ENERGY TRANSITION BRIDGE FUEL

Do We Still Need Natural Gas?

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INTELLIGENCE THAT WORKS

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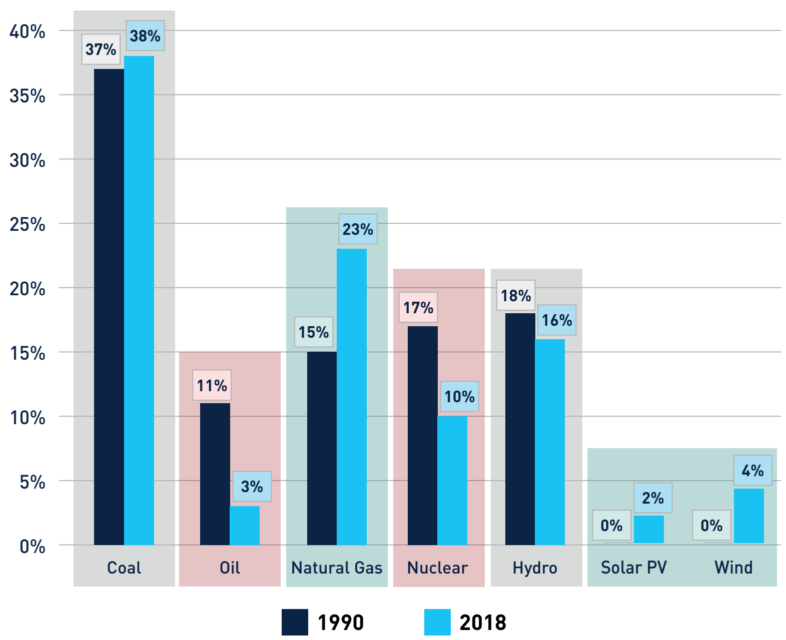
The notion that natural gas would serve as a "bridge fuel" to facilitate the transition toward a cleaner energy future from the dominance of fossil fuel consumption in power generation, industrial production, and transportation sectors first was promoted in the 1970s in the wake of the energy crisis. The idea was that natural gas could be used to replace heavier fuels like oil and coal which produce substantially more emissions of carbon dioxide (CO_2), nitrogen oxides (NOx), and sulfur oxides (SOx); help countries decrease their dependence on foreign oil (Bordoff, 2019); and buy time until renewable energy could be developed to levels of economic efficiency, scale, and reliability to replace all fossil fuels.

A Bridge Across the Decades

Natural gas substitution of fuel oil in the residential and commercial heating markets proceeded swiftly in the 1970s and 1980s, but fuel switching didn't get much attention in the power sector until the 1990s, when technological advances in high-efficiency natural gas combustion technologies ushered in a decade of massive investments in power generation, along with expansions in natural gas productive capacity and infrastructure needed to meet growing demand.

Over the last several decades, natural gas has lived up to its promise worldwide. As illustrated in Figure 1, which shows the share of total worldwide electricity production of the major generation technologies for 1990-2018, the natural gas generation share surged from 15% to 23%, while renewables (wind and solar) grew from zero to 7%. Coal generation held stable at 37% to 38%, whereas hydropower decreased from 18% to 16%, nuclear fell from 17% to 10%, and oil collapsed from 11% to 3% (according to the International Energy Agency (IEA)).[1] In other words, natural gas and renewable energy largely have taken market share from oil and nuclear generation, but coal generation has held steady.

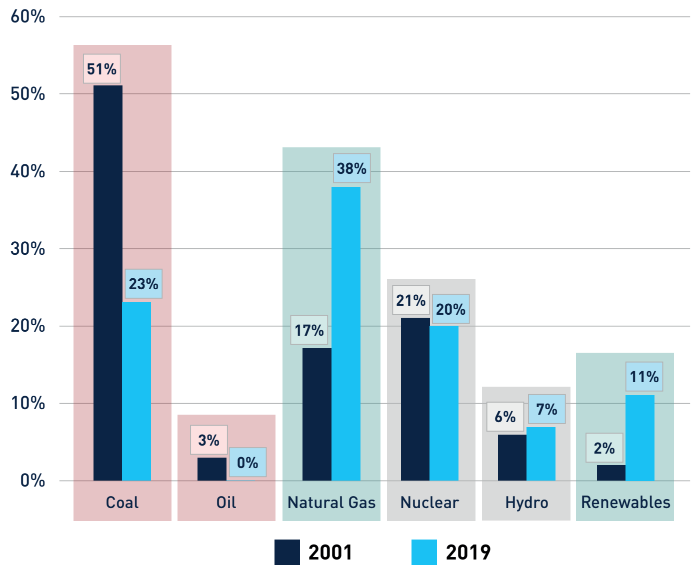
Figure 1: Share of Global Electricity Generation by Technology (1990–2018)



1 IEA, "Data and Statistics, Electricity," available at: https://www.iea.org/data-and-statistics/data-tables?country=WORLD&energy=Electricity&year=2017

The story is different in the US over the last two decades, as the US has embraced the use of natural gas as a transition fuel for the electric sector. Since 2000, in particular, the surges in natural gas and renewable energy generation have driven about half of the coal and most of the oil generation out of the market. These trends are set forth in Figure 2.

