Paper #4-4
IMPACT OF EPA REGULATIONS ON THE POWER SECTOR

Prepared by the EPA Regulations Team
of the
Carbon and Other End-Use Emissions Subgroup

On September 15, 2011, The National Petroleum Council (NPC) in approving its report, *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Task Groups and/or Subgroups. These Topic and White Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic and White Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 57 such working documents used in the study analyses. Also included is a roster of the Team that developed or submitted this paper. Appendix C of the final NPC report provides a complete list of the 57 Topic and White Papers and an abstract for each. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

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Abstract

This paper specifically reviews existing literature related to the impact of upcoming EPA rules on coal-fired power plants and addresses the range of potential emissions reductions and increased natural gas demand associated with replacing the coal fired generation with gas-fired generation.

Abbreviations used throughout this document

Item	Abbreviation	Note
billion	B	
billion (giga)	G	
British thermal units	Btu	
carbon dioxide	CO2	measured in tonnes
carbon dioxide equivalent	CO2e	measured in tonnes
Clean Air Transport Rule	CATR	
cubic feet	cf	
Environmental Protection Agency	EPA	
hazardous air pollutants	HAPs	
greenhouse gas	GHG	measured in tonnes
maximum achievable control technology	MACT	
mercury	Hg	
metric tonne	Tonne, Mt	
nitrogen oxides	NOx	measured in tons
short ton	Ton, t	equivalent to 0.907 tonnes
sulfur dioxide	SO2	measured in tons
thousand (mille)	M	
trillion	T	
Watt-hour	Wh	

I. Introduction

The North American Resource Development study is investigating the "contribution that natural gas can make in a transition to a lower carbon fuel mix." This paper specifically reviews existing literature related to the impact of upcoming EPA rules on coal-fired power plants and addresses the range of potential emissions reductions and increased natural gas demand associated with replacing the coal fired generation with gas-fired generation.

The power sector will be subject to several key environmental rules over the next several years, including the Clean Air Transport Rule (CATR), the Hazardous Air Pollutants (HAPs) Maximum Achievable Control Technology (MACT) rule, and potential regulations regarding cooling water intake structures and coal combustion byproducts (coal ash). Some of the new rules will be finalized in the next year or two and compliance is set to begin as early as next year for some rules and by mid to late-decade for others. Compliance costs associated with these regulations may cause some owners to retire inefficient coal-fired power plants rather than retrofit them to comply with the new environmental rules. While significant uncertainty remains surrounding the level of stringency, required emissions controls, timing of the rules, impact to grid reliability, and availability of engineering resources, several analysts have recently published research reports on the topic. These reports indicate that an average of 58 GW of coal capacity may retire by 2020, representing a potential increase in gas-fired generation of about 295 TWh.

II. Background

This section provides brief, additional details for some EPA regulations.

Clean Air Transport Rule (CATR)

The CATR was designed to improve air quality in the eastern United States and limit interstate air pollution transport. The CATR requires 31 states and the District of Columbia to reduce power plant SO2 and NOx emissions. Combined with other state and EPA actions, the CATR would reduce SO2 and NOx by 71 % and 52% below 2005 levels, respectively. The CATR replaces the Clean Air Interstate Rule (CAIR) that was vacated in 2008.

Hazardous Air Pollutants Maximum Achievable Control Technology Rule (HAPs MACT)

HAPs MACT are standards designed to reduce HAPs emissions, most notably, mercury (Hg). The EPA plans to propose standards for coal and oil utilities by March 2011 and finalize rules by November of 2011. In general, the research reports analyzed in this report assumed that some combination of flue gas desulfurization (FGD, or a scrubber), activated carbon injection (ACI) and a fabric filter will suffice.

Clean Water Act, Section 316 (b) (316b)

This section of the Clean Water Act (CWA) "requires that the location, design, construction and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." The EPA plans to release proposed rules in March 2011 and finalized rules in July 2012.

