2012 Integrated Resource Plan

BC hydro

Appendix

4E

Market Scenario Probability Assessment Report

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Market Scenario Probability Assessment for BC Hydro

June 9, 2011

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION – WHY BC HYDRO USES MARKET SCENARIOS

BC Hydro is preparing a long-term Integrated Resource Plan (IRP) for submission to the Government of British Columbia by early December 2011. The IRP will establish BC Hydro's plan for conservation and set its course for acquiring sufficient generation and transmission resources to reliably and cost-effectively meet customers' anticipated future electricity needs over the coming decades. Underpinning this plan is the long-standing electricity planning objective to ensure a reliable, cost-effective electricity supply, as well as important new objectives contained in B.C.'s Clean Energy Act related to clean energy, greenhouse gas reduction and achieving electricity self-sufficiency.

The financial impacts of different policy choices vary widely depending on what assumptions are made about the underlying future market conditions over a given planning horizon. Given the exposure of BC's electricity sector through extensive trade to the US market, these market conditions include both domestic and US influences. Any single "best estimate" of where prices may go in the future will surely be wrong. BC Hydro's Risk Framework is the way in which uncertainty and risk are being characterized explicitly where possible and brought into the IRP analysis. The Risk Framework is designed to encourage a wide enough range of possible future outcomes for a limited number of key variables that there is a good chance the future will unfold within these bounds and that the "best" policy options identified will be robust to different values within the broad ranges identified.

The Risk Framework is supported by *scenario analysis*. In this approach, a set of scenarios, each encompassing assumed levels of possible future market influencers or drivers, is used to describe potential ways in which the world (as it impacts BC Hydro and resource planning decisions and outcomes) could unfold. The purpose of this report is to document the exercise undertaken by Black and Veatch to assess the market scenarios used by BC Hydro in its IRP, and assign relative probability weightings to facilitate the risk analysis. The remainder of this section (I.1) provides background to how the scenarios were created; Sections II – IV describe the probability assignment exercise and its results.

I.1 Background: Market Scenarios for the IRP

There are a large number of market variables that have the potential to impact, either directly or indirectly, BC Hydro's future resource requirements, revenues and trade opportunities and trade revenues. Through its previous work on GHG price forecasting, Black and Veatch isolated eleven variables listed in the first column of Table 1. The first nine variables shown on Table 1 are discussed in detail in Section 5 of "Greenhouse Gas Price Forecast: Scenario Development and Modeling" report prepared for BC Hydro by Black & Veatch, dated April 2010. The last two variables shown in Table 1 are discussed in detail in the "Report on U.S. Renewable Energy Credit (REC) Markets" prepared for BC Hydro by Black & Veatch dated April 2011. However, even categorizing these into high/mid/low future trends still leaves far too many combinations to examine ($3 \times 3 \times 3 \times \ldots \times 3 = 3^{11}$ combinations). In addition, to build scenarios that are internally consistent for GHG price modeling, use of "high/mid/low" categories may not be the optimum approach to scenario design. BC Hydro estimated that, due to resource and time constraints, it could incorporate only up to five different views of how market prices might unfold in the future. The challenge then was to collect and combine these variables in a way that was coherent and internally consistent.

The approach used to address the wide number and range of interrelated variables impacting future electricity market prices and revenues is *scenario analysis*. Here, a scenario is defined as a specified collection of key uncertain variables. By letting these variables take on particular values (for instance, Scenario X might have: GHG prices are "high", natural gas prices are "low", economic growth as "mid", etc), the scenario will describe a specific way in which the world relating to market prices and impacting BC Hydro's resource planning might develop. And by considering a number of different scenarios, it is hoped that the scenario analysis will span some part of the spectrum of what might happen to market prices in the future.

The goal of creating market scenarios was twofold. First, it was important that a wide range of inputs - external factors describing how the world that impacts and influences BC Hydro resource planning decisions might arise - were considered. Here, these factors were: Global Economic Growth and a collection of Government Actions, Policies, most

notably, the breadth of GHG policies in the US, including the stringency of GHG reduction targets and the compliance flexibility allowed. Through judicious selection of these factors, combinations that were clearly implausible were dropped, and combinations that appeared to fit together in a coherent way became scenarios of focus.

