Emissions Arbitrage in the Natural Gas Market

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Abstract

Analysts have long-expected Liquefied Natural Gas (LNG) imports to provide a steady, dependable source of natural gas feedstock for end-use in the United States. However, climate change legislation and the availability of domestic unconventional gas supplies are recasting the long-term relevance of LNG in the United States. "Emissions arbitrage" opportunities that result from competition between LNG and shale gas providers will reorient the U.S. market for imported natural gas, causing it to increasingly be supplied by domestic sources.

Although it currently accounts for one percent of natural gas that is consumed in the United States, analysts have consistently forecasted that Liquefied Natural Gas (LNG) imports would provide a steady, dependable source of natural gas feedstock in the decades to come. However, climate change legislation that levies a price on greenhouse gas emissions and the availability of domestic unconventional gas supplies will limit the long-term relevance of LNG in the U.S.

The cap-and-trade system envisaged by the U.S. House of Representatives requires foreign suppliers of fossil fuels to surrender "emissions allowances" to the government for each unit of carbon dioxide (CO_2) or methane (CH_4) that is emitted in the process of making a shipment of fuel to the United States. LNG is especially impacted by this provision, because 20 percent of the gas that is extracted abroad gets consumed in the process of delivering a shipment of LNG to a distribution company (LDC) in the United States. The cost of upstream emissions that results from liquefying, shipping and regasifying natural gas will significantly increase the price of LNG in the U.S. and limit the market for imports.

Concurrent to the forthcoming carbon price regime is an ongoing renaissance in the U.S. natural gas industry. In the last century, it was considered uneconomical to extract hydrocarbons locked in shale rock formations. However, advanced drilling techniques have made the development of shale natural gas reserves in Texas and Louisiana economically viable, and the successes in the South have spurred investment in shale gas plays across the country. There is estimated to be enough shale gas to supply 100 years' worth of U.S. domestic demand (at current rates), and gas from shale is projected to supply more than 50 percent of the U.S. market by 2020.

The added carbon cost of importing LNG, in addition to the increasingly favorable economics of shale gas extraction, stand to limit long-term demand for LNG in the United States. To the extent that these two sources of natural gas compete with one another,

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emissions arbitrage opportunities that arise by purchasing domestic shale gas, as opposed to LNG, will encourage further development of shale reserves and limit the relevance of LNG.

Liquefied Natural Gas

The Liquefied Natural Gas supply train to the United States starts when methane gas is extracted from foreign reserves (predominantly located in Trinidad and Tobago). The gas is piped to processing facilities that remove water, sulfur and certain distillates, and then to liquefaction plants, where the gas is cooled, pressurized, and transformed into a liquid. In liquid form, the LNG is loaded onto tankers, which travel to their U.S. ports of call. Tankers offload their cargo at regasification terminals, where LNG is heated until it returns to its gaseous phase. The gas is then pumped into a pipeline system that leads to distribution hubs, and is finally routed to end-users.

Liquefaction facilities use fans and refrigerants to cool methane gas to -163 degrees Celsius. They are energy intensive, and consume eight to ten percent of the initial volume of extracted natural gas to power various processes.[1] The actual amount of CO_2 that is emitted depends on the energy intensity of the gas (in British Thermal Units) and the efficiency of the liquefaction plant itself.

After it has been liquefied, the LNG is stored until a shipment order is filled. Any type of container used to store LNG has an inflow of heat that results in evaporation. This is generally referred to as “boil-off.” For typical storage containers the boil-off varies between 0.04-0.20 percent of the total storage volume per day, which is released into the atmosphere in the form of methane gas.[2]

When there is enough LNG to fill an order, the product is loaded onto a ship and transported across the ocean in specially insulated tankers. The insulation maintains the temperature of the cargo, thereby limiting boil-off, but on a typical voyage, 0.1-0.25 percent of the methane is released into to atmosphere.[3]

LNG carriers are traditionally powered by steam turbines burning marine diesel or heavy fuel oil.[4] The new generation of LNG carriers is increasingly powered by diesel-electric propulsion systems in which two to four large engines generate electricity that power electric drives. Some ships use the LNG boil-off as fuel for the journey, but over a typical 20-day return voyage from a liquefaction facility to a regasification terminal, the total net loss is two to six percent of the volume.[5] [6]