Resource Conservation and Recovery Act (RCRA)

Currently, the EPA does not regulate coal combustion byproducts (coal ash). However, RCRA gave the EPA the power to control hazardous wastes and the framework for managing non-hazardous wastes. The

EPA has proposed rules to regulate coal ash as either a hazardous or non-hazardous waste. Final rules are expected in early 2012.

III. Methodology

To conduct our analysis, we took these broad steps:

1- Compiled relevant studies and extracted available data[1]
2- Interviewed study authors to better understand their analysis and fill data gaps[2]
3- Computed ranges and averages of key statistics across all studies, including estimated coal plant capacity at risk for retirement, lost coal plant generation from retiring plants, CO2 emission reductions, and increased natural gas demand.

The 12 studies reviewed had varying assumptions and approaches. Some studies conducted qualitative assessments (e.g. filtering by age or lack of control requirements) while other studies conducted integrated energy and emissions modeling. As a study of studies, the team paid particular attention to the differences in of key variables among the studies: regulations/policies analyzed (e.g. Transport Rule, HAPs MACT, Coal Ash, Cooling Water Intake, and GHG regulation), base years, target years, heat rates, energy prices, modeling methodology, and control technology options and costs.

IV. Results

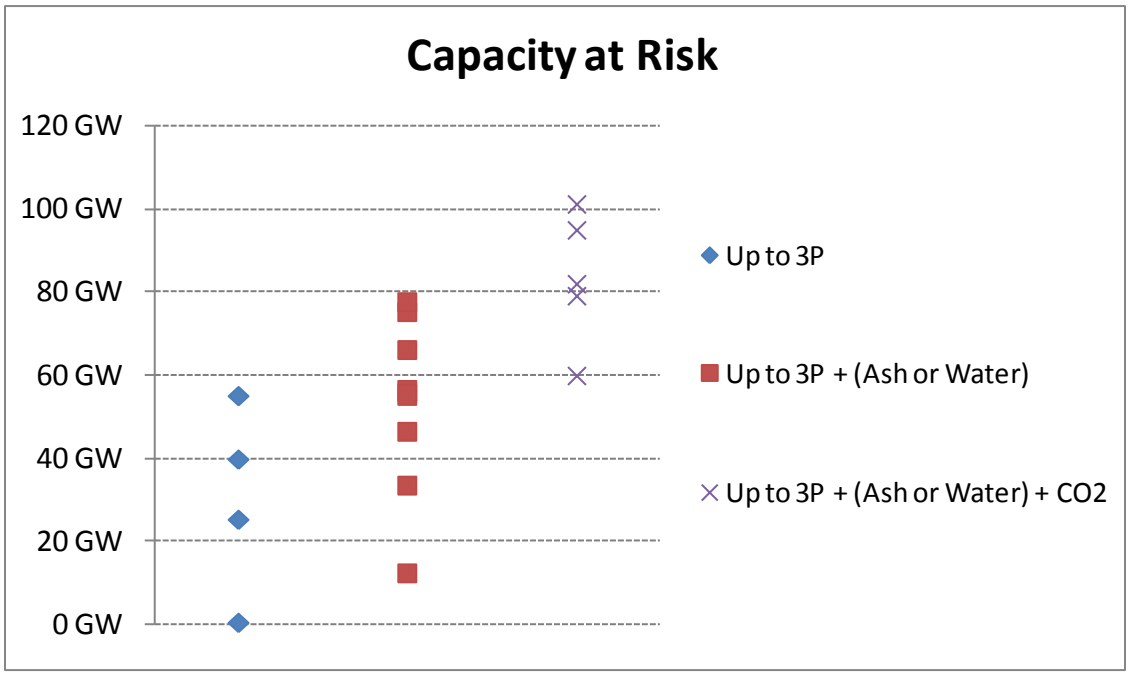
General Findings

The average estimated coal plant retirements through 2020 across all studies (regardless of scenario) is 58 GW, or roughly 18% of the 316 GW of total U.S. coal-fired generation capacity (see Figure 1 for more detailed results). All of the studies make the assumption that gas-fired generation will replace some or all of the lost coal generation and as a result find (on average): a gas-fired generation increase of 295 TWh, a natural gas consumption increase of 2.2 Tcf per year (6.6 Bcf/d) or about 10% of total U.S. gas demand, and reduced annual power sector emissions of 254 MM $MtCO_2e$. (Please refer to the Appendix for plots of other statistics of interest.)