Figure 2: Share of US Electricity Generation by Technology (2001–2019)[2]



From 2001 to 2019, US annual power generation from natural gas, wind, and solar generation facilities grew by a combined 1,318 TWh, displacing 1,044 TWh of coal- and oil-fired power generation. Largely as a result of these trends, CO_2 emissions from power generation have fallen from 2.3 to 1.6 gigatons per annum, according to the Energy Information Agency (EIA).[3]

The primary drivers of these results have been two-fold: policy changes and tax incentives. Congress and the Federal Energy Regulatory Commission (FERC) adopted landmark policies that unbundled and liberalized natural gas investment and competition across the supply chain, leading to vast natural gas supply, ample transportation and storage capacity, and competitive natural gas prices. These policy shifts were augmented by oil and gas production tax credits and renewable energy investment tax credits, which helped these industries achieve the early successes and growth to reach critical technological efficiencies and economies of scale in areas like shale gas production and wind and solar power generation. At the same time, increasingly stringent clean water and clean air policies increased environmental costs, creating investment and production headwinds for coal-fired generation.

Most recently, wind and solar investment and operating costs have declined to the point where they now beat coal and natural gas power plants on a Levelized Cost of Electricity (LCOE) basis in many regions, even without government subsidies (Lazard, 2018). In addition, distributed energy resources (DERs) for power supply, from sources such as household batteries, electric vehicle batteries, and rooftop solar, are surging and are expected to transform the US power grid, with studies forecasting up to 380 GW of DERs coming online by 2025 (Meyer, 2020). FERC's Order 2222 is aimed at removing barriers to the participation of DERs in wholesale power markets. Renewable energy generation and DER facilities have pulled ahead of natural gas generation investments, and coal-fired generation is subject to increasingly rapid retirements and shutdown.

Nevertheless, the US electricity grid is far from being carbon neutral, and the energy transition is incomplete in that respect. The critical energy transition question is not whether natural gas and renewable energy can displace coal-fired generation, because that transition is already occurring, but whether renewable energy can completely displace coal- *and* natural gas-fired generation, and how quickly it can do so.

Are We Getting Close?

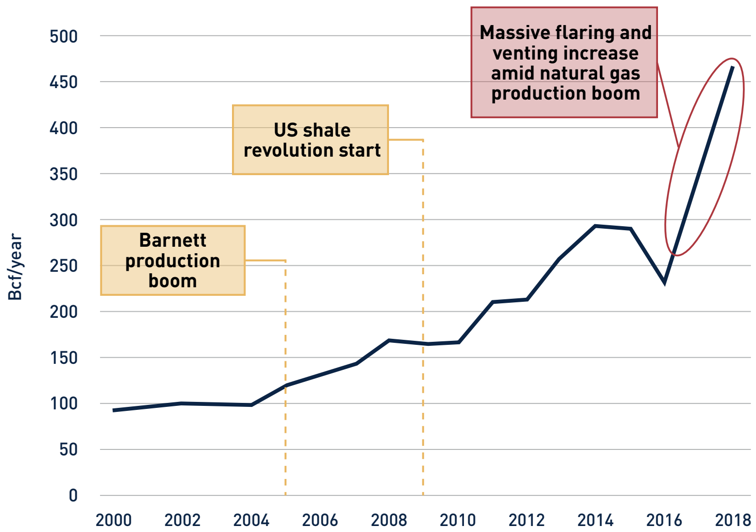
The progress facilitated by natural gas has been impressive, but the costs are coming into sharp focus, especially in the US natural gas industry over the last decade. The US produces over 22% of global gas supply (IEA, Atlas of Energy) and has emerged in recent years as a key driver of global natural gas pricing due to growing US liquefied natural gas (LNG) export capacity. Over the last decade, US natural gas production has shifted sharply from

2 Graph illustrates utility-scale electricity generation but does not include small-scale distributed energy resources. Data from EIA net generation by energy source report.
3 EIA, Carbon Dioxide Emissions from Energy Consumption: Electric Power Sector (August 2020).

conventional to unconventional resources (i.e., shale gas) as a result of technological innovations in hydraulic fracking and horizontal drilling. In 2010, when the shale gas revolution was starting to accelerate, only 23% of US production came from shale (EIA, 2011). By the beginning of 2020, shale gas had grown to account for almost 80% of US natural gas production. The cost of shale gas production has fallen from early estimates north of $8/MMBtu to around $2/MMBtu in some "sweet spots" and even lower for associated gas and some "wet" shale gas basins.

Over the last decade, shale gas producers have been accused of many environmental vices, such as contamination of groundwater and fugitive methane emissions. The surge in shale oil production in the Permian, Bakken, and other basins has also produced large volumes of natural gas that have surpassed the pipeline takeaway capacities out of these regions. The excess supply has resulted in the flaring and venting of massive volumes of natural gas, reaching 493 Bcf of methane, a potent greenhouse gas (GHG), into the atmosphere in 2019 (Reuters, 2020). This is significant and represents 1.6% of total US natural gas production (based on EIA, Natural Gas Gross Withdrawals and Production). As a result, the US now ranks as the third-largest flaring country in the world, closely behind Russia and Iraq (The World Bank, 2019).

