in these markets, coal and oil are used only in specific industries where technical considerations limit the substitution of natural gas. The iron and steel industry, which requires high-calorific fuels—such as coking coal and other bituminous coals—for specific technical processes, is an example.

In the developing world's industrial sector, the situation is different. (See Exhibit 2.) Coal accounts for almost 60% of fossil-fuel consumption in non-OECD countries, as shown in the right side of the exhibit. Hence there is considerable scope for substitution of natural gas for coal in this sector in these countries. And policymakers in some of these nations, concerned about the environmental effects of heavy coal use in the industrial sector, are already taking action to reduce their emphasis on it. China, for example, addresses this in its Action Plan on Prevention and Control of Air Pollution.

If more developing countries were to head in the same direction, the effect on emissions could be quite meaningful. As the left

**EXHIBIT 2 | Emission Rates and Fuel Consumption Mix in the Industrial Sector**




**Sources:** International Energy Agency; BCG analysis.
**Note:** Data is for 2013.

side of the exhibit indicates, the average industrial-sector rate of emissions per unit of energy consumed is about 20% greater in non-OECD countries than in OECD countries, largely because of the non-OECD countries' greater emphasis on coal in their energy mix. If the industrial sector in non-OECD countries were to match the performance of OECD countries on this metric, by substituting natural gas for coal and by adopting other efficiency measures, the countries' emissions would decline by about 1 gigaton of $CO_2$ equivalent, or 2% of current global emissions. Demand for natural gas, in turn, would increase by about 400 bcma—an amount roughly five times the size of current annual demand for natural gas in Germany.

## Transportation

Emissions from the transportation sector represent about 14% of global greenhouse gas emissions.[10] Currently, oil products dominate the transportation sector, accounting for more than 90% of the energy that the sector consumes. Natural gas plays a very limited role in this area, accounting for less than 4% of the consumed energy.

Although these percentages suggest that additional substitution of natural gas for oil products may be possible in the transportation sector, the actual potential for such change is limited by economic and logistical constraints. One area in which a very strong environmental argument could be made for substituting natural gas for oil products is with regard to the road transportation subsector, especially in large commercial and freight vehicles. For light commercial vehicles and private automobiles, other options, such as hybrid vehicles, are more attractive than natural-gas-fueled vehicles.

According to the Center for Climate and Energy Solutions, replacing diesel fuel with natural gas could reduce fuel life-cycle greenhouse-gas emissions from such heavy-duty vehicles by up to 29%.[11] The economic argument for pursuing this change could be particularly compelling in the US, given the country's abundance of natural gas and the resource's price competitiveness against other fuel options.

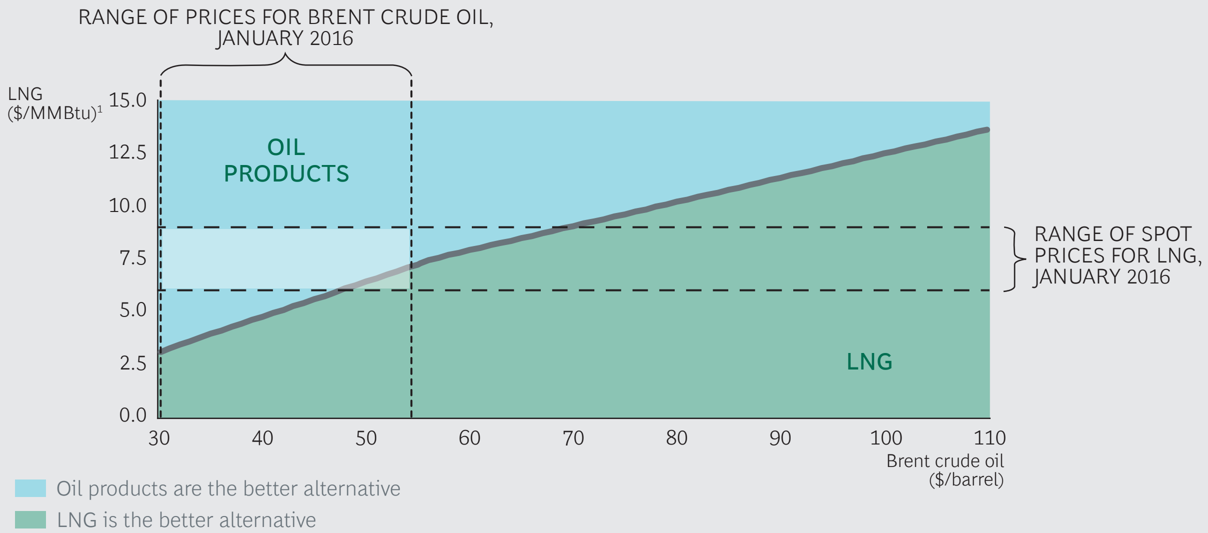
Substituting natural-gas-powered vehicles for diesel-fuel-powered vehicles requires buyers to make a substantial initial investment, however: natural-gas-fueled trucks currently cost 35% to 40% more than traditional diesel-fueled alternatives. In addition, because the cost of operating natural-gas-fueled vehicles (excluding fuel costs) tends to be higher than the cost of operating traditional vehicles, buyers seeking to recover their investment must do so via lower fuel costs. But the annual cost savings of using natural gas in place of oil has diminished significantly as a result of the recent drop in oil prices, rendering the substitution economics far less compelling. According to the International Energy Agency, the payback period in the US for long-haul trucks fueled by liquefied natural gas (LNG) is currently more than five years, versus three years in 2014.

