ONTARIO POWER GENERATION

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January 14, 2013

RESS and Overnight Courier

Ms. Kirsten Walli
Board Secretary
Ontario Energy Board
PO Box 2319
2300 Yonge Street, Suite 2700
Toronto, ON M4P 1E4

Dear Ms. Walli:

Re: EB-2012-0002 – Ontario Power Generation Inc. Payment Amounts for Prescribed Facilities

In accordance with Rule 10 of the Ontario Energy Board's (OEB) *Rules of Practice and Procedure* and section 5.3 of the Board's *Practice Direction on Confidential Filings* (the Practice Direction), Ontario Power Generation Inc. (OPG) requests the confidential treatment of certain of its information that has been requested by way of interrogatories in the above-noted proceeding. Specifically, OPG seeks confidential treatment of part of its written response to AMPCO Interrogatory #7, found at L-2-2 AMPCO-7, and attachments to SEC Interrogatory #5, found at Ex. L-1-7 SEC-5 (parts of Attachments 1 and 2).

In accordance with section 5 of the Practice Direction, the reason for this confidentiality request, including the reasons why OPG considers parts of the responses to these interrogatories to be confidential and the reasons why public disclosure of the information would be detrimental to OPG, are set out below. In addition, non-confidential descriptions or versions, as the case may be, of the subject documents are provided as attachments.

In accordance with the Practice Direction, this letter is being provided to the OEB along with the attachments identified below. The information *for which confidentiality is being requested*, which is included at each of **Attachment A and B** is to remain confidential at least until the OEB makes its determination on this request. A copy of this letter, including the *non-confidential attachments* at **Attachments A1 and B1**, respectively, is being provided to each party to the proceeding.

As an interim measure and in the interests of efficiency, prior to the OEB making its final determination, OPG is content that the OEB makes provision that Board Staff and intervenors proceed as though OPG's request has been granted. In so doing, OPG requests that the OEB require by procedural order that Board Staff and each intervenor requesting a copy of L-2-2 AMPCO-7, and certain attachments to L-1-7 SEC-5 complete and sign a Declaration and Undertaking in the form included at **Attachment C**, being the form set out in Appendix D of the *Practice Direction* and file it with the Board in order to be given a copy of the confidential portion of the interrogatory response.

On a final determination, should the OEB grant OPG's request for confidentiality, OPG proposes that the OEB order that the confidential information be disclosed, subject to any conditions the OEB may find appropriate, to only those persons that have signed the Declaration and Undertaking.

OPG requests that any reference to confidential information contained in the documents produced be conducted *in camera* so as to preserve its confidential nature.

At the conclusion of the proceeding or in the event that the confidentiality request is refused and OPG requests that the information be withdrawn in accordance with 5.1.12 of the Practice Direction, all persons in possession of the information will be required to destroy or return to the OEB Secretary for destruction the confidential information in accordance with 6.1.6 of the Practice Direction.

Reasons for the Request for Confidential Treatment of L-2-2 AMPCO-7

Interrogatory #7 from AMPCO, along with the OPG response as filed, is provided at **Attachment A** (confidential version). The document at Attachment A sets out the volumes of low and intermediate level waste which are based on waste volume information received from Bruce Power. OPG and Bruce Power are parties to a Low and Intermediate Level Waste Agreement made in May 2011 (the "Agreement"). Under the terms of the Agreement, Bruce Power's waste volume information is confidential information and disclosure of it requires the consent of Bruce Power in the circumstances**.**

Specifically, Bruce Power has advised OPG that the information related to Bruce Power, including, without limitation, handling, processing, and volumes of low and intermediate level waste, contained in the confidential response to the subject interrogatory is confidential commercial information of Bruce Power and is supplied on the basis that OEB and OPG will keep all such information confidential in accordance with the OEB's usual confidentiality process. Bruce Power believes that the disclosure of this information could reasonably be expected to cause material financial loss to Bruce Power, prejudice Bruce Power's competitive position or would interfere with negotiations in which Bruce Power is engaged. In the event that there is opposition to all or any part of the Bruce Power information being protected as confidential, Bruce Power has requested that it be advised at P.O. Box 1540, Building B10, 177 Tie Road, RR#2 Tiverton, Ontario, NOG 2T0 (fax 519 361-4333), to the attention of Chief Legal Officer, so that it can make appropriate detailed representations to the OEB about the nature of the information.

Confidential treatment of this type of information is specifically contemplated by Appendix B, subsections (a) i, ii and iv and (b) of the Practice Direction.

A non-confidential version of L-2-2 AMPCO-7 is attached hereto as **Attachment A1** and it has been filed on the RESS as part of OPG's answers to interrogatories.

Reasons for the Request for Confidential Treatment of Ex. L-1-7 SEC-5

Interrogatory #5 from SEC, along with the OPG response as filed, is provided at **Attachment B** (confidential version). The documents at Attachment B set out background information, valuation and technical information on the Bruce Lease embedded derivative. The parts of Attachments 1 and 2 which have been redacted on the basis of OPG's assertion of confidentiality protection over them contain OPG proprietary forward prices and related inputs. The subject information is commercially sensitive data. OPG consistently treats this information as confidential. Disclosure of this information would prejudice OPG's competitive, trading and negotiating positions and would likely produce a significant loss to OPG and unfair gains to other persons. Confidential treatment of this type of information is specifically contemplated by Appendix B, subsections (a) i, ii and iv and (b) of the Practice Direction.

Non-confidential versions of the subject attachments to Ex. L-1-7 SEC-5 are reproduced here as **Attachment B1** and have been filed on the RESS.

Respectfully submitted,

[Original signed by]

Garry M. Hendel
Director (Acting), Ontario Regulatory Affairs
Ontario Power Generation

Attach:

cc: Charles Keizer Torys LLP
Carlton Mathias OPG
EB-2012-2002 Intervenors (but with attachments A1, B1 and C only)

Attachment – A1

AMPCO Interrogatory #07
(NON-CONFIDENTIAL VERSION)

Ref: Exhibit H2-1-2 Page 7 Lines 2-4

Issue Number: 2
Issue: Are the balances for recovery in each of the deferral and variance accounts appropriate?