Figure 3: Flaring and Venting of US Natural Gas[4]



The gas industry promotes itself as the bridge to a clean energy future, but controversies regarding the fracking process, fugitive methane, venting, and flaring have delivered a massive environmental black eye. And while the COVID-19 pandemic has reduced shale oil production, and with it an expected modest decrease of 2% of natural gas output in 2020 (EIA expects lower natural gas production in 2020), this is only a partial and probably temporary solution. Despite opposition to methane emissions deregulation by oil and gas industry leaders who promote natural gas as cleaner-burning than coal (Brady, 2020), the US Environmental Protection Agency rolled back the 2016 New Source Performance Standards for the Oil & Natural Gas Industry (EPA, 2020), which required the detection and repair of methane leaks (Brady, 2020).

In Europe, governments are eschewing expansion of natural gas infrastructure, largely due to the EU's ambitious climate goals and desire to reduce dependence on fossil fuel imports. Recently, European Commission President Ursula von der Leyen announced a new Green Deal climate plan to reduce carbon emissions to 55% below 1990 levels by 2030 (Simon, 2020). To achieve this level, capital will be raised from green bonds, green recovery funds, and sources of national and private capital. The EU is also moving rapidly toward green hydrogen deployment, which is hydrogen produced by carbon-free power from renewable energy (as compared to blue and grey hydrogen, which are produced by fossil fuel power generation). To this effect, the European Commission recently launched the Hydrogen Strategy to become world leaders in green hydrogen technology.

As a result of these trends and the rapid advances in hydrogen and renewable energy generation efficiency and scale, the natural gas industry mantle of "bridge fuel" has come under question. Environmentalists no longer associate natural gas with longer-term clean energy solutions, but rather see the industry as part of the environmental and climate change problem—a problem requiring increasingly urgent and aggressive solutions.

After three decades of massive global development of natural gas and LNG production, consumption, and trade, and more recent advances in renewable energy production technology scale and efficiency, the question arises: If natural gas is the "bridge fuel," have we already crossed the bridge, or are we getting close to the other side?

4 EIA, "Natural Gas: Natural Gas Gross Withdrawals and Production, Vented and Flared" (August 2020), available at https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGV_mmcf_a.html

Where Does the Energy Transition Bridge End?

The debate about the continued role of natural gas as an energy transition bridge fuel is at the core of a larger global debate about energy policy and sector transformation, transition to a carbon-free economy, and the economic costs and benefits of these changes. Where does the bridge lead, and what is the energy transition goal? How will we know when we have arrived? When will it be economically and operationally safe to switch from natural gas to zero-carbon solutions?

Over the last decade, these issues have become central to the increasingly prominent and polarized debate about energy and climate policy in the US. This policy debate is plainly apparent in the current election cycle:

- As incumbent, President Donald Trump and the Republican Party's platform of America First and American Energy Dominance calls for increased US fossil fuel production, consumption, and exports. This platform also calls for the reduction of environmental regulations that impede these goals.
- As challengers, former Vice President Joe Biden and Democratic candidates are running on a platform based upon $2 trillion in green stimulus investments as a solution to the dual imperatives of COVID-induced economic malaise and climate change under the mantra "Build Back Better." This platform calls for transition to a 100% clean energy economy and net-zero emissions by 2050. The platform leaves open critical policy questions about the extent and timing of drilling and fracking controls, carbon taxes, and carbon border tariffs.

The US elections are likely to leave open for deliberation and debate in 2021 several critical policy decisions, and the congressional results could play a large role in constraining, facilitating, or compelling the policies of a second Trump administration or a new Biden administration.

The policy positions range from the Democratic left wing (led by Senator Bernie Sanders and Representative Alexandria Ocasio-Cortez), which wants to rapidly shut down all fossil fuel industries in the swiftest time possible, maximize environmental regulation, and maximize renewable energy incentives; to the Republican right wing (led by Trump), which favors increased fossil fuel production, weakened environmental regulation, and the removal of incentives for renewable energy. In the middle are Democratic centrists (led by Biden), who favor the of use of green energy stimulus, economic incentives such as carbon taxes, and strict environmental regulation to drive the rapid retirement of coal plants and growth of renewable energy sources; and some Republican moderates, who broadly favor limited environmental regulation and economic incentives for natural gas, nuclear, and clean energy (often including carbon taxes).

On energy and climate, the intense polarization of the Republican and Democratic party policy platforms stands in contrast with a broad popular consensus regarding the anthropogenic nature and harmful consequences of climate change and the need for rapid energy transformation. For example, approximately 80% of Americans believe that human activity causes (or has at least played a critical role in causing) climate change, 63% believe climate change is impacting their local communities, and 79% believe that the US should prioritize the development of alternative energy supply (Tyson & Kennedy, 2020).