A second goal of this scenario analysis was that the outputs – the prices driven by these scenarios - covered a wide (but plausible) range; wide enough that they would truly test the robustness of policy choices, but not so wide that they would be ruled as totally unrealistic. To test this, four key price variables were tracked:

- Natural Gas Prices
- Electricity Prices
- GHG Prices
- Renewable Energy Credit Prices.

Black and Veatch and BC Hydro ran through a number of attempts to find a small set of credible combinations of external factors that gave rise to a wide enough range of market prices to be surprising but not incredible. These are summed up below.

Scenario A – High global economic growth leads to high commodity demand and broad environmental regulation

This scenario is characterized by high global economic growth driven by successful fiscal and monetary policies. Although the strong economy renews public and government interest in environmental impacts and issues, the costs of regulation are attenuated to some extent by increased government spending on R&D. A national RPS is assumed, and this combined with strong spending on R&D and high natural gas prices, drives significant development of renewable energy, lowering their costs.

Scenario B – Slow but steady global economic growth sees regional leaders paving the way for national GHG markets

With slower but promising economic growth, regional initiatives such as the WCI take the lead in establishing GHG regulatory markets, with national US and Canadian governments following suit by 2020. Medium levels of growth soften government's ability to take on environmental initiatives. Although there are delays in national renewable energy standards, development is strong in later years (post 2020).

Scenario C – Low economic growth delays national GHG market development

With slow economic growth and activity, this scenario envisions that GHG emissions start to fall worldwide, taking the urgency out of the climate change debate and lowering public and government interest in GHG regulation. Lower natural gas prices and low electricity load growth delay spending on renewable energy and RPS development. Investments in R&D in conservation are also down.

Scenario D – High global economic growth with declining national interest in GHG controls

Under this scenario there is high global economic growth, but no consensus can be reached on national efforts to control green house gasses. Instead, regional efforts on controlling green house gasses become the long term policy approach to this matter. At a national level plug in hybrids and renewables continue to be encouraged. Natural gas prices remain at base line since no national cap and trade allows coal to continue to operate but higher economic growth and need to integrated renewables results in growing needs for natural gas

Scenario E – Delayed high economic growth and lower international cooperation stifles national environmental initiatives.

This scenario assumes a world where National Action on GHG does not occur and it would be reasonable to assume that under these global growth conditions, the Western Climate Initiative does not gain traction resulting in no GHG prices, even at the regional level. Further, it assumes low economic growth and low natural gas prices. Under such conditions, some stakeholders may also believe that RPS will not be necessary. However, RPS requirements have been implemented to accomplish a number of goals including working toward a "sustainable" energy future that does not rely on burning limited fossil fuels and reducing exposure of the population to other emissions such as mercury, particulate matter, SO_X, NO_X, etc.. RPS goals are also offered as a way to put more people to work. It is reasonable to expect that RPS goals now in place will not be reduced even if GHG concerns wane.

Table 1 gives a more complete description of the collection of external forces and market prices that made up the final five scenarios. The text following the table gives a brief explanation of each line. A more detailed explanation of what these factors are and how they can be interpreted can be found in Section 5 of "Greenhouse Gas Price Forecast: Scenario

Development and Modeling" report prepared for BC Hydro by Black & Veatch, dated April 2010 and in the "Report on U.S. Renewable Energy Credit (REC) Markets" prepared for BC Hydro by Black & Veatch dated April 2011.

