



*How Less Became More:
Wind, Power and Unintended Consequences
in the Colorado Energy Market*
BENTEK Energy, LLC

Executive Summary

Study Objectives:

- To improve understanding of the electricity markets in Colorado and the Intermountain West
- To understand how wind, coal, and natural gas interact and what that interaction means for future natural gas use in electricity generation
- To help generate productive and informed discussions on how our nation will meet its future energy needs through the integration of various energy resources

Key Findings:

- State renewable portfolio standards (RPS) mandate that wind energy be considered a “must take” resource. As such, when wind blows, generation from coal and natural gas must be adjusted to accommodate wind generation. This adjustment, called cycling, is defined as the sudden increase or decrease in generation.
- Most coal plants are not designed to be cycled, and doing so makes their operations inefficient, increasing SO₂, NO_x and CO₂ emissions.
- Contrary to their stated goals, implementation of RPS in Colorado and Texas appear to be adding to the air pollution problem, especially in areas where older plants are cycled more frequently. This is particularly problematic when cycled coal facilities are located near major urban centers.
- Emissions issues related to cycling can be minimized by careful design of the generation mix. Inadequate flexible resources, such as that provided by natural gas, exacerbate the need to cycle coal, resulting in increased emissions. Alternatively, incorporating adequate flexible fuel capacity facilitates the goals of RPS without increasing emissions.

Summary

In 2004, Colorado became the 17th state to adopt renewable energy standards when voters passed Amendment 37. Colorado reaffirmed its commitment to wind and solar energy in 2007 when the Legislature passed HB 1281, increasing the requirement for utilities to purchase renewable energy

by 100%. Colorado also approved the *Climate Action Plan*, which relies on renewable energy to play a central role in the state's strategy of reducing "greenhouse gas emissions by 20% below 2005 levels by 2020"¹.

Policymakers' stated hope was that renewable energy would not only be a major tool to reduce carbon emissions, but also, by displacing conventional fuels, would reduce smog and other air pollution, presumably by reducing sulfur dioxide (SO₂) and nitrous oxides (NO_x), the principal components of ozone and smog.

This report, which examines four years of Public Service Company of Colorado (PSCO) hourly operational history, illustrates how coal cycling, which in part results from wind generation, negates the emission benefits of wind energy. Integrating an intermittent, must take resource, such as wind energy, requires PSCO to cycle its coal and natural gas-fired plants². The incidents of coal cycling have risen markedly with the introduction of 775 MW of wind capacity since 2007.

Coal-fired power plants are designed to run most efficiently at stable rates and are not well-suited to accommodate the load variability imposed by the integration with wind generation. Cycling causes coal-fired power plants to operate less efficiently, and reduces the effectiveness of their environmental control equipment, which together drive up emissions. Paradoxically, using wind energy in such a way that it forces utilities to cycle their coal generation often results in greater SO₂, NO_x and CO₂ emissions than would have occurred if less wind energy were generated and coal generation was not cycled.

An analysis of the Electric Reliability Council of Texas (ERCOT), which also operates under a RPS mandate to utilize wind energy, validates the emissions findings for PSCO. The underlying problem is the same for both PSCO and ERCOT: wind generation frequently cannot be accommodated without forcing coal-fired units to cycle.

Whereas natural gas-fired combustion turbines and combined-cycle facilities are designed to accommodate cycling, coal equipment is not. Coal boilers are designed to be operated as a base load resource – in other words, to operate at a consistent output level all the time. Because gas resources are not fully utilized to offset wind energy produced in PSCO and ERCOT, coal units are being cycled. Emission levels are increasing, not decreasing, at PSCO and ERCOT coal units because the units are being cycled to compensate for wind generation.

The results of this study help explain why PSCO's coal-fired plants located in the Denver non-attainment area have experienced an increase in SO₂, NO_x and CO₂ over the past few years. Four of the five most frequently cycled coal plants are located in proximity to Denver. The results also suggest that this problem will worsen over time unless more gas generation is utilized to absorb wind generation variability.

¹ "Colorado Climate Action Plan: A Strategy To Address Global Warming", November, 2007. P10.
http://www.colorado.gov/energy/in/uploaded_pdf/ColoradoClimateActionPlan_001.pdf

² As used in this report the term cycling refers to sudden increases or decreases in power generation output. Cycling occurs for a variety of reasons including making way for alternative generation, maintenance and/or equipment failure or sudden changes in load size.

There are national implications as well. Congress and the Obama Administration are considering a national RPS. Before such a national standard is implemented, there is a compelling need to better understand how intermittent sources of energy such as wind can be integrated with existing nuclear, coal and natural gas capacity without producing cycling-induced emissions problems.

Conclusions:

- The use of wind energy by PSCO has resulted in increased levels of SO₂, NO_x and CO₂ from coal plants in the non-attainment area. Wind-induced coal cycling in ERCOT has resulted in increased SO₂ and NO_x, with only minimal savings of CO₂.
- The mechanism driving increased emissions is the need to cycle coal facilities in order to accommodate wind generation, which is considered a “must take” resource due to the RPS mandates.
- When coal plants are cycled, the heat rate rises, resulting in higher emissions of SO₂, NO_x and CO₂ than would have been the case if the units had not been cycled. This problem can persist for up to 24 hours after cycling the facility, increasing emissions even further.

Recommendations:

Effective wind energy requires sufficient flexible natural gas generation in order to avoid cycling coal facilities. Enacting RPS's that require more than 5-10% of wind energy for electricity generation will significantly add to emissions unless more flexible natural gas generation is utilized. The report recommends:

1. Short term. (1-2 years)

Limit the utilization of wind generation to that which can be offset by cycling existing natural gas facilities.

2. Long term (Beyond 2012)

Utilities operating under RPS should consider adding significantly more combined cycle and combustion turbine gas plants to their generation mix. Adding more natural gas plants will reduce the need to cycle coal facilities in all but the most extreme situations.

This report was prepared for the Independent Petroleum Association of Mountain States (IPAMS).

About BENTEK Energy, LLC

BENTEK Energy, LLC, is the leading energy markets information company. Based in Evergreen, Colorado, BENTEK brings customers the analytical tools and competitive intelligence needed to make time-critical, bottom-line decisions in today's natural gas and power markets. Additional information about BENTEK Energy is available on the Web at www.bentekenergy.com.