In contrast to the polarization of US energy and climate policy options in the 2020 elections, EU member countries have already chosen to redouble their leadership of the energy transition as a means to the dual ends of climate change mitigation and post-pandemic economic recovery. They have broadly lined up in support of the Green Deal stimulus program that calls for a climate-neutral economy by 2050. Nevertheless, policymakers continue to wrestle with critical questions regarding the speed with which renewable energy and electricity storage can support substantial green energy electrification and the economic cost and feasibility of using green hydrogen to displace natural gas and fossil fuel consumption.

In East Asia, the leading economies of Japan, South Korea, and China are watching the policies of their Atlantic trading partners with interest as they debate the uptake of renewable energy, increased use of natural gas, and continued substantial use of coal throughout their electric and industrial sectors. There is no Asian consensus, and national policies vary widely. For example, Japan has returned to building 20 GW of new coal plants (ECTL), and South Korea is planning the retirement of 15.3 GW of coal-fired capacity (Argus). Most notably, however, mainland China has over 250 GW of new coal plants under construction as of 2020, further intensifying the country's extensive reliance on the world's heaviest, most carbon-intensive fossil fuel over the coming decades. Concurrently, and in apparent contradiction to this coal-building boom, President Xi Jinping recently announced to the United Nations that that China would achieve a peak in carbon dioxide emissions before 2030 and carbon neutrality before 2060.

Similarly, policymakers in the large emerging markets and hydrocarbon producer and consumer nations of Southeast Asia, the Middle East, Africa, and Latin America are studying the evolution of energy transition and climate policies with keen interest to see whether global and regional economic recovery from the pandemic will favor business as usual or require more aggressive climate and energy transition policies.

As global policymakers weigh energy transition policies, economic costs, and commercial risks, it is fair to say that all eyes are focused on the US elections and their implications for US energy and climate policies. It remains to be seen whether the US will continue on President Trump's path of pursuing US economic competition and energy dominance based upon increased fossil fuel production and reduced environmental regulation; or shift toward ambitious climate and energy transformation policies under a Biden administration. Whichever party wins the White House, the electoral outcomes in Congress also will play a critical role in shaping and constraining or enabling the next administration's energy and climate policies, the nature and velocity of US energy transition, and the role of natural gas in that transition.

Will the November political outcomes lead to a US energy transition that proceeds gradually based solely on economic fundamentals, or will the transition be accelerated based on some mix of redoubled environmental regulation, new carbon taxes, or perhaps a ban on oil and gas fracking? In other words, are we nearing the end of the energy transition bridge, or are we only halfway across?

Energy Transition Bridge Scenarios

On the strength of popular opinion and the broad contours of energy and climate policy in the US, we can posit at least three scenarios for energy transition, its velocity, and the role of natural gas:

1. **The Long Bridge (BAU):** Assuming a Trump presidency that is checked by increasingly strong climate policy preferences in Congress, a business as usual (BAU) scenario that assumes no significant change in current energy policy, neither to further promote nor further constrain oil and gas or renewable energy production and consumption. Market economics govern, and environmental regulation and climate change externalities play little or no role.
2. **Strategic Transition (carbon tax):** Assuming a Biden presidency and a strong showing by Democratic centrist and Republican moderates, a rapid transition scenario driven by market economics and long-term carbon taxes and border tariffs.
3. **Aggressive Transition (fracking ban):** Assuming a Biden presidency and a strong swing to the Democratic left in Congress, an aggressive transition scenario driven by rapid coal shutdowns, and a near-term oil and gas fracking ban.

As compared to the BAU assumptions in the Long Bridge scenario, the more accelerated "transition bridge" scenarios for Strategic Transition and Aggressive Transition have potentially significant impacts for natural gas and LNG production, pricing, and trade, and for generation costs and carbon emissions in the electricity sector. To evaluate these impacts, we ran the three scenarios through our global gas and power model.[5] In particular, we focus on BAU, carbon tax, and fracking ban as the central pillars of these scenarios. The central assumptions of each transition scenario with respect to carbon taxes, renewable energy stimulus and growth, and/or fracking ban are presented in Table 1:

Table 1: US Energy Transition Scenarios

BRG Scenarios	Assumptions
The Long Bridge (BAU)	- Business as usual, assuming no substantial changes to current energy and environmental policy. Assumes renewable generation capacity will reach 425 GW by 2030.
Strategic Transition (carbon tax)	- Based on the Energy Innovation and Carbon Dividend Act, which we assume will start in 2022 at $25 per metric ton of CO_2, increases by $10 a year, and plateaus at $100 dollars per metric ton of CO_2. - Assumes renewable generation capacity will reach 744 GW by 2030, requiring an annual average investment of $60 billion (at average renewable installation costs of $1,492/Kw).[6]
Aggressive Transition (fracking ban)	- Based on a fracking ban in 2025 to all new drilling sites, including federal land. Only existing fields can continue to drill. - Assumes renewable generation capacity will reach 504 GW by 2030, requiring an average annual investment of $34 billion (at average installation costs of $1,535/Kw).[7]

5 BRG's global gas and power model, LNG Horizon, is an integrated global model that is used to analyze and forecast natural gas and LNG markets and prices worldwide. Find out more at thinkbrg.com/energy/brgdrive. To analyze the impact of each scenario on natural gas markets and prices, LNG trade, US coal and natural gas power generation economics, carbon emissions, and other factors, we utilized as the basis for renewable energy deployment EIA's Alternative Low Oil and Gas Supply case for our Aggressive Transition scenario and EIA's Alternative Carbon Tax $35 case for our Strategic Transition scenario.