Interrogatory

Preamble: OPG projects revenues based on waste volume information received from Bruce Power and is projecting those volumes to be higher in 2012 than originally anticipated.

a) Please provide updated data for actual volumes in 2012.

b) Please quantify and comment on any variance from the projections for 2012.

Response

a) & b) As noted in Ex. H2-1-2, section 4.3 and the preamble to this question, OPG's revenue projections for the provision of low and intermediate level waste management services to Bruce Power L.P. ("Bruce Power") are based on forecasted waste volume information from normal operations of the Bruce facilities as received from Bruce Power. OPG is required to maintain the capacity to accept all of the waste generated by Bruce Power. However, as a result of volume reduction initiatives by Bruce Power, the actual volumes received by OPG during 2012 were approximately 60 per cent and 70 per cent below the projected volumes reflected in the pre-filed evidence for low level and intermediate level waste, respectively. The following chart provides confidential information for the 2012 projected and actual volumes of low and intermediate level waste and resulting variances.

	Low Level Waste			Intermediate Level Waste		
	Projection	Actual	Variance (actual < projection)	Projection	Actual	Variance (actual < projection)
Volume (m^3)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Attachment – B1

ONTARIO POWER GENERATION

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Donn Hanbidge
Chief Financial Officer

February 25, 2010

Robin Heard
VP Finance and Chief Controller

Bruce Lease Supplemental Rent Claim for 2009

Background

In May 2001, OPG entered into a Lease Agreement with Bruce Power for the Bruce Nuclear Power Development site, which included the Bruce-A and Bruce-B generating stations. The lease requires Bruce Power to pay OPG both a Base Rent and a Supplemental Rent tied to the operational Bruce-A and Bruce-B generating units. The initial calculation for Supplemental Rent involved a rate per megawatt hour (MWh) of production and included a compensation factor for the ultimate disposal of used fuel.

In January 2002 the Supplemental Rental clause of the Lease was amended to provide for a fixed annual Supplemental Rent per unit, adjusted annually by a Consumer Price Index (CPI) quotient. The amended clauses additionally provided that the Supplemental Rent rate would be significantly reduced if the annual arithmetic average hourly price of electricity in the Ontario market (i.e. HOEP) was below $30.00 per MWh.

Subsequent amendments to the lease in 2003 and 2005 have modified the conditions of Supplemental Rent payments but have retained the concept of reduced rental payments below the HOEP threshold of $30.00 per MWh. The amendment to the Lease in 2005 made the HOEP reduction applicable only to the Bruce B operating units; the Bruce-A units are not eligible for the HOEP as long as the agreement between Bruce Power and the Province of Ontario for the refurbishment of the Bruce-A units is in effect.

The 2009 HOEP closed out at $29.58/MWh. As a result, and in accordance with Schedule 3.1 Section 3.1.3.4 of the lease agreement, OPG received the annual Supplemental Rent Certificate from Bruce Power on January 19, 2010, claiming a return of Supplemental Rent overpayments for the Bruce generating facilities. The value of the claim is $72,826,903.80 including GST (approximately $69 million excluding GST). [redacted]

Actions Taken

Upon receipt of the transmittal a number of activities were completed to validate and substantiate the claim, including:

1. Notification of appropriate stakeholders of the receipt of claim.
2. Review of contract documents in order to confirm the validity of the claim.
3. Independent calculation of the value of the claim using terms and conditions of the contract and amendments.
4. Consultation with corporate stakeholders in order to obtain consensus of conclusions.
5. Accounting entries and financial reporting for 2009 rent rebate.
6. Quantification of future exposure for OPG from subsection 3.1.3.4 of Schedule 3.1 and appropriate accounting entries.

1. Notification of Stakeholders

Upon receipt of the claim the following individuals were notified:

Dietmar Reiner, Senior Vice President - IM&CS.

Steve Reeves, Controller - IM&CS

Law Division representatives were also notified as the transmission had been addressed to David Brennan, Senior Vice President – Law and General Counsel.

2. Review of Contract Documents

Terry Dereski of the Bruce Lease Management Office provided copies of the relevant sections of the Bruce Lease Agreement and amendments #1 - 3 that deal with Supplemental Rent. The original provisions of the Lease with respect to rent payments have gone through some modification in the amendments to the Agreement.

The amendment to the contract calls for Supplemental Rent to be paid in the amount of $25,500,000 per operating unit per year (as set in 2002) adjusted by CPI factors thereafter. Providing that the average arithmetic cost of power (HOEP) exceeds $30.00 per MWh, the full Supplemental Rent per operating unit at the Bruce A and B units will be payable is monthly installments by Bruce Power to OPG.

In the event that the average HOEP falls below $30.00 per MWh the annual Supplemental Rent is reduced to $12,000,000 per year per unit for each operational Bruce B unit. Supplemental Rent for operational Bruce A units remain unchanged as long as the Bruce Power Refurbishment Implementation Agreement ("Implementation Agreement") between Bruce Power and the Province remains in effect. This provision was introduced in the 3rd amendment to the lease subsequent to the execution of the BPRIA.

During the course of the year Bruce Power pays to OPG monthly the full Supplemental Rent, and then issues to OPG a Supplemental Rent Certificate in the month of January of the following year summarizing the rent payments for the 12 preceding months. At this point, Bruce Power assesses the HOEP for the preceding year and makes a claim for reimbursement of Supplemental Rent overpayments if the HOEP value is less than $30.00 per MWh

3. Independent Calculation of Claim Values

To validate the value of the claim, an independent calculation was performed by OPG. This calculation included the following steps:

1. Verification of the arithmetic average cost of power per MWh was conducted by consulting the HOEP values published by the IESO. Based on the monthly values reported the annual average for 2009 is $29.58 per MWh. A subsequent discussion on the terms of reference and the definitions of which average should apply concluded that the $29.58 average calculated by the IESO is the appropriate value for this calculation.
2. Validation of the CPI values used by Bruce Power. Published CPI values were obtained from the Bank of Canada and were compared to the values used. While some minor differences were found these differences were not material to the calculations.
3. A spreadsheet was created to calculate the total Supplemental Rental payments per the Lease Agreements in the event that the average rate is greater than $30.00 per MWh. The total value of payments was then reconciled to monthly payments received by Bruce Power in 2009.

