GAS BOOM POSES CHALLENGES

FOR RENEWABLES AND NUCLEAR

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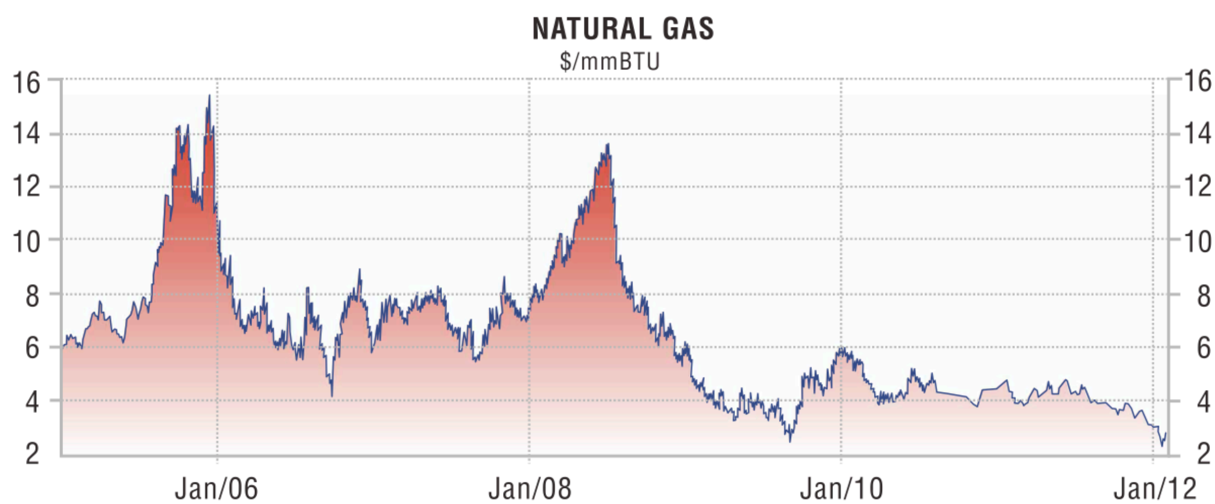
→ SUMMARY ←

The combination of falling natural gas prices and a scheduled, precipitous decline in federal support for clean energy technologies foreshadows new challenges for wind, solar, and nuclear energy markets in the United States.

From a high of $13 per million British Thermal Units (mmBTU) in 2008, natural gas prices have plummeted to below $2.50 per mmBTU today and are likely to stay in the $3-4 range over the next several years. Ultimately, we project that given the marginal production costs of domestic gas supplies, gas prices over the medium term are likely to settle within a $4-6 per mmBTU band, still well below levels prior to the North American shale gas boom.