6 Based on EIA's capital cost assessment for the 2020 Annual Energy Outlook, the installed capital cost for onshore wind is $1,265/Kw, for offshore wind $4,377/Kw, and for solar $1,313/Kw. Out of the total 486 GW required by 2030 to reach 744 GW of renewable capacity, we assume that solar and onshore wind technologies are developed and deployed in approximate equal capacities, while offshore wind reaches 30 GW (per the American Wind Energy Association high case forecast) in the Strategic Transition carbon tax case, yielding a weighted average installed cost for all renewable energy sources of $1,492/Kw.

7 Based on EIA's capital cost assessment for the 2020 Annual Energy Outlook, the installed capital cost for onshore wind is $1,265/Kw, for offshore wind $4,377/Kw, and for solar $1,313/Kw. Out of the total 271 GW required by 2030 to reach 504 GW of renewable capacity, we assume that solar and onshore wind technologies are developed and deployed in approximate equal capacities, while offshore wind reaches 20 GW (per the American Wind Energy Association base case forecast) in the Aggressive Transition fracking ban case, yielding a weighted average installed cost for all renewable energy sources of $1,535/Kw.

Transition Scenario Impacts

As set forth below, the results of this scenario analysis for US natural gas production and prices, LNG trade, and power generation costs and carbon emissions are striking. A key conclusion of our analysis is that under a Strategic Transition, natural gas production actually *increases,* and it does so with limited price impacts and substantial GHG benefits.

US natural gas production

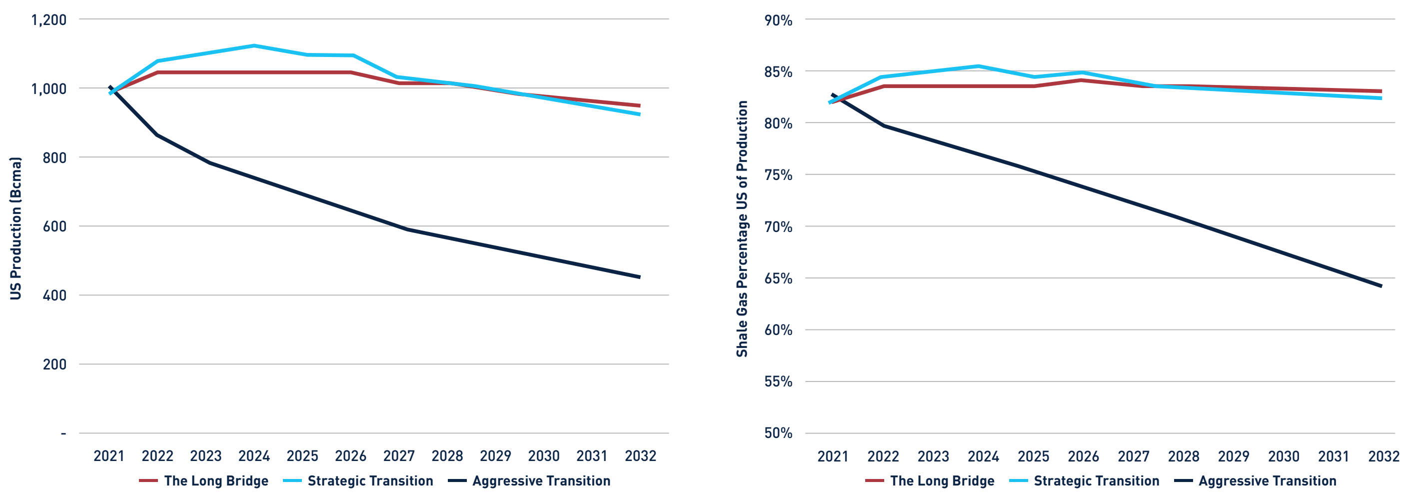
As compared to the Long Bridge (BAU) scenario, there is a slight midterm increase in natural gas production resulting from the escalating carbon tax in the Strategic Transition (carbon tax) scenario. This results from the accelerated shutdown of coal-fired generation, which are rendered uneconomic by the carbon tax, and the need to provide increased volumes of gas-fired baseload and renewable energy-firming power generation until renewable energy and storage investments can catch up to provide these supplies.

The Aggressive Transition (fracking ban) scenario yields more dramatic results, perhaps unsurprisingly, in the form of a sharp and sustained decline in US natural gas production. Without new drilling and fracking, shale gas production would decline quickly due to the high initial production rates and steep decline curves associated with production. Therefore, the share of US natural gas production accounted for by shale gas broadly declines.

Whereas the fracking ban in the Aggressive Transition scenario sharply and immediately reduces shale gas production, the carbon taxes in the Strategic Transition scenario keep the shale gas share slightly above the Long Bridge scenario through the 2020s before it declines. Under a Strategic Transition scenario, shale gas plays a critical role before going into a slight decline mid-decade.

These results are set forth in Figure 4.