[1] We used 12 studies; the sample included research from private consultants, investment banks, trade associations and the North American Electric Reliability Council.

[2] We contacted five research firms that conducted complex, integrated modeling of the impact of the new environmental rules on the U.S. coal-fired generation fleet.

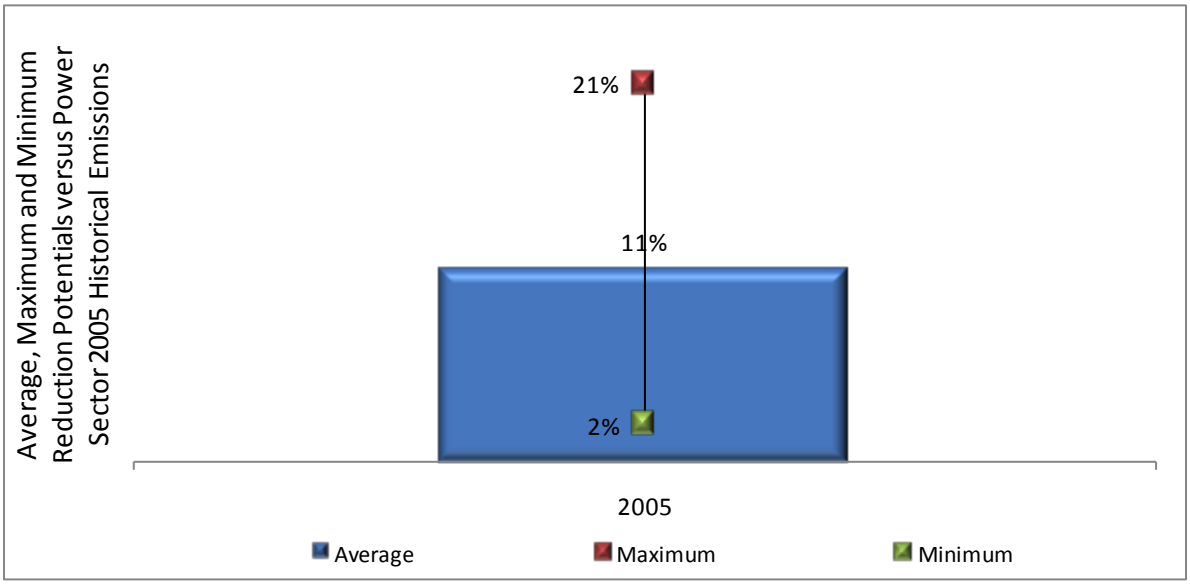
Figure 1: Plot of Capacity at Risk of Retirement by Regulations



Note: In general, 3P refers to SO2, NOx, and Hg.

Figure 2 displays the CO2 reduction potential due to the coal plant retirements as a percentage of power sector emissions in 2005. As shown, the studies find average annual CO2 emissions reductions of roughly 11% of total 2005 power sector emission as a result of coal plant retirements by 2020 and the assumed replacement of some or all of the lost generation by gas-fired power plants.