Figure 1

Historic Natural Gas Prices

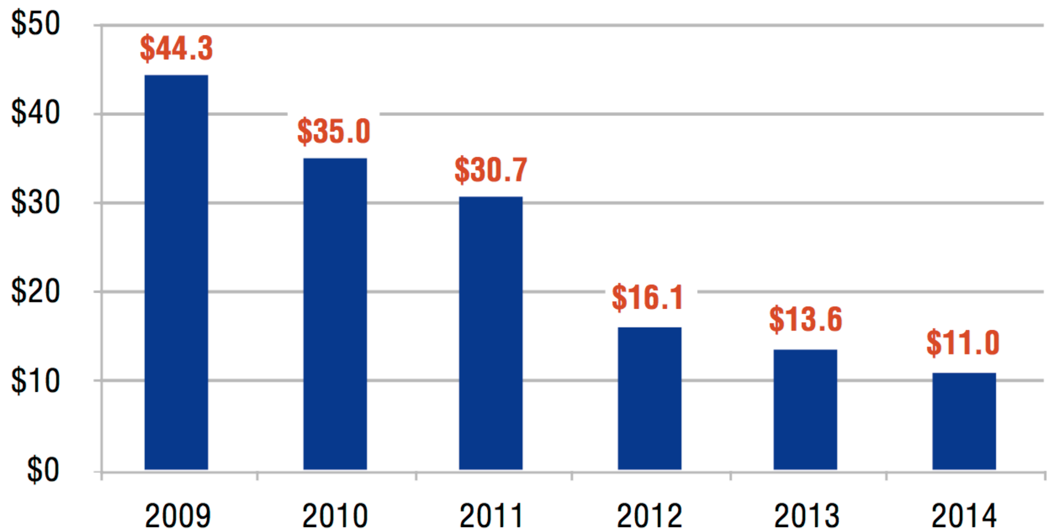


Source: NYMEX - www.tradingeconomics.com

At the same time, a temporary period of generous federal support for clean energy technologies – in the form of direct grants, loan guarantees, tax credits, and other subsidy programs, many of them initiated or expanded by the American Recovery and Reinvestment Act of 2009 – is poised to end. Unless congressional action is taken, annual federal expenditures on clean technology segments will fall 75 percent from 2009 to 2014.[1]

Figure 2

Annual Federal Clean Tech Spending 2009-2014 (billions)



Source: "Beyond Boom and Bust: Putting Clean Tech on a Path to Subsidy Independence," April 2012.

As this analysis illustrates, the combination of low-cost natural gas and declining federal incentives will make it more difficult for renewable technologies like wind and solar to compete in electricity markets without subsidy, except in relatively constrained locations. Meanwhile, any American nuclear renaissance will be hard to sustain if gas prices remain low and the capital requirements of nuclear plants do not fall significantly.

In order for zero-carbon energy to contribute significantly to the United States' national energy portfolio, significant innovations and cost declines must be achieved. Improvements on the order needed to mitigate carbon emissions and replace incumbent fossil energy technologies will require a public policy regime that drives these innovations through RD&D, commercialization policy, support for advanced manufacturing, smart deployment that drives cost declines, and advanced energy education.

For more detailed policy discussion, see "Beyond Boom and Bust: Putting Clean Tech on a Path to Subsidy Independence," April 2011, at http://bit.ly/Beyond_Boom_and_Bust.

→ ANALYSIS ←

NATURAL GAS-FIRED GENERATION

With gas prices expected to hover in the $3-6 per mmBTU range for the foreseeable future,[2] we project the following levelized costs for electricity generated by both advanced combined cycle gas plants (typically used for baseload and intermediate or load-following generation) and plants using conventional combustion turbines (typically used for peak power generation).[3] We also include electricity generation costs at $2 per mmBTU and at $7-8 per mmBTU as higher-end possibilities, should estimates of shale gas supplies or production costs prove either too conservative or generous.

Figure 3

Estimated Levelized Cost for Natural Gas–Fired Electricity

Natural Gas Prices ($/mmBTU)	Cost for Advanced Combined Cycle Gas Plant ($/MWh)	Cost for Conventional Combustion Turbine Plant ($/MWh)
2	45.1	60.5
3	52.1	71.5
4	59.1	81.5
5	66.1	92.5
6	72.1	103.5
7	79.1	114.5
8	86.1	125.5