4. Rental payments were then calculated using the rates assuming an average rate per MWh lower than $30.00. The difference between these two methods was calculated and found to be consistent with the Bruce Power claim value.

[redacted]

4. Consultation with Corporate Stakeholders

During the investigation process a consultation process was implemented by Mario Cornacchia to ensure that stakeholders were informed of the existence and progress of the claim and to elicit opinions and other input relative to the validity and payment of the claim.

Individuals included in the consultation process included:

Dietmar Reiner	Senior VP, IM&CS
Mario Cornacchia	Commercial Services, IM&CS
Terry Dereski	Commercial Services, IM&CS
Dennis Dodo	Nuclear Finance
Randy Leavitt	VP Nuclear Finance
Steve Reeves	Nuclear Finance
Dickson Harkness	Law Division
David Brennan	Law Division
Paul Burke	Planning – Energy Markets
Joanne Barradas	Financial Services
Robin Heard	VP Finance and Chief Controller

Through this process it was concluded that the claim submitted by Bruce Power was valid in terms of the contractual obligations set out in the Lease Agreements and that the value had been correctly calculated.

It was also recommended that OPG's shareholder would be consulted prior to final approval and payment of the claim.

5. Accounting Treatment and Financial Disclosure

The accounting treatment and disclosure issues have been broken down into the following discussion areas:

5.1 Regulatory Treatment

5.2 Accounting Treatment of Embedded Derivative

5.3 Bruce B Units

5.4 Bruce A units 3-4

5.5 Valuation Model

5.6 Bruce Lease Net Revenue Variance Account

5.7 HB3862 disclosure

5.8 Tax Impact

5.9 Future Period Impact

The payment will be made pending consultation with OPG's shareholder.

The journal entry recorded reflected a reduction to lease revenue of $69 million. The reduction in revenue reflected Bruce's claim for the lower Supplemental Rent payments for 4 units at the Bruce B nuclear generating station. This reduction of $69 million was determined by subtracting the amount collected (excluding GST) for the Bruce B units minus $48 million ($12 million per unit for four Bruce B units).

This calculation excludes Bruce A. This is because the Supplemental Rent for the Bruce A units remains unchanged unless the Implementation Agreement was terminated. Currently, there is no indication that the Implementation Agreement will be terminated; thus there was no claim on the Bruce A units for 2009.

5.1 Regulatory Treatment

Although the Bruce generating stations are not prescribed facilities, the income and expenses related to the Bruce generating stations are included in the determination of OPG's regulated prices. Specifically, forecasted Bruce lease revenues were applied against OPG's revenue requirement. In the OEB's 2009 decision, the OEB authorized a Bruce Lease Net Revenue Variance account. Under the Bruce Lease Net Revenue Variance account, OPG is required capture in a variance account the difference between actual and forecast revenues and costs related to the nuclear generating stations on lease to Bruce Power. Accordingly, OPG has recorded an offsetting regulatory asset of $69 million for the 2009 reduction in Supplemental Rent.

5.2 Accounting treatment of embedded derivative

In accordance with CICA HB Section 3855, Financial Instruments – Measurement and Recognition, this adjustment to the Supplemental Rent would be considered an embedded derivative that needs to be bifurcated from the lease agreement. Embedded derivatives are measured and recognized at fair value in the statement of income, which is in addition to the current claim by Bruce Power already recognized for 2009.

This embedded derivative is similar to a series of put options written by OPG requiring OPG to "pay" Bruce Power an amount that is equal to the normal Supplemental Lease payment minus $12 million with a strike price linked to a HOEP price (arithmetic average) of $30/MWh for that year, which is exercisable by Bruce Power every year for the duration of the lease.

The value of this embedded derivative is determined based on a number of factors including forward price curves for future years (excluding the impact of any risk premium included in the forward prices), the volatility of the HOEP price, forecasted consumer price index, and a discount rate. Further details of the pricing models and inputs will be discussed later in this memo. The following discusses which of the options are included in the valuation model.

5.3 Bruce B Units

Supplemental lease payments are only applicable in years where the units are operating at any time during the year. Consistent with OPG's assumption for depreciation purposes, Bruce B units have an average useful life of 2014. To be consistent with this assumption, OPG has concluded that the valuation would only be applicable to the four units up to 2014. This is because, if the units are not operating, OPG would not collect Supplemental Rent from Bruce Power for those units and the embedded derivative would have no value.

In addition, based on the current forecast, the forward price beyond 2014 is estimated to be $45/MWh or higher, hence options value beyond 2014 will likely have a value of close to zero. In the future, if the useful life of the Bruce B generating station for accounting purposes is extended, the options related to years beyond 2014 will need to be evaluated.

5.4 Bruce A Units 3 and 4

For Bruce A Units 3 and 4, the $30/MWh trigger is only effective if the Implementation Agreement related to the Bruce A refurbishment is terminated. Currently, however, there is no indication that the Implementation Agreement will be terminated. If the Implementation Agreement were to be terminated in the future, the Bruce A option would be valued the same way as the Bruce B options as discussed above.

5.5 Valuation Model

A write-up of the valuation model is included in Appendix A and Appendix B. The model was prepared by Energy Markets and reviewed by the Corporate Portfolio Risk Management group in Finance. The basic steps to estimate the fair value of the options are as follows:

1) The valuation model estimates the probability of the strike price being met in each year;

2) The probability for the year is then multiplied by the maximum exposure for each year;

3) The result of the probability-adjusted value is discounted at OPG's credit adjusted rate;

4) The sum of all present values is the present value for the series of the options.