Figure 2: % Reduction Potential versus Power Sector 2005 Historical Emissions



Note: Please see appendix for absolute figures

Intra-Study Trends and Themes

These studies cover various combinations of regulations covering three categories of air pollutants: criteria air pollutants (including sulfur dioxide (SO2) and nitrogen oxides (NOx)), HAPs (namely mercury (Hg)), and carbon dioxide (CO2). Some studies also reviewed coal combustion residuals (CCR) disposal regulations and cooling water intake rules under Section 316(b) of the Clean Water Act. As mentioned above, there are significant differences in the approaches and methodologies of the individual studies but we were able to draw the following inferences from these studies:

1- Compounding Impact of EPA regulations (non-GHGs)

Studies that considered more uncertain EPA regulations (e.g., coal ash disposal, cooling water intake, and CO2 regulations) in addition to those that are more likely (such as the CATR and HAPs MACT rule) generally found increased coal plant retirements. Conversely, to the extent some rules were excluded from the analysis, retirements decreased.

For example, EEI reported that compliance with the Transport Rule, HAPs MACT and Ash and Water rules puts 56 GW of coal capacity at risk of retirement versus a reference case of 25 GW with rules focusing on just SO2, NOx and state regulations. The associated incremental gas demand from the increased retirements was 0.6 Tcf (1.6 Bcf/d) and the CO2 reductions were 115 MM MtCO2e per year by 2020. Brattle's analysis indicates that by considering the cooling water intake rules on top of a scrubber and SCR mandate by 2015, coal plant retirements increase to 66 GW relative to 40-55 GW without cooling tower rules.

The majority of the researchers contacted responded that the HAPs MACT rule will have the largest impact on a utility's retirement decisions.

2- Carbon price

The addition of carbon restrictions to upcoming EPA rules increases the coal plant retirements (these studies used a carbon price as a proxy for regulation or legislation). For example, in the EEI study, coal plant retirements in 2020 increase by 23 GW to 79 GW with a price of $10/MtCO2e (beginning in 2017 and escalating each year thereafter) and increase by 39 GW to 95 GW with a price of $25/MtCO2e. The incremental gas demand increases to 1 Tcf (2.7 Bcf/d) and 1.6 Tcf (4.4 Bcf/d), respectively, and the associated GHG reductions range from 300 to 474 MM MtCO2e.

3- Gas prices have a significant impact on retirements

For this sensitivity, gas prices and the number of coal-retirements exhibited a negative correlation: as gas price projections increase, the number of retirements decline, and vice-versa.

For example, PA Consulting Group concludes that retirements may increase from 12 GW to 75 GW when low gas prices ($4.5/Mcf versus $5-7/Mcf) are coupled with EPA rules on SO2, HAPs, Ash and Water. The EEI analysis concludes that even with a carbon price and the EPA rules, a $1.5/MMBtu increase in gas prices ($8.82/MMBtu in 2008 dollars) lowers potential retirements to 61GW from 95GW in 2020 and lowers gas consumption by 1.8 Tcf (4.9 Bcf/d) versus the alternative scenario without the gas price increase. If natural gas prices increase by $3/MMBtu to $10.33, gas consumption will decrease by about 3.1 Tcf (8.6 Bcf/d).

4- Control technology costs

Similar to the "Compounding Impact of EPA regulations" sensitivity, the easier it is for a facility to comply with rules (i.e., less expensive control options) the fewer the retirements.

For example, the Brattle Group report includes two retrofit-cost scenarios for compliance with the Transport Rule and HAPs MACT: (1) low-costs at $250-400/kW and (2) high-costs at $500-800/kW. In the low cost scenario, 40 GW may retire with up to 2.1 Tcf of incremental gas demand per year (or 5.8 Bcf/d). In the high cost scenario, these numbers increase to 55 GW and 2.6 Tcf per year (or 7.1 Bcf/d).

Similar observations can be seen in the EEI Study. If dry sorbent injection (DSI) technology can be employed for MACT compliance, the coal plant retirement potential drops to 46 GW from 56 GW, associated gas demand drops to 0.4 Tcf from 0.6 Tcf, and emissions would rise by 27 MM MtCO2e.