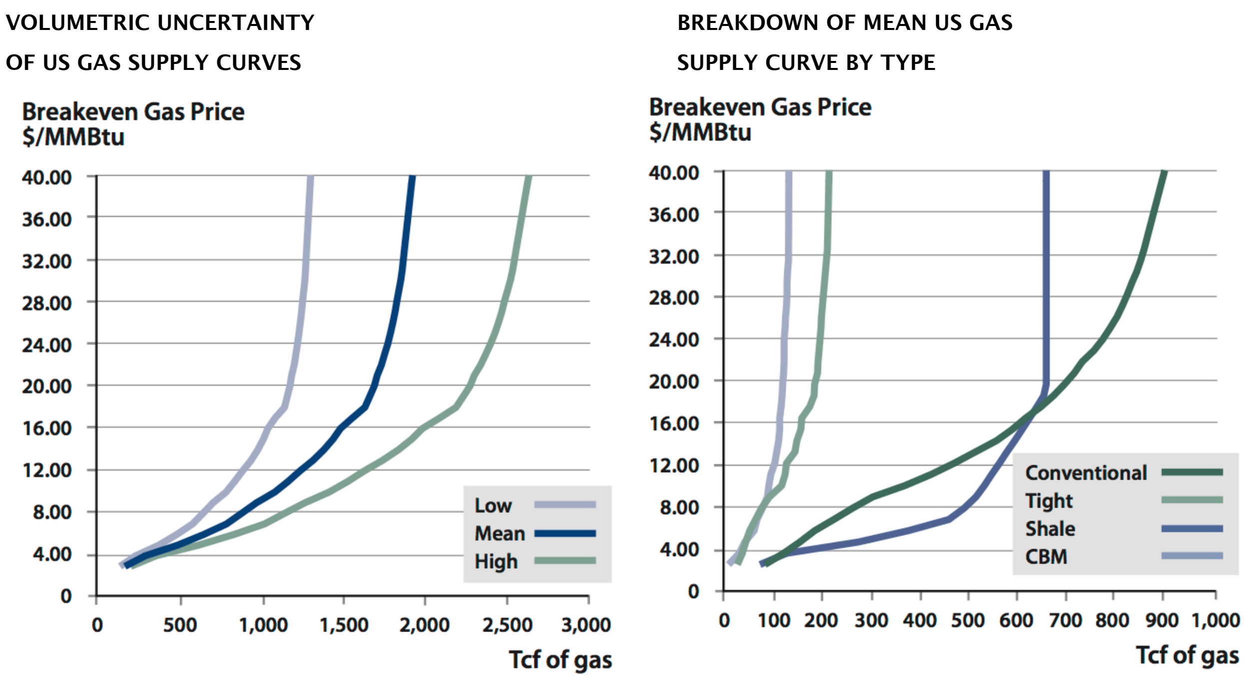
Source: Breakthrough Institute Analysis

Current market prices for gas of as low as $2.15 per mmBTU are now well below the marginal production costs of many shale gas wells and most conventional gas wells (see Figure 4 below). Some gas producers are already reacting to depressed market prices by halting production at existing wells, and by shifting exploration away from new dry gas wells.[4] Based on industry testimony and estimates of US natural gas supply curves,[5] we believe current prices below $3 per mmBTU are unsustainable and predict that North American natural gas prices are most likely to rebound slightly towards the $3-4 per mmBTU range for the next few years. Prices in this range would yield levelized costs for combined cycle gas-fired power plants in the $52-59 per megawatt-hour (MWh) range.

Over the medium-term, natural gas supply curves indicate that it's reasonable to expect prices to hover in the $4-6 per mmBTU range during the second half of the decade, which is consistent with price projections from the Energy Information Administration (EIA).[6] This would keep the levelized cost of combined cycle gas plants in the $59-72 per MWh range in the medium term.