As of December 31, 2009, the sum of all present values for four units of Bruce A up to year 2014 is estimated to be $118 million. The fair values of the embedded derivatives are recorded in long-term accounts payable and as a reduction to revenue (Regulated – Nuclear Generation segment).

OPG uses market-based variables as input into the valuation to the extent those variables are available. The fair value of the derivative is calculated based on a number of inputs and the key inputs are listed as follows:

To calculate the probability of the strike price being met: Forward curve for electricity for Ontario[1], estimation of risk premium included in the forward curve value (to remove risk premium), and calibration of volatility.

To calculate the maximum exposure: Supplemental Rent and the Expected Consumer Price Index

To calculate present value: OPG's credit adjusted rate (In accordance with EIC 173, *Credit Risk and the Fair Value of Financial Assets and Financial Liabilities*, OPG is required to include its credit risk for the valuation of a financial liability).

To determine which options to include: Number of Units that operate during the year and Useful life of the stations.

5.6 Bruce Lease Net Revenue Variance Account

As discussed in the above, OPG is required to capture in a variance account the difference between actual and forecast revenues and costs related to the nuclear generating stations on lease to Bruce Power. Accordingly, OPG has recorded a regulatory asset of $118 million in the Bruce Lease Net Revenue Variance account.

5.7 HB3862 Disclosure

The estimation of risk premium requires the use of an assumption of implied profitability probability of 80%. This assumption is not a significant input and is not based on observable market information. Hence, the instruments are classified as level 3 for fair value disclosure purposes. In accordance with HB3862, OPG is required to present a sensitivity analysis for instruments that are classified at level 3.

The sensitivity analysis was performed by varying key assumptions to a reasonably possible degree. OPG varied the profitability probability range from 70% - 90% and volatility sigma from 0.012 to 0.018. These ranges are determined based on professional judgment of what is reasonably possible given the knowledge of the market and variability in the surrounding environment. By varying these variables, OPG disclosed sensitivity of an increase of $45 million or a decrease of $44 million, respectively.

5.8 Tax Impact

As a result of the OEB's prescribed method for calculating the income tax related to Bruce, which differs from OPG's income tax method, OPG recorded $5 million of income tax recovery in 2009 related to the $69 million. The income tax recovery related to the fair value of the embedded derivative is approximately $6 million

1. Given the illiquidity in the Ontario market for electricity forward contracts and electricity related options, forward price curves and volatilities are estimated based on limited actual transactions, bid/ask spreads posted from time to time, and inferred prices from other liquid hubs.

5.9 Prior Period Impact

Upon review of the material there is no prior period impact caused by this issue. Both parties have been applying the contract in strict accordance with its terms, and 2009 is the first year the HOEP value has dropped below $30 per MWh.

6.0 Ongoing Accounting, Reporting, and Internal Control Processes

Concurrent with the activities listed in this document Nuclear Finance has undertaken a study to improve the level of control and management reporting for the Bruce Lease Management Office. Recommendations of the study performed include the following:

1. Recommended accountabilities should be validated and accepted by identified OPG business units, including Finance, Corporate Real Estate, Law Division, Business Services & Information Technology, Risk Services, Regulatory Affairs & Corporate Strategy, and Nuclear business units with specific accountabilities.
2. Specific requirements for regular reporting should be outlined for financial results, strategic decisions, and emerging issues in order to ensure the relationship is well managed and obligations are discharged in a timely and effective manner.

[redacted]

4. Governance should be created or updated to reflect accepted accountabilities and reporting requirements. In addition, guidelines should be developed to assist OPG business units who interface with Bruce Power or receive requests outside the existing agreements. These guidelines should address materiality provisions and limits requiring formal agreement or amendment.
5. With a firm understanding of the accountabilities of OPG business units, reporting requirements and the strategic goals of the BLMO, resource levels should be reviewed for adequacy. If transactional responsibilities are to be retained by the BLMO, additional resources may be required to adequately fulfill oversight responsibilities.
6. With regard to organizational placement of the BLMO, three organizations should be considered:
   (i) Nuclear Commercial Relations,
   (ii) Corporate Affairs, and
   (iii) Corporate Business Development.

Dedicated financial support within the appropriate Controllership is also recommended.

Organizational alignment with a non-operational group will enhance BLMO capabilities to coordinate and drive the discharge of OPG obligations and service new requests. In addition, periodic reports to OPG Senior Management (and the OEB) could be appropriately integrated with other corporate initiatives.

Randy Leavitt
VP Nuclear Finance

Appendix A

Year Ended December 31, 2009
Bruce Emedded Derivative Estimate

	Input fields
Assumptions:	
Supplemental Rent for 2009	117,358,596
Reduced Supplemental Rent	12,000,000
Number of Units	4
Total Reduced Supplemental Rent	48,000,000
CPI - 2010	1.50%
CPI - 2011 to 2014	2.00%
CPI - 2015 to 2018	2.50%
Probability 2010 - 2014	50%
Probability 2015 - 2018	0%
Discount Rate	4.12%

Summary of Results:

Maximum refund (undiscounted)	736,703,307
Maximum value of derivative (PV)	599,494,478
Expected value of derivative (undiscounted)	132,000,605
Expected value of derivative (PV)	**117,973,985**

