IS ABUNDANT NATURAL GAS A BRIDGE TO A LOW-CARBON FUTURE OR A DEAD-END?

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Overview

In recent decades, there has been a dramatic boom in natural gas production in the United States, spurred by the hydraulic fracturing ("fracking") technological innovation, which opened up vast shale formations to economic recovery of natural gas. Fuel switching away from coal (and to a lesser extent oil), can reduce emissions from electricity generation due to lower carbon content of the natural gas. However, many have argued that while a large-scale transition to natural gas may reduce emissions in the short-run, it may actually increase emissions in the long-run by leading to lock-in of a low-cost emitting technology. This paper uses a large-scale energy-economic model of the United States—the National Energy Modeling System (Yale-NEMS, a NEMS model running at a Yale server)—to assess the extent to which abundant natural gas availability reduces or increases long-run local air pollution, greenhouse gas emissions, and welfare, and the effectiveness in reducing emissions relative to climate policy.

This paper makes several contributions to the literature. First, we develop a concise economic theory framework that illustrates how adding natural gas could either increase or decrease emissions and elucidates the theoretical links between the outcomes from the computational model, which distinguishes this work from previous modeling papers on natural gas. Second, we are not aware of any other study that uses the same modeling platform to tackle our research question from both economic and environmental perspectives using the most recent estimates of U.S. natural gas resources. Third, we are the first to calculate the welfare effects of abundant natural gas both with and without a carbon policy, including monetized CO_2 and air pollutant impacts. Finally, we examine the winners and losers of an abundant natural gas scenario, accounting for both direct welfare and environmental effects from greenhouse gas emissions and air pollution emissions.

Methods

We propose a simple static partial equilibrium model with a single output market that utilizes energy inputs and maximizes profits. The purpose of this section is purely to provide some intuition for the economics at work. In this model, we both consider the cases of existent carbon externalities and internalized carbon externalities. The model presents the mathematical conditions that determine the direction of emissions changes due to abundant natural gas. The static framework we present also clearly lays out the welfare effects of supply increase in natural gas, identifying the economic forces of driving welfare. This short theory section crystallizes the basic insights that we then explore using Yale-NEMS.

In this study we are especially interested in quantitative estimates of energy production, energy consumption, energy prices, emissions, and welfare effects of the abundant natural gas scenario.Yale-NEMS is an ideal tool for our analysis because of its granularity and comprehensiveness. Yale-NEMS is a copy of the NEMS model from EIA. This detail of the model has led numerous authors to use NEMS platform for the analysis of changes in the energy system (e.g., Nogee et al. 2007; Goulder 2010; Brown et al. 2010; Auffhammer and Sanstad 2011). Yale-NEMS consists of 13 modules that cover all major fuel supply markets, conversion sectors, end-use demand markets, macroeconomic activity, and links to international energy market. The model projects energy market movements for around 25 years into the future, including consumption, production, imports, exports, substitution, and prices subject to a set of economic, resource availability, technology, behavior, and demographics assumptions. To answer our research questions, we propose two alterative scenarios that take the reference case of Annual Energy Outlook 2017 published by EIA as a starting point: (1) a scenario with abundant natural gas and (2) a carbon pricing policy. We further explore a third scenario that interacts these two scenarios.

Results

We find that a scenario of truly abundant natural gas does reduce local air pollutant and greenhouse gas emissions, while at the same time providing a large welfare benefit. However, the reduction in emissions is modest relative to what a carbon price (e.g., from a carbon tax) set linearly rising to roughly \$46 per ton CO_2 in 2040 could achieve. Furthermore, as we approach 2050, emissions under the abundant natural gas scenario are even slightly higher than

the reference case due largely to less innovation in renewables. This implies that abundant natural gas is not an ideal bridge fuel to a low carbon future.

We further examine heterogenous welfare effects across regions, illustrating that while all regions see welfare gains from abundant natural gas (regardless of whether there is a carbon policy), there is substantial heterogeneity in the welfare effects. Our welfare estimates are subject to the caveat that we cannot quantify all of the potential local impacts of natural gas production and distribution, but illustrative calculations suggest that even if these are included, the welfare benefits would remain large.

Conclusions

First, we conclude that although abundant natural gas supply results in welfare gains both with and without carbon pricing scenarios, it does not reduce CO_2 emissions significantly over the projected period, because cheaper natural gas replaces not only coal but also renewables, but it is relatively effective in reducing air pollutions from burning fossil fuels. Second, climate policy—such as a carbon pricing policy—reduces CO_2 and air pollutant emissions, reaching even lower emission levels when combined with increased gas supply in the market. A major contribution of this work is to estimate the economic welfare impacts of abundant natural gas. We find large potential welfare gains from abundant natural gas due to increases in consumer surplus (i.e., lower prices of energy) and reduced air pollutant emissions due to a substitution of natural gas for coal. While nearly all regions benefit—regardless of whether there is carbon pricing or not—we the greatest benefits accrue to the region around Texas and the West Coast.

References

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