Table 1 Scenario Assumptions

Scenario Assumptions.					
Scenario	**A**	**B**	**C**	**D**	**E**
Nat/Reg GHG	National	Reg/Nat	Reg/Nat	Regional	Regional
Gas Prices	High	EMP	Low	EMP	Low
Load Growth	High	EMP	Level	High	Level
Nuclear Adds	0.5	1.5	0.5	EMP	EMP
PEV[1]	Yes	Yes	No	Yes	No
Renewables	High	High	Low	EMP	Low
CCS Cost[2]	-0.25	0.25	0.25	0.5	0.5
2020/2030 Caps	Less Stringent	EMP	EMP	Base WCI	Base WCI
LRS of Offsets[3]	Full	Full	Full	Full	Full
ITC/PTC continue?	ITC expires after 2016, no incentives after	ITC expires after 2016, no incentives after	ITC (2016), PTC after	ITC (2016), PTC after	ITC expires after 2016, no incentives after
Renewable cost	Faster decline	Faster decline	Slower decline	Baseline	Slower decline
Tree Probability	0.0168	0.1	0.0378	0.0063	0.0081

[1] Plug-in Electric Vehicle
[2] Carbon Capture and Sequestration
3 Load Ratio Share

The term "EMP" in the table means that the scenario used the "best estimate" for that value, taken from the Black & Veatch Fall of 2009 25-year Energy Market Perspective forecast. The items under the "Scenario" column are more fully described as:

- National GHG means a linked, national-level cap and trade program that covers the US and Canada.
- Regional GHG means a cap and trade program that covers only the Western Climate Initiative (WCI) states and provinces located in the Western Electricity Coordinating Council (WECC)
- Reg/Nat GHG means a regional, WCI cap and trade system until 2020, which is then superseded by a move to national-level cap and trade.
- Gas price EMP means "best estimate" natural gas price forecast. Then higher or lower than that. For more detail, see Figure 9, page 27 of "Greenhouse Gas Price Forecast: Scenario Development and Modeling" report prepared by BC Hydro by Black & Veatch, dated April 2010
- Load Growth EMP means "Expected" US and Canada and regional electric load growth. Level means fairly flat (e.g. no growth). High is "High Growth" (i.e. Higher than "Expected"). For more detail, see Figure 3, page 23 of "Greenhouse Gas Price Forecast: Scenario Development and Modeling" report prepared by BC Hydro by Black & Veatch, dated April 2010
- Nuclear Adds EMP means "best estimate" US and Canada and Regional nuclear additions. Then either 50% or 150% of that.

- PEV means the penetration level of plug in hybrid vehicles. Yes means a material impact on light load hour loads (all PEV load was assumed to occur on light load hours). No means no material impact on any hourly loads. For more detail, see Section 5.4.7, page 28 of "Greenhouse Gas Price Forecast: Scenario Development and Modeling" report prepared by BC Hydro by Black & Veatch, dated April 2010
- Renewables EMP means "best estimate" assumption on renewable penetrations. Then higher (2.5 times best estimate) or lower (reduced by one-third from best estimate).
- Carbon Capture and Storage (CCS) cost -25% means a significant reduction in capital costs that was assumed for this CCS technology in the baseline case. 25% and 50% mean increases over assumed CCS cost in the baseline case.
- 2020/2030 caps. EMP means baseline assumption on flexibility in banking and borrowing of GHG compliance instruments (allowances). Less stringent gives more flexibility by limiting the amount of banking and borrowing. WCI means matching the WCI regional goal of reducing emissions to 15 percent below 2005 levels by 2020 and only comes into play in the Regional GHG scenario.
- LRS of Offsets - Load Ratio Share of allowable "offsets" for meeting GHG targets. This means the amount of offsets that would be available to the electricity sector, and is assumed to be the same in all 5 Scenarios selected.
- Tax credits for renewables indicates whether US tax credits for renewable will be extended (PTC and ITC as indicated on Table 1).
- Renewable cost trends indicates whether the baseline assumption reflected in the Black & Veatch 2009 Energy Market Perspective forecast of renewable cost reductions will occur or whether the cost reductions will be higher or lower than that.
- Tree Probability: In its earlier work for BC Hydro on GHG pricing, Black and Veatch had put together a larger probability tree incorporating the overarching variables of Global Economic Growth, Government Actor, 2020/2030 Caps, and LRS of Offsets in a 3 x 3 x 3 x 2 (54-branch) tree. This work formed the basis for the Market Price Scenario work. The probabilities listed arose from this initial probability tree. These were then normalized to the selected 5 scenarios so that they sum to 100%.