	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Full Supplemental Rent	119,118,975	121,501,354	123,931,382	126,410,009	128,938,209	132,161,665	135,465,706	138,852,349	142,323,658	1,168,703,307
Reduced Supplemental Rent	48,000,000	48,000,000	48,000,000	48,000,000	48,000,000	48,000,000	48,000,000	48,000,000	48,000,000	432,000,000
Maximum refund	71,118,975	73,501,354	75,931,382	78,410,009	80,938,209	84,161,665	87,465,706	90,852,349	94,323,658	736,703,307
Probability	41.66%	41.72%	36.71%	27.51%	27.51%	0.00%	0.00%	0.00%	0.00%	
Maximum Fair Value of Derivative (100% probability)	68,302,783	67,795,546	67,263,588	66,708,803	66,132,988	66,043,758	65,918,631	65,759,642	65,568,738	599,494,478
Total expected adjustment	29,630,350	30,663,908	27,877,529	21,566,718	22,262,100	-	-	-	-	132,000,605
PV of expected adjustments	**28,457,038**	**28,283,511**	**24,695,227**	**18,348,294**	**18,189,916**	**-**	**-**	**-**	**-**	**117,973,985**

Valuation of Bruce Power's Embedded Put Option

Hans J. H. Tuenter

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February 11th, 2010

1 Introduction

Bruce Power negotiated an embedded put option in their long-term lease contract for the Bruce A and Bruce B nuclear stations with Ontario Power Generation (OPG). Whenever the arithmetic average of the Hourly Ontario Electricity Price (HOEP) over a calendar year falls below 30$, they can exercise a provision in their contract with OPG that entitles them to a rebate on part of the rent for that year. For the calendar year 2009 this rebate is about 72.8 M$. This option is in place for the duration of the lease until the end of the year 2018.

The embedded put option constitutes an obligation for OPG that needs to be valued in the companies financial statements. The question to be answered is:

> "What is the fair value of the options for 2010–2018, as of December 31st, 2009?"

We shall answer this question by constructing a model from which the probability that the option is exercised for a given year can be derived. Multiplying these probabilities by the maximum exposure for each year and summing the discounted values gives the Present Value (PV) that is needed for the company's financial statements. This value needs to be updated during the course of the year for the quarterly financial statements.

2 Analysis

This contingent claim has elements of the following option types:

1. **Binary Put.** Such a contract pays a pre-determined, fixed amount, if the value of the underlying asset falls below a certain level,
2. **Asian Option.** Such a contract is written on the arithmetic average of the value of the underlying asset over a specific time period,
3. **Forward Starting Option.** An option where part of the components that determine the value of the option are already known when the contract is entered into.

The underlying asset on which the option is written, is the Hourly Ontario Electricity Price (HOEP). For notational brevity and to adhere to standard financial notation, we will denote this as a spot-price $S(t)$, where the time t is measured in hours. The average price over the hours $t = 1, \ldots, T$, where T is 8760 (or 8784 for a leap year), is given by

$$\bar{S} = \frac{1}{T} \sum_{t=1}^{T} S(t). \tag{1}$$

The option that Bruce Power holds is an annual recurring, binary put on $\bar{S}$, with a strike of $K = 30\$$ and notionals in the order of 72.8M\$.

2.1 Model

Rather then to propose a model for the spot-price process and its evolution, we have chosen to directly model the annual, arithmetic average of the spot price. The reasons for this are given in greater detail in Section 7.1, but boil down to the generally acknowledged difficulty of accurately modeling hourly electricity prices, certainly over longer periods of time, and the calibration of the model parameters.

The traded instruments for electricity in the Ontario market are limited to forward contracts only; options on electricity do not exist. The fact that one can synthesize the annual average over the spot price by purchasing a 7×24 forward contract over the same period, for a volume of 1 MW, forms the basis of our model. The power that we receive over that period, by paying a forward price of F per MW over a period of T hours, has a total market value of $\sum_{t=1}^{T} S(t)$. So, for a payment of $F \times T$, we receive $\sum_{t=1}^{T} S(t)$, and this establishes a connection between the forward price and the arithmetic average of the spot price over a calendar year. We formally relate the two through the following model:

$$\bar{S} \cong F e^{-\lambda - \frac{1}{2}\sigma^2 + \sigma Z}, \tag{2}$$

where the symbol $\cong$ denotes equality in distribution, F is the latest observed forward price, $\lambda > 0$ represents a discount factor, σ is a standard deviation, and Z is a standard normal variate, so that $\bar{S}$ follows a lognormal distribution. The expected value of $\bar{S}$ is given by:

$$\mathsf{E}\,\bar{S} = F e^{-\lambda}. \tag{3}$$

This incorporates the well-documented fact that the forward price in electricity markets is not an unbiased estimator of the expected (average) spot price, and incorporates a risk premium. Moreover, when the distribution of spot prices exhibits positive skewness and there is a risk of price spikes, the forward contract trades at a risk premium over the expected spot. Section 7.2 discusses this in more detail. Examining Table 1, we can see that the prices in Ontario are positively skewed and experience large price spikes, so that the assumption of a positive risk premium is plausible.

As there is no options market, from which one can derive implied volatilities, we are limited to the historical forward-price series to quantify the uncertainty around the annual average. For the standard deviation σ of the logarithmic of the annual average for the next calendar year (2010), we assume that this is the same as the standard deviation that the logarithm of the forward price would experience over a period of a calendar year. With the usual assumption that there are 250 trading days in a year, this implies that

$$\sigma = \sqrt{250}\, \sigma_F, \tag{4}$$

where σ_F is the standard deviation of the daily log-returns of the forward. For all the subsequent calendar years (2011 and beyond), we use $2 \times 250 = 500$ trading days, as the electricity price process is mean-reverting and thus the volatility will stabilize for longer periods of time, which we assume occurs after two years.

2.2 Exercise Probability

Under model (2) for the distribution of the annual average spot price, we can determine the probability that the option will be exercised for a particular year as the expected value of a \$1 binary put option B, with strike $K = 30\$$:

$$\mathsf{E}\, B = \mathsf{E}\ \mathbf{1}(\bar{S} < K) = \mathsf{Prob}\,(\bar{S} < K) = \mathsf{Prob}\,(F\, e^{-\lambda - \frac{1}{2}\sigma^2 + \sigma Z} < K) = \Phi\left(\frac{\ln(K/F) + \lambda + \frac{1}{2}\sigma^2}{\sigma}\right), \tag{5}$$

where Φ is the cumulative density function (cdf) of the standard normal distribution.