There is limited capacity for transporting LNG over land; once it reaches the port, LNG is returned to its gaseous state and transported via pipeline. More natural gas is needed to provide the energy for regasification, which uses vaporizers that convert the liquefied cryogenic methane back into gas. Regasification terminals run heated seawater through heat exchangers inside the vaporizers. All told, between 1.5-3 percent of the throughput gas is used to fuel the water heater system.[7]

After unloading their cargo, tanker ships steam home to reload. The return voyage incurs additional boil-off. The “heel” refers to five percent of the cargo, which remains on board to keep LNG transport containers at the right temperature and pressure. The boil-off losses can be 10-50 percent of the heel on a return voyage, or the equivalent of .5-2.5 percent of the total load.[8]

All told, 20 percent of the initial volume of extracted gas is consumed during the LNG train, which in and of itself makes LNG very expensive. But the carbon cost of gases that are lost or used as fuel will significantly increase the price of importing LNG to the United States.

Shale Natural Gas

In the last ten years, innovative drilling techniques have economized the production of natural gas from shale rock formations. These formerly untapped reservoirs of methane gas are now producing large quantities of gas. Due to the enormous shale formations that underlie the continental United States, analysts expect that shale gas will be an increasingly reliable supply of natural gas.

Traditional natural gas wells are drilled down vertically to the depth of a subsurface layer that contains a gas reservoir. The pressure and weight of overlying rock forces hydrocarbons up through the depressurized well, which essentially acts as a straw. However, due to the impermeability of shale rock formations, gas trapped in subsurface shale reservoirs does not move to the surface in large quantities. As a result, the economic viability of vertical shale wells has been marginal.

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Advances in horizontal drilling and hydraulic fracturing techniques have made shale gas wells more economical. In the last decade, shale formations in Texas, Louisiana, and Arkansas have seen major development. As the drilling techniques are refined, companies are becoming eager to expand operations to Pennsylvania, Ohio, New York, West Virginia and other areas of the country that overlie shale formations.

The process of developing a shale gas well begins by securing mineral rights and permits to drill on land that is close to existing pipeline infrastructure and a source of water. Operators get a sense of the subsurface hydrocarbon density by using seismic monitors and four-dimensional modeling, and by drilling test wells.

A vertical well is drilled down to the subsurface layer of shale, and a specially curved bit is used to turn the well so that it bores horizontally through the formation. After the well is capped and cemented, small explosive charges are detonated in the horizontal section of the well to create spider web-like fissures in the surrounding rock. Water mixed with sand and chemicals is pumped into the well at high pressures to force sand particles into the fissures, artificially creating porosity that enables gas to flow into the well bore more easily. The hydraulic fracturing process exposes vast volumes of hydrocarbons to the depressurized bore, and is a key element in the increased efficiency of drilling shale gas wells.

In the oil and gas industry, excitement about the prospects for shale natural gas development is palpable around the world. European nations that are dependent on imports of gas from Russia are now commencing studies of their domestic shale reserves. And although stratigraphy of the countryside is not easily accessible, further study may reveal that mainland China is also home to vast reserves of shale natural gas.

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Recent analysis has suggested that there is enough recoverable shale gas to satisfy U.S. domestic demand for 100 years. Although the price point at which shale gas development will be economical has yet to be determined, experts generally agree that the U.S. shale gas resource is vast, that operators in certain shale plays are already profitable, and that cost of carbon allowances for a shale gas well will be significantly less impactful than for the LNG train.

Conclusion

It is impossible to be sure what share of the gas market will be supplied by LNG in the long run. But to the extent that there is competition between shale and LNG, the emissions arbitrage that arises from purchasing local shale supply as opposed to imported-LNG is reshaping projections about the U.S. market. Only 12-13 percent of the US regasification capacity is currently being utilized, and financing has been withdrawn from projects to develop additional regasification terminals.

We contend that climate change legislation and economical shale gas extraction will limit the long-term demand for imports of LNG to the United States, and that emissions arbitrage opportunities will arise for LDCs purchasing feedstock from shale reserves as opposed to LNG.

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