II. APPROACH TO ASSIGNING RELATIVE LIKELIHOODS TO THE FIVE SCENARIOS

BC Hydro has also requested that Black & Veatch assign relative "probabilities" to each of the five scenarios. More specifically, BC Hydro wanted Black and Veatch to provide their professional advice as to the relative likelihoods of the five scenarios. That would allow Hydro to shape its interpretation of how these scenarios will perform in "stress testing" a given policy choice based on:

- how much of a change the market price scenario made, and
- how likely this was to happen (compared to the other scenarios).

For this exercise, there are several important factors to keep in mind. First, the numbers assigned to any scenario are **not** intended to be forecast probabilities that a given scenario will occur. Rather, if Scenario X is assigned a likelihood of 10% and Scenario Y a likelihood of 20%, the numbers are to be understood that Y is twice as likely as X to occur. In reality, it is close to impossible that that a specific combination of long term price forecasts and external events will occur (making the forecast probability for Scenario X to be close to zero), particularly when working with only five scenarios. So these quantifications only make sense in relative terms.

A second point to keep in mind when looking at these results is that they apply to the scenarios as a whole, not to the individual underlying variables or drivers. For instance, if Scenarios X and Y (at probability 10% and 20% again) are the only two scenarios with high gas prices, it is not correct to infer that the probability of high gas prices is 30%.

The estimates were developed using the Modified Delphi Method[1], a methodology that systematically assists experts in reaching consensus. This report describes the activities undertaken by the experts to assign the likelihood estimates, indicates some of the key factors used by the experts in their deliberations, and provides the resulting probabilities assigned to each of the five scenarios. For this study, the expert panel (Panel) consisted of Richard Lauckhart, Mark Griffith, Andrew Byers, Natalie Rolph, Mon Hong, and Dr. Hua Fang whose qualifications are summarized in Appendix A to this report. The Panel members have diverse backgrounds in the energy field but share an emphasis on expertise in energy fuels. The goal of this section of the report is to assign quantified likelihood estimates to these five scenarios.

A secondary goal of this report is to assign quantified likelihood estimates to the 3 natural gas price forecasts included in the scenarios. BC Hydro asked B&V to provide a separate estimate of the relative likelihoods of the three gas price forecasts alone to support its regulatory filings. While it is recognized by BC Hydro that the market scenarios provide a more comprehensive view of how these markets might unfold, BC Hydro also wants to be have the ability to address questions that require a more narrowly focused consideration of future prices. The same panel of experts separately assigned probabilities to the three natural gas price forecasts.

The panel of experts was asked to gather in Rancho Cordova, California on March 14, 2011 to weight the probabilities of the five scenarios. Mr. Basil Stumborg of BC Hydro was the facilitator of the meeting. Also in attendance were Kevin Maxwell and Patrice Rother of BC Hydro. In advance of the gathering, the panel of experts was provided a number of documents to review in preparation. The items provided to the panel of experts for review were:

IRP Technical Advisory Committee[2] presentations covering:
http://www.bchydro.com/planning_regulatory/irp/document_centre/tac.html

- Risk Framework (why Scenarios),
- GHG forecast and assumptions
- Gas forecast and assumptions
- Electricity forecast and assumptions
- REC forecast and assumptions.

And Black and Veatch materials:

- The Black & Veatch GHG report dated April 2010 and draft appendix dated January 2011
- The Black & Veatch Low Gas Price Forecast report
- The Black & Veatch June 2010 Gas Scenario Probability report
- The Black & Veatch draft REC price report
- The CEC Scenario report, CEC Case 5b+ and Case 2 (See CEC website)

In addition, the panel of experts was asked to provide information to the facilitator prior to the March 14 gathering pertaining to:

- What they thought the most likely scenario was (and why);
- What they thought the least likely scenario was (and why);
- A preliminary rank ordering of all five scenarios; and
- Special issues required for discussion when the group met.

This pre-work formed a starting point for discussion and allowed the facilitator to move through the agenda more efficiently by noting areas of consensus and highlighting areas that required more discussion.

The following actions were accomplished at the March 14 meeting:

[1] For a description and discussion of the Modified Delphi Method, please refer to "Experts, Stakeholders, and Elicitation," in Mark A. Burgman, Risks and Decisions for Conservation & Environmental Management, 2005, Cambridge University Press, Box 4.1, Page 104.
[2] The IRP Technical Advisory Committee is a multi-stakeholder group of experts that BC Hydro is consulting with while developing the IRP analysis.

1. Review and discussion of the pre-meeting reading materials to ensure thorough and common understanding of the scenarios, how they were developed, and the assumptions and variables underpinning each.
2. Feedback for initial questionnaire
   - key drivers for the initial ranking responses
   - opportunity for questions
3. Assessing relative likelihoods – robust discussion of the meeting participants of the key considerations and approaches to assessing and ranking relative likelihoods for the scenarios
   - key drivers of uncertainty
   - mental models
   - rank order
   - relative magnitude
4. Final assignment of probabilities of Scenarios

III. KEY CONSIDERATIONS AND FINAL ASSIGNMENT OF RELATIVE LIKELIHOODS

At the March 14, 2011 meeting the panel of experts were provided the results of the initial questionnaire. All panelists ranked Scenario B as the most likely Scenario and there was broad agreement that C was second most likely. Rationale given included:

- Momentum for a US national level cap and trade program has recently stalled, while some momentum remains for a regional program, particularly in California and British Columbia.
- "Best estimate" load growth assumption from the 2009 EMP continues to be best estimate
- "Best estimate" natural gas price forecast assumption from the 2009 EMP continues to be best estimate

The panelists believed that Scenarios A, D and E were much less likely. Scenario D was felt to have smaller likelihood due to the fact that panelists felt the maintaining a regional only GHG program beyond the year 2020 with a very high GHG price was unlikely. If the nations in North America had not chosen to move ahead on GHG matters by 2020, if was felt that the regional program would likely not continue due to competitiveness issues for regional economic activity. Scenario E (which ends up with no GHG emissions allowance costs for the entire forecast period) was felt to have smaller likelihood due to the fact that global climate change concerns seem to have a strong following and eventually something is expected to be done. Scenario A was felt to have a smaller likelihood due to the high gas price assumption that is included in this scenario. The Panelist felt there was some probability of such a high natural gas price in the future, but not a very high probability. Initial assessments regarding Scenarios A, D, and E showed a range of rankings across the group of experts.

Before looking for consensus, the group revisited the 11 variables listed in Table 1. This was done using the following structure:

- Check for understanding of the variable and how it is defined
- Discuss the range across which it varies. Are the ends of the range so broad they are implausible, or quite likely?
- What are the relationships among these variables?
- Finally, does the collection of variables within each scenario make sense, or is it contradictory/incoherent in some way?

The group was then asked to reconsider their original scenario rankings. This resulted in the likelihood rankings shown in Table 2.

Table 2 Panel Rankings after Robust General Discussion

Indicated Rank Order of Scenarios after panel robust discussion							
	Panelist	Panelist	Panelist	Panelist	Panelist	Panelist	Group
	1	2	3	4	5	6	Tendency
Scenario A	3	4	4	5	4	5	4
Scenario B	1	1	1	1	1	1	1
Scenario C	2	2	2	2	2	2	2
Scenario D	5	5	5	4	5	4	5
Scenario E	4	3	3	3	3	3	3

To move from ranking likelihoods to assigning quantified likelihoods, the group was reminded of the GHG price scenario work, whereby the 54-branch probability tree was created, with relative probabilities assigned to each of the four overarching variables (Section I.1) . By multiplying the variable probabilities, a probability could be worked out for each end node. The five probability values for the five selected scenarios are shown in Table 3, along with normalized *relative likelihoods* for these five scenarios. Note that these are not the probability estimates that one particular scenario might occur. It is best to interpret these as judgments of likelihood relative to the other scenarios.

Table 3 GHG Price Initial Probabilities and Normalized Likelihoods

	Scenario	Scenario	Scenario	Scenario	Scenario
	A	B	C	D	E
Initial Prob	1.68%	10.00%	3.78%	0.63%	0.81%
Normalized	9.9%	59.2%	22.4%	3.7%	4.8%

This normalization would have Scenario B as the most likely scenario, C was the second most likely scenario, and the others were much less likely. This is consistent with the results of the initial questionnaire responses from the panelists. However, the panelists reviewed their qualitative considerations of the eleven key uncertainties and used these to adjust the values from Table 3 to arrive at a final group probability in Table 4.

As a general overview of the panelists' considerations in developing the probabilities in Table 4, the panelists started with their individual rank order mindset shown Table 2. The panelists reaffirmed their belief that Scenario B was the most likely outcome and Scenario C was second most likely. But the panelists have seen some pushback on the whole concept of global warming from elements of society. While the panelist were not of an opinion that this pushback activity likely would carry the day over the longer period, they did think there was some reasonable possibility of that. This future with GHG prices of zero, Scenario E, was assumed to be a little more probable than Scenario D which had a very high GHG charge but only for the region. The Scenario A probability continues to be smaller than Scenario B and D due to the high gas price forecast assumption, however the panelists felt that Scenario A would have a higher probability than either Scenario E (with its zero GHG assumption for the forecast period) and Scenario D (with its very high GHG price, but only in the WCI region).

Table 4 Final Relative Likelihood Assessments.

Final Assignment	
	Group
	Probability
Scenario A	10%
Scenario B	45%
Scenario C	25%
Scenario D	5%
Scenario E	15%

IV. NATURAL GAS PRICE SCENARIO'S AND THEIR RELATIVE LIKELIHOODS

BC Hydro also wanted to be have the ability to address questions that required a more narrowly focused consideration of future prices So as a related matter, BC Hydro requested of Black and Veatch to assign separate, stand alone estimates of the relative likelihoods to the three natural gas price forecasts used in the Market Price Scenarios. The three natural gas price forecasts are as follows:

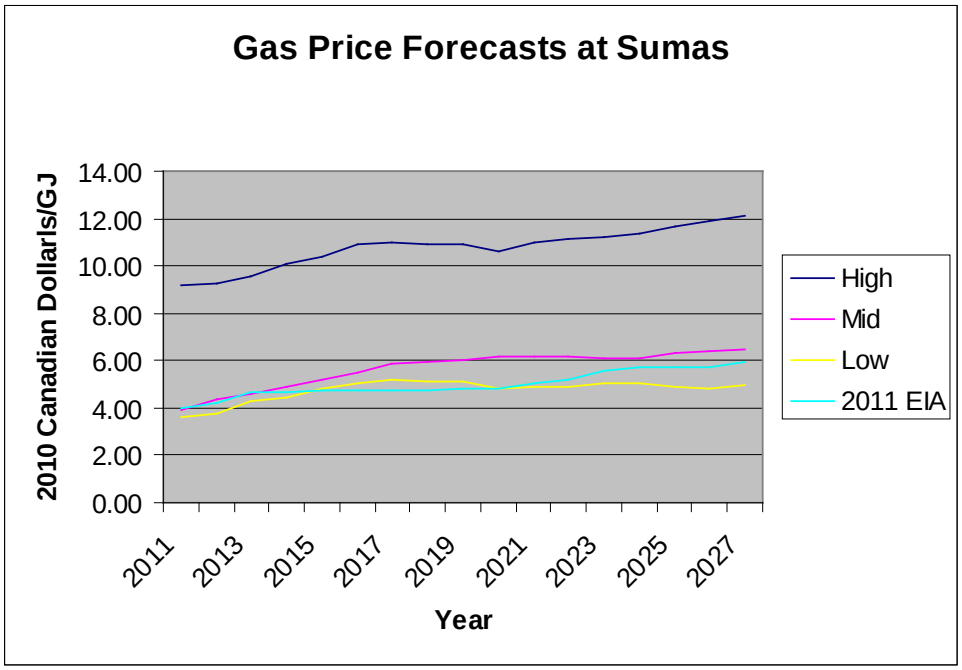
1. The high gas price forecast came from the California Energy Commission Scenarios project. The basis for that high natural gas price forecast is described in detail in Natural Gas Price Forecast Probability Assessment report prepared for BC Hydro by Black & Veatch dated June 16, 2010.
2. A baseline natural gas price forecast. BC Hydro chose a natural gas price forecast prepared by Ventyx in the Spring of 2010
3. A low natural gas price forecast prepared by Black & Veatch described in a Black & Veatch November 2010 report entitled "The Low Natural Gas Price Scenario: Technological Success in Shale Production in a Stagnant Demand Environment"

As highlighted in Section II, the relative likelihoods assigned to these variables alone need not line up exactly with the probabilities from Table 4. The natural gas estimates are best thought of as *conditional estimates*, whereas the estimates shown in Table 4 are for a scenario that consists of many, interrelated elements.

Black & Veatch used the modified Delphi Technique to assign probabilities to these three natural gas price forecasts. Because of the recent understandings of economics of shale gas, the panel assigned a low probability to the High gas price forecast. However, because it is possible that future environmental regulations could seriously restrict "fracking" needed to extract the shale gas, the panel assigned a probability of the high gas forecast occurring to be 10%.

The panel initially assigned the Mid and Low gas price forecast probabilities as 65% and 25% based on work that Black & Veatch has done on natural gas markets. However, the panel then looked at the U.S. Energy Information Administration's (EIA) latest forecast of natural gas prices. The figure below is a graphic showing the High, Mid, Low and EIA 2011 forecasts.

Figure 1 Gas Price Forecasts



The 2011 EIA forecast is nearly identical to the Low gas price forecast for the period until 2020. The EIA 2011 forecast is lower than the Mid forecast in part because the EIA has assumed no federal cap and trade program will exist throughout the EIA forecast period. As such, there is considerable more coal being used and an offsetting reduction in natural gas consumed in natural gas fired power plants. The panel felt this might be a reasonable future through the year 2020. With this understanding, the panel modified its probability assessment of the Mid and Low gas price forecast to be 50% Mid and 40% Low. However, the panel noted that the 2011 EIA forecast rises above the Low gas price forecast beyond the year 2020. Therefore, if the probabilities are to reflect the forecast through 2040, the panel would weight the Mid forecast at 55% and the low at 35%.

The table below summarizes the probability assessments.

Table 5 Gas Price Forecast Probabilities

Probability Assessments for gas price forecasts		
	Through 2027	Through 2040
High Gas	10%	10%
Mid Gas	50%	55%
Low Gas	40%	35%

APPENDIX A
Black & Veatch EXPERT PANEL FOR BC HYDRO

Richard Lauckhart is a Managing Director in Black & Veatch's Management Consulting division. He has been actively involved in power supply planning, electricity price forecasting and asset valuation for more than 35 years. For the past 12 years, he has performed consulting assignments related to power market analyses, price forecasting services, asset market valuation, integrated resource planning, transmission line congestion analysis and management of strategic consulting engagements for many clients in North America. His clients have included investor-owned and publicly owned utilities, independent power producers, lenders and others. Before beginning his consulting career, Mr. Lauckhart held various positions at Puget Sound Power & Light (now Puget Sound Energy) in power supply planning. He culminated his service as Vice President of Power Planning for the last four years of his tenure.

Mark Griffith is a Managing Director in Black & Veatch's Management Consulting division. He focuses on the Market Assessment consulting service area and directs the market analysis contained in Black & Veatch's Energy Market Perspective. An accomplished senior executive whose career has been focused on the energy industry, his specializations include energy market analysis, strategic planning, electric power asset valuation, transaction due diligence and project finance. Working as an applied energy economist, Mr. Griffith is focused on providing clients with an integrated understanding of the world and North American energy markets, and translating that knowledge into value. Widely respected by clients as a truly objective expert on energy market conditions, Mr. Griffith is a strategic business decision-maker with an emphasis on quantitative techniques, who understands how to integrate technical, financial and engineering issues to arrive at sound decisions. An experienced communicator and expert witness, Mr. Griffith writes or edits several major consulting studies each year and is also a frequent speaker at workshops and conferences. Before joining Black & Veatch, he was a Senior Vice President and a practice leader at another national consulting company, where he provided clients with portfolio valuation, merger and acquisition due diligence, strategic planning and energy market analyses throughout North America. Prior to that, Mr. Griffith held a series of staff and management positions related to risk management, power marketing, resource planning and fuel management at Kansas City Power & Light Company.

Andrew Byers, Associate Vice President and Project Manager, is currently assigned to the Environmental Management Consulting Services Section. His position involves management of licensing and environmental services primarily for the electric utility and public works industries. Principal responsibilities include the identification and analysis of applicable local, state, federal, and international environmental laws; coordination of project siting and permitting efforts; client consultation and representation with regulatory agencies; evaluation of environmental impact, mitigation, and remediation issues; and preparation of advisory memoranda to assist project personnel. He also serves as the Energy Division's Regulatory and Legislative Policy Advisor, responsible for tracking developments and advising on risks and opportunities arising from key federal legislative, regulatory and judicial initiatives.

Natalie Rolph is Chief Economist and Project Manager responsible for strategic planning studies, electric load forecasting, integrated resource planning studies, forward electric price curve forecasting, GHG emissions allowance price forecasting, asset valuation and economic feasibility studies. She has developed market-based regional forecasts of emission allowance prices and has advised utilities regarding least-cost regulatory compliance plans throughout the Eastern United States. She has directed the development of strategic power supply and integrated resource plans throughout such countries as the United States, Thailand and Indonesia as well as a number of African countries. She has conducted large purchased power solicitations and sales on behalf of utility clients and testified as an expert witness in cases before the Missouri Public Service Commission, the Kansas Corporation Commission and in power plant site certification proceedings in Florida. Her clients, both U.S. and international, include energy companies, public- and investor-owned electric utilities, as well as government agencies. Her energy master planning experience involves the development of economic models to compare chilled water, steam and electric system options for large users, such as cities, industrial complexes, wastewater districts and universities. She has supervised the development of an optimal cogeneration dispatch

model that identifies the least-cost hourly operating mode for a combined-cycle cogeneration facility based on hourly steam demands, market electric prices and back-up boiler steam production costs.

Dr. Hua Fang is a principal consultant with expertise in fundamental market assessment, price and basis forecasting, energy derivative asset pricing, econometrics modeling and stochastic simulations. At Black & Veatch, she has led many engagements in assessing natural gas market trends, portfolio strategies and risks exposure by modeling the interaction of natural gas market components, including production, demand, pipeline infrastructure and LNG imports. Dr. Fang has designed a process of projecting natural gas production potentials from the emerging Shale plays using reserve size, well productivity and drilling success rate. Dr. Fang is also responsible for producing Black & Veatch's views on North America energy fuels for Black & Veatch Enterprise Market Perspective.

Mon-Fen Hong has managed consulting projects in the areas of renewable energy market potential, renewable energy resource and economic assessment, renewable energy certificate (REC) price analysis, renewable energy project bid evaluation, transmission feasibility studies, power market analysis, and integrated resource planning. She has advised regulators and policy-makers on renewable portfolio standard policy development, both in crafting regulations and analyzing costs. Prior to joining Black & Veatch in 2009, Mon-Fen Hong led the renewable energy practice at La Capra Associates, a Boston-based energy consulting firm. She conducted numerous studies related to renewable energy potential and financial analysis of renewable energy projects, including wind, solar and biomass. She has experience with integrated resource planning and project due diligence. Prior to becoming a consultant, she also worked for power project development companies, PPM Energy (now part of Iberdrola) and Edison Mission Energy, on a variety of market analysis projects. Her role with these companies included managing energy (gas and power) price forecasts and developing business plans for renewable energy products. She also conducted long-term forecasting for various power markets.