2.3 Risk Premium

The risk premium in the forward is estimated by means of the following trading strategy: at the start of the calendar year, we sell a forward at price F. During the calendar year we have to deliver the commodity at the spot price, so that the profit or loss at the end of the year is given by:

$$\text{P\&L} = F \times T - \sum_{t=1}^{T} S(t).$$

The probability of not loosing money on this trade is given by

$$\mathsf{Prob}\,(\text{P\&L} \geq 0) = \mathsf{Prob}\,(\bar{S} \leq F) = \cdots = \Phi\left(\frac{\lambda}{\sigma} + \frac{1}{2}\sigma\right).$$

If we insist that we need a minimum probability p, so that we do not loose money on the trade, we can determine the discount factor as:

$$\lambda = \Phi^{-1}(p)\sigma - \frac{1}{2}\sigma^2. \tag{6}$$

This gives the (relative) risk premium, embedded in the forward price, as:

$$\frac{F - \mathsf{E}\,\bar{S}}{F} = 1 - e^{-\lambda} \tag{7}$$

Note that p is a reflection of the risk-aversion of the trader and the market liquidity. In a market that is not very liquid, there would not be many trade opportunities to off-set a trade that lost money, and hence p would be relatively high. The more liquid a market is, the more possibilities there are to recover any losses, and consequently, the lower p would be. Note that, by (6), the risk premium λ also incorporates the volatility of the traded asset.

3 Data and Model Inputs

This Section describes the data that was used to calibrate the volatility of the forward price series, and the assumption that was made for the required probability of a trade being profitable.

3.1 Daily Volatility of the Forward

The data for the analysis was provided by the Market Risk group of Energy Markets. This comprised the historical, daily forward prices for Cal-2008, Cal-2009, and Cal-2010, as recorded on business days, over the preceding calendar years, 2007, 2008, and 2009, respectively. A volatility estimate for each time series was estimated as the standard deviation of the equally weighted, log returns. This resulted in the following estimates:

	Cal-2008	Cal-2009	Cal-2010
$\hat{\sigma}_F$	0.014528	0.016571	0.015395

.

We note that these estimated volatilities are very similar, and support the simplifying assumption that we can treat all forward price series as having the same daily volatility. Hence, we will take the rounded average of these three volatilities as the final daily, volatility estimate of the forward price: $\sigma_F = 0.015$.

3.2 Required probability of a trade being profitable

It was judged that $p =$ [redacted] would be too high, as it would probably price any potential transactions out of the market, and that $p =$ [redacted] would be too low in a very thin and volatile market to have a reasonable profit expectation. In the end, we made a judgment call, and have chosen $p =$ [redacted] as a reasonable value.

4 Sanity Check

To see what the effects of the key parameters (σ and p) of the model are, we have varied these parameters over a reasonable range and computed what the corresponding risk-premium for a Cal-2010 forward would be. The results are displayed in Table 2 and Table 3. Where the former gives the risk premium, relative to the forward price, as per (7), and the latter the risk premium, relative to the spot price.

The parameter choice of $\sigma = 0.015$ and $p =$ [redacted] results in a risk premium, relative to spot price, of [redacted] This value is comparable to the results from the market studies that OPG commissioned before market opening.

4.1 Internal Validation

Prior to market opening in Ontario on May 1st, 2002, OPG conducted several studies on how to construct forward curves and what risk premiums to charge. The findings [2, p. 18] were that there was a [redacted]% premium based on forwards over historical spots. Electricity industry consultant, C. Pirrong, reached similar conclusions. A [redacted]% premium was recommended to and approved by the Risk Oversight Committee (ROC).

5 Risk-Neutral Probabilities

We can now apply the model to give an estimate for the risk-neutral probabilities that the put option will be exercised. Combining the last quoted forward prices in 2009, for the 7×24 contracts for the calendar years 2010–2014, with the parameter estimates, previously derived, gives

	2010	2011	2012	2013	2014
FWP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$\mathsf{E}\,\bar{S}$	\$32.44	\$34.04	\$35.56	\$38.78	\$38.78
Prob.	41.7%	41.7%	36.7%	27.5%	27.5%

6 Quarterly Valuation

At the start of the period of the exposure, the probability that the option will be exercised is given by (5). For the probability during the period, when time has passed, we need to account for the fact that some portion of the average is already known, and that this reduces the uncertainty

around the probability of exercise and this has an effect on the option value. At time t_1, the prices $S_1, S_2, \ldots, S_{t_1}$ are known, and the average can be decomposed into a known and unknown part:

$$\bar{S} \times T = \sum_{t=1}^{T} S(t) = \sum_{t=1}^{t_1} S(t) + \sum_{t=t_1+1}^{T} S(t).$$

We can relate the forward price F_1, of a 7×24 over the period $t_1 + 1, \ldots, T$, to the sum of the spot prices over that period in exactly the same manner as we have done for the entire calendar year. This allows us to generalize equation (2) to

$$\bar{S} \cong \frac{t_1}{T}\bar{S}_1 + \frac{T - t_1}{T} F_1 e^{-\lambda_1 - \frac{1}{2}\sigma_1^2 + \sigma_1 Z},$$

where $\bar{S}_1$ is the average over the time period $t = 1, \ldots, t_1$, which is known at t_1. The other variables are the latest observed forward price F_1, the discount factor $\lambda_1 > 0$, and the standard deviation σ_1, all for the remainder of the year; the period $t = t_1 + 1, \ldots, T$. These can all be computed in a fashion similar to the parameters for the distribution of the annual average.