Figure 4: US Natural Gas Production and Shale Gas Share by Scenario



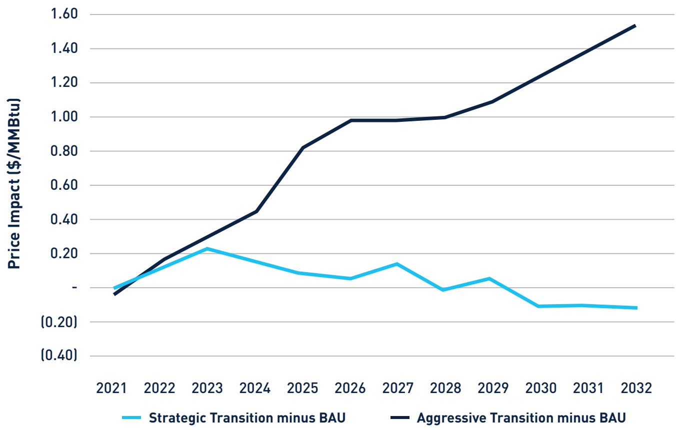
US natural gas prices

As compared to the Long Bridge scenario, the Strategic Transition scenario has a minimal impact on Henry Hub prices. Although the carbon tax increases the cost of gas-fired generation, it increases coal-fired generation more and therefore results in increased natural gas demand in the near term. Longer term, renewable power generation displaces both coal and gas more rapidly with the carbon tax.

By comparison, the Aggressive Transition scenario would have a dramatic upward impact on US natural gas prices as new shale gas drilling is curtailed. The projected Henry Hub price increases by about $1.50/MMBtu by 2032, representing almost a 50% increase compared to the Long Bridge scenario.

These results are set forth in Figure 5.

Figure 5: US Henry Hub Price Impacts By Scenario

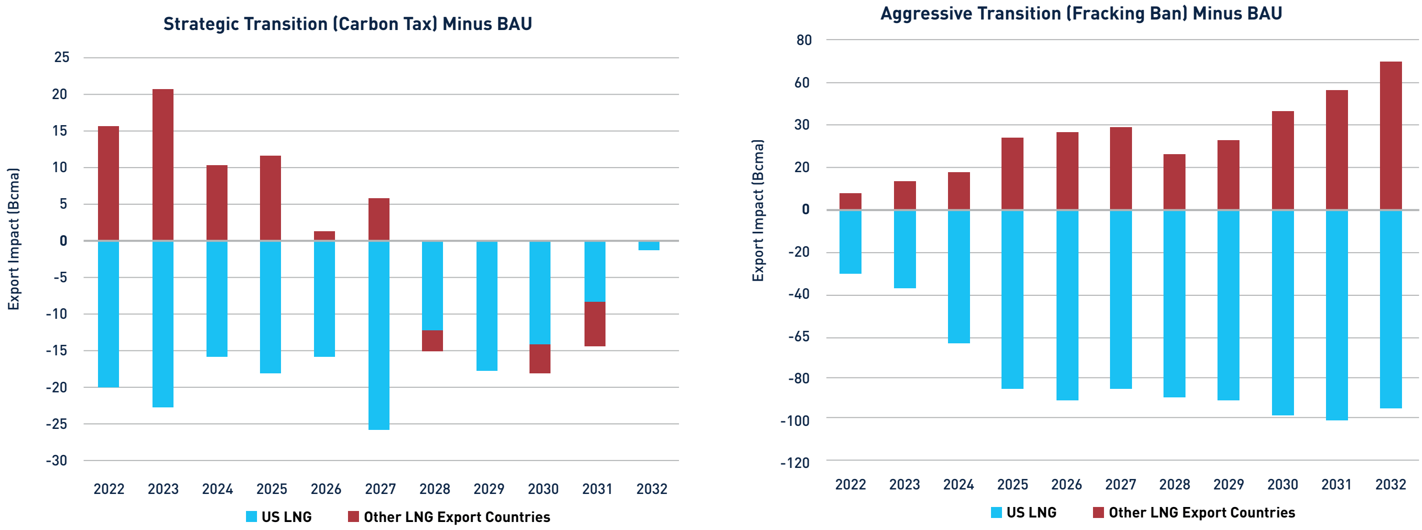


LNG exports

The various policies could have substantial impacts on US natural gas production and prices and could compromise the competitiveness of US LNG production and exports on the global market, assuming that other major LNG producers do *not* implement similar policies. Under the Strategic Transition scenario, US LNG exports would moderately decrease over the coming years, but in the Aggressive Transition scenario, US LNG exports would be decimated throughout the decade.

These scenario impacts are set forth in Figure 6. In the Strategic Transition scenario, US LNG exports decrease by as much as 25 Bcma in the first six years after the carbon tax is imposed, because the tax discourages coal-fired generation, stimulates gas-fired generation, and raises US gas and thus LNG export prices. The higher cost and lower volume of US LNG exports during these years would enable global LNG competitors to increase exports. After 2027, as carbon taxes mount, more renewable energy would enter the market, reduce gas-fired generation, and soften US gas and LNG export prices such that US LNG exports decline less after 2027 than before. In the Aggressive Transition scenario, US LNG exports would decrease by substantial levels that increase from 31 Bcma in 2022 to 100 Bcma by 2031, leaving a market vacuum that would be partially filled by increased exports from other major LNG exporters. (Increased pipeline imports and domestic production in import countries compensate for the rest of reduced US LNG exports.)