Figure 4

Natural Gas Supply Production Curves

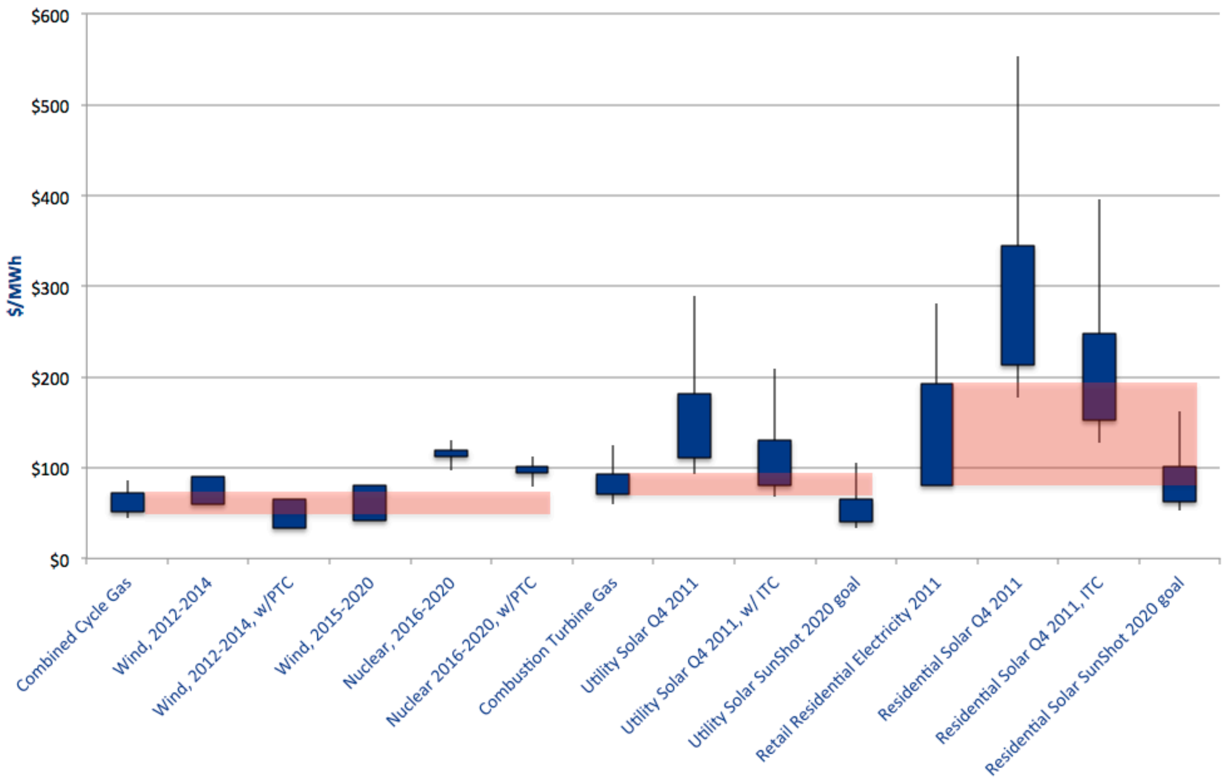


Source: "The Future of Natural Gas," Massachusetts Institute of Technology, 2011.

NATURAL GAS VS. ZERO-CARBON POWER TECHNOLOGIES

Figure 5

Levelized Cost of Electricity by Technology



Source: Breakthrough Institute Analysis. Red bars indicate the price ranges clean technologies compete against.

A. Wind Power

The current unsubsidized cost for wind-generated electricity is $60-90 per MWh,[7] depending on the available wind resource at various locations (figures provided for Class 3 and above wind sites). In contrast, prices for combined cycle gas-fired electricity fall in the $52-72 range under likely gas prices. On an unsubsidized basis, wind is therefore only competitive with natural gas-fired generation at the best wind sites with access to existing transmission lines, or in markets where state renewable portfolio mandates create market demand for wind power despite its marginally higher costs.

At present, the production tax credit (PTC) for wind power production, combined with the modified accelerated cost recovery system (MACRS) for depreciation, brings the cost of wind electricity down to an estimated range of $33-65 per MWh,[8] making wind power broadly competitive with new gas-fired generation and supporting robust market expansion. However, the PTC is currently scheduled to expire at the end of 2012, which is expected to prompt a sizable contraction in the domestic wind market.[9] This follows the expiration of the Section 1603 Treasury grant program at the end of 2011, which forced wind developers to return to the complex and more expensive tax equity market to monetize the value of the PTC and secure project finance, raising cost of capital and potentially constraining available investment for wind energy projects.[10]

We note that these levelized cost estimates exclude any costs associated with integrating variable wind generation into utility systems. However, the near-term costs of wind integration are expected to be fairly marginal. Utility studies reliably conclude that wind integration costs generally fall below $10 per MWh, and often closer to $5 per MWh, for wind power capacity penetrations up to around 40 percent of utility system capacity.[11] To the degree that utility operators begin to charge wind generators for integration costs, as some utilities have already begun to do, this will add incrementally to the cost of wind generation.[12] Aside from integration costs, wind suffers from inferior resource adequacy and "capacity credit" — the larger a contribution wind makes to a region's electricity portfolio, the larger the effect of intermittent power — leading to further difficulties in markets with high wind generation.[13]