V. Other Considerations

While each study has varying assumptions and results, we draw this central thesis: enforcement of EPA regulations designed to protect human health and natural resources has ancillary benefits of reduced greenhouse gas emissions (GHGs). On the low end, some combination of EPA regulations may result in a 2% reduction versus 2005 historical emissions. On the high end, reductions may reach nearly 21%.

As per the purpose of these rules, SO2, NOx and Hg emissions will decrease, even if only accounting for the impact of retiring coal facilities. The studies reviewed did not provide the reduction potential for these pollutants; however, reductions can be extrapolated using fleet-wide average emission factors. Figure 3 summarizes the reduction potential.

Figure 3: Potential Annual Reductions in Criteria Pollutants

Total potential switch from coal to gas	326 TWh		
Emissions (short tons)	SO2	NOx	Hg
Coal	2.1 MMt	1.0 MMt	7.0 t
Gas	0.0 MMt	0.3 MMt	0.0 t
Avoided Emissions	2.1 MMt	0.7 MMt	7.0 t

Note: Coal emissions factors for SO2, NOx, and Hg – 13 lbs./MWh, 6 lbs./MWh, and 4.1x10^-5 lbs./MWh, respectively
Gas emissions factors SO2, NOx, and Hg – 0.1 lbs./MWh, 1.7 lbs./MWh, and 0 lbs./MWh, respectively

Limitations

Analyzing the impact of EPA regulations and carbon policy requires a comprehensive, dynamic modeling effort. This "study-of-studies" is not a substitute for such effort; rather, it is a collection of studies, some of which conducted thorough modeling.

Additionally, we have not covered two important topics in this report: the impact of coal plant retirements on the reliability of the electric system and the need for improved/additional natural gas infrastructure (including both midstream and transmission pipeline infrastructure) to support the increased generation needed by gas plants. There is literature that discusses these issues, but at this time, these important

considerations are beyond the scope of this report.[3] We recommend the FERC, PUCs, EPA and DOE carefully analyze these important issues.