Similarly, the economic argument in favor of substituting natural gas for oil products in the marine transportation subsector is not compelling at the moment. (See Exhibit 3.) Given recent prices for LNG and for Brent crude oil, the most cost-effective option for participants in this subsector today is to continue to favor oil products for fuel, despite the adoption of new desulfurization regulations that have raised the cost to ship owners of doing so. To comply with the new regulations, ship owners must choose one of three technologies: heavy fuel oil as a fuel and scrubber (an exhaust-gas cleaning system that uses fluids capable of absorbing sulfur-oxide emissions and neutralizing the effluent in contact with the exhaust gas); marine gas oil as a fuel; or liquefied natural gas as a fuel.

Recent data suggests that expanded substitution of natural gas for oil products in the transportation sector is unlikely at the moment. An upturn in natural-gas adoption will depend on a further decrease in gas prices relative to oil or on a change in policies that alters the relative competitiveness of these technologies.

Material use of natural gas in the transportation sector would also require a substantial investment in infrastructure to ensure

**Exhibit 3 | Substitution Economics of LNG Versus Oil in Marine Transportation**




**Source:** BCG analysis.
[1]LNG = liquefied natural gas; MMBtu = millions of British thermal units.

adequate supply for users. In the US and Europe, for example, relatively few stations currently supply LNG or compressed natural gas, making a major push toward use of natural gas in this sector problematic. Concerted efforts such as those of Blue Corridor (http://www.bluecorridor.org) are underway, however, to encourage increased adoption of natural gas in transportation. The European Union is also actively promoting the establishment of corridors equipped with LNG refueling stations for LNG-fueled trucks that use the major heavy-transportation routes.

## The Role of Natural Gas in Emissions Reduction

Natural gas, with its relatively clean environmental footprint and its current economic competitiveness versus other fossil fuels, stands to get a significant boost in deployment in the next decade as countries collectively strive to reach their COP21 targets and as individual nations seek to mitigate the effects of greenhouse gas emissions on their local environments. The power generation sector and the industrial sector, in particular, have ample scope for increased reliance on natural gas, and the effects of such change on emissions could be large. If non-OECD countries were to reach the same fossil-fuel generation mix in the power generation sector that OECD countries have achieved, and if the industrial sector in non-OECD countries were to match the emissions rates of OECD countries by substituting natural gas for coal, then global energy-related emissions would decline by about 2 gigatons of $CO_2$ equivalent—an amount equal to roughly 20% of the additional emissions reduction that must be reached by 2025 to meet the COP21 objectives, as mentioned above.

What would implementation of these measures mean for natural-gas demand? Current forecasts call for demand of about 3,800 bcma in 2025. But if these measures were pursued and achieved, actual demand in 2025 could reach roughly 4,500 bcma—a sizable increase in the volume of demand, but one that could certainly be met, given the vast size of existing natural-gas reserves. With regard to projections of future demand, of course, demand could be materially influenced by the evolution of commodity prices and by technological developments, especially those related to renewable energy.

Notes
1. Source: http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.ht.

2. Source: International Energy Agency.

3. Source: United Nations Framework Convention on Climate Change.

4. Source: International Energy Agency.

5. Source: International Energy Agency.

6. These estimates are for average levelized costs (in dollars per megawatt hour) for plants entering service in 2020. Source: https://www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf.

7. Source: http://english.mep.gov.cn/News_service/infocus/201309/t20130924_260707.htm.

8. Source: United Nations Framework Convention on Climate Change.

9. See, for example, Directive 2010/75/EU of the European Parliament and of the Council, November 24, 2010 (http://www.energy-community.org/pls/portal/docs/2394177.PDF).

10. Source: United Nations Framework Convention on Climate Change.

11. Source: R. Alvarez, S. Pacala, J. Winebrake, W. Chameides, and S. Hamburg, Greater focus needed on methane leakage from natural gas infrastructure (2012), http://www.pnas.org/content/early/2012/04/02/1202407109.full.pdf+html.

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*This article is the first of a planned series of articles on the effects of COP-21 on the energy sector.*