In subsequent years, analysts estimate that incremental turbine technology improvements have the potential to decrease costs by 10-30 percent in the 2015-2020 period, bringing the unsubsidized levelized cost into the $42-67 per MWh range.[14] If such innovation occurs, and if natural gas prices inch upwards, wind power could be broadly competitive in that time frame.[15]

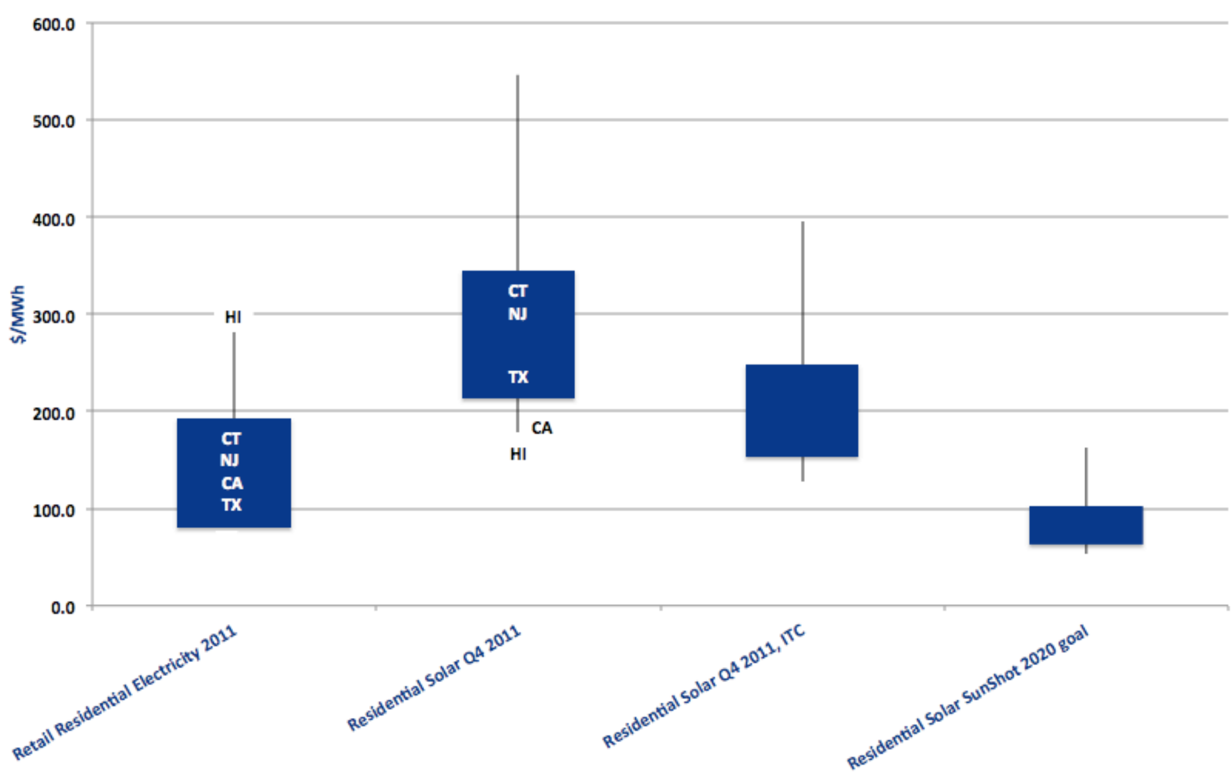
B. Solar Power

Behind-the-meter rooftop solar installations do not compete directly with natural gas-fired electricity, but must rather reach costs competitive with retail electricity prices, a point often referred to as "grid parity." After a 60% decline in module prices in 2011 alone, typical levelized costs for residential rooftop solar photovoltaic (PV) power systems in late 2011 ranged between $213 and $345 per MWh,[16] while the best commercial and residential sites with high solar resource may fall to as low as $178 per MWh.[17] After significant recent cost reductions, rooftop solar installations on residential or commercial buildings are therefore now at or near unsubsidized prices that are competitive with retail electricity rates in Hawaii, where average residential electricity prices are $281 per MWh. Depending on the pace of innovation and cost reductions, rooftop solar is also within range of cost parity in certain US markets with high average electricity prices and/or high solar irradiance, including California, Texas, Florida, and Nevada. Solar is approaching grid parity in a set of Northeastern states as well (Connecticut, New York, New Hampshire, and New Jersey), where retail rates exceed $160 per MWh and solar irradiance is modestly high (see Figure 6).[18]

The federal investment tax credit (ITC) for solar combines with numerous state and local inventive programs to open up wider opportunities for solar in select markets. By our estimates, the ITC brings the levelized cost of solar electricity to between $153 and $248 per MWh, pushing rates into cost parity in states with high electricity prices. Recent subsidized projects have achieved rates even lower than this: reverse-auction policy mechanisms in California have initiated 20-year contracts as low as $89 per MWh, inclusive of state and federal subsidies and incentives.[19]

Figure 6

Nearing Grid Parity: Solar Electricity Costs and Retail Electricity Rates



Source: Breakthrough Institute Analysis. State residential electricity prices are from EIA data. Estimates for state solar energy costs are approximations based on an index of residential electricity rates, average solar irradiance, and maximum capacity factors.