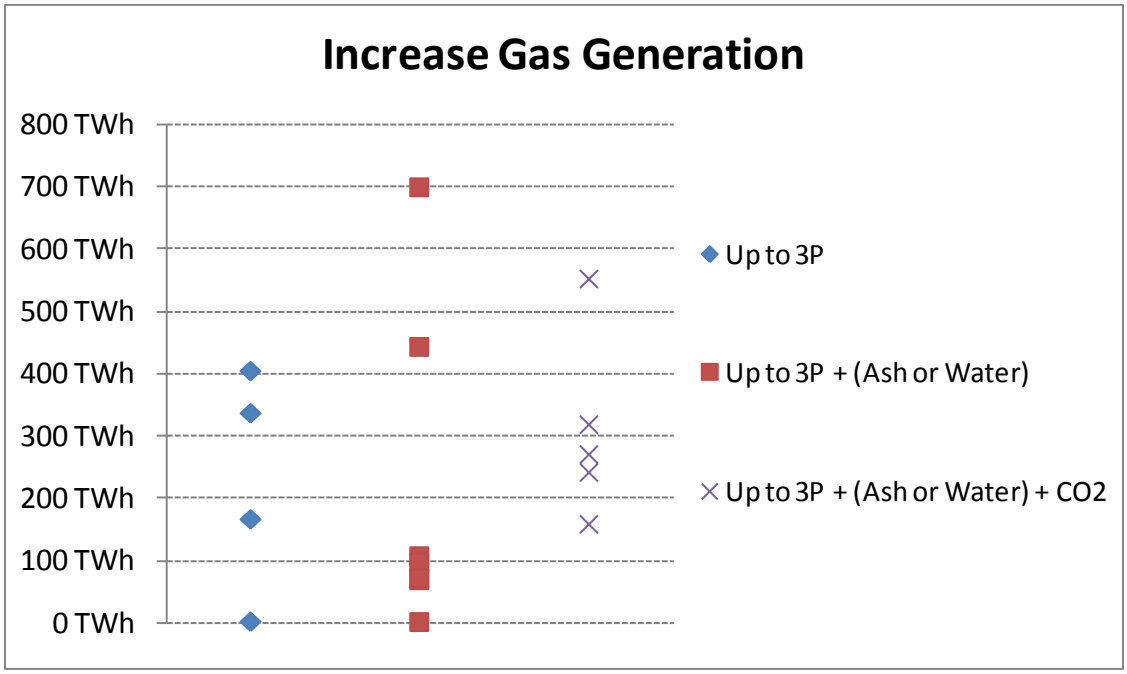
VI. Appendix

This section provides additional data and figures.

Figure 4: Data for Figure 2

Scenario	CO2 Reductions	As % of 2005 Power Sector Emissions
Average	254 MM MtCO2e	11%
Minimum	50 MM MtCO2e	2%
Maximum	496 MM MtCO2e	21%

Figure 5: Plot of Potential Increase Gas Generation due to Retirements



[3] See NERC's report (http://www.nerc.com/files/EPA_Scenario_Final.pdf), MJ Bradley's report (http://www.mjbradley.com/documents/MJBAandAnalysisGroupReliabilityReportAugust2010.pdf), or CRA's report (http://crai.com/uploadedFiles/Publications/CRA-Reliability-Assessment-of-EPA's-Proposed-Transport-Rule.pdf)