Figure 6: LNG Export Impacts by Scenario



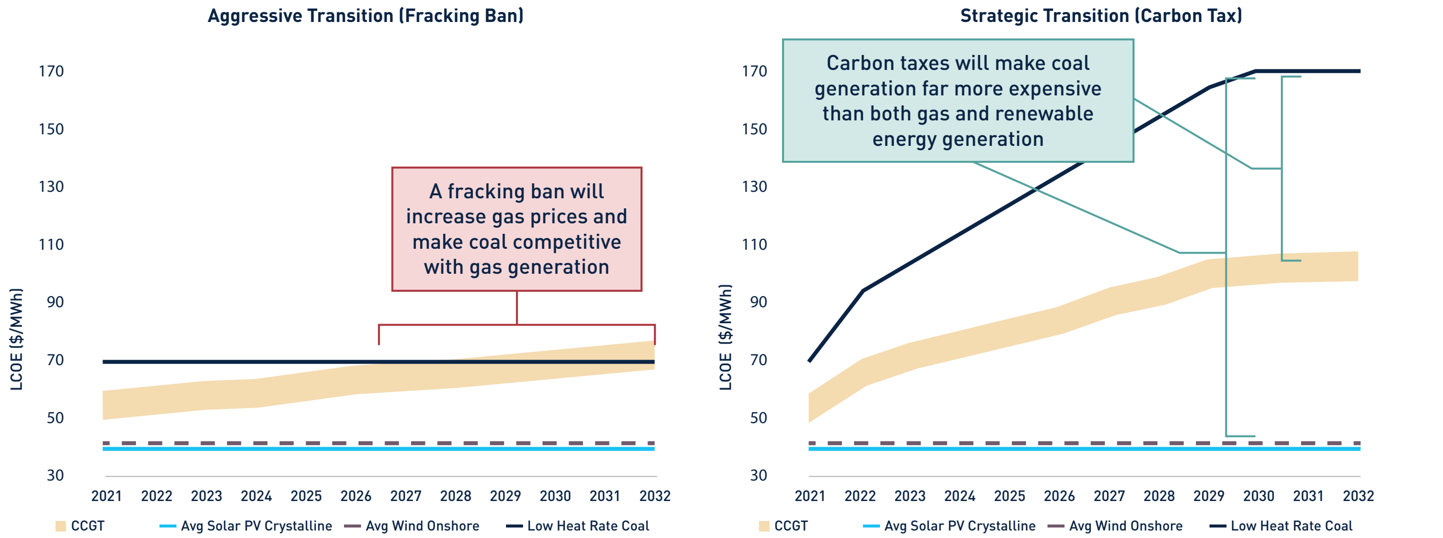
US power generation costs and competition

The Aggressive Transition scenario increases US natural gas prices and the cost of natural gas-fired power generation, thereby reducing its competitiveness with coal-fired generation and renewable energy, both of which tend to have more predictable generation economics than natural gas generation. The significant natural gas price increases not only make natural gas generation increasingly uncompetitive with renewable energy,[8] but by 2027 also make the LCOE of the least efficient natural gas-fired generation less competitive than the LCOE of the most efficient coal-fired generation. Without additional policies to drastically scale up clean dispatchable power generation, such as energy storage batteries and/or green hydrogen, a fracking ban could have the perverse effect of increasing utilization of coal plants and delaying coal retirement. This would be counterproductive, because in addition to emitting twice as much CO_2 per MWh as natural gas combined cycle gas turbines (CCGTs) (Union of Concerned Scientists, 2014), coal plants also are operationally inflexible and poorly suited to provide the flexible power generation required to facilitate large-scale utilization of renewable energy.

Under the carbon taxes in the Strategic Transition scenario, natural gas-fired plants will always be more competitive than coal, because natural gas prices do not vary that much as compared to the base case.

The implications of these scenarios for the LCOE levels of competing coal, natural gas, and renewable energy generation sources are illustrated in Figure 7.

Figure 7: Power Generation Cost Implications by Scenario



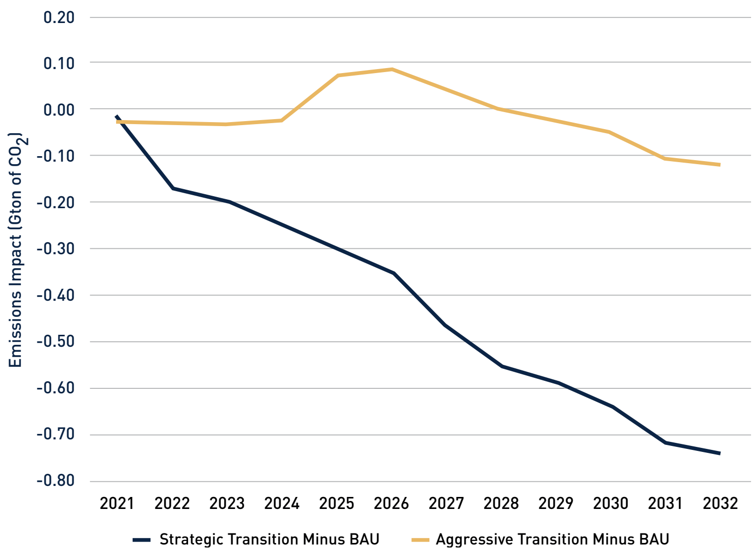
8 Price sensitivity calculations are based on Lazard's LCOE report (Lazard, 2019), using our forecasted Henry Hub prices for natural gas CCGT technology.