Large, utility-scale solar power plants must compete more directly with gas-fired generating units in wholesale power markets. Solar typically competes most closely with peaking power plants of the combustion turbine variety, with estimated costs in the $71.5-103.5 per MWh range at likely gas prices. We estimate levelized costs for utility-scale central-station solar PV range from $111 to $289 per MWh. While utility-scale solar installations typically achieve lower costs than rooftop installations due to greater economies of scale, solar power remains more costly (absent subsidies) than new gas-fired generation in wholesale power markets, except perhaps in regions with the highest solar resource. Absent subsidies, solar markets in the vast majority of regional markets would thus contract substantially.

Luckily for solar power producers, solar currently benefits from the 30 percent investment tax credit not scheduled to expire until 2016, helping make solar cost competitive in a much wider range of markets. The ITC pushes the levelized cost of utility-scale solar to $81 to $131 per MWh.[20] Solar thus has a more positive near-term outlook than wind power, given the uncertainty surrounding the fate of PTC benefiting wind developers. Solar will likely continue to expand its market size throughout the coming decade, particularly in regions with high solar irradiance, high retail electricity prices, and/or generous state incentives or financing structures. That said, the recently-expired Section 1603 Treasury grants has begun to make solar project financing more expensive, and solar projects now face the same tax equity financing challenges as wind power developers.[21]

By the end of the decade, solar may be beyond “grid parity” in a large portion of all retail electricity market segments in the United States.[22] However, even with further cost reductions of this magnitude, competitive, subsidy-independent solar markets will remain largely constrained to retail, behind-the-meter installations. An MIT study projects line-of-sight module costs in 2020 at $0.89 per watt (W), and accelerations in materials and efficiency improvements could drive module costs down to $0.52 per watt, resulting in electricity costs at $90 per MWh.[23] In comparison, DOE’s SunShot initiative’s stated goal is total installed costs (module and non-module costs) for solar between $1.00 per watt for utility-scale and $1.50 per watt for residential scale, which if achieved would result in levelized costs as low as $40-102 per MWh.

While solar markets enjoy continued policy support for the time being, achieving true subsidy independence and sustainable market expansion will require industry to aggressively pursue cost reductions and performance improvements across the solar value chain.

