NATURAL GAS SUPPLY AND NORTHEAST BASELOAD POWER PLANTS

Research Summary Prepared by

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The U.S. has substantial natural gas resources. This has led to proposals to expand the use of natural gas beyond its current consumption levels for space/water heating and electricity generation. The proposals call to expand the use of natural gas as a transportation fuel to reduce oil consumption and for added electricity supply to replace baseload coal and nuclear power plants. Before natural gas use is expanded, there is a need to evaluate long-term natural gas supply/demand projections since natural gas industry estimates may be overly optimistic.

OPTIONS FOR NATURAL GAS USE INCLUDE:

A) Continuing consumption at current uses and rates. This path fails to address oil reduction, replacement of coal and nuclear electricity supply, or reduction of CO_2 emissions.
B) Expand natural gas use as a transportation fuel to replace oil and for added electricity supply to replace coal and nuclear electricity. This path leads to a large increase in natural gas use.
C) Construction of a Wind/Solar-CAES electricity system combined with an interstate HVDC electricity transmission system. This path minimizes long-term natural gas use and prices.

NATURAL GAS SUPPLY RESEARCH FINDINGS:

1) The production rates of conventional U.S. natural gas resources are in decline.
2) Future U.S. natural gas supplies and prices will be driven by development of the core areas of the nation's shale gas plays.
    a. The core area of a shale gas play is the highest quality portion of the shale formation with the best average well production rates and lowest wellhead gas prices.
    b. Shale gas production companies concentrate well development in the core areas of shale gas plays to achieve highest average well production rates.
    c. When the core areas of all shale gas plays are saturated with well development, average well production rates decrease, and wellhead natural gas prices increase.
        i. Core area well development is with wells having 80-100 acre well spacing.
        ii. Core area well saturation is found by dividing the area by 80-100 acre wells.
3) Natural gas supplies are sufficient to sustain current consumption uses and levels post-2040.
4) If natural gas supplies are allocated to expand natural gas use as a transportation fuel or for added electricity supply, then natural gas well production rates will decline by 2040 and wellhead gas prices will likely increase to greater than $10 per Mcf (thousand cubic feet).
5) Shale gas supply may be constrained in response to the growing concerns about hydraulic fracturing causing pollution of potable water supplies and waste-water disposal issues.
6) If U.S. natural gas is exported, then U.S. natural gas supplies will diminish at a faster rate.
7) These factors suggest adoption of policies that enhance rather than diminish long-term natural gas supply.

One such policy is the large-scale expansion of wind and solar (PV) electricity production with the variable wind and solar electricity supply firmed with compressed air energy (CAES) power plants, which have a very low natural gas consumption rate. Wind/Solar-CAES electricity is cost competitive with electricity from natural gas combined-cycle power plants with a wellhead gas price of $10/Mcf. The benefits of the Wind/Solar-CAES electricity path are: 1) a reduction in natural gas use by over three trillion cubic feet per year; and 2) the large-scale adoption of electric vehicles with a corresponding 50+% reduction in oil consumption and CO_2 emissions.

BASELOAD POWER PLANT OPTIONS:

1) Natural Gas Combined-Cycle Power Plants (NGCC).
    a. Fuel consumption rate is 7,000 Btu/kWh of electricity produced (high heat value).
    b. Cost of natural gas is a significant component of electricity price.
    c. Electricity price is the average price of electricity produced by new (financed) and old (amortized) power plants. Power plants selected today will be fully amortized post-2040. Hence, natural gas prices post-2040 will affect the post-amortization value of NGCC power plants that are proposed to be built today.
    d. Shale gas is the marginal unit of natural gas supply. It follows that natural gas prices to electric generators are determined by shale gas wellhead prices.
        i. The trajectory of long-term natural gas prices will be determined by the timing of well saturation in the core area of the Marcellus shale gas play.
            1. The high production, core area of the Marcellus play is in northeast Pennsylvania counties and south-central New York counties.
            2. The core area of the Marcellus shale gas play is about twice the size of the core area of the next largest shale gas play, the Haynesville. It follows that well saturation of the core areas of all other shale gas plays will occur before it occurs in the Marcellus.
        ii. Based on EIA projections of annual shale gas production levels from 2010 to 2035, well saturation of the Marcellus core area will occur by 2040.
        iii. When well saturation of the core areas of U.S. shale gas plays occurs and production is left to the lower quality, non-core areas of the shale gas plays, average well production rates will decrease by about 50%, and wellhead gas prices will increase by about 50% to over $10/Mcf. This is likely to occur by 2040, if natural gas use is expanded, or it is exported.
    e. A carbon tax will also affect future electricity prices. A carbon tax will increase electricity price commensurate with a power plant's fuel consumption rate.
2) Wind power firmed by combined-cycle natural gas (NGCC) power plants. The aggregate fuel consumption rate for Wind-NGCC power supply is about 4,000 Btu/kWh.
3) Wind power firmed by compressed air energy storage (CAES) power plants. The aggregate fuel consumption rate for Wind-CAES power supply is only about 1,000 Btu/kWh. Wind-CAES plants insulate long-term electricity prices from natural gas price increases.
    a. The lowest cost baseload capacity credit Wind-CAES power supply for the Northeast is using wind power produced in the Midwest (Iowa, South Dakota, and North Dakota). The Midwest wind electricity is gathered at CAES plant nodes, and the baseload capacity credit Wind-CAES power is delivered to markets in the Northeast (*e.g.*, Norwalk, Connecticut switching station) via HVDC power lines.
4) Coal power plants.
    a. Pulverized coal power plants with and without carbon capture and storage (CCS).
        i. Coal plants with CCS are required in the Northeast, and the electricity price is greater than all other baseload power plant options, except nuclear.
    b. Coal integrated gasification combined-cycle (IGCC) plants with and without CCS.
        i. Coal plants with CCS are required, and electricity price is greater than all other baseload power plant options except pulverized coal and nuclear.
5) Nuclear power plants are the most expensive, and safety issues are a major concern.

References (available on ASAP's website, www.solarplan.org, in the Research folder)

Mason, Jame E. 2011. Shale gas potential as a transportation fuel and for added electricity supply with implications for wind and solar Energy. Research article prepared for the American Solar Action Plan and the Hydrogen Research Institute, Farmingdale, NY, 10 June 2011.

Mason, James E. and Cristina L. Archer. In review. Baseload, low-cost, low-CO_2, electricity from wind via compressed air energy storage (caes). Submitted to *Renewable & Sustainable Energy Review*, 1 March 2011.