US power-sector CO_2 emissions

The counterproductive effects of the Aggressive Transition fracking ban on power generation economics would yield even less desirable results for CO_2 emissions. The CO_2 results of the Strategic Transition and Aggressive Transition scenarios are very different in scale compared to the Long Bridge scenario, as apparent in Figure 8.

- The Strategic Transition carbon taxes cause CO_2 emissions to decline rapidly and significantly over the coming decade, as the combination of increased natural gas and renewable energy generation drive coal-fired generation rapidly out of the market.
- The Aggressive Transition fracking ban forces natural gas out of the market, increasing natural gas prices sharply, and constraining gas-fired generation before renewable energy and storage can fill the generation void. This results in higher gas and power prices and a more prolonged process of coal-generation retirements. As a result, the Aggressive Transition results in CO_2 emissions increasing through mid-decade and then declining slightly by the end of the decade. Overall, these CO_2 reductions are far lower than those of the Strategic Transition scenario.

Figure 8: Power Sector CO_2 Emissions Impacts by Scenario



This analysis indicates that over the coming decade, a carbon tax would be a far more effective tool for reducing power-sector CO_2 emissions, whereas a fracking ban would have unintended negative consequences.

In other words, the Strategic Transition scenario is better suited to effect a swift and environmentally beneficial energy transition. The Aggressive Transition scenario could have the perverse effect of increasing coal-fired generation and CO_2 emissions in the near term by seeking to force too much natural gas out of the market too soon.

Staying the Course for a Strategic Transition

The foregoing scenario analysis yields clear conclusions and suggests that a market-based approach, rather than a mandate, will yield the best results. Above all, our analysis indicates that:

- The Long Bridge (BAU) scenario has the highest GHG emissions over the coming decade and results in only marginally lower gas prices than the Strategic Transition scenario. Although the Long Bridge scenario features the highest levels of LNG exports, it does not feature the same level of renewable energy development and penetration as the Strategic Transition scenario, and as a result it does not achieve the same reductions in natural gas and power prices or GHG emissions. The energy price reductions would stimulate industrial production and enhance the competitiveness of US exports.
- The Strategic Transition scenario yields a smooth transition to a less carbon-intensive economy—with comparable natural gas production, lower natural gas prices, lower short-term but equivalent long-term LNG exports, more competitive power generation economics, and lower GHG emissions than BAU. It is superior with respect to environmental benefits and economic costs than the rapid Aggressive Transition scenario.
- The Aggressive Transition scenario is economically unfavorable and environmentally counterproductive. In addition to green stimulus, it halts future fracking so that natural gas prices rise sharply in the future. As a result, the balance shifts toward coal over gas generation and competitive costs over the time period needed for massification of renewable energy, storage, transmission, and smart-grid technologies. This scenario leads to a reversal of the coal to gas transition in power generation and vast increases in carbon emissions. The increased US natural gas prices also result in plummeting US LNG exports to the benefit of foreign competitors, and would similarly penalize industrial production and diminish US trade competitiveness. By seeking to accelerate and complete the energy transition in the fastest possible time, it goes too fast too soon and yields counterproductive environmental and economic results.

On balance, these results indicate that we have come far in crossing the energy transition bridge built upon the use of natural gas as a bridge fuel—but that we still have a decade or more of continued, substantial reliance on natural gas to achieve the energy transition to a zero-carbon future. Over recent decades, massive development of natural gas- and gas-fired generation have stimulated a substantial reduction in coal-fired generation and facilitated the early development and implementation of increasingly economic and efficient renewable energy technologies. But we have not yet arrived at a jumping-off point to rapidly achieve GHG-free power generation and industrial production in the near term. The US still has over 200 GW of coal-fired generation that has yet to be retired, and renewable energy storage technologies are not mature and cost effective enough that renewable energy can rapidly replace and efficiently and reliably serve all fossil fuel power generation. Racing or jumping off the energy transition bridge now would be folly, defeating the purpose of reducing GHG emissions and yielding negative economic impacts.

We need to stay the course of pursuing a strategic, stepwise energy transition built upon first retiring all coal-fired generation and then replacing it with renewable energy where possible and natural gas where necessary. Only after that objective is complete will it make sense to replace natural gas with renewable energy. Given the additional technological development and massive scale of investment required, this will be a project of at least one and perhaps two decades. During that time, natural gas must continue to serve as a strategic pillar that, along with rapid deployment of renewable energy and storage technologies, will enable completing the energy transition to a carbon-free economy in an effective, orderly, and economically manageable fashion.

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