C. Nuclear Power

The EIA estimates the levelized cost of electricity from new nuclear power plants constructed in the 2016-2020 period at around $114 per MWh.[24] Due to overall uncertainty about the construction costs of the first new nuclear power plants in the United States in decades, we present this estimate with a plus-or-minus 15% error bar in Figure 3 above.

As a recent MIT Energy Initiative report shows, "nuclear power can be economically competitive under appropriate market conditions."[25] However, two of the most substantial obstacles to nuclear development in the United States are comparatively low natural gas prices and the high cost of financing for new nuclear builds, both of which figure powerfully into levelized cost comparisons.

The two Westinghouse AP1000 reactors currently under construction by Georgia Power are expected to have total overnight capital costs in the $5,000-6,000 per kW range, consistent with EIA capital cost assumptions used in their levelized cost estimates. Thus, the first few nuclear power plants built in the United States are likely to have levelized costs of more than $100 per MWh. An $18 per MWh federal production tax credit, available over the first eight years of generation for the first 6,000 MW of new nuclear power capacity, helps bring this price down somewhat. However, at those costs, new nuclear power plants will remain uncompetitive with new natural gas-fired generation at likely gas prices. As Exelon CEO John Rowe, whose company owns one-seventh of the nuclear generating capacity in the United States, recently noted, "Neither new nuclear, coal with carbon capture and sequestration, wind nor solar are economic [with current gas prices]."[26]

It is worth noting that due to labor cost differentials and financial and regulatory costs in the United States, the total systems cost of Georgia Power's new nuclear power units is estimated to be over 50 percent more expensive than four identical AP1000 reactors now being built in China, which have expected overnight capital costs between $1,700-2,400 per kW plus financing costs, which are reliably lower than in the United States.[27]

It is critical to note the substantial role that the cost of financing contributes to new nuclear builds. Different financing structures in the US result in wide differences in total construction costs. The planned Turkey Point, Florida reactors are expected to cost between 20 and 25 percent more in construction compared to the Vogtle reactors in Georgia, the latter of which use progressive ratepayer financing during construction. Divergences in construction costs for identical reactors between China and the United States stem in part from similar financing constraints.[28]

New nuclear power plant construction costs within a given nation have sometimes experienced fairly rapid learning curves after the first few plants are built (e.g. in South Korea, Japan, China), and deployment of next-generation nuclear designs could capitalize on these learning curves to potentially achieve competitive levelized costs. This is a tall order, however, particularly for current-generation designs: learning curves would have to approach 20 to 30 percent in order for new nuclear power plant levelized costs to achieve costs of of $67-104 per MWh. This would still be more expensive than combined-cycle gas-fired units at current gas prices but would possibly prove competitive if gas prices rise in the future. The prospects for a nuclear renaissance in the United States are thus significantly dimmed by today's very low natural gas prices.

→ CONCLUSION ←

In summary, zero-carbon power sources require continued improvements in technology costs and performance to achieve full market competitiveness. These challenges are amplified by astonishingly low natural gas prices in the wake of the ongoing American shale revolution.However, lessons for zero-carbon energy advocates can be found in the history of shale gas itself: just as the sustained public and private research and commercialization efforts drove breakthrough innovations in hydraulic fracturing and microseismic mapping technologies that enabled the shale revolution,[29] so must the nation initiate smart and strategic public-private partnerships to drive technical improvements and cost-declines in solar, wind, nuclear, and other zero-carbon energy technologies.

The United States is not entirely lacking in such policy. Important advances have been made as a result of smart RD&D efforts like the Advanced Research Projects Agency-Energy and the DOE-wide SunShot Initiative. However, as we document in our report "Beyond Boom and Bust," the bulk of America's clean energy support regime is scheduled for expiration. In order to counteract the daunting obstacles facing clean energy today, the United States must create policies that simultaneously drive market growth *and* continual technological improvement.

Significant progress has already been made. But considering the competition of newly cheap and abundant natural gas and the technical and infrastructural challenges facing clean energy today, more innovation is needed to secure a zero-carbon energy future.

→ NOTES AND CITATIONS ←

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