By the same mechanism as before, we can determine the probability that the option will be exercised, given the information up to t_1, as an expectation:

$$\mathsf{E}\, B_1 = \Phi\left(\frac{\ln\left(\frac{KT - t_1\bar{S}_1}{(T-t_1)F}\right) + \lambda_1 + \frac{1}{2}\sigma_1^2}{\sigma_1}\right).$$

As the option is typically revalued for the quarterly reports, the formula simplifies to:

$$\mathsf{E}\, B_i = \Phi\left(\frac{1}{\sigma_i}\ln\left(\frac{4K - i\bar{S}_i}{(4-i)F_i}\right) + \frac{\lambda_i}{\sigma_i} + \frac{1}{2}\sigma_i\right), \quad i = 0, 1, 2, 3,$$

where $\mathsf{E}\, B_i$ is the probability of exercise, when i quarters have passed, and F_i and σ_i are the forward price and implied volatility for a 7×24 forward contract over the remaining quarters. Note that for $i = 0$, at the start of the calendar year, this formula reduces to (5). Also note that, although we have taken a quarterly valuation as typical, this is easily adapted to a monthly frequency.

7 Discussion and Motivation

This Section provides a more in-depth discussion and motivation behind the modeling choices that have been made.

7.1 Spot Price Modeling

When the underlying asset follows a well-defined stochastic process, such as a Geometric Brownian Motion (GBM), an Ornstein-Uhlenbeck (OU) mean-reverting process, or any one- or multi-factor model, one can use standard approaches to value Asian-type options. For a GBM one can use moment-matching techniques to derive a proxy distribution, and for any of the more general models one can use Monte-Carlo techniques. Unfortunately, the hourly spot-price for electricity does not follow a simple stochastic process. In fact, it is general acknowledged that electricity is one of the most difficult asset classes to model. The main reasons are that electricity is a non-storable commodity, and that supply and demand must be managed and balanced in real time. The first means that standard arbitrage arguments to price derivatives that rely on buy-and-hold strategies and replication arguments do not apply. The second implies that the spot electricity price can exhibit large price spikes, as temporary surges in demand are satisfied by flexible but potentially, very expensive generation.

The result is that the hourly electricity price is determined by a host of fundamental factors, reflecting load patterns that translate into strong diurnal, weekly and seasonal price patterns, and cause strong mean-reversing in the electricity prices. Any realistic stochastic model for the spot price of electricity must also incorporate price spikes that reflect the inelasticity of demand. Weron [6, Ch. 4] gives an overview of various modeling approaches for the spot price. Another feature that has only started to occur in the last few years in the Ontario market are negative prices, due to low demand and a surplus of generation, which leads inflexible base-load generation, such as nuclear to offer at negative prices in order to avoid having to shut-down. This phenomenon has been observed much earlier in more mature markets, that have a sizeable amount of renewable generation in their generation mix, see Sewalt and de Jong [5]. The feature of negative prices is of particular importance in our setting, as these prices are a major contributing factor to the average HOEP for 2009 being as low as $29.517. With this in mind, it is important to note that in almost all of the spot-price models in the literature, it is tacitly assumed that negative prices cannot occur. Finally, even if an appropriate model can be formulated, one still has to calibrate a large number of parameters, which is challenging in a stationary market, let alone in a market such as Ontario where the generation mix is changing.

For all of the above reasons we have chosen not to use the approach of modeling the evolution of the spot price through some stylized stochastic process. This ruled out a straightforward Monte Carlo simulation approach.

7.2 Risk Premium

If we were dealing with a normal financial asset, the forward price would be equal to the discounted, expected value of its stochastic counterpart. However, this is not the case for electricity forwards. It is well documented in the literature that the forward price in electricity markets is not an unbiased estimator of the spot price, and incorporates a risk premium. Bessembinder and Lemmon [1] study the PJM market and find that the risk premium, defined as the difference between the forward and expected spot price over the period that the forward covers, increases when the spot power-price distribution exhibits positive skewness. Longstaff and Wang [4] also find significant forward premia in electricity forward prices. They also find that forward premia are positively correlated with skewness of the spot price distribution. Diko et al. [3], using data from the three major and most liquid continental European energy markets: the Dutch, German, and French electricity markets, also show significant risk premia in the forward price.

References

[1] Hendrik Bessembinder and Michael L. Lemmon. Equilibrium pricing and optimal hedging in electricity forward markets. *The Journal of Finance*, 57(3):1347–1382, June 2002.

[2] OPG Corporate. Forward price curve process: Forward price analysis, commercial operations, October 26th, 2000. OPG Confidential.

[3] Pavel Diko, Steve Lawford, and Valerie Limpens. Risk premia in electricity forward prices. *Studies in Nonlinear Dynamics & Econometrics*, 10(3):Article 7, 24 pp., September 2006.

[4] Francis A. Longstaff and Ashley W. Wang. Electricity forward prices: A high-frequency empirical analysis. *The Journal of Finance*, 59(4):1877–1900, August 2004.

[5] Michael Sewalt and Cyriel de Jong. Negative prices in electricity markets. *Commodities Now*, pages 74–77, June 2003.

[6] Rafał Weron. *Modeling and Forecasting Electricity Loads and Prices: A Statistical Approach*. John Wiley, Chichester, England, 2006.

	2003	2004	2005	2006	2007	2008	2009
Mean	54.045	49.950	68.492	46.383	47.806	48.830	29.517
SDev	35.929	21.892	40.739	23.984	24.658	29.762	30.864
Skewness	2.979	1.819	2.871	5.450	1.563	2.591	30.214
Kurtosis	22.323	11.804	20.540	106.719	12.803	25.394	1654.762
Min	11.540	5.250	8.600	-3.100	-0.400	-34.000	-52.080
Max	548.520	340.450	639.970	699.650	436.530	563.620	1891.140

Table 1. HOEP statistics

$\sigma \backslash p$					
0.010					
0.012					
0.014					
0.015					
0.016					
0.018					
0.020					

Table 2. Risk Premium embedded in a Cal-2010 Forward (relative to the Forward price)

$\sigma \backslash p$					
0.010					
0.012					
0.014					
0.015					
0.016					
0.018					
0.020					

Table 3. Risk Premium embedded in a Cal-2010 Forward (relative to the spot price)

Bruce Embedded Derivative — Technical Disclosure.