Figure 6: Plot of Potential CO2 Reductions

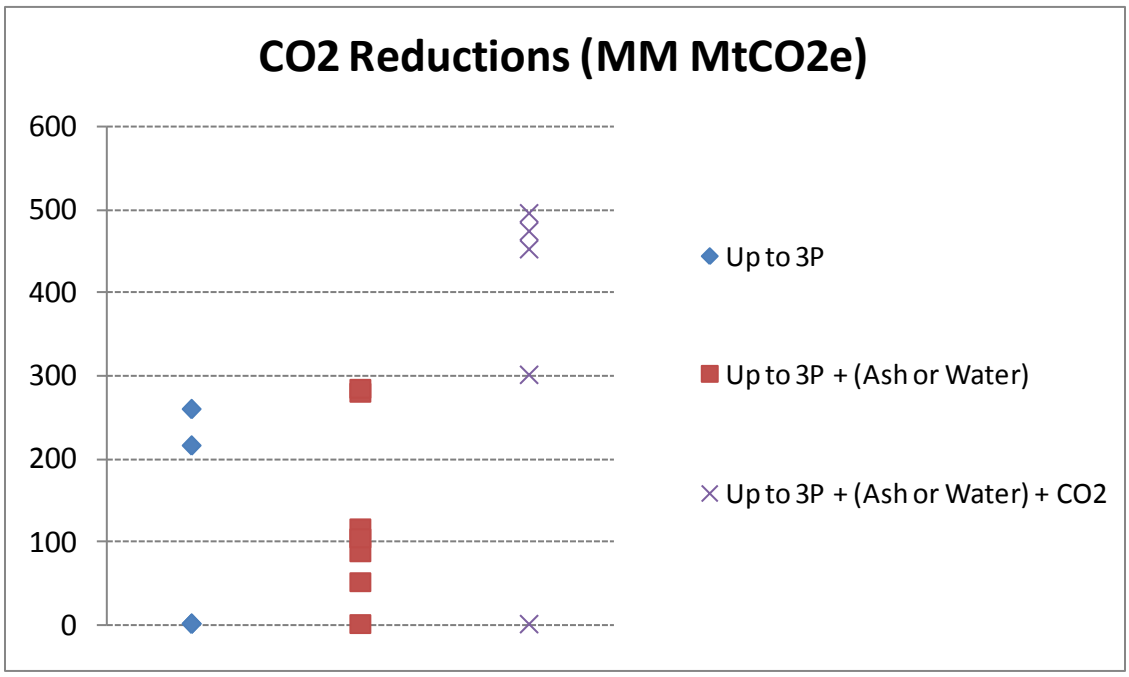
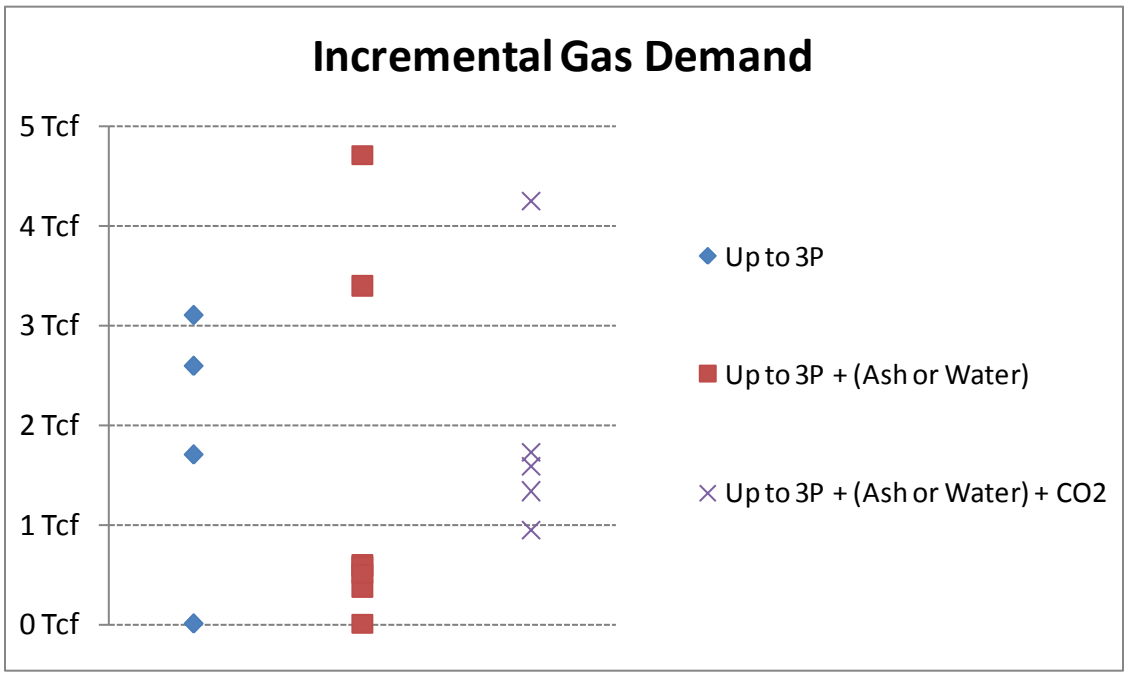


Figure 7: Plot of Potential Incremental Gas Demand



VII. Studies

ANGA (Black and Veatch). "Forecasts of Resource Mix – Scenario Analysis." March 2010.

Bernstein. "U.S. Utilities: Who Will Outperform?" December 2010.

Brattle Group. "Potential Coal Plant Retirements under Emerging Environmental Regulations." December 2010.

Charles River Associates. "A Reliability Assessment of EPA's Proposed Transport Rule and forthcoming Utility MACT." December 2010.

Credit Suisse. "Growth from Subtraction: Impact of EPA Rules." September 2010.

Deutsche Bank. "Natural Gas and Renewables." November 2011.

EEI. "Potential Impacts of Environmental Regulation on the U.S. Generation Fleet." January 2011.

ICF. "2010 Q4 Integrated Energy Outlook." December 2010.

INGAA (ICF). "Coal-Fired Electric Generation Unit Retirement Analysis." May 2010.

NERC. "2010 Special Reliability Scenario Assessment." October 2010.

PA Consulting Group. "The Coal Generation Squeeze: Environmental Regulations, Natural Gas Prices, Carbon Uncertainty and the Future of Coal-Fired Generation in the U.S." October 2010.

Wood Mackenzie. "North America Power Long Term View." October 2010.