The references in this document are to Equations and Sections in the Technical Document. Words in **boldface** indicate corresponding variable names and constants in the mathematical model, described in the Technical Document.

The exercise probability **EB** of the binary option is calculated as per Eqn (5), with the discount factor **lambda** determined as per Eqn (6). Combining these two equations, this can be coded in Excel, as follows:

EB = NORMSDIST(NORMSINV(**p**)+LN(**K/F**)/**sigma**).

As described in Section 3.2, the value for **p** is taken as p=[redacted] and is fixed throughout and used equally for all valuations. The strike price **K** is $30, as per the lease agreement. The forward price **F** is the price for a 7x24 forward contract over the relevant calendar year, as seen on the valuation date. The aggregate volatility **sigma** is computed as the square root of the number of trading days **NTD** (that are left to the expiry of the option), multiplied by the historical daily volatility. The aggregate of volatility is capped at 500 trading days, as explained towards the end of Section 2.1.

The discount factor **lambda** is calculated as per Eqn (6). This can be coded in Excel as follows:

lambda = NORMSINV(**p**)***sigma** – ½***sigma**^2.

The discount factor determines the risk premium that is embedded in the forward price and is calculated as per Eqn (7). This can be coded in Excel as follows:

Risk Premium (in %)= 100*(1-EXP(-**lambda**)).

The expected annual average HOEP can then be computed by stripping out the risk premium from the forward price, as per Eqn (3). This can be coded in Excel as follows:

Exp HOEP = **F***EXP(-**lambda**).

The parameter values that were used in the valuations that were provided are given in the following tables.

Valuation Date				**Bruce Embedded Derivative Valuation**				
Sat 31-Dec-2011				Parameter Values				
	Forward Price	Nr Trading Days	Daily Volatility				Strike Price	Prob of Exercise
	F	**NTD**		**sigma**	**lambda**		**K**	**EB**
2012	[redacted]	250.0	0.013792	0.218075	[redacted]	$	30.00	88.93%
2013		500.0	0.013792	0.308405		$	30.00	82.10%
2014		500.0	0.013792	0.308405		$	30.00	74.26%

Valuation Date				**Bruce Embedded Derivative Valuation**				
Fri 29-Jun-2012				Parameter Values				
	Forward Price	Nr Trading Days	Daily Volatility				Strike Price	Prob of Exercise
	F	**NTD**		**sigma**	**lambda**		**K**	**EB**
2012	[redacted]	126.4	0.011659	0.131061	[redacted]	$	30.00	99.91%
2013		376.4	0.010945	0.212336		$	30.00	98.92%
2014		500.0	0.010945	0.244740		$	30.00	95.69%

Valuation Date				**Bruce Embedded Derivative Valuation**				
Fri 29-Jun-2012				Parameter Values	**Life Extension**			
	Forward Price	Nr Trading Days	Daily Volatility				Strike Price	Prob of Exercise
	F	**NTD**		**sigma**	**lambda**		**K**	**EB**
2015	[redacted]	500.0	0.010945	0.244740	[redacted]	$	30.00	89.24%
2016		500.0	0.010945	0.244740		$	30.00	81.71%
2017		500.0	0.010945	0.244740		$	30.00	77.42%
2018		500.0	0.010945	0.244740		$	30.00	71.32%
2019		500.0	0.010945	0.244740		$	30.00	61.64%

Attachment – C

ATTACHMENT C

Form of Declaration and Undertaking

EB-2012-0002

IN THE MATTER OF the Ontario Energy Board Act, 1998;

AND IN THE MATTER OF an Application by Ontario Power Generation Inc. for an order or orders approving payment amounts for prescribed generating facilities commencing March 1, 2011

DECLARATION AND UNDERTAKING

I, _____, am counsel of record or a consultant for

_____.

DECLARATION

I declare that:

1. I have read the *Rules of Practice and Procedure* of the Ontario Energy Board (the "Board") and all Orders of the Board that relate to this proceeding.

2. I am not a director or employee of a party to this proceeding for which I act or of any other person known by me to be a party in this proceeding.

3. I understand that this Declaration and Undertaking applies to all information that I receive in this proceeding and that has been designated by the Board as confidential and to all documents that contain or refer to that confidential information ("Confidential Information").

4. I understand that this Declaration and Undertaking is a condition of an Order of the Board, that the Board may apply to the Superior Court of Justice to enforce it.

UNDERTAKING

I undertake that:

1. I will use Confidential Information exclusively for duties performed in respect of this proceeding.

2. I will not divulge Confidential Information except to a person granted access to such Confidential Information or to the Board.

3. I will not reproduce, in any manner, Confidential Information without the prior written approval of the Board. For this purpose, reproducing Confidential Information includes scanning paper copies of Confidential Information, copying the Confidential Information onto a diskette or other machine-readable media and saving the Confidential Information on to a computer system.

4. I will protect Confidential Information from unauthorized access.

5. I will, promptly following the end of this proceeding or within 10 days after the end of my participation in this proceeding:

   (a) return to the Board Secretary, under the direction of the Board Secretary, all documents and materials in all media containing Confidential Information, including notes, charts, memoranda, transcripts and submissions based on such Confidential Information; or

   (b) destroy such documents and materials and file with the Board Secretary a certification of destruction in the form prescribed by the Board pertaining to the destroyed documents and materials.

   For this purpose, the end of this proceeding is the date on which the period for filing a review or appeal of the Board's final order in this proceeding expires, or, if a review or appeal is filed, upon issuance of a final decision on the review or appeal from which no further review or appeal can or has been taken.

6. I will inform the Board Secretary immediately of any changes in the facts referred to in this Declaration and Undertaking.

Dated at _____ this _____ day of _____, _____.

Signature:
Name:
Company/Firm:
Address:
Telephone:
Fax:
E-mail: