

BEFORE THE  
PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of the Application of  
Columbus Southern Power Company for  
Approval of its Electric Security Plan  
Including Related Accounting Authority;  
and an Amendment to its Corporate  
Separation Plan; and the Sale or Transfer  
Of Certain Generating Assets

Case No. 08-917-EL-SSO

In the Matter of the Application of  
Ohio Power Company for Approval of  
of its Electric Security Plan Including  
Related Accounting Authority;  
and an Amendment to its Corporate  
Separation Plan

Case No. 08-918-EL-SSO

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DIRECT TESTIMONY OF  
  
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ON BEHALF OF  
  
INDUSTRIAL ENERGY USERS- OHIO

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June 30, 2011

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**I. INTRODUCTION, PURPOSE AND SUMMARY OF CONCLUSIONS**

1 **Q PLEASE STATE YOUR NAME, TITLE, AND BUSINESS ADDRESS.**

2 A My name is Jonathan A. Lesser. I am President of Continental  
3 Economics, Inc., an economic consulting firm that provides litigation, valuation,  
4 and strategic services to law firms, industry, and government agencies. My  
5 business address is 6 Real Place, Sandia Park, NM 87047.

6 **Q PLEASE DESCRIBE YOUR PROFESSIONAL QUALIFICATIONS,**  
7 **EMPLOYMENT EXPERIENCE, AND EDUCATIONAL BACKGROUND.**

8 A I am an economist specializing in litigation support and market analysis in  
9 the energy industry. I have over 25 years of experience in the energy industry  
10 working with utilities, consumer groups, competitive power producers and  
11 marketers, and government entities. I have provided expert testimony before  
12 state utility commissions in Alaska, Arkansas, Connecticut, Illinois, Maryland,  
13 New Jersey, New York, Oklahoma, Texas, and Vermont, as well as before the  
14 Federal Energy Regulatory Commission ("FERC"), state legislative committees,  
15 and before international regulators and courts of law.

16 Before founding Continental Economics, I was a Partner in the Energy  
17 Practice with the consulting firm Bates White, LLC. Prior to that, I was the  
18 Director of Regulated Planning for the Vermont Department of Public Service.  
19 Previously, I was employed as a Senior Managing Economist at Navigant  
20 Consulting. Prior to that, I was the Manager, Economic Analysis, for Green  
21 Mountain Power Corporation. I also spent seven years as an Energy Policy  
22 Specialist with the Washington State Energy Office, and I worked for Idaho

Power Corporation and the Pacific Northwest Utilities Conference Committee (an electric industry trade group), where I specialized in electric load and price forecasting.

I hold MA and PhD degrees in economics from the University of Washington and a BS, with honors, in mathematics and economics from the University of New Mexico. My doctoral fields of specialization were applied microeconomics, econometrics and statistics, and industrial organization and antitrust. I also completed the doctoral sequence of courses in Finance, and have developed empirical models to value options associated with electric contracts. I am the coauthor of three textbooks, including *Environmental Economics and Policy* (1997), *Fundamentals of Energy Regulation* (2007), and, most recently, *Principles of Utility Corporate Finance* (2011). I have attached a copy of my curriculum vita as Exhibit JAL-1.

**Q ARE YOU A MEMBER OF ANY PROFESSIONAL ORGANIZATIONS?**

A Yes. I am a member of the International Association for Energy Economics, the Energy Bar Association, and the Society for Benefit-Cost Analysis.

**Q ON WHOSE BEHALF ARE YOU TESTIFYING?**

A I am testifying on behalf of Industrial Energy Users-Ohio.

**Q WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THIS PROCEEDING?**

A I have been asked to respond to the testimony submitted by Columbus Southern Power Company and Ohio Power Company (collectively "AEP Ohio" or

1 "the Company") witnesses Laura Thomas,<sup>1</sup> Dr. Chantale LaCasse,<sup>2</sup> and Dr. Anil  
2 Makhija,<sup>3</sup> regarding AEP Ohio's use of an option pricing model to value its  
3 provider of last resort ("POLR") obligation during its current Electric Security Plan  
4 ("ESP"), which expires on December 31, 2011. I will explain why the option  
5 model used by AEP Ohio as the basis for establishing POLR charges levied on  
6 its Standard Service Offer ("SSO") customers does not correctly establish POLR  
7 charges that compensate utilities "for customers who shop and then return to [the  
8 utility] for generation service" as described by the Ohio Supreme Court in its April  
9 19, 2011 opinion, *In re Application of Columbus S. Power Co.*, 128 Ohio St.3d  
10 512, 517 (2011) (citing *Constellation NewEnergy, Inc. v. Pub. Util. Comm.*, 104  
11 Ohio St.3d 530, ¶ 39, fn. 5). I will also explain that AEP Ohio has presented no  
12 evidence supporting its purported actual out of pocket costs for serving as the  
13 POLR. Finally, I will explain that AEP Ohio has presented no evidence justifying  
14 a non-cost based POLR rider. See *id.* at 519.

15 **Q PLEASE SUMMARIZE YOUR CONCLUSIONS.**

16 **A** AEP Ohio proposes to set its POLR charges based on what it terms the  
17 "option value" to AEP Ohio customers for the right, but not the obligation, to  
18 return to SSO service. To estimate this option value, AEP Ohio uses what is  
19 called the "Black" model, named after economist Fisher Black. The Black model

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<sup>1</sup> Direct Testimony of Laura Thomas on Behalf of Columbus Southern Power Company and Ohio Power Company, Case Nos. 08-917-EL-UNC and 08-918-EL-UNC, June 6, 2011 ("Thomas Direct").

<sup>2</sup> Direct Testimony of Chantale LaCasse on Behalf of Columbus Southern Power Company and Ohio Power Company, Case Nos. 08-917-EL-UNC and 08-918-EL-UNC, June 6, 2011 ("LaCasse Direct").

<sup>3</sup> Direct Testimony of Anil Makhija on Behalf of Columbus Southern Power Company and Ohio Power Company, Case Nos. 08-917-EL-UNC and 08-918-EL-UNC, June 6, 2011 ("Makhija Direct").

1 is a variant of the more well-known "Black-Scholes" option pricing model, and is  
2 used to price so-called "European" futures options.

3 In brief, my conclusions regarding AEP Ohio's use of this model to  
4 estimate its POLR-related costs are as follows:

5 **AEP Ohio's Cost To Provide POLR Service Is Not Equal To Its Customers'**  
6 **Option Value- Described in Section III of Testimony.**

7 (1) Despite the Ohio Supreme Court's clear language that AEP Ohio may be  
8 able to recover the POLR-related costs the Company incurs from  
9 "standing ready to service customers who shop and return," AEP Ohio  
10 continues to insist that its POLR-related costs precisely equal the option  
11 value to SSO customers. AEP Ohio is fundamentally wrong. AEP Ohio  
12 not only includes as its POLR obligation cost the option value of SSO  
13 customers returning to SSO service, it also includes the option value of  
14 SSO customers leaving AEP Ohio to take service with competitive retail  
15 electric service ("CRES") providers. Fundamentally, POLR costs do not  
16 include costs to AEP Ohio stemming from SSO customers deciding to  
17 purchase from CRES providers.

18 (2) The cost to AEP Ohio of providing POLR service is not equal to the overall  
19 option value its customers have for having to return to SSO service. AEP  
20 Ohio's costs stem from standing ready to serve customers who return to  
21 SSO service. The cost of doing so will include either costs related to a  
22 competitive procurement that auctions off AEP Ohio's POLR risk to  
23 competitive suppliers, who would then provide the electric energy needs of  
24 customers returning to SSO service, or some other form of energy hedge  
25 purchased directly by AEP Ohio. However, AEP Ohio has presented no  
26 evidence of the cost of any hedging activity.

27 **The Black Model Is Not Appropriate To Estimate SSO Customers' Option**  
28 **Values- Described in Section IV of Testimony.**

29 (3) Even if, *arguendo*, AEP Ohio's cost to provide POLR service did equal its  
30 distribution customer's overall option value, the Black model used by AEP  
31 Ohio is not appropriate to estimate that option value, because key  
32 assumptions that underlie that model's use in the context of valuing  
33 futures options do not apply. Specifically, the Black model makes the  
34 following assumptions that are not met in this case: (a) markets are  
35 perfect and customers will always act in their economic best interest; (b)

price volatility is constant and is reflected by the PJM wholesale market price, even though consumers pay a retail price; (c) the strike price, *i.e.*, AEP Ohio's ESP price, is constant; (d) returns are lognormally distributed; and (e) the option to be priced is a European option.

(4) AEP Ohio's claims regarding the Black model are overstated. Specifically, the Black model is not an appropriate method to calculate: (a) the cost of the risk to AEP Ohio of serving as a POLR provider; (b) the "value" received by AEP's customers; or (c) the simultaneous value of a "put" and "call" option.

#### **AEP Has Used Incorrect Volatility Input Values In The Black Model- Described in Section V of Testimony.**

(5) Even if, *arguendo*, one determined that the Black model could be used to value SSO customers' option values to return, AEP Ohio uses inappropriate volatility values in the option pricing model that render the estimates derived from its use of the Black model incorrect and excessive.

#### **AEP Has Not Identified Its Actual POLR-Related Costs- Described in Section VI of Testimony.**

(6) AEP Ohio has not identified, let alone substantiated, any actual POLR related costs. Therefore, AEP Ohio has failed to demonstrate that its POLR related costs meet the "known and measurable" standard that is basic to ratemaking and should not be included as a nonbypassable charge in its rates.

## **II. BACKGROUND OF THE PROCEEDING**

### **1. AEP's Choice of an Option Model to Value POLR Risk**

#### **Q WHAT IS THE GENESIS OF THIS PROCEEDING?**

A In 2008, AEP Ohio calculated and valued its POLR-related risk using what is called the Black-Scholes option pricing model. According to AEP Ohio witness Craig Baker, "customers have the right to leave the utility and take service from an alternative supplier as well as the right to return to AEP Ohio's ESP pricing if future market price fluctuations make it advantageous for them to do so. AEP

1 Ohio is holding the other side of that arrangement; AEP Ohio is obligated to  
2 stand ready to handle whatever load fluctuations may result from such  
3 switching.”<sup>4</sup>

4 Based on his reasoning, Mr. Baker concluded that an option pricing  
5 model, specifically the Black-Scholes option pricing model, was the appropriate  
6 way to value this risk, stating “When determining the cost of AEP Ohio’s POLR  
7 obligation, it is important to realize that in financial terms, such one-sided rights  
8 that customers receive through retail choice are equivalent to a series of options  
9 on power.”<sup>5</sup> Using the Black-Scholes model, AEP Ohio determined that its POLR  
10 costs were \$108.2 million for Columbus Southern Power (“CSP”) and \$60.9  
11 million for Ohio Power Company (“OPC”) each year of the ESP.

12 **Q IN ITS RECENT DECISION, DID THE OHIO SUPREME COURT DETERMINE**  
13 **THAT AEP OHIO’S COST OF PROVIDING POLR SERVICE EQUALED ITS**  
14 **CUSTOMERS’ OPTION VALUE ASSOCIATED WITH THE ABILITY TO**  
15 **RETURN TO SSO SERVICE?**

16 **A** No. In its April 19, 2011 decision, the Court stated, “We have carefully  
17 reviewed the record, and we can find no evidence suggesting that AEP Ohio’s  
18 POLR charge is related to any costs it will incur.”<sup>6</sup> The Court further stated:

19 Contrary to the order, this formula simply does not reveal “the cost  
20 to the Companies to be the POLR and carry the risks associated  
21 therewith.” The record shows that the model does not even purport

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<sup>4</sup> *In the Matter of the Application of Columbus Southern Power Co. for Approval of an Electric Security Plan; an Amendment to its Corporate Separation Plan; and the Sale or Transfer of Certain Generating Assets, Case Nos. 08-917-EL-SSO et al., Direct Testimony of J. Craig Baker on Behalf of Columbus Southern Power Company and Ohio Power Company, July 31, 2008 (“Baker Direct”), at 30:1-5 (“ESP I”).*

<sup>5</sup> *Id.* at 30:20-23.

<sup>6</sup> *In re Application of Columbus S. Power Co.*, 128 Ohio St.3d 512, 518 at ¶ 25 (2011).

1 to estimate costs, but instead tries to quantify "the value of the  
2 optionality [to shop for power] that is provided to customers under  
3 Senate Bill 221." *Value to customers* (what the model shows) and  
4 *cost to AEP Ohio* (the purported basis of the order) are simply not  
5 the same thing.<sup>7</sup>

6 The Court concluded that AEP Ohio had not presented any evidence of the costs  
7 the Company would incur from having to serve customers who wished to return  
8 to SSO service.

9 **Q DID THE COURT DEFINE THE SCOPE OF AEP'S POLR RISK?**

10 A Yes. In this same decision the Ohio Supreme Court defined POLR risk as  
11 the obligation "to stand ready to accept **returning customers**."<sup>8</sup> This admonition  
12 is a continuation of well-established Ohio authority, as the Ohio Supreme Court  
13 has consistently described POLR charges as compensating utilities for standing  
14 ready to serve "customers who shop **and then return**."<sup>9</sup>

15 **2. The Black-Scholes and Black Option Models**

16 **Q CAN YOU DESCRIBE THE "BLACK" MODEL IN SIMPLE TERMS?**

17 A Yes. The genesis of the Black model, and the better known Black-  
18 Scholes model that preceded it, was a straightforward question: how does one  
19 value a stock option? This model can also be used to value commodity spot  
20 options, including electricity, that are widely traded in liquid markets.

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<sup>7</sup> *Id.* at ¶ 26 (emphasis added).

<sup>8</sup> *Id.* at 517, ¶ 23 (emphasis added).

<sup>9</sup> *In re Application of Ormet Primary Aluminum Corp.*, 2011-Ohio-2377, ¶ 15 (May 24, 2011) (emph. added), quoting *Constellation NewEnergy, Inc. v. Pub. Util. Comm.*, 104 Ohio St.3d 530, ¶ 39 fn.5.

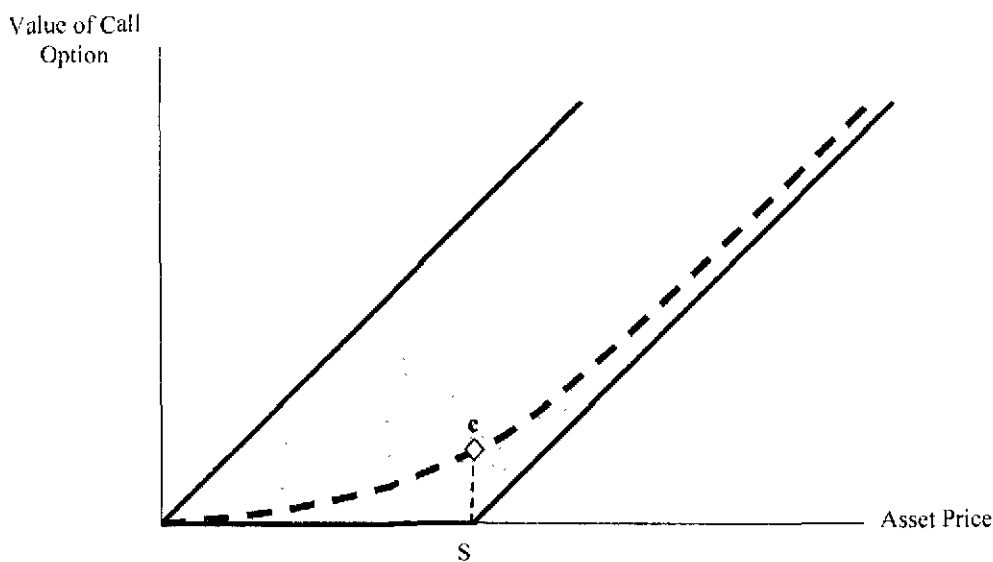
1           To understand the Black model, let me begin by describing the Black-  
2       Scholes model on which it is based. The Black-Scholes model is easiest to  
3       describe by using examples that describe the model and its inputs. For example,  
4       suppose the price of AEP stock closed at \$37 today. And suppose I am offered  
5       an option that will give me the right, but not the obligation, to purchase one share  
6       of AEP stock six months from today at a price of \$40. That price is called the  
7       *strike price* and this type of option is called a *European call option*, because it  
8       has a fixed exercise date. If AEP's stock increases to \$45 tomorrow, I cannot  
9       exercise my option to buy one share of AEP stock for \$40 tomorrow because  
10      under the terms of the option I can only exercise it six months from now. A  
11      *European put option* would give me the right, but not the obligation, to sell one  
12      share of AEP stock six months from today at a price of \$40.

13           If, on that day six months from now, AEP's stock price is actually \$45, I will  
14      earn \$5 profit, because I can exercise my call option to buy the share of stock for  
15      \$40 and immediately sell it for \$45. Of course, the price of AEP's stock may not  
16      be \$45 six months from today. In fact, the price could fall to less than \$40. In  
17      that case, my call option would be worthless, but a put option would be worth the  
18      *difference between \$40 and the stock's closing price.*

19           Intuitively, the value of the call option to buy one share of AEP's stock six  
20      months from today depends on the likelihood that the price will be greater than  
21      the \$40 strike price at that time. And, because stock prices follow what is called  
22      a "random walk," the likelihood of the market price exceeding the \$40 strike price  
23      six months from today depends on how volatile the stock price is.

The Black-Scholes model calculates a *spot* option value. That is, the option value associated with buying or selling an asset (e.g., stocks, bonds, gold, corn, etc.) on a fixed date in the future. The value of the spot option depends on a number of factors, including the volatility of the underlying asset's market price, the time until the option expires, and the risk-free interest rate. The value of a call option always falls within the shaded area shown in Figure 1.<sup>10</sup>

**Figure 1: Call Option Value**



The reasons are as follows. First, ignoring the purchase price of the option itself, the value of the option can never be less than zero. For example, if I purchase a call option on AEP stock with a strike price of \$40, but the actual market price on the exercise date is \$35, I simply will not exercise the option. Second, the value of an option can never be greater than the price of the asset. If the price of AEP stock is \$45 on the exercise date, the value of the option cannot be greater than

<sup>10</sup> Adapted from L. Giacchino and J. Lesser, *Principles of Utility Corporate Finance*, (Vienna, VA: Public Utilities Reports, Inc. 2011), p. 305.

\$45. This defines the leftmost boundary of the shaded area, because along that line the value of the call option equals the asset price. Once the asset price exceeds the strike price, then the value of the option is positive. For example, if the price of AEP stock is \$45 and the option has a \$40 strike price, then the value of the option is  $\$45 - \$40 = \$5$ . The rightmost border of the shaded area is the line along which the call option value just equals the asset price less the strike price.

The market value of the call option when it is purchased will fall along the dashed line inside the shaded area. For example, if the strike price of the AEP stock option is \$40 and that is also the price of the stock the day the option itself is purchased, then the value of the call option must be positive. The reason is that, because the price of AEP stock is volatile, there is a non-zero probability that the price of the stock on the exercise date will be greater than \$40. Hence, the value of the option must be greater than zero. In fact, the value of the option today is, in essence, the expected net present value of the option on its exercise date. In Figure 1, the value of the option today is labeled as point c. The Black-Scholes option valuation model provides a compact formula for determining the value of call and put options.

**Q HOW DOES THE BLACK MODEL DIFFER FROM THE BLACK-SCHOLES MODEL?**

A Black extended the Black-Scholes model to value futures options, and this extension is known as the Black model. A futures option is a right, but not the

obligation, to enter into a futures contract.<sup>11</sup> A futures contract is just a standardized contract for the sale or delivery of a commodity, like corn or electricity, or a financial instrument, like a U.S. Treasury bond, at a specified time in the future. Futures contracts are actively traded in liquid markets, such as the New York Mercantile Exchange ("NYMEX") or the Chicago Board of Trade ("CBOT").

**Q ARE THERE ELECTRICITY FUTURES CONTRACTS?**

A Yes. For example, electricity futures contracts for delivery of power to the PJM West Hub during peak hours are traded on NYMEX. The size of each contract is 80 megawatt-hours ("MWh") delivered at a rate of 5 MW per peak hour over the 16-hour period from 7AM to 11PM, Monday-Friday.<sup>12</sup>

On Tuesday, June 14, 2011, the price of the August futures contract closed at \$67.40/MWh. Thus, if you purchased one futures contract for delivery in August 2011, you would be agreeing to pay \$67.40/MWh for 80 MWh of electricity to be delivered in August. If you sold that futures contract, you would agree to deliver 80 MWh of electricity at a price of \$67.40/MWh during peak-hours in August.

**Q IF YOU BUY AN ELECTRICITY FUTURES OPTION, DO YOU HAVE TO PHYSICALLY TAKE THE ELECTRICITY?**

A No. In fact, in most cases, holders do not take physical delivery. Instead, the contracts can be used to hedge risk. Suppose you hold one August 2011

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<sup>11</sup> See *id.* pp. 294-98 for a discussion.

<sup>12</sup> The full contract terms can be found at: [www.cmegroup.com/trading/energy/electricity/pjm-western-hub-peak-calendar-month-real-time-lmp\\_contract\\_specifications.html](http://www.cmegroup.com/trading/energy/electricity/pjm-western-hub-peak-calendar-month-real-time-lmp_contract_specifications.html).

1 electricity futures call option with a strike price of \$69/MWh. Suppose that on  
2 July 30, the closing price is \$70.00/MWh. If you exercise your option on that  
3 date, you will earn:  $80 \text{ MWh} \times (\$70/\text{MWh} - \$69/\text{MWh}) = \$80$ , and you will now  
4 hold a contract entitling you to 80 MWh of electricity delivered in August at the  
5 current futures price. Thus, whereas a spot option provides the right, but not the  
6 obligation to buy or sell an asset, a futures option provides the right, but not the  
7 obligation, to enter into a specific futures contract. Either type of option can be  
8 used to hedge risk.

9 **III. AEP OHIO'S COST TO PROVIDE POLR SERVICE IS NOT EQUAL TO**  
10 **ITS CUSTOMERS' OPTION VALUE**

11 **1. AEP Ohio's POLR Costs Do Not Include Costs Associated with**  
12 **Consumers Leaving SSO Service**

13 **Q DOES AEP OHIO'S PROPOSED POLR CHARGE INCLUDE THE OPTION**  
14 **VALUE ATTRIBUTED TO CUSTOMERS FOR LEAVING SSO SERVICE TO**  
15 **TAKE SERVICE FROM CRES PROVIDERS?**

16 **A** Yes. AEP's proposed POLR charge improperly includes the option value  
17 attributed to customers leaving SSO service to take service from CRES  
18 providers. According to AEP Ohio, the component related to customers leaving  
19 to take service from CRES providers accounts for 88% of the Company's POLR  
20 option value as calculated by its new constrained option pricing model.<sup>13</sup> In its  
21 original direct testimony relating to the unconstrained option model AEP witness  
22 Baker calculated this component as 90% of the Company's POLR option value.<sup>14</sup>

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<sup>13</sup> See *In the Matter of the Application of Columbus Southern Power Co. and Ohio Power Co. for Authority to Establish a Standard Service Offer Pursuant to Section 4928.143, Ohio Revised Code, in the Form of an Electric Security Plan*, Case No. 11-346-EL-SSO, et al., AEP Ohio response to OCC INT-037 ("ESP II").

<sup>14</sup> See *ESP I*, Testimony of AEP Witness Baker, Transcript Volume XIV, page 409 of 544.

1 This is known as the "First-Leave Cost Component." Hence, under AEP Ohio's  
2 own hypothesis, only 10% of the POLR option value is related to customers  
3 returning to POLR service--which is the risk for which they may be compensated.

4 **Q IS INCLUDING THE OPTION VALUE PURPORTEDLY RECEIVED BY**  
5 **CUSTOMERS LEAVING SSO SERVICE TO TAKE SERVICE FROM CRES**  
6 **PROVIDERS A LEGITIMATE COMPONENT OF AEP OHIO'S POLR**  
7 **CHARGE?**

8 **A** No. The "First-Leave Cost Component" is the option value attributed to  
9 migrating customers. This is not a noncompetitive cost, but instead is a  
10 competitive cost of providing generation service. Migration away from the SSO  
11 results when market prices are expected to be lower than the SSO price for the  
12 foreseeable future. This is a risk of competitive markets, not a risk of being a  
13 POLR provider. When this occurs, AEP Ohio may sell any surplus generation  
14 into the PJM markets, so it is compensated for its generation at market prices  
15 and no additional POLR compensation is necessary or appropriate.

16 **2. Customer Option Value to Return to SSO Service is Not Equal to AEP**  
17 **Ohio's Cost**

18 **Q AEP OHIO WITNESS MAKHIJA TESTIFIES THAT THE VALUE OF THE POLR**  
19 **OPTION TO AEP OHIO CUSTOMERS IS, BY DEFINITION, EQUAL TO THE**  
20 **COST INCURRED BY AEP OHIO. DO YOU AGREE?**

21 **A** No. Dr. Makhija states that, "the benefits provided to the customers  
22 cannot appear out of thin air. Someone has to provide these benefits, and for  
23 that party it constitutes a cost. The cost to the utility that provides the POLR

1        optionality is no more or less than the value of the option received by the  
2        customers.”<sup>15</sup> That is incorrect.

3                To understand why, suppose you have been wandering in the desert and  
4        are extremely thirsty. In fact, you are so thirsty that you would pay \$100 for a  
5        bottle of water. Suddenly, you come to a grocery store. You rush in and  
6        discover the store sells large bottles of cold water for one dollar. You reach into  
7        the cooler for a bottle and start drinking it before you reach the cash register.

8                Feeling refreshed, you pay the cashier a dollar for the bottle of water you  
9        have consumed. You would have been willing to pay up to \$100 for the bottle of  
10       water. So, you received \$99 worth of additional benefit, what economists call  
11       “consumer’s surplus.” Now, consider this transaction from the store’s point of  
12       view. If selling the bottle of water cost the store two dollars, based on the actual  
13       cost to stock and sell the bottle of water, presumably the store would not sell it for  
14       less than two dollars. Thus, it must be the case that the store’s cost was less  
15       than one dollar. In fact, suppose the store’s cost was 75 cents. In that case, the  
16       store benefited by 25 cents, what economists call “producer’s surplus.” Clearly,  
17       the value of the bottle of water to you was much different than the cost of the  
18       water to the store.

19    **Q       DOES THIS SAME PRINCIPLE APPLY TO FINANCIAL OPTIONS?**

20    **A** Yes. For example, the reason someone will buy a call option is that he  
21       values the option at least as much as its market price. Similarly, the reason  
22       someone will sell that same call option is that the revenue he receives from

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<sup>15</sup>        Makhija Direct at 3:22-4:2.

1 selling the option is greater than the expected cost. The market price is  
2 determined by the interactions of those wishing to buy the option and those  
3 wishing to sell, settling when last buyer values the option the same as the last  
4 seller values it. Dr. Makhija's statement applies only for the last (marginal) buyer  
5 and seller. For all others, the value of the option to the buyer is greater than the  
6 cost to the seller.

7 The fact that I can buy a futures option today for delivery of electricity into  
8 PJM in August at a known average market price does not mean I will buy that  
9 option. I will only do so if I value the option at least as much as its market price  
10 today. As the futures option for peak-hour August delivery continues to be traded  
11 until the market for it closes (on July 31), its price will change, reflecting changes  
12 in buyers' and sellers' expectations of actual market prices during the month of  
13 August. However, these expectations are not necessarily related to the seller's  
14 cost.

15 **Q AEP OHIO WITNESS THOMAS SAYS THE POLR CHARGE REFLECTS THE**  
16 **COST OF PROVIDING CUSTOMERS WITH THE OPTION TO SWITCH. DO**  
17 **YOU AGREE?**

18 **A** No. Ms. Thomas, like Dr. Makhija, wrongly presumes that the value of the  
19 option to AEP Ohio consumers equals the cost to AEP Ohio.<sup>16</sup> Ironically, to  
20 bolster her argument Ms. Thomas quotes the language in the Ohio Supreme's  
21 Court's decision that POLR charges compensating utilities for standing ready to  
22 serve customers who shop and return.<sup>17</sup> However, Ms. Thomas ignores the

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<sup>16</sup> Thomas Direct at 11:16-18.

<sup>17</sup> *Id.* at 12:2-5.

1 language in this same opinion, which clearly states that the value received by  
2 customers does not necessarily equal the cost to AEP to provide this option.  
3 *See In re Application of Columbus S. Power Co.*, 128 Ohio St.3d 512, 518 (2011)  
4 (“Even assuming that AEP accurately priced the option, we fail to see how the  
5 amount a customer would be willing to pay for the right to shop necessarily  
6 establishes AEP's costs to bear the attendant risks.”)

7 **Q AEP OHIO WITNESS LACASSE COMPARES AEP OHIO'S PROPOSED POLR**  
8 **CHARGE TO THE RESULTS OF TWO COMPETITIVE BIDDING**  
9 **PROCUREMENT AUCTIONS. IS THIS AN “APPLES TO APPLES”**  
10 **COMPARISON?**

11 A No. The studies that Dr. LaCasse relies upon provide calculated  
12 “premiums” above cost included in winning bids for SSO-type supply products.<sup>18</sup>  
13 In all of these cases, the “premiums” are collected as part of bypassable charges.  
14 This is very different from AEP Ohio's proposed POLR charge, which is non-  
15 bypassable other than for those very few customers who choose not to pay the  
16 POLR charge after switching. The POLR charge that would be required by a  
17 competitive supplier would be higher for a bypassable POLR charge than it  
18 would be for a non-bypassable POLR charge under the same circumstances.  
19 The reason for this is simple. Assuming a fixed POLR charge, a non-bypassable  
20 charge would be imposed on more customers, and thus would be lower on a per  
21 customer basis than a bypassable charge which would be paid for by fewer  
22 customers to the extent shopping occurred. Thus, all else equal, one would  
23 expect that AEP Ohio's non-bypassable POLR charge would be lower than

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<sup>18</sup> See LaCasse Direct at 18-20.

estimates of competitive bypassable POLR charges. Therefore, it is likely that AEP's calculated POLR charge is too high.

Even leaving aside this substantial difference in the two types of "premiums", AEP Witness LaCasse also admits that the premiums she identified encompass more than just the shopping related risk identified in those studies.<sup>19</sup> This includes, without limitation, uncertainty in demand, cost component risk, and shopping related risk.

The studies relied on by Dr. LaCasse inappropriately compare an effectively non-bypassable POLR charge with a bypassable POLR charge. These studies also analyze "premiums" which include factors other than the POLR charge. As a result, these studies are not relevant to this dispute, and should not be credited by the Commission.

**Q HAS AEP OHIO PURSUED A COMPETITIVE BIDDING PROCESS OR TAKEN OTHER STEPS TO INSURE AGAINST ITS PURPORTED POLR RISK?**

A To my knowledge, AEP Ohio has not pursued a competitive bidding process similar to the studies analyzed by Dr. LaCasse. AEP Ohio has also failed to present any evidence establishing that it has taken any steps to insure against its purported POLR risk, such as engaging in hedging transactions to limit this risk, or any evidence of any costs it has incurred related to the purported POLR risk.

**IV. THE BLACK MODEL IS NOT APPROPRIATE TO ESTIMATE SSO CUSTOMERS' OPTION VALUES**

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<sup>19</sup> See LaCasse Direct at 9:18-20.

1    **Q     WHAT IS THE PURPOSE OF THIS SECTION OF YOUR TESTIMONY?**

2    A            In the previous section, I discussed why AEP Ohio customers' option  
3            value to return to SSO service is distinct from AEP Ohio's cost of "standing ready  
4            to serve customers who shop and return." In this section, I review the Black  
5            model itself and show that, even if, *arguendo*, one somehow concluded that AEP  
6            Ohio's cost was equal to customer option value, the Black model is not an  
7            appropriate model to use to estimate that option value.

8            **1.    The Black Model Is Not Appropriate For Use In This Case Because**  
9            **Several Essential Assumptions Of The Black Model Are Not Met.**

10   **Q     WHAT ASSUMPTIONS FORM THE BASIS FOR THE BLACK MODEL?**

11   A            The model assumes the following:

- 12            1. Markets are perfect and there are no transactions costs.
- 13            2. Price volatility is constant.
- 14            3. The risk-free interest rate is constant over time.
- 15            4. The strike price is constant.
- 16            5. The returns on the underlying asset are distributed lognormally.
- 17            6. The option can be exercised only on the expiration date (European
- 18            option).

19   **Q     ARE THESE ASSUMPTIONS SO RESTRICTIVE THAT THE MODEL CANNOT**  
20   **BE USED TO VALUE ANY OPTIONS?**

21   A            No. Despite the limiting assumptions, the Black model, like the better-  
22            known Black-Scholes model, is a useful tool that can quickly estimate the value  
23            of a futures option. Options traders may not rely solely on these models, but they  
24            are extremely useful to establish initial estimates of option values. Moreover, the  
25            data used to estimate option values is all observable. Option prices then change  
26            over time based on market factors, including the expectations of market

participants. However, the Black model is not appropriate for use to calculate AEP Ohio's POLR costs, as described in detail below.

**Q DO THE SIX ASSUMPTIONS HOLD SUFFICIENTLY TO USE THE BLACK MODEL TO ESTIMATE THE AEP CUSTOMERS' OPTION VALUE OF POLR SERVICE?**

A No. In my opinion, the Black model should not be used to value the option value of AEP Ohio customers to return to SSO service, because too many of the assumptions underlying the model do not apply. Moreover, the Black model is not designed to calculate the value received by the purchaser of an option, or the cost incurred by the seller of an option. Instead, this model is designed to price options for the purpose of engaging in financial transactions, including hedging. As AEP Ohio is attempting to use the model for purposes beyond which it was designed, AEP Ohio's proposed use of the Black model is inappropriate.

**Q IS IT REASONABLE TO ASSUME THAT THE FIRST ASSUMPTION, MARKETS ARE PERFECT AND THERE ARE NO TRANSACTIONS COSTS, HOLDS FOR CUSTOMERS DECIDING TO RETURN TO SSO SERVICE?**

A No. The Black model assumes perfectly rational consumers and zero transactions costs. These are reasonable assumptions for traders in futures markets, such as NYMEX or the CBOT. Those markets are designed to minimize transactions costs and traders typically develop complex trading strategies based on their own expectations about the future.

In contrast, most electricity consumers are not options traders. They probably do not follow wholesale electric prices in PJM closely. Moreover, the fixed price options consumers can sign up for with CRES providers are designed so that consumers do not have to spend their time evaluating the wholesale

1 market. Furthermore, under many of those options, consumers are committed to  
2 staying with a CRES provider for a defined time frame, meaning they do not have  
3 the option to return to SSO service within that time frame.

4 Second, a consumer who wishes to return to SSO service cannot do so  
5 instantaneously. The consumer must contact AEP Ohio and arrange to have the  
6 Company start providing him with service on a specified date (this date is  
7 potentially limited by switching rules imposed by the Commission and by  
8 contract). That is quite different from the options trader who will make buy and  
9 sell decisions on a minute-to-minute basis.

10 **Q DOES THE “PERFECTLY RATIONAL CUSTOMER” EXPECTATION ASSUME**  
11 **THAT CUSTOMERS WILL ALWAYS ACT PERFECTLY IN THEIR ECONOMIC**  
12 **SELF-INTEREST?**

13 **A** Yes. The Black model assumes that market participants will always act in  
14 their economic self-interest. For the purposes of this analysis, this means that  
15 the Black model assumes that all customers will switch to a CRES provider  
16 whenever market prices are lower than the strike price, and will switch back to  
17 AEP whenever market prices rise above the strike price. As recognized by AEP  
18 Witness LaCasse, not all customers will necessarily switch to a CRES provider  
19 the moment that it may be advantageous to do so.<sup>20</sup> This means that the Black  
20 model's assumption that customers will always and immediately act in their  
21 economic self-interest is not met, and AEP's POLR calculation is accordingly  
22 overstated.

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<sup>20</sup> See LaCasse Direct Testimony at 14:15-17.

1   **Q     DOES THE SECOND ASSUMPTION HOLD, THAT PRICE VOLATILITY IS**  
2   **CONSTANT?**

3   **A**No. From an empirical standpoint, the historic volatility of an asset can  
4   change over time. The price of AEP's stock, for example, may be more volatile  
5   this year than it was last year. Similarly, electricity prices may be more volatile  
6   during some periods than during others.

7               From an option pricing standpoint, however, what we want to use in the  
8   Black model is the future volatility of the asset. Although historic volatility is one  
9   predictor of future volatility, future volatility cannot be directly observed. (In  
10   addition, AEP Ohio provides no evidence that historic PJM wholesale market  
11   volatility has remained constant.) It turns out, however, that one can calculate  
12   implied volatilities for an option based on the prices at which options trade.<sup>21</sup>  
13   These implied volatilities are forward looking. Moreover, it also turns out that  
14   these implied volatilities depend on the option's strike price and the option's time  
15   to maturity.

16              As volatility is not constant in this case, the second assumption of the  
17   Black model is not met.<sup>22</sup> This means that AEP Ohio's calculated POLR charge  
18   may be overstated, and is additional evidence that the Black model is not an  
19   appropriate choice to determine POLR costs.

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<sup>21</sup> For a discussion, see J. Hull, *Options, Futures, and Other Derivatives*, 7<sup>th</sup> ed., (Upper Saddle River, NJ: Pearson Prentice Hall 2009) (Hull), pp.296-7.

<sup>22</sup> As I discuss in the next section, AEP Ohio has also used the wrong estimate of volatility.

**Q WHY IS THE STRIKE PRICE NOT CONSTANT?**

A The strike price in AEP Ohio's model is the ESP price. However, the ESP price varies over the term of the ESP period. Specifically, the fuel cost added onto the base generation price changes over time. This violates one of the fundamental assumptions of the Black model.

Furthermore, the ESP price is correlated with the PJM market price. This violates another fundamental assumption of the Black model. Specifically, the ESP price is, in part, based on AEP Ohio's fuel costs, and fuel prices affect the market price of electricity in PJM. Thus, the ESP price is correlated with the underlying market price, even if the underlying market price—the competitive benchmark price—is an artificial construct put together by AEP Ohio itself.

**Q CAN OPTIONS BE VALUED IF THE STRIKE PRICE IS CORRELATED WITH THE PRICE OF THE UNDERLYING ASSET?**

A Yes. However, one cannot use either the Black-Scholes or Black models to do so. Instead, such options must be valued using empirical models, such as monte-carlo models that examine the option's value under multiple price paths. As the strike price is correlated to the price of the underlying asset in this case, AEP Ohio's purported POLR charge again may be overstated.

**Q THE FIFTH ASSUMPTION IS THAT RETURNS ARE LOGNORMALLY DISTRIBUTED. WHAT DOES THAT MEAN?**

A Most of us are familiar with a bell-shaped curve, which corresponds to a normal distribution. For example, if I measured the heights of a random sample of 1,000 adults, the heights would be distributed like a normal bell-shaped curve.

1 A lognormal distribution is one where the logarithm of the underlying values is  
2 normally distributed, hence the term "lognormal."

3 The Black-Scholes and Black models assume that returns on the asset  
4 are lognormally distributed. For example, suppose we measure the daily returns  
5 on a stock that does not pay dividends. (A dividend paying stock's returns are  
6 more complex because of the dividend payments themselves.) The daily return  
7 is just the ratio of today's stock price divided by yesterday's, minus one. So, if  
8 XYZ Corporation's stock closed at \$50/share yesterday and closed at \$52 today,  
9 the return would equal  $\$52/\$50 = 1.04 - 1 = 4.0\%$ .

10 Assuming XYZ Corp. has not fundamentally changed over the relevant  
11 period, we could examine the daily returns over, say, a one-year period. Next,  
12 we would calculate the logarithms of each of the daily returns. If the resulting  
13 distribution of those daily returns looked like a bell-shaped curve, then the returns  
14 are lognormally distributed. Empirically, this has been found to be true for  
15 stocks.

16 **Q ARE THE "RETURNS" ON PJM WHOLESALE ELECTRIC PRICES**  
17 **LOGNORMALLY DISTRIBUTED?**

18 **A** The distribution of the daily price changes in the PJM wholesale market is  
19 not clear. For example, according to Michael Guth, Managing Director of Risk  
20 Management Consulting, "Most pricing models and software used in the power  
21 industry assume prices are lognormally distributed and their returns are normally

distributed. As shown in this article, other distributions fit power price data much better than either the lognormal or normal distribution.”<sup>23</sup>

Even if the underlying PJM wholesale market is lognormal, the distribution of retail prices paid by consumers is almost certainly not lognormal. The value of the option to return will depend on the volatility of the retail market price, i.e., the competitive benchmark price. Given the multitude of competitively priced alternatives, including fixed price options that last 1-3 years, there is simply no basis to conclude that the distribution of retail price “returns” is lognormally distributed. Accordingly, this assumption of the Black model is not met, and the POLR charge may be overstated.

**Q THE SIXTH AND FINAL ASSUMPTION CONCERNS WHEN THE OPTION TO RETURN CAN BE EXERCISED. DOES THAT CONFORM TO THE DEFINITION OF A EUROPEAN OPTION?**

A No. A European option has a fixed exercise date. Because customers can return to SSO service whenever they please, their option more closely resembles what is called an American option. Unlike a European option, an American option can be exercised at any time up to its expiration date.

**Q AEP OHIO STATES THAT ITS NEW MODEL VALUES CUSTOMERS' OPTION AS A SERIES EUROPEAN OPTIONS. IS THE VALUE OF A SERIES OF EUROPEAN OPTIONS THE SAME AS THE VALUE OF AN AMERICAN OPTION?**

A No. Valuing a series of European futures options with the Black model, as AEP Ohio has done, is unlikely to be a reasonable approximation of an American

<sup>23</sup> M. Guth, “Benefits of Accurately Determining Electricity Price Distributions: Better Risk Metrics, Beating the Market on Trades,” undated article. Available at: <http://michaelguth.com/economist/tradejournals/benefitsaccurately.htm>.

1 futures option. Because the Black model uses a European option model, it is not  
2 appropriate for use in this case.

3 **2. AEP Ohio's Claims Regarding The Black Model Are Overstated.**

4 **Q AEP OHIO WITNESS THOMAS CLAIMS THE PROPOSED POLR CHARGE**  
5 **REFLECTS "THE COST OF THE RISK OF PROVIDING CUSTOMERS THE**  
6 **OPTION TO SWITCH SUPPLIERS AND RETURN TO THE COMPANY AT SSO**  
7 **GENERATION RATES WHEN CUSTOMERS CHOOSE TO DO SO."<sup>24</sup> DO**  
8 **YOU AGREE THAT THE BLACK MODEL CALCULATES THE COST OF THIS**  
9 **RISK?**

10 **A** No. As discussed above, the Black model calculates the initial market  
11 value of an option. The option also provides a calculation for market participants  
12 to calculate an arbitrage value for the asset underlying the option. However,  
13 nothing in the Black model is intended to estimate the cost of the risk to the seller  
14 of an option (AEP Ohio) of providing this option. The Black model simply is not  
15 designed to estimate the potential risk assumed by the seller of an option, as this  
16 risk is dependent on factors outside of the Black model, such as the actual out of  
17 pocket cost to AEP Ohio of providing energy to returning customers and AEP  
18 Ohio's potential hedging of this risk through other transactions.

19 **Q AEP OHIO WITNESS MAKHIJA CLAIMS THAT AEP'S COST OF PROVIDING**  
20 **"THE POLR OPTIONALITY IS NO MORE OR LESS THAN THE VALUE OF**  
21 **THE OPTIONS RECEIVED BY THE CUSTOMERS."<sup>25</sup> DO YOU AGREE THAT**  
22 **THE BLACK MODEL CALCULATES THE VALUE OF THE OPTIONS**  
23 **RECEIVED BY THE CUSTOMERS?**

24 **A** No. The Black model was designed to price options for the purpose of  
25 hedging transactions for the underlying asset, and the actual price of an option is  
26 then subject to traditional market forces. The Black model was not designed to

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<sup>24</sup> See Thomas Direct Testimony at 11:17-18.

<sup>25</sup> See Makhija Direct Testimony at 4:1-2.

calculate the “value” of the options received by AEP Ohio's customers. Moreover, as discussed above, the value of the options received by customers has no relationship to the cost incurred by AEP Ohio, as each customer will value this optionality differently.

**Q DOES THE BLACK MODEL CALCULATE A “PUT” OPTION AND A “CALL” OPTION SIMULTANEOUSLY?**

A No. The Black model does not calculate a “put” option and a “call” option simultaneously. Two different equations are used in the Black model to value European put and call futures options, respectively, just as there are two different equations in the Black Scholes model to value European put and call spot options.

**V. AEP OHIO HAS USED INCORRECT INPUT VALUES IN THE BLACK MODEL**

**Q IF ONE ASSUMES THAT USING THE BLACK MODEL CAN BE USED TO VALUE CUSTOMERS’ POLR OPTION VALUE, HAS AEP OHIO USED THE CORRECT INPUTS?**

A No. Even if, *arguendo*, one assumes the Black model provides a valid estimate of consumers’ option value to return to SSO service and that this option value equals AEP Ohio's cost to provide POLR service, the Company has still used incorrect values in the model. Specifically, AEP Ohio has used the wrong volatility estimate.

**Q WHAT VOLATILITY ESTIMATE DOES AEP OHIO USE?**

A AEP Ohio used an estimate of the volatility of the PJM wholesale market in the Black Model. That is the wrong volatility for valuing the option to return to

SSO service because customers do not pay the wholesale market price. Rather, they pay a retail market price, which AEP assumes is the competitive benchmark price.

**Q WHAT IS THE COMPETITIVE BENCHMARK PRICE?**

A The competitive benchmark price was developed by AEP Ohio using a variety of estimated values, some of which are simply assumed by AEP Ohio itself. The volatility of the competitive benchmark price is significantly less than the volatility of the PJM wholesale market price, meaning that AEP Ohio overestimates option value in the Black model.

**Q PLEASE EXPLAIN WHY THE VOLATILITY OF THE COMPETITIVE BENCHMARK PRICE IS LESS THAN THE VOLATILITY OF THE PJM WHOLESALE MARKET PRICE.**

A The competitive benchmark price components were set out by Staff witness Daniel Johnson in his original testimony in the proceeding, in Exhibit DRJ-1.<sup>26</sup> The competitive benchmark price begins with the “ATC simple swap” price, which is just the “around-the-clock” (i.e., peak and off-peak hours) forward price in the PJM market. To that ATC price, however, is added the basis differential between the AEP Dayton hub price and the AEP load zone, a load following/shaping adjustment, a capacity cost equal to the PJM market price of capacity during the period of the ESP, as determined in the RPM auction, an assumed cost for ancillary services, an assumed cost associated with distribution

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<sup>26</sup> *ESP I*, Prepared Testimony of Daniel Johnson on behalf of the Staff of the Public Utilities Commission of Ohio, (Nov. 1, 2008) (“Johnson Direct”).

1 and transmission system losses, an assumed cost for transaction risk, an offset  
2 for congestion costs, and an assumed retail administration fee.

3 The competitive benchmark price thus adds to the PJM market price what  
4 are essentially a number of fixed costs. As such, the volatility of the PJM market  
5 price is effectively "dampened" by the fixed costs. For example, in Mr. Johnson's  
6 Exhibit DJB-1, he adjusted the competitive benchmark price estimate developed  
7 by AEP witness Baker. Mr. Johnson assumed an average PJM market price of  
8 \$48.24/MWh. For CSP residential customers, Mr. Johnson added to that PJM  
9 market price an additional \$34.69 in fixed costs, arriving at an overall competitive  
10 benchmark price price of \$82.93/MWh.

11 In estimating option value using the Black model, AEP Ohio used as the  
12 "market" price the competitive benchmark price. The reason is that AEP  
13 assumed customer switching back to POLR would take place if the competitive  
14 benchmark price exceeded the ESP. However, AEP Ohio used the volatility  
15 estimate for just the PJM market price, not the competitive benchmark price.  
16 Yet, it is the volatility of the latter that determines the POLR option value. As  
17 such, AEP Ohio has used the wrong volatility measure in its model and  
18 significantly overestimated the correct volatility.

19 **Q CAN YOU PROVIDE AN EXAMPLE SHOWING THAT THE VOLATILITY OF**  
20 **THE COMPETITIVE BENCHMARK PRICE, WHICH INCLUDES FIXED COSTS,**  
21 **IS LOWER THAN THE VOLATILITY OF JUST THE PJM MARKET PRICE?**

22 **A** Yes. Using the data from Exhibit DRJ-1, I constructed a set of PJM prices  
23 whose average equaled his ATC swap price of \$48.24. To evaluate the impacts  
24 of adding the fixed price components of the competitive benchmark price, I

constructed a set of 365 daily prices such that daily returns would have a corresponding annual volatility of approximately 0.333, or 33.3%, the value that Thomas reports in her Exhibit LJT-4.<sup>27</sup> I then added to each of the randomized PJM daily prices the \$34.69 in other costs that Mr. Johnson determined as making up the remainder of the competitive benchmark price, recalculated the daily returns, and estimated the resulting volatility, which averaged around 19.5%.<sup>28</sup>

Because AEP Ohio used assumed different competitive benchmark price component values for the residential, commercial, and industrial customer classes, the volatilities for each classes' "market price" would also be different, unlike AEP Ohio's assumption of constant volatilities for all three customer classes.

**Q IF CUSTOMERS WHO PURCHASE ELECTRICITY FROM CRES PROVIDERS RECEIVE FIXED PRICE OFFERS, DOES THAT AFFECT THE VOLATILITY ESTIMATE THAT SHOULD BE USED?**

**A** Yes. For example, CRES providers offer commercial and industrial customers fixed price offers of varying durations, but they are predominantly for specified terms such as one, two, or three years. Customers who sign up for such contracts have limited switching abilities, reducing their option value to return to SSO service. For example, a customer who signs up for a three-year

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<sup>27</sup> Because I used a set of 365 random numbers, the actual volatility will differ slightly. I also repeated the exercise numerous times using a monte-carlo approach to confirm that the volatility of the individual samples would average very close to the AEP Ohio's 33.3% value.

<sup>28</sup> The daily return on the electric price equals the logarithm of the ratio of price on day  $t$  divided by the price on day  $t-1$ , i.e.,  $\ln(P_t/P_{t-1})$ . The daily volatility is just the standard deviation of these returns. To calculate the annualized volatility, the daily volatility value is multiplied by the square root of the number of trading days per year, typically assumed to be 252. A copy of these workpapers is attached hereto as Exhibit JAL-2.

fixed price contract at the start of a three-year ESP would not have the option to switch back to SSO, and thus could have no option value for switching back.

**Q IF CUSTOMERS ARE EVALUATING FIXED PRICE OFFERS FOR DIFFERENT TIME PERIODS, THEN SHOULD THEIR OPTION VALUES OF RETURNING TO SSO SERVICE BE BASED ON VOLATILITY IN THE PJM MARKET?**

A Absolutely not. This is another fundamental error of the AEP Ohio option model framework. The AEP Ohio model assumes that customers who purchase from CRES suppliers pay the daily PJM market price, thus experiencing significant price fluctuations. However, even correcting for the competitive benchmark price fixed price "adders" that AEP assumes, the actual price volatility still does not reflect the actual economic comparisons on which customers will base SSO-return decisions.

Instead, customers who have switched to CRES providers will face different volatilities, and thus have different option values, depending on the type of CRES service they purchased. For example, a customer could sign up for a CRES offer that provided a fixed price for one year that was below the ESP price. Unless the CRES provider defaults, that customer will never switch back to the ESP during the first year. The volatility of the PJM market price has no bearing on that customer's rational economic decisions. Moreover, that customer's option values would not be properly valued as a series of monthly European options because the customer would not have the option to switch prior to the end of the one-year contract. Instead, for that customer, the option value would be properly determined based on a one-year European option.

1 VI. AEP OHIO HAS NOT IDENTIFIED ITS ACTUAL POLR-RELATED  
2 COSTS

3 Q HOW DOES AEP OHIO PLAN TO MEET RETURNING CUSTOMER DEMAND?

4 A Based on my experience in the industry and standard industry best  
5 practices, I would presume AEP Ohio uses the long-term forecasts of customer  
6 demand it prepares and then evaluates alternative resource portfolios, taking  
7 account of the uncertainty over future PJM market prices, environmental  
8 regulations, fossil fuel prices, and so forth.

9 Q CAN AEP OHIO "STAND READY TO SERVICE" SSO CUSTOMERS BY  
10 COMPARING PJM MARKET PRICES FOR ENERGY AND CAPACITY TO THE  
11 COST OF ITS OWN GENERATING RESOURCES?

12 A Yes. Prudent utilities will evaluate all options for providing energy and  
13 capacity, including PJM pricing. As I have no reason to believe that AEP is not  
14 prudent, I would presume AEP Ohio planners evaluate all resource alternatives,  
15 including purchases from the market, as well as evaluate the cost of potential  
16 hedging strategies that meet the increased demand for energy and capacity if  
17 customers return to SSO service.

18 Q IF CUSTOMERS RETURN TO SSO SERVICE, WILL AEP OHIO NEED TO  
19 OBTAIN ADDITIONAL ENERGY?

20 A Yes. AEP Ohio would need to obtain more energy or reduce off-system  
21 sales of surplus energy. Alternatively, AEP Ohio could auction off its POLR  
22 obligation to wholesale providers, as was done by FirstEnergy. In fact, this  
23 approach is discussed by Dr. LaCasse in her testimony, stating

24 A common method used by [electric distribution utilities]  
25 without generation assets to manage the costs and risks

1 associated with POLR obligations is to transfer these risks to  
2 procure supply for their SSO customers using a competitive  
3 bidding process for full-requirements contracts. ... A  
4 competitive procurement process is used to arrive at a  
5 market determination of the costs associated with providing  
6 full-requirements [sic] service and all related risks.<sup>29</sup>

7 **Q WOULD ALL BIDDERS INTO SUCH A COMPETITIVE PROCUREMENT BID**  
8 **EXACTLY THE SAME AMOUNT TO PROVIDE FULL REQUIREMENTS**  
9 **SERVICE TO SSO CUSTOMERS?**

10 **A** It is theoretically possible, but to the extent that competitive bidders have  
11 different risk management strategies, different portfolios, and so forth, it is  
12 doubtful that all bidders would bid the exact same amount.

13 **Q WOULD AEP OHIO NEED TO ACQUIRE ADDITIONAL CAPACITY TO SERVE**  
14 **RETURNING SSO CUSTOMERS?**

15 **A** No. Because AEP Ohio elected the FRR option, rather than participate in  
16 PJM's RPM capacity market, the Company is already obligated to satisfy PJM's  
17 resource adequacy (capacity) requirement. When a customer returns to SSO  
18 service, AEP has no need to secure any additional capacity resources. Likewise,  
19 when a customer is supplied by a CRES, AEP Ohio is paid by the CRES for  
20 supplying that capacity. Thus, AEP Ohio's capacity costs are independent of  
21 customers returning to SSO service.

22 **Q DR. LACASSE STATES THAT THE VALUE OF THE OPTION MEASURES**  
23 **THE EXPECTED COST TO THE ELECTRIC DISTRIBUTION UTILITY ("EDU")**  
24 **ON AN A PRIORI BASIS.<sup>30</sup> DO YOU AGREE?**

25 **A** No. Moreover, Dr. LaCasse's own description of a competitive  
26 procurement process that I quoted previously demonstrates why. First, the value

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<sup>29</sup> See LaCasse Direct Testimony at 8:1-7.

<sup>30</sup> *Id.* at 12:20.

of the option to consumers to return to POLR is not the same as the market price of such an option, even if such an option existed. Second, the fact that competitive bidders will bid different amounts to take on all of the EDU's risk shows that bidders have different expectations of the costs to provide SSO service and take on the EDU's POLR risk. It is the bids that are the *a priori* expected cost—including a risk-based return—of taking on the POLR risk. The fact that bidders have different expectations of the costs of providing SSO service for the EDU, and assuming all of the EDU's POLR risk, proves that AEP Ohio's cost to provide POLR service is not equal its customers' option value.

**Q HAS AEP OHIO IDENTIFIED ANY CATEGORIES OF COSTS THAT IT WILL INCUR AS A RESULT OF CUSTOMERS RETURNING TO SSO SERVICE?**

A Other than Dr. LaCasse's general and unsupported statement regarding forgone revenues from off-system sales, no. And, Dr. LaCasse does not quantify that cost.

**Q DR. MAKHIJA STATES THAT THE COST OF POLR RISK EQUALS THE DECREASE IN SHAREHOLDERS EQUITY STEMMING FROM THE INCREASED RISK PREMIUM THAT IS REQUIRED TO COMPENSATE AEP OHIO SHAREHOLDERS?<sup>31</sup> DO YOU AGREE?**

A No. Dr. Makhija assumes that there is an actual cost to AEP for bearing this risk, and that AEP Ohio has not taken (and cannot take) any steps to hedge this risk. Moreover, this cost is clearly not the same as the option value to AEP Ohio consumers to return to SSO service, for the simple reason that the option value to consumers will depend on their perception of future market risk, whereas

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<sup>31</sup> Makhija Direct at 5:17-21.

the equity premium cost will depend on AEP shareholders' view of AEP Ohio's risk and how that risk is itself hedged as part of a broader investment portfolio.

**VII. CONCLUSION: AEP OHIO HAS NOT MET ITS BURDEN OF PROOF**

**Q IN YOUR OPINION, HAS AEP OHIO PROVIDED CLEAR EVIDENCE OF THE COST OF WHAT THE OHIO SUPREME COURT TERMED, "STANDING READY TO SERVICE CUSTOMERS WHO SHOP AND THEN RETURN?"**

A No. AEP Ohio has not provided any estimates of the actual cost it would incur to stand ready to serve customers who returned to SSO service. The best evidence of those costs would be if AEP Ohio held a competitive procurement and allowed firms to bid on taking on all of the Company's POLR risk—though of course this would include risks other than POLR risk as acknowledged by Dr. LaCasse. This would provide clear evidence of a known-and-measurable cost born by AEP. I am not aware of AEP Ohio having done so.

In the absence of a competitive procurement, AEP Ohio could demonstrate how POLR risk would require it to obtain additional energy and capacity resources to hedge its POLR risk. AEP Ohio has not provided any such estimates. Again, such estimates would provide a known-and-measurable cost of POLR service.

**Q DID EITHER MS. THOMAS, DR. LACASSE, OR DR. MAKHIJA PROVIDE ANY EMPIRICAL ESTIMATES OF THE COST TO AEP OHIO, SUCH AS THE COST ASSOCIATED WITH A COMPETITIVE PROCUREMENT THAT AUCTIONS OFF AEP OHIO'S POLR RISK?**

A No. Therefore, AEP Ohio's cost is not known and measurable and, as such, not properly included as a nonbypassable charge in its rates.

1 Q DOES THIS CONCLUDE YOUR TESTIMONY?

2 A Yes.

## CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing *Direct Testimony of Jonathan A. Lesser, Ph.D. on Behalf of Industrial Energy Users-Ohio* was served upon the following parties of record this 30<sup>th</sup> day of June 2011, via electronic transmission, hand-delivery or first class mail, postage prepaid.

  
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**SUMMARY OF EXPERIENCE**

Dr. Jonathan Lesser is the President of Continental Economics, Inc., and has over 25 years of experience working for regulated utilities, government, and as an economic consultant. He has analyzed critical economic and regulatory issues affecting the energy industry, including cost-benefit analysis of transmission, generation, and distribution investment, gas and electric utility structure and operations, generating asset valuation under uncertainty, mergers and acquisitions, cost allocation and rate design, resource investment decision strategies, cost of capital, depreciation, risk management, incentive regulation, economic impact studies of energy infrastructure development, including FERC hydroelectric relicensing applications, and general regulatory policy.

Dr. Lesser has prepared expert testimony and reports in cases before utility commissions in numerous states; before the Federal Energy Regulatory Commission (FERC); before international regulators in Belize, Guatemala, Mexico, and Puerto Rico; in commercial litigation cases; and before legislative committees in Connecticut, Maryland, New Jersey, Ohio, Texas, Vermont, and Washington State. He has also served as an independent arbiter in disputes involving regulatory treatment of utilities and valuation of energy generation assets.

Dr. Lesser has designed economic models to value nuclear, fossil fuel, and renewable generating assets, as well as long-term power contracts in the presence of market, regulatory, and environmental uncertainty. He is the coauthor of three textbooks: *Environmental Economics and Policy*, *Fundamentals of Energy Regulation*, and *Principles of Utility Corporate Finance*. He is also the author of numerous academic and trade press articles, and a contributing columnist and Editorial Board member for *Natural Gas & Electricity*.

## **AREAS OF EXPERTISE**

- ♦ Utility rate regulation – cost of capital, depreciation, cost of service, cost allocation, rate design, and alternative regulatory structures
- ♦ Economic impact analysis and input-output studies
- ♦ Load forecasting
- ♦ Energy asset valuation and due diligence
- ♦ Commercial damages estimation
- ♦ Cost-benefit analysis
- ♦ Regulatory policy and market design
- ♦ Environmental compliance and litigation
- ♦ Market power analysis

## **SELECTED EXPERT TESTIMONY AND REPORTS**

### **Portland Natural Gas Shippers**

- FERC rate proceeding regarding the rate application by Northern Border Pipeline Company (*Re: Portland Natural Gas Transmission System*, Docket No. RP10-729-000)
  - FERC rate proceeding regarding the rate application by Northern Border Pipeline Company (*Re: Portland Natural Gas Transmission System*, Docket No. RP08-306-000)
- Subject: Natural gas supplies, economic lifetime, and depreciation rates.

### **Independent Power Producers of New York**

- ♦ FERC proceeding (*New York Independent System Operator, Inc.*, Docket No. ER11-2224-000)

Subject: Reasonableness of the proposed installed capacity demand curves and cost of new entry values proposed by the New York Independent System Operator.

### **Maryland Public Service Commission**

- ♦ Merger application of FirstEnergy Corporation and Allegheny Energy, Inc. (*I/M/O FirstEnergy Corp and Allegheny Energy, Inc.*, Case No. 9233)

Subject: Proposed merger between FirstEnergy Corporation and Allegheny Energy. Testimony described the structure and results of a cost-benefit analysis to determine whether the proposed merger met the state's positive benefits test, and included analysis of market power and merger synergies.

### **Alliance to Protect Nantucket Sound**

- ♦ Proceeding before the Massachusetts Department of Public Utilities (*Petition of Massachusetts Electric Company and Nantucket Electric Company each d/b/a National Grid For Approval of Proposed Long-Term Contracts for Renewable Energy With Cape Wind Associates, LLC, Pursuant to G.L. c. 169, §83, Case No. D.P.U. 10-54*)

Subject: Approval of Proposed Long-Term Contracts for Renewable Energy With Cape Wind Associates, LLC.

### **Brookfield Energy Marketing, LLC**

- ♦ FERC proceeding (*New England Power Generators Association, et al. v. ISO New England, Inc.*, Docket Nos. ER10-787-000, ER10-50-000, and EL10-57-000 (consolidated)).

Subject: Proposed forward capacity market payments for imported capacity into ISO-NE.

### **Public Service Company of New Mexico**

- ♦ Proceeding before the New Mexico Public Regulation Commission (Case No. 10-00086-UT)

Subject: Load forecast for future test year, residential price elasticity study.

### **M-S-R Public Power Agency**

- ♦ FERC proceeding (*Southern California Edison Co.*, Docket No. ER09-187-000 and ER10-160-000)

Subject: Allowed rate of return for construction work in progress (CWIP) expenditures for certain transmission facilities.

- ♦ FERC proceeding (*Southern California Edison Co.*, Docket No. ER10-160-000)

Subject: Allowed rate of return for construction work in progress (CWIP) expenditures for certain transmission facilities.

### **Financial Marketers**

- ♦ FERC proceeding (*Black Oak Energy, LLC v PJM Interconnection, L.L.C.*, Docket No. EL08-014-002)

Subject: Allocation of surplus transmission line losses under the PJM tariff.

**Southwest Gas Corporation and Salt River Project**

- ♦ FERC proceeding regarding rate application of El Paso Natural Gas Company (Docket No. RP08-426-000)

Subject: Analysis of proposed capital structure and recommended capital structure adjustments

**New York Regional Interconnect, Inc.**

- ♦ Proceeding before the New York Public Service Commission (Case No. 06-T-0650)

Subject: Analysis of economic and public policy benefits of a proposed high-voltage transmission line.

**Occidental Chemical Corporation**

- ♦ FERC Proceeding (*Westar Energy, Inc.* ER07-1344-000)

Subject: Compliance of wholesale power sales agreement with FERC standards

**EPIC Merchant Energy, LLC, et al.**

- ♦ FERC Proceeding (*Ameren Services Company v. Midwest Independent System Operator, Inc.*, Docket Nos. EL07-86-000, EL07-88-000, EL07-92-000 (Consolidated))

Subject: Allocation of revenue sufficiency guarantee costs.

**Cottonwood Energy, LP**

- ♦ Proceeding before the Public Utility Commission of Texas (*Application of Kelson Transmission Company, LLC for a Certificate of Convenience and Necessity for the Amended Proposed Canal to Deweyville 345 kV Transmission Line with Chambers, Hardin, Jasper, Jefferson, Liberty, Newton, and Orange Counties*, Docket No. 34611, SOAH Docket No. 473-08-3341)

Subject: Benefits of transmission capacity investments.

### **Redbud Energy, LP**

- ♦ Proceeding before the Oklahoma Corporation Commission (*Request of Public Service Company of Oklahoma for the Oklahoma Corporation Commission to Retain an Independent Evaluator*, Cause No. PUD 200700418)

Subject: Reasonableness of PSO's 2008 RFP design.

### **The NRG Companies**

- ♦ FERC Proceeding (*ISO New England Inc. and New England Power Pool*, Docket No. ER08-1209-000)

Subject: Compensation of Rejected De-list Bids Under ISO-NE's Forward Capacity Market Design

### **Dynegy Power Marketing, LLC**

- ♦ FERC proceeding, *KeySpan-Ravenswood, LLC v. New York Independent System Operator, Inc.*, Docket No. EL05-17-000

Subject: Estimation of damages accruing to Dynegy arising from a failure by the NYISO to accurately calculate locational installed capacity requirements in NYISO during the summer of 2002.

### **Constellation Energy Group**

- ♦ FERC proceeding (*Maryland Public Utility Commission, et al., v. PJM Interconnection, LLC*, Docket No. EL08-67-000)

Subject: "Just and reasonableness" of PJM's Reliability Pricing Mechanism.

### **Government of Belize, Public Utility Commission**

- ♦ Proceeding before the Belize Public Utility Commission, *In the Matter of the Public Utilities Commission Initial Decision in the 2008 Annual Review Proceeding for Belize Electricity Limited*.

Subject: Arbitration and Independent Expert's report, in dispute between the Belize PUC and Belize Electricity Limited in an annual electric rate tariff review, as required under Belize law.

### **Federal Energy Regulatory Commission**

- ♦ Technical hearings on wholesale electric capacity market design.

Subject: Analysis of proposal to revise RTO capacity market design developed by the American Forest and Paper Association.

### **Dogwood Energy, LLC**

- ◆ Proceeding before the Missouri Public Service Commission, *In the Matter of the Application of Aquila, Inc., d/b/a Aquila Networks - MPS and Aquila Case No. EO-2008-0046, Networks - L&P for Authority to Transfer Operational Control of Certain Transmission Assets to the Midwest Independent Transmission System Operator, Inc., Case No. EO-2008-0046.*

Subject: Cost-benefit analysis to determine whether Aquila should join either the Midwest Independent System Operator (MISO) or the Southwest Power Pool (SPP).

### **Competitive Power Ventures, LLC**

- ◆ FERC proceeding (*Re: New York Independent System Operator, Inc., Docket No. ER08-283-000*)

Subject: Revisions to the installed capacity (ICAP) market demand curves in the New York control area, which are designed to provide economic incentives for new generation development.

### **Empresa Eléctrica de Guatemala**

- ◆ Rate proceeding before the Comisión Nacional de Energía Eléctrica

Subject: Rate of return for an electric distribution company

### **Electric Power Supply Association**

- ◆ FERC proceeding (*Re: Midwest Independent Transmission System Operator, Inc., Docket No. ER07-1182-000*)

Subject: Critique of cost-benefit analysis by MISO Independent Market Monitor concluding that permanent establishment of Broad Constrained Area mitigation was appropriate.

### **Constellation Energy Commodities Group, LLC**

- ◆ FERC proceeding regarding rate application for ancillary services by Ameren Energy (*Re: Ameren Energy Marketing Company and Ameren Energy, Inc., Docket Nos. ER07-169-000 and ER07-170-000*)

Subject: Analysis and testimony on appropriate "opportunity cost" rates for ancillary services, including regulation service and spinning reserve service. Case settled prior to testimony being filed.

**Suiza Dairy Corporation and Vaquería Tres Monjitas, Inc.**

- ♦ Rate proceeding before the Office of Milk Industry Regulatory Administration of Puerto Rico.

Subject: Analysis and testimony on the appropriate rate of return for regulated milk processors in the Commonwealth of Puerto Rico.

**DPL Inc.**

- ♦ Proceeding before the Ohio Board of Tax Appeals (*DPL, Inc. and its subsidiaries v. William W. Wilkins, Tax Commissioner of Ohio*, Case No. 2004-A-1437)

Subject: Economic impacts of generation investment and qualification of electric utility investments as “manufacturing” investments for purposes of state investment tax credits.

**IGI Resources, LLC and BP Canada Energy Marketing Corp.**

- ♦ FERC proceeding regarding the rate application by Gas Transmission Northwest Corporation (*Re: Gas Transmission Northwest*, Docket No. RP06-407-000)

Subject: Natural gas supplies, economic lifetime, and depreciation rates.

**Baltimore Gas and Electric Co.**

- ♦ Maryland Public Service Commission (Case No. 9099)

Subject: Standard Offer Service pricing. Testimony focused on factors driving electric price increases since 1999, and estimates of rates under continued regulation

- ♦ Maryland Public Service Commission (Case No. 9073)

Subject: Stranded costs of generation. Testimony focused on analysis of benefits of competitive wholesale power industry.

- ♦ Maryland Public Service Commission (Case No. 9063)

Subject: Optimal structure of Maryland’s electric industry. Testimony focused on the benefits of competitive wholesale electric markets. Presented independent estimates of benefits of restructuring since 1999.

**Pemex-Gas y Petroquímica Básica**

- ♦ Expert report in a rate proceeding. Presented analysis before the Comisión Reguladora de Energía on the appropriate rate of return for the natural gas pipeline industry.

**BP Canada Marketing Corp.**

- ♦ FERC proceeding regarding the rate application by Northern Border Pipeline Company (*Re: Northern Border Pipeline*, Docket No. RP06-072-000)

Subject: Natural gas supplies, economic lifetime, and depreciation rates.

**Transmission Agency of Northern California**

- ♦ FERC rate proceeding (*Re: Pacific Gas & Electric Company*, Docket No. ER10-2026-000)

Subject: Analysis of appropriate return on equity, capital structure, and overall cost of capital. Case settled prior to filing expert testimony.

- ♦ FERC rate proceeding (*Re: Pacific Gas & Electric Company*, Docket No. ER09-1521-000)

Subject: Analysis of appropriate return on equity, capital structure, and overall cost of capital. Case settled prior to filing expert testimony.

- ♦ FERC rate proceeding (*Re: Pacific Gas & Electric Company*, Docket No. ER08-1318-000)

Subject: Analysis of appropriate return on equity, capital structure, and overall cost of capital. Case settled prior to filing expert testimony.

- ♦ FERC rate proceeding (*Re: Pacific Gas & Electric Company*, Docket No. ER07-1213-000)

Subject: Analysis of appropriate return on equity, capital structure, and overall cost of capital. Case settled prior to filing expert testimony.

- ♦ FERC rate proceeding (*Re: Pacific Gas & Electric Company*, Docket No. ER06-1325-000)

Subject: Analysis of appropriate return on equity, capital structure, and overall cost of capital. Case settled prior to filing expert testimony.

- ♦ FERC rate proceeding (*Re: Pacific Gas & Electric Company*, Docket No. ER05-1284-000)

Subject: Analysis of appropriate return on equity, capital structure, and overall cost of capital. Case settled prior to filing expert testimony.

- ♦ FERC rate proceeding (*Re: Pacific Gas & Electric Company*, Docket Nos. ER03-409-000, ER03-666-000)

Subject: Analysis and development of recommendation for the appropriate return on equity, capital structure, and overall cost of capital.

#### **State of New Jersey Board of Public Utilities**

- ♦ Merger application of Public Service Enterprise Group and Exelon Corporation (*I/M/O The Joint Petition Of Public Service Electric And Gas Company And Exelon Corporation For Approval Of A Change In Control Of Public Service Electric And Gas Company And Related Authorizations, BPU Docket No. EM05020106, OAL Docket No. PUC-1874-050*)

Subject: Proposed merger between Exelon Corporation and PSEG Corporation. Testimony described the structure and results of a cost-benefit analysis to determine whether the proposed merger met the state's positive benefits test, and included analysis of market power, value of changes in nuclear plant operations, and merger synergies.

#### **Sierra Pacific Power Corp.**

- ♦ FERC proceeding regarding the rate application by Paiute Pipeline Company (*Re Paiute Pipeline Company Docket No. RP05-163-000*)

Subject: Depreciation analysis, negative salvage, and natural gas supplies. Case settled prior to filing expert testimony.

#### **Matanuska Electric**

- ♦ Regulatory Commission of Alaska rate proceeding (*In the Matter of the Revision to Current Depreciation Rates Filed by Chugach Electric Association, Inc.*, Docket No. U-04-102)

Subject: Analysis of the reasonableness of Chugach electric's depreciation study.

#### **Duke Energy North America, LLC**

- ♦ FERC proceeding (*Re: Devon Power, LLC, et al.*, Docket No. ER03-563-030)

Subject: Appropriate market design for locational installed generating capacity in the New England market to ensure system reliability.

#### **Keyspan-Ravenswood, LLC**

- ♦ FERC proceeding, *KeySpan-Ravenswood, LLC v. New York Independent System Operator, Inc.*, Docket No. EL05-17-000

Subject: Estimation of damages arising from a failure by the NYISO to accurately calculate locational installed capacity requirements in New York City during the summer of 2002.

### **Electric Power Supply Association**

- ♦ FERC proceeding (*Re: PJM Interconnection, LLC*, Docket No. EL03-236-002)

Subject: Analysis and critique of proposed pivotal supplier tests for market power in PJM identified load pockets.

### **Vermont Department of Public Service**

- ♦ Vermont Public Service Board Rate Proceeding, Concurrent proceedings: *Re: Green Mountain Power Corp.*, Dockets No. 7175 and 7176. Subject: Cost of capital and allowed return on equity under cost of service regulation, as well as under a proposed alternative regulation proposal.
- ♦ Vermont Public Service Board Rate Proceeding, *Re: Shoreham Telephone Company*, Docket No. 6914. Subject: Analysis and development of recommendations for the appropriate return on equity, capital structure, and overall cost of capital.
- ♦ Vermont Public Service Board Rate Proceeding, *Re: Vermont Electric Power Company*, Docket No. 6860. Subject: Development of a least-cost transmission system investment strategy to analyze the prudence of a major high-voltage transmission system upgrade proposed by the Vermont Electric Power Company.
- ♦ Vermont Public Service Board Rate Proceeding, *Re: Central Vermont Public Service Company*, Docket No. 6867. Subject: Analysis and development of recommendations for the appropriate return on equity, capital structure, and overall cost of capital.
- ♦ *Re: Green Mountain Power Corporation*, Docket No. 6866. Subject: Analysis and development of recommendations for the appropriate return on equity, capital structure, and overall cost of capital.

### **Pipeline Shippers Group**

- ♦ FERC proceeding regarding the rate application of Northern Natural Gas Company (*Re: Northern Natural Gas Company*, Docket No. RP03-398-000)

Subject: Gas supply analysis to determine pipeline depreciation rates as part of an overall rate proceeding.

**Arkansas Oklahoma Gas Corp.**

- ◆ Oklahoma Corporation Commission rate proceeding (*Re: Arkansas Oklahoma Gas Corporation*, Docket No. 03-088)  
  
Subject: Analysis and development of recommendations for the appropriate return on equity, capital structure, and overall cost of capital.
- ◆ Arkansas Public Service Commission rate proceeding, *In the Matter of the Application of Arkansas Oklahoma Gas Corporation for a General Change in Rates and Tariffs*, Docket No. 05-006-U. Subject: Analysis and development of recommendations for the appropriate return on equity, capital structure, and overall cost of capital.
- ◆ Arkansas Public Service Commission rate proceeding, *In the Matter of the Application of Arkansas Oklahoma Gas Corporation for a General Change in Rates and Tariffs*, Docket No. 02-24-U. Subject: Analysis and development of recommendations for the appropriate return on equity, capital structure, and overall cost of capital.

**Entergy Nuclear Vermont Yankee, LLC**

- ◆ Vermont Public Service Board proceeding (*Re: Petition of Entergy Nuclear Vermont Yankee for a Certificate of Public Good*, Docket No. 6812)  
  
Subject: Analysis of the economic benefits of nuclear plant generating capacity expansion as required for an application for a Certificate of Public Good.

**Central Illinois Lighting Company**

- ◆ Illinois Commerce Commission rate proceeding (*Re: Central Illinois Lighting Company*, Docket No. 02-0837)  
  
Subject: Analysis and development of recommendations for the appropriate return on equity, capital structure, and overall cost of capital.

**Citizens Utilities Corp.**

- ◆ Vermont Public Service Board rate proceeding (*Tariff Filing of Citizens Communications Company requesting a rate increase in the amount of 40.02% to take effect December 15, 2001*, Docket No. 6596)  
  
Subject: Analysis of the prudence and economic used-and-usefulness of Citizens' long-term purchase of generation from Hydro Quebec, including the estimated environmental costs and benefits of the purchase.

**Dynegy LNG Production, LP**

- ♦ FERC proceeding (*Re: Dynegy LNG Production Terminal, LP*, Docket No. CP01-423-000), September 2001

Subject: Analysis of market power impacts of proposed LNG facility development.

**Missouri Gas Energy Corp.**

- ♦ FERC rate proceeding (*Re: Kansas Pipeline Corporation*, Docket No. RP99-485-000)

Subject: Gas supply analysis to determine pipeline depreciation rates as part of an overall rate proceeding.

**Green Mountain Power Corp.**

- ♦ Vermont Public Service Board rate proceeding, *In the Matter of Green Mountain Power Corporation requesting a 12.93% Rate Increase to take effect January 22, 1999*, Docket No. 6107. Subject: Analysis of the appropriate discount rate, treatment of environmental costs, and the treatment of risk and uncertainty as part of a major power-purchase agreement with Hydro-Quebec.
- ♦ Vermont Public Service Board rate proceeding, *Investigation into the Department of Public Service's Proposed Energy Efficiency Utility*, Docket No. 5980. Subject: Analysis of distributed utility planning methodologies and environmental costs.
- ♦ Vermont Public Service Board rate proceeding, *Tariff Filing of Green Mountain Power Corporation requesting a 16.7% Rate Increase to take effect 7/31/97*, Docket No. 5983. Subject: Analysis of distributed utility planning methodologies and avoided electricity costs.
- ♦ Vermont Public Service Board rate proceeding, *Tariff Filing of Green Mountain Power Corporation requesting a 16.7% Rate Increase to take effect 7/31/97*, Docket No. 5983. Subject: Valuation of a long-term power purchase contract with Hydro-Quebec in the context of a determination of prudence and economic used-and-usefulness.

**United Illuminating Company**

- ♦ Connecticut Dept. of Public Utility Control proceeding (*Application of the United Illuminating Company for Recovery of Stranded Costs*, Docket No. 99-03-04)

Subject: Development and application of dynamic programming models to estimate nuclear plant stranded costs.

## **OTHER COMMERCIAL LITIGATION EXPERIENCE**

- ♦ *IMO Industries v. Transamerica*. Estimated the appropriate discount rate to use for estimating damages over time associated with a failure of the insurance companies to reimburse asbestos-related damage claims and the resulting losses to the firm's value.
- ♦ *John C. Lincoln Hospital v. Maricopa County*. Performed statistical analysis to determine the value of a class of unpaid hospital insurance claims.
- ♦ *Catamount/Brownell, LLC. v. Randy Rowland*. Prepared an expert report on the damages associated with breach of commercial lease.
- ♦ *Lyubner v. Sizzling Platters, Inc.*. Performed an econometric analysis of damage claims based on sales impacts associated with advertising.
- ♦ *Pietro v. Pietro*. Estimated pension benefits arising from a divorce case.
- ♦ *Nat'l. Association of Electric Manufacturers v. Sorrell*. Testified on the costs of labeling fluorescent lamps and the impacts of labeling laws on the demand for electricity.

## **ARBITRATION CASES**

***TransCanada Hydro Northeast, Inc. v. Town of Littleton, New Hampshire, (CPR File No. G-09-24).***

Subject: dispute regarding valuation for property tax purposes of a hydroelectric facility located on the Connecticut River.

Served as neutral on a three-person arbitration panel.

***Belize Electricity Limited v. Belize Public Utilities Commission (Claim No. 512 of 2008).***

Subject: Proceeding before the Supreme Court of Belize alleging that the Final Decision by the Belize Public Utilities Commission setting electric rates and tariffs for the 2008-2009 period were unreasonable and non-compensatory.

Prepared independent report on behalf of the Belize Supreme Court for arbitration of the dispute.

## **SELECTED BUSINESS CONSULTING EXPERIENCE**

- ♦ For an environmental advocacy group, critically evaluated the financial implications of operating restrictions for an off-shore wind generating facility stemming from requirements under the U.S. Endangered Species Act.

- ◆ For a major investor-owned utility in the US, prepared a new system of short-term peak and energy forecasting models.
- ◆ For a major wholesale electric generation company, prepared comprehensive economic impact studies for use in FERC hydroelectric relicensing proceedings.
- ◆ For a major investor-owned utility in the Southwest US, prepared a detailed econometric model and wrote a comprehensive report on residential price elasticity that was required by regulators.
- ◆ For a major investor-owned utility in the Southwest US, developed a methodology to value nuclear plant leases that incorporated future uncertainty regarding greenhouse gas regulations.
- ◆ Faculty member, PURC/World Bank International Training Program on Utility Regulation and Strategy, University of Florida, Public Utility Research Center, Gainesville, FL, 2008 – 2009. Courses taught:
  - Sector Issues: Basic Techniques–Energy
  - Sector Issues in Rate Design: Energy
  - Sector Issues in Rate Design: Energy–Case Studies
  - Transmission Pricing Issues
- ◆ For a major solar energy firm, evaluated costs and benefits of alternative solar technologies; assisted with siting and transmission access issues.
- ◆ For industrial customers in the State of Vermont, prepared a position paper on the impacts of demand side management funding on electric rates and competitiveness.
- ◆ For a major New York brokerage firm, performed a fairness opinion valuation of a gas-fired electric generating facility.
- ◆ For electric utilities undergoing restructuring, developed comprehensive economic models to value buyer offers associated with nuclear power plant divestitures.
- ◆ For a large municipal electric utility in Florida, analyzed real option values of alternative proposed purchased generation contracts whose strike prices were tied to future natural gas and oil prices, and developed contract recommendations.
- ◆ For a municipal electric utility in Florida, developed an analytical model to determine risk-return tradeoffs of alternative generation portfolios, identify an efficient frontier of generation asset portfolios, and recommended asset purchase and sale strategies.
- ◆ For Central Vermont Public Service Corp. and Green Mountain Power Corp., developed analyses of distribution capacity investments accounting for uncertainty over future peak load growth.

- ◆ For a major electric utility in Latin America, developed risk management strategies for hedging natural gas supplies with minimal up-front investment; prepared training materials for utility staff; and wrote the utility's risk management Policies and Procedures Manual.
- ◆ For a major nuclear plant owner and operator in the U.S., prepared reports of the economic benefits of nuclear plant operation and development.
- ◆ For the Electric Power Supply Association, prepared numerous policy papers addressing wholesale electric market design and competition.
- ◆ For the California Energy Commission, developed a new policy approach to renewables feed-in tariffs and developed portfolio analysis models to develop an "efficient frontier" of generation portfolios for the state.
- ◆ For a major nuclear plant owner and operator, assessed the likelihood of relicensing a specific nuclear plant in New England, given state regulatory concerns over on-site spent fuel storage.
- ◆ For a large investor-owned utility in the Southeast, analyzed alternative environmental compliance strategies that directly incorporated uncertainty over future emissions costs, environmental regulations, and alternative pollution control technology effectiveness.
- ◆ For a Special Legislative Committee of the Province of New Brunswick, served as an expert advisor on the development of a deregulated electric power market.
- ◆ For the Bonneville Power Administration, developed models to assess the economic impacts of local generation resource development in Washington State and Oregon.
- ◆ For an electric utility in the Pacific Northwest, assisted in negotiations surrounding relicensing of a large hydroelectric generating facility.
- ◆ Served as an expert advisor for the Northwest Power Planning Council regarding future power supplies, load growth, and economic growth.

## **EDUCATION**

- ◆ Ph.D., Economics, University of Washington
- ◆ M.A., Economics, University of Washington
- ◆ B.S., Mathematics and Economics (with honors), University of New Mexico

## **EMPLOYMENT HISTORY**

- ◆ 2009–Present: Continental Economics, President.
- ◆ 2004–2009: Bates White, LLC, Partner, Energy Practice.

- ♦ 2003–2004: Vermont Dept. of Public Service, Director of Planning.
- ♦ 1998–2003: Navigant Consulting, Senior Managing Economist.
- ♦ 1993–1998: Green Mountain Power Corporation, Manager, Economic Analysis.
- ♦ 1986–1993: Washington State Energy Office, Energy Policy Specialist.
- ♦ 1984–1986: Pacific Northwest Utilities Conference Committee, Energy Economist.
- ♦ 1983–1984: Idaho Power Corporation, 1982-1983. Load Forecasting Analyst.

## PROFESSIONAL ACTIVITIES

- ♦ Reviewer, *Journal of Regulatory Economics*
- ♦ Reviewer, *The Energy Journal*
- ♦ Reviewer, *Energy*

## PROFESSIONAL ASSOCIATIONS

- ♦ Society for Benefit-Cost Analysis
- ♦ Energy Bar Association
- ♦ International Association for Energy Economics

## PUBLICATIONS

### Peer-reviewed journal articles

- ♦ Lesser, J., "Gresham's Law of Green Energy," *Regulation*, Winter 2010-2011, pp. 12-18.
- ♦ Lesser, J., and E. Nicholson, "Abandon all Hope? FERC's Evolving Standards for Identifying Comparable Firms and Estimating the Rate of Return," *Energy Law Journal* 30 (April 2009): 105-132.
- ♦ Lesser, J. and X. Su. "Design of an Economically Efficient Feed-in Tariff Structure for Renewable Energy Development." *Energy Policy* 36 (March 2008) 981–990.
- ♦ Lesser, J. "The Economic Used-and-Useful Test: Its Origins and Implications for a Restructured Electric Industry." *Energy Law Journal* 23 (November 2002): 349–82.
- ♦ Lesser, J., and C. Feinstein. "Electric Utility Restructuring, Regulation of Distribution Utilities, and the Fallacy of 'Avoided Cost' Rules." *Journal of Regulatory Economics* 15 (January 1999): 93–110.

- ♦ Lesser, J., and C. Feinstein. "Defining Distributed Utility Planning." *The Energy Journal*, Special Issue, Distributed Resources: Toward a New Paradigm (1998): 41–62.
- ♦ Lesser, J., and R. Zerbe. "What Can Economic Analysis Contribute to the Sustainability Debate?" *Contemporary Policy Issues* 13 (July 1995): 88–100.
- ♦ Lesser, J., and R. Zerbe. "The Discount Rate for Environmental Projects." *Journal of Policy Analysis and Management* 13 (Winter 1994): 140–56.
- ♦ Lesser, J., and D. Dodds. "Can Utility Commissions Improve on Environmental Regulations?" *Land Economics* 70 (February 1994): 63–76.
- ♦ Lesser, J. "Estimating the Economic Impacts of Geothermal Resource Development." *Geothermics* 24 (Winter 1994): 52–69.
- ♦ Lesser, J. "Application of Stochastic Dominance Tests to Utility Resource Planning Under Uncertainty." *Energy* 15 (December 1990): 949–61.
- ♦ Lesser, J. "Resale of the Columbia River Treaty Downstream Power Benefits: One Road From Here to There." *Natural Resources Journal* 30 (July 1990): 609–28.
- ♦ Lesser, J., and J. Weber. "The 65 M.P.H. Speed Limit and the Demand for Gasoline: A Case Study for the State of Washington." *Energy Systems and Policy* 13 (July 1989): 191–203.
- ♦ Lesser, J. "The Economics of Preference Power." *Research in Law and Economics* 12 (1989): 131–51.

### **Books and contributed chapters**

- ♦ Lesser, J., and L.R. Giacchino, *Principles of Utility Corporate Finance*, (Vienna, VA: Public Utilities Reports, 2011).
- ♦ Lesser, J., and L.R. Giacchino. *Fundamentals of Energy Regulation*, (Vienna, VA: Public Utilities Reports, 2007).
- ♦ Lesser, J., and R. Zerbe. "A Practitioner's Guide to Benefit-Cost Analysis." In *Handbook of Public Finance*, edited by F. Thompson, (New York: Rowan and Allenheld, 1998), 221–68.
- ♦ Lesser, J., D. Dodds, and R. Zerbe. *Environmental Economics and Policy*, (Reading: MA: Addison Wesley Longman, 1997).

### **Trade press publications**

- ♦ Lesser, J., "Nuclear Fallout," *Natural Gas & Electricity* (May 2011):31-33.

- ◆ Lesser, J., "Texas Two-Step: EPA's Greenhouse Gas Permitting Takeover," *Natural Gas & Electricity* (March 2011):21-23.
- ◆ Lesser, J., "Looking Forward: Energy and the Environment through 2012," *Natural Gas & Electricity* (January 2011):30-32.
- ◆ Lesser, J., "First-Mover Disadvantage: Offshore Wind's False Economic Promises," *Natural Gas & Electricity* (November 2010): 26-28.
- ◆ Lesser, J., "Will the BP Disaster Affect Natural Gas and Electricity Markets?," *Natural Gas & Electricity* (August 2010): 23-24.
- ◆ Lesser, J., "Renewable Energy and the Fallacy of 'Green' Jobs," *The Electricity Journal* (August 2010):45-53.
- ◆ Lesser, J., "Let the Tough Choices Begin: Affordable or Green?," *Natural Gas & Electricity* (June 2010): 27-29.
- ◆ Lesser, J., "Will Shale Gas Production be Damaged by Too Many Fracking Complaints?," *Natural Gas & Electricity* (April 2010): 31-32.
- ◆ Lesser, J., "As the Climate Turns: The Saga Continues," *Natural Gas & Electricity* (February 2010): 29-32.
- ◆ Lesser, J. and N. Puga, "Public Policy and Private Interests: Why Transmission Planning and Cost-Allocation Methods Continue to Stifle Renewable Energy Policy Goals," *The Electricity Journal* (December 2009): 7-19.
- ◆ Lesser, J., "Short Circuit: Will Electric Cars Provide Energy and Environmental Salvation?" *Natural Gas & Electricity* (November 2009): 27-28.
- ◆ Lesser, J., "Green is the New Red: The High Cost of Green Jobs," *Natural Gas & Electricity* (August 2009): 31-32.
- ◆ Lesser, J., "Regulating Greenhouse Gas Emissions: EPA Gets Down," *Natural Gas & Electricity* (June 2009): 31-32.
- ◆ Lesser, J., "Being Reasonable While Regulating Greenhouse Gas Emissions under the Clean Air Act," *Natural Gas & Electricity* (April 2009): 30-32.
- ◆ Lesser, J., "Renewables, Becoming Cheaper, Are Suddenly Passé," *Natural Gas & Electricity* (February 2009): 30-32.
- ◆ Lesser, J., "Measuring the Costs and the Benefits of Energy Development," *Natural Gas & Electricity* (December 2008): 30-32.
- ◆ Lesser, J., "Comparing the Benefits and the Costs of Energy Development," *Natural Gas & Electricity* (October 2008): 31-32.
- ◆ Lesser, J., "New Source Review Is Still Anything but Routine," *Natural Gas & Electricity* (August 2008): 31-32.

- ♦ Lesser, J., and N. Puga, "PV versus Solar Thermal," *Public Utilities Fortnightly* 146 (July 2008), pp. 16-20, 27.
- ♦ Lesser, J., "Cap-and-Trade for Gasoline?," *Wall Street Journal*, June 14, 2008, A14.
- ♦ Lesser, J., "Kansas Secretary Unilaterally Bans Coal Plants," *Natural Gas & Electricity* (June 2008): 30-32.
- ♦ Lesser, J., "Seeing Through a Glass, Darkly, Banks Approach Coal-Fired Power Financing," *Natural Gas & Electricity* (April 2008): 29-31.
- ♦ Lesser, J., "The Energy Independence and Security Act of 2007: No Subsidy Left Behind," *Natural Gas & Electricity* (February 2008): 29-31.
- ♦ Lesser, J., "Control of Greenhouse Gases: Difficult with Either Cap-and-Trade or Tax-and-Spend," *Natural Gas & Electricity* (December 2007): 28-31.
- ♦ Lesser, J., "Déjà vu All Over Again: The Grass was not Greener Under Utility Regulation," *The Electricity Journal* 20 (December 2007): 35-39.
- ♦ Lesser, J., "Blowin' in the Wind: Renewable Energy Mandates, Electric Rates, and Environmental Quality," *Natural Gas & Electricity* (October 2007): 26-28.
- ♦ Lesser, J., "No Leg to Stand On," *Natural Gas & Electricity* (August 2007): 28-31.
- ♦ Lesser, J., "Goldilocks Chills Out," *Natural Gas & Electricity* (July 2007): 26-28.
- ♦ Lesser, J., "Goldilocks and the Three Climates," *Natural Gas & Electricity* (April 2007): 22-24.
- ♦ Lesser, J., "Command-and-Control Still Lurks in Every Legislature," *Natural Gas & Electricity* (February 2007): 8-12.
- ♦ Lesser, J., and G. Israilevich, "The Capacity Market Enigma," *Public Utilities Fortnightly* 143 (December 2005): 38-42.
- ♦ Lesser, J., "Overblown Promises: The Hidden Costs of Symbolic Environmentalism," *Living Vermont* 1 (January/February 2005): 7, 27.
- ♦ Lesser, J., "Regulation by Litigation," *Public Utilities Fortnightly* 142 (October 2004): 24-29.
- ♦ Lesser, J., "ROE: The Gorilla is Still at the Door," *Public Utilities Fortnightly* 144 (July 2004): 19-23.
- ♦ Lesser, J., and S. Chapel, "Keys to Transmission and Distribution Reliability," *Public Utilities Fortnightly* 142 (April 2004): 58-62.
- ♦ Lesser, J., "DCF Utility Valuation: Still the Gold Standard?" *Public Utilities Fortnightly* 141 (February 15, 2003): 14-21.

- ◆ Lesser, J., "Welcome to the New Era of Resource Planning: Why Restructuring May Lead to More Complex Regulation, Not Less." *The Electricity Journal* 15 (July 2002): 20-28.
- ◆ Lesser, J., and C. Feinstein, "Identifying Applications for Distributed Generation: Hype vs. Hope." *Public Utilities Fortnightly* 140 (June 1, 2002): 20-28.
- ◆ Lesser, J., et al., "Utility Resource Planning: The Need for a New Approach." *Public Utilities Fortnightly* 140 (January 15, 2002): 24-27.
- ◆ Lesser, J., "Distribution Utilities: Forgotten Orphans of Electric Restructuring?" *Public Utilities Fortnightly* 137 (March 1, 1999): 50-55.
- ◆ Lesser, J., "Regulating Distribution Utilities in a Restructured World." *The Electricity Journal* 12 (January/February 1999): 40-48.
- ◆ Lesser, J., "Is it How Much or Who Pays? A Response to Rothkopf." *The Electricity Journal* 10 (December 1997): 17-22.
- ◆ Lesser, J., and M. Ainspan, "Using Markets to Value Stranded Costs." *The Electricity Journal* (October 1996): 66-74.
- ◆ Lesser, J., "Economic Analysis of Distributed Resources: An Introduction." *Proceedings, First Annual Conference on Distributed Resources*, Electric Power Research Institute, Kansas City, MO, July 1995.
- ◆ Lesser, J., "Distributed Resources as a Competitive Opportunity: The Small Utility Perspective." *Proceedings, First Annual Conference on Distributed Resources*, Electric Power Research Institute, Kansas City, MO, July 1995.
- ◆ Lesser, J., and M. Ainspan, "Retail Wheeling: Deja vu All Over Again?" *The Electricity Journal* 7 (April 1994): 33-49.
- ◆ Lesser, J., "An Economically Rational Approach to Least-Cost Planning: Comment." *The Electricity Journal* 4 (October 1991).
- ◆ Lesser, J., "Long-Term Utility Planning Under Uncertainty: A New Approach." Paper presented for the Electric Power Research Institute: *Innovations in Pricing and Planning*, May 1990.
- ◆ Lesser, J., "Centralized vs. Decentralized Resource Acquisition: Implications for Bidding Strategies." *Public Utilities Fortnightly* (June 1990).
- ◆ Lesser, J., "Most Value—The Right Measure for the Wrong Market?" *The Electricity Journal* 2 (December 1989): 47-51.

### **Selected speaking engagements**

- ◆ “The Failures of Transmission Planning and Policy,” Harvard Electric Policy Group, February 25, 2010.
- ◆ “Financing the Smart Grid,” Energy Bar Association Seminar, Washington, DC, December 4, 2009.
- ◆ “Renewable Power: At the Crossroads of Economics and Policy,” Presentation to the Utilities State Government Organization, Newport, Rhode Island, July 13, 2009.
- ◆ “The Stimulus Act and Laws they Didn’t Teach You in Law School,” presentation to the 27<sup>th</sup> National Regulatory Conference, Williamsburg, VA, May 19, 2009.
- ◆ “Rate Recovery for Capital Intensive Generation: Rate Base and Construction Work in Progress,” Law Seminars International, Las Vegas, NV, February 5, 2009.
- ◆ “Financial Risks Faced by Regulated Utilities: Implications for the Cost of Capital and Ratemaking Policies,” Law Seminars International, Las Vegas, NV, February 7, 2008.
- ◆ “Alternative Regulatory Structures and Tariff Mechanisms: Practical approaches to providing low-cost, environmentally responsible energy and how to avoid some dangerous pitfalls,” Western Energy Institute, October 1, 2007.
- ◆ “Economics and Energy Regulation,” Law Seminars International, Washington, DC, March 15-16, 2007.
- ◆ “Energy in the Northeast: Resource Adequacy & Reliability,” Law Seminars International, Boston, MA, October 16–17, 2006.
- ◆ “Energy in the Southwest: New Directions in Energy Markets and Regulations,” Law Seminars International, Santa Fe, NM, July 14, 2006.
- ◆ “Energy and the Environment,” Vermont Journal of Environmental Law, South Royalton, VT, March 10, 2006.
- ◆ “Electricity and Natural Gas Regulation: An Introduction,” Law Seminars International, Washington, DC, March 17–18, 2005.

Daily Return	Std Dev of Return	Annual Volatility	14.51% Day	PJM Forward Price		48.24	Daily Return	std dev	annual vol	0.333 annual volatility
				random nos	daily prices					
0.000921517	0.914%			1	0.677985279	48.71215486	1.009740033			
0.001074032				2	0.572171011	48.8987426	1.003823097	0.003823097		
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0.005127021				17	0.203283862	44.58212318	0.982740816	-0.017259184		
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-0.002161162	58	0.330302086	48.92314124	0.990831711	-0.009168289
0.003239994	59	0.07160942	47.46576799	0.969758257	-0.030241743
0.001077669	60	0.383544656	47.17268283	0.993806194	-0.006193806
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0.000308309	62	0.298304474	47.46365012	0.988958618	-0.011041382
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-0.000613779	67	0.575522327	50.59854329	1.004003098	0.004003098
-0.006004175	68	0.068045531	49.06471424	0.969217338	-0.030782662
0.004929154	69	0.591818207	49.30489625	1.004883266	0.004883266
-0.006165248	70	0.6528582	49.7147896	1.008279075	0.008279075
0.004781377	71	0.626659657	50.05395174	1.006798992	0.006798992
-0.006793295	72	0.874473693	51.2887288	1.024369558	0.024369558
0.001857298	73	0.258993232	50.60254641	0.986530883	-0.013469117
0.002625281	74	0.377261696	50.27280401	0.993462356	-0.006537644
0.003540917	75	0.913638683	51.75285317	1.029015309	0.029015309
0.004140793	76	0.599070866	52.02672245	1.005277915	0.005277915
-0.001071894	77	0.633841402	52.40271303	1.007200886	0.007200886
-0.004145243	78	0.993743961	55.29829703	1.053783748	0.053783748
-0.004008021	79	0.356083786	54.87361232	0.99279047	-0.00770953
0.001389211	80	0.367472145	54.48665692	0.992923262	-0.007076738
-0.000771545	81	0.133842688	53.2486765	0.977017105	-0.022982895
-0.003866682	82	0.777026847	54.11383816	1.016116992	0.016116992
0.003712301	83	0.001581291	50.96068224	0.939964457	-0.060035543
-0.010398169	84	0.268776384	50.37005487	0.987250555	-0.022849445
-0.003594596	85	0.556032247	50.45921303	1.002960393	0.002960393
0.008108574	86	0.808864906	51.40124573	1.018497061	0.018497061
-0.00763898	87	0.918574038	52.95113333	1.029707067	0.029707067
0.001876173	88	0.576650605	53.16675239	1.00406377	0.00406377
0.001248829	89	0.547064804	53.29896097	1.002483591	0.002483591
-0.004534446	90	0.287162281	52.67828446	0.988286474	-0.011713526
-0.004397683	91	0.65238307	53.11477724	1.008251869	0.008251869
0.000314762	92	0.36536459	52.73407405	0.992806633	-0.007193367
0.005805304	93	0.813786039	53.73948846	1.018886271	0.018886271
0.008102257	94	0.126041203	52.4787997	0.976261189	-0.023738811
-0.000465658	95	0.569245871	52.67155281	1.003666242	0.003666242
-0.00326569	96	0.805424159	53.64048907	1.018228661	0.018228661
-0.002495523	97	0.100921018	52.24195893	0.973581807	-0.026418193
0.002183748	98	0.412900822	52.00187656	0.995393823	-0.004606177
0.011618131	99	0.102404994	50.63471198	0.973752451	-0.026247549
-0.006334513	100	0.08697374	49.25023663	0.971881916	-0.028118084
0.002012852	101	0.33517822	48.81437602	0.991110688	-0.008889312
0.000154667	102	0.776738333	49.60646901	1.016096389	0.016096389

-0.006205419	103	0.166416687	48.61886252	0.979890324	-0.020109676
0.00372787	104	0.655611213	49.03079503	1.008436997	0.008436997
0.000310029	105	0.492029925	49.01075447	0.999580981	-0.000419019
-0.004193529	106	0.733420559	49.65941858	1.013158521	0.013158521
0.001710598	107	0.708098041	50.23672576	1.011558276	0.011558276
0.007584589	108	0.110130304	48.97743895	0.974613414	-0.025386586
0.000308356	109	0.511816861	49.00789444	1.000621634	0.000621634
-0.006805504	110	0.643224195	49.38820281	1.00773019	0.00773019
-0.00544706	111	0.96717292	51.37136113	1.039369255	0.039369255
-0.000156067	112	0.808854193	52.33037892	1.018496221	0.018496221
-0.007991894	113	0.692021302	52.88683462	1.010577374	0.010577374
0.009863094	114	0.18922874	51.92751004	0.981694273	-0.018305727
-0.007976894	115	0.29120554	51.33539192	0.98531707	-0.011468293
-0.009308263	116	0.451775519	51.70523205	0.9974613	-0.0025387
0.007736677	117	0.073761855	49.69562305	0.970075147	-0.029934853
-0.00631116	118	0.93016409	51.28432816	1.03146835	0.03146835
-0.001267026	119	0.266056307	50.62090353	0.986979393	-0.013020607
0.001425291	120	0.796973977	51.5187786	1.01758177	0.01758177
-0.000474871	121	0.027896089	49.53199232	0.960672396	-0.039327604
-0.00095042	122	0.56481189	49.70212458	1.00342891	0.00342891
-0.006199845	123	0.946431056	51.44037356	1.034375662	0.034375662
-0.016888502	124	0.269842771	50.78701797	0.987217428	-0.012782572
-0.013552334	125	0.4001589	50.51897353	0.994708209	-0.005291791
-0.002633746	126	0.136548497	49.38374319	0.977272306	-0.022727694
0.001153118	127	0.990060152	51.91881843	1.05006003	0.05006003
0.006236685	128	0.202214852	51.02644659	0.982662744	-0.017337256
0.009606847	129	0.532919792	51.11502606	1.001734447	0.001734447
-0.005036157	130	0.801368262	52.03905803	1.017916046	0.017916046
-0.004243519	131	0.54490545	52.16248527	1.002369011	0.002369011
0	132	0.424005667	51.95361244	0.995987689	-0.004012311
0.009117614	133	0.141053699	50.80735128	0.977689802	-0.022310198
0.008713949	134	0.875187598	52.06459017	1.024444012	0.024444012
0.002887857	135	0.294611339	51.48148138	0.988737092	-0.011262908
-0.000961693	136	0.913550143	52.99647147	1.029003177	0.029003177
-0.004822385	137	0.879725443	54.33398183	1.024924512	0.024924512
-0.004198295	138	0.11258068	52.98598254	0.974877551	-0.025122449
-0.015491545	139	0.186203404	52.01282878	0.981462997	-0.018537003
0.000657138	140	0.389475323	51.70837295	0.994129326	-0.005870674
0.003606561	141	0.777900037	52.55179018	1.016179442	0.016179442
-0.014837067	142	0.640393328	52.95111503	1.007569967	0.007569967
-0.000333226	143	0.872392989	54.24568173	1.02415426	0.02415426
-0.004495886	144	0.201722648	53.31139544	0.982626717	-0.017373283
-0.005019251	145	0.398611736	53.07559514	0.994624618	-0.005375382
0.016468808	146	0.448895183	52.88309834	0.997309062	-0.002690938
-0.004796172	147	0.312631876	52.34680094	0.989807041	-0.010192959
-0.010331703	148	0.13957589	51.1849055	0.977553848	-0.022446152
0.011988156	149	0.649751295	51.60126098	1.008101436	0.008101436
0.000496401	150	0.87298603	52.86605648	1.024215369	0.024215369
-0.01533619	151	0.472366961	52.78929277	0.998546903	-0.001453097
-0.000840266	152	0.337793395	52.32990816	0.991259684	-0.008740316
0.003524381	153	0.893396024	53.73282193	1.026455959	0.026455959
0.004346379	154	0.119698622	52.4387964	0.975622683	-0.024377317

-0.002003674	155	0.683567498	52.96957919	1.010071064	0.010071064
0.015259875	156	0.702557288	53.56710518	1.011217399	0.011217399
0.004598464	157	0.883003439	54.93853007	1.025279755	0.025279755
0.006044289	158	0.174322718	53.87932563	0.98053191	-0.01946809
0.000152853	159	0.900543358	55.37130181	1.027314606	0.027314606
0.004711243	160	0.783306295	56.29641142	1.016569351	0.016569351
0.004205085	161	0.600432072	56.59852912	1.005352205	0.005352205
-0.006639163	162	0.75762633	57.44036716	1.014764319	0.014764319
-0.000162483	163	0.338982046	56.94435607	0.991327265	-0.008672735
-0.019029446	164	0.847095835	58.19437191	1.021714066	0.021714066
0.004131896	165	0.970925166	60.60220923	1.040542701	0.040542701
0.011968337	166	0.395371297	60.26675536	0.994449283	0.005550717
0.003741363	167	0.728791344	61.04681473	1.012860393	0.012860393
0.014346386	168	0.775558112	62.03218076	1.01601227	0.01601227
-0.003848626	169	0.226663317	61.07154852	0.984392808	-0.015607192
-0.006932716	170	0.829582025	62.31660909	1.020181885	0.020181885
-0.005027989	171	0.681738232	62.94052893	1.009962307	0.009962307
-0.002605016	172	0.701255856	63.64546468	1.011137773	0.011137773
0.006337878	173	0.746271781	64.5428162	1.014000752	0.014000752
0.003880361	174	0.533750708	64.65769922	1.001778368	0.001778368
-0.000484222	175	0.198891582	63.53085392	0.982418488	-0.017581512
-0.000484457	176	0.753229726	64.45659456	1.014466368	0.014466368
0	177	0.990912149	67.81532654	1.05079618	0.05079618
-0.002263908	178	0.102232119	66.0571904	0.973732663	-0.026267337
-0.001133879	179	0.965498811	68.67618265	1.038881565	0.038881565
0.000648088	180	0.888989743	70.48147845	1.025947505	0.025947505
0.001941748	181	0.961868617	73.20311995	1.037888084	0.037888084
0.002583146	182	0.866216345	74.94596966	1.023529407	0.023529407
0.000161225	183	0.929270698	77.33079693	1.031324835	0.031324835
0.00289762	184	0.304238325	76.50869126	0.989312061	-0.010687939
-0.004672529	185	0.442085428	76.27559209	0.996948648	-0.003051352
0.00177491	186	0.340055111	75.62154227	0.9913882	-0.0086118
0.003379741	187	0.27749107	74.69659998	0.987693382	-0.012306618
0.000160655	188	0.17120578	73.23809885	0.980281186	-0.019718814
0.002777201	189	0.492482861	73.20916024	0.999604791	-0.000395209
-0.004817739	190	0.098251132	71.27821622	0.973270205	-0.026729795
0.003695674	191	0.742195575	72.26370174	1.013731195	0.013731195
-0.000802246	192	0.241897773	71.21766946	0.985419002	-0.014580998
-0.004182087	193	0.183265361	69.89381501	0.981236208	0.018763792
-0.002905571	194	0.886841503	71.71372134	1.025704939	0.025704939
0.001453841	195	0.02304739	68.83456974	0.959023985	-0.040976015
0.004670272	196	0.8360857	70.27697008	1.020738064	0.020738064
-0.003379741	197	0.192473493	69.0188911	0.981936101	-0.018063899
0.006587957	198	0.651378622	69.58678327	1.008194403	0.008194403
0.003676769	199	0.555332943	69.79049356	1.002923151	0.002923151
0.000956938	200	0.523520441	69.87696349	1.001238226	0.001238226
-0.000797385	201	0.900741717	71.81368882	1.027339079	0.027339079
-0.005760016	202	0.844413518	73.37235011	1.021472053	0.021472053
-0.00434189	203	0.002121534	69.22256578	0.941779741	-0.058220259
0.001777194	204	0.295868361	68.45246297	0.988812629	-0.011187371
-0.000965717	205	0.129522249	66.86942466	0.976602299	-0.023397701
-0.000483209	206	0.136433256	65.36607143	0.977261506	-0.022738494

0.000805218	207	0.4310994342	65.1285667	0.996359927	-0.003640073
0.001126217	208	0.973932395	67.89362529	1.041578881	0.041578881
-0.005158806	209	0.174270873	66.58437291	0.980527763	-0.019472237
0.000969305	210	0.016620558	63.73852759	0.956319299	-0.043680701
0.002258065	211	0.673508861	64.3454087	1.009476374	0.009476374
-0.002742601	212	0.252282883	63.4571357	0.986099067	-0.013900933
-0.004858309	213	0.291798445	62.73579566	0.988567539	-0.011432461
0.000811359	214	0.434862709	62.52070079	0.996565526	-0.003434474
0.003562118	215	0.271832683	61.73429366	0.987341875	-0.012658125
-0.002913566	216	0.701432412	62.42639328	1.011148566	0.011148566
-0.000973078	217	0.053241785	60.48776632	0.96845298	-0.03154702
0.004855595	218	0.113944974	58.99566711	0.975022867	-0.024977133
-0.00696754	219	0.848186436	60.29669475	1.021813286	0.021813286
0.000487686	220	0.154787605	59.03838359	0.978910513	-0.021089487
0.002272728	221	0.003150416	55.84029458	0.944307932	-0.055692068
-0.011415649	222	0.518510785	55.89471794	1.000974151	0.000974151
0.001966247	223	0.567336298	56.09428035	1.003563968	0.003563968
-0.00098264	224	0.872432857	57.46592794	1.024158362	0.024158362
0.002781643	225	0.854892484	58.76970589	1.022434302	0.022434302
-0.00573537	226	0.152026702	57.52947931	0.978670984	-0.021329016
0.006225446	227	0.893976236	59.07581102	1.026524051	0.026524051
0.001631854	228	0.150474536	57.82126587	0.978535078	-0.021464922
0.014407372	229	0.139152232	56.53564506	0.977514696	-0.022485304
0.005289745	230	0.321690844	55.99186856	0.990335151	-0.009664849
-0.006898239	231	0.59164854	56.26544226	1.004874057	0.004874057
0.00080457	232	0.250562946	55.48251819	0.985987451	-0.014012549
0.006093669	233	0.270824512	54.60129316	0.983989583	-0.016010417
0.007009747	234	0.527985811	54.68182569	1.001473833	0.001473833
0.00111067	235	0.694024081	55.2699656	1.010698244	0.010698244
0.000158567	236	0.023467792	53.05915406	0.959177762	-0.040822238
-0.003017073	237	0.607437153	53.36435882	1.005735568	0.005735568
0.010126669	238	0.392170566	53.0597601	0.994275742	-0.005724258
0.006121027	239	0.624042576	53.41395417	1.006653198	0.006653198
-0.001252544	240	0.128163311	52.17178932	0.976469889	-0.023530111
-0.006286364	241	0.772826433	53.00363372	1.015818558	0.015818558
0.002833755	242	0.313505998	52.46880173	0.989858268	-0.010141732
-0.002045795	243	0.469921737	52.38587153	0.998418187	-0.001581813
-0.006479675	244	0.635730493	52.77005999	1.007307056	0.007307056
0.005218641	245	0.982154918	55.20149692	1.045046087	0.045046087
-0.005377207	246	0.465761538	55.10217369	0.998199094	-0.001800906
-0.00620379	247	0.939039772	56.94966337	1.032978614	0.032978614
-0.004477858	248	0.183575118	55.89237691	0.981260222	-0.018739778
-0.005142226	249	0.10980643	54.4894004	0.974578194	-0.025421806
0.005943315	250	0.473727206	54.41417468	0.998618489	-0.001381511
-0.00224467	251	0.533414064	54.51005917	1.001760573	0.001760573
0.007037777	252	0.123285627	53.21667699	0.975986568	-0.024013432
0.000796622	253	0.741225916	53.94900421	1.013667409	0.013667409
-0.00430932	254	0.311933575	53.39970963	0.989766075	-0.010233925
0.001438504	255	0.519497298	53.45453301	1.001026134	0.001026134
-0.00592713	256	0.559932511	53.62416184	1.003168305	0.003168305
0.001765792	257	0.250592227	52.87809139	0.985989355	-0.014010645
0.004959613	258	0.957998354	54.86636814	1.036911457	0.036911457

-0.001437356	259	0.47624537	54.797882	0.998750985	-0.001249015
-0.003843079	260	0.213118852	53.89834444	0.983448218	-0.016551782
0.005280435	261	0.295938814	53.29894941	0.988816858	-0.011183142
-0.001757049	262	0.820590974	54.34496709	1.019435387	0.019435387
0.005261911	263	0.105824546	52.95757156	0.974139049	-0.025860951
0.002382655	264	0.847451842	54.12182143	1.021746402	0.021746402
-0.009725067	265	0.486686233	54.08395243	0.999300056	-0.000699944
-0.004174031	266	0.850742225	55.28962238	1.022047717	0.022047717
-0.004676297	267	0.619184698	55.64369059	1.006383464	0.006383464
-0.001132045	268	0.891054253	57.11989937	1.076183862	0.026183862
-0.006982248	269	0.015532228	54.64887461	0.955776065	-0.044223935
0.003903079	270	0.094135877	53.18127438	0.972777777	-0.027222773
-0.001624432	271	0.286968086	52.5613472	0.988274656	-0.0111725344
-0.013750421	272	0.330264029	52.08153822	0.990829528	-0.009170472
-0.012939796	273	0.572679987	52.28246028	1.003850414	0.003850414
-0.010068889	274	0.428864149	52.08659003	0.996246579	-0.003753421
0.009567845	275	0.90147636	53.53510245	1.027430033	0.027430033
0.000334057	276	0.540280069	53.64892406	1.002123855	0.002123855
-0.005022612	277	0.784903134	54.55159941	1.016685618	0.016685618
-0.009274158	278	0.4474882	54.40095373	0.997234654	-0.002765346
-0.004414269	279	0.171207725	53.33874707	0.980281344	-0.019718656
0.010494341	280	0.026011403	51.25049223	0.960062193	-0.039937807
0.00470352	281	0.946103215	53.03943797	1.034310527	0.034310527
0.002510672	282	0.367996825	52.66694419	0.992952264	-0.007047736
-0.007719454	283	0.493736996	52.64960497	0.999670722	-0.000329278
-0.003713084	284	0.95621928	54.60611455	1.036487129	0.036487129
0.004891635	285	0.430382473	54.40593482	0.996327379	-0.003672621
0.000336474	286	0.950430772	56.35497745	1.035197324	0.035197324
-0.001683502	287	0.377680036	55.98903498	0.9934853	-0.0065147
-0.009140213	288	0.354608631	55.55446505	0.992208024	-0.007791976
-0.001701838	289	0.833191157	56.70444818	1.020488767	0.020488767
-0.009068417	290	0.346956449	56.24016161	0.991778462	-0.008221538
-0.002926244	291	0.845533923	57.46660049	1.021572797	0.021572797
-0.002761956	292	0.834372448	58.66211263	1.02059016	0.02059016
-0.002769605	293	0.424986806	58.43027075	0.996040013	-0.003959987
0.008801506	294	0.736719163	59.21688364	1.013372608	0.013372608
-0.017681168	295	0.132899318	57.86623256	0.976927314	-0.023072686
0.008532921	296	0.860010805	59.20794116	1.022921662	0.022921662
0.003462008	297	0.619164785	59.58703608	1.006382361	0.006382361
0.00620157	298	0.425755709	59.35397164	0.996081003	-0.003918997
0.007527837	299	0.649370488	59.83547678	1.008079704	0.008079704
-0.004441415	300	0.168553893	58.65450341	0.980065614	-0.019934386
0.004100467	301	0.035151495	56.50949276	0.962744281	-0.037255719
0.006966301	302	0.886589211	57.97925703	1.025676672	0.025676672
-0.004412021	303	0.276880025	57.08223644	0.984407663	-0.015592337
-0.007339796	304	0.139785525	55.81631245	0.977573192	-0.022426808
-0.007221489	305	0.669506189	56.33455535	1.009241921	0.009241921
-0.000690489	306	0.847870107	57.57523593	1.021784458	0.021784458
0.005854011	307	0.669997608	58.11147709	1.009270641	0.009270641
-0.001890197	308	0.56982738	58.32673651	1.003697406	0.003697406
-0.002583313	309	0.269316796	57.58401724	0.98718446	-0.01281554
0.002755297	310	0.808032657	58.65524005	1.018431865	0.018431865

0.001031282	311	0.969951716	61.06284177	1.040226611	0.040226611
-0.002235791	312	0.108169605	59.51941665	0.974399063	-0.025600937
-0.004313698	313	0.432445342	59.30773114	0.996437081	-0.003562919
0.007579709	314	0.620904007	59.69322142	1.006478799	0.006478799
0.002057261	315	0.5311339031	59.79121958	1.00164035	0.00164035
0.001027046	316	0.717606483	60.52215415	1.012150662	0.012150662
0.002050932	317	0.498702387	60.51802497	0.999931772	-6.82284E-05
-0.003077978	318	0.893165789	62.13877983	1.026429014	0.026429014
0.001882112	319	0.539627559	62.26874203	1.002089299	0.002089299
0.003923915	320	0.617856268	62.66289373	1.006309899	0.006309899
0.001531264	321	0.668537952	63.24112828	1.009185388	0.009185388
0.007621343	322	0.876576942	64.81549113	1.024589782	0.024589782
0.001854194	323	0.115739571	63.22860502	0.975212174	-0.024787826
-0.006759066	324	0.127075499	61.75160792	0.976363204	-0.023636796
0.003047234	325	0.474496757	61.5688535	0.998658984	-0.001341016
-0.004040547	326	0.557864752	61.85772772	1.003058036	0.003058036
-0.005447749	327	0.397737725	61.52320343	0.994577361	-0.005422639
-0.007883503	328	0.871286031	63.07018841	1.024040731	0.024040731
-0.000172073	329	0.81788674	64.24286912	1.019215605	0.019215605
0.003435839	330	0.704346997	64.97469598	1.01132717	0.01132717
-0.000514624	331	0.442840239	64.77932764	0.996988633	-0.003011367
0.001885661	332	0.555417448	64.9692568	1.002927651	0.002927651
-0.002915704	333	0.281911308	64.19207825	0.9879565626	-0.012034374
-0.000171777	334	0.089667018	62.43366951	0.972224894	-0.027775106
0.004456641	335	0.248690503	61.55740755	0.98586549	-0.01413451
0.005628053	336	0.204473136	60.50933112	0.982827391	-0.017172609
0.006610754	337	0.071123632	58.70255959	0.969685744	-0.030314256
-0.003384671	338	0.877527027	60.16997481	1.02469014	0.02469014
-0.002716009	339	0.740043317	60.99325351	1.013589789	0.013589789
-0.003234871	340	0.841342911	62.30001646	1.02119843	0.02119843
0.004424033	341	0.846383812	63.66348954	1.021649546	0.021649546
-0.000849257	342	0.949853242	65.93613946	1.035075454	0.035075454
-0.004598492	343	0.882558454	67.62094714	1.025231114	0.025231114
-0.007023583	344	0.272746405	66.77419312	0.987398871	-0.012601129
-0.001031992	345	0.477656918	66.69579555	0.99882524	-0.00117476
0.003264327	346	0.869239469	68.30442523	1.02383264	0.02383264
0.003424661	347	0.931947436	70.50853215	1.03175917	0.03175917
-0.000683995	348	0.882550657	72.31011258	1.025230263	0.025230263
0.001196684	349	0.922439806	74.53252953	1.030271679	0.030271679
-0.0010215641	350	0.386176643	74.08295146	0.993949763	-0.006050237
-0.000684346	351	0.816442617	75.51146677	1.019099091	0.019099091
0.002563885	352	0.354956457	74.92699452	0.992229711	-0.007770289
-0.006851688	353	0.189174954	73.56757814	0.981690181	-0.018309819
-0.005688199	354	0.932699751	75.95097448	1.031883645	0.031883645
0.001381931	355	0.738304312	76.98141657	1.01347599	0.01347599
0.001897043	356	0.12288524	75.15182233	0.975946316	-0.024053684
-0.000861846	357	0.69848454	75.98068196	1.010968758	0.010968758
-0.004840113	358	0.772391991	77.18977482	1.015787875	0.015787875
-0.002081527	359	0.258161663	76.15301544	0.986477679	-0.013522321
-0.000347343	360	0.396761056	75.7371809	0.994524524	-0.005475476
0.01002428	361	0.508116	75.76951795	1.000426873	0.000426873
-0.003100244	362	0.843488366	77.40762636	1.021389234	0.021389234

-0.011450507  
-0.007707167  
0.008230499

363  
364  
365

0.107213933 75.44311248  
0.907583587 77.60139052  
0.172814138 76.09604248

0.974293588  
1.028206451  
0.980410913

-0.025706412  
0.038206451  
-0.019589087

Residential Add in Costs (Baker)

Monte-Carlo Results

33.3% annual volatility (assumed)

std deviation

48.24

Mean PIM Forward Price

\$34.69

std deviation

19.8%

PIM

33.1%

Day	random nos	daily prices	inv LN from random nos		Daily Return	0.018975	0.020977	daily return volatility
			random Nos	na				
1	0.492061608	48.21987105	0.99582646	na				0.301225
2	0.342796007	47.81382045	0.99154353	-0.00845647				
3	0.138295869	46.74699801	0.977435311	-0.022564689				
4	0.390129244	46.47501765	0.994164873	-0.005835127				
5	0.119932647	45.35866598	0.975646652	-0.024353348				
6	0.038123221	43.73088461	0.963493029	-0.036506971				
7	0.40704547	43.51622926	0.995079361	-0.004920639				
8	0.509698802	43.53843512	1.000510159	0.000510159				
9	0.326252036	43.13103974	0.990598803	-0.009401197				
10	0.666587196	43.52409149	1.009071695	0.009071695				
11	0.632502422	43.83534088	1.007125749	0.007125749				
12	0.464916175	43.75451983	0.998154557	-0.001845443				
13	0.849267332	44.73385463	1.021912102	0.021912102				
14	0.424140032	44.54508736	0.995994855	-0.0040005145				
15	0.651999663	44.91320285	1.008229926	0.008229926				
16	0.907013842	46.19466071	1.028132421	0.028132421				
17	0.116155809	45.0656363	0.975255789	-0.024744211				
18	0.556062891	45.19931976	1.002962026	0.002962026				
19	0.934981011	46.68159274	1.03226789	0.03226789				
20	0.820870057	47.59882697	1.01945819	0.01945819				
21	0.65998589	48.01421401	1.008688975	0.008688975				
22	0.443992327	47.87276384	0.997049646	-0.002950354				
23	0.462065302	47.77731996	0.998004311	-0.00195689				
24	0.811150861	48.67804509	1.01867706	0.01867706				
25	0.718988201	49.27740547	1.01223756	0.01223756				
26	0.498130462	49.2725618	0.999901701	-9.82989E-05				
27	0.789490889	50.11848599	1.017022552	0.017022552				
28	0.581034029	50.33445186	1.004299848	0.004299848				
29	0.947262893	52.10350118	1.034542377	0.034542377				
30	0.649878529	52.52771032	1.008108698	0.008108698				
31	0.042023608	50.69099589	0.964407453	-0.035592547				
32	0.177717335	49.72710328	0.980801823	-0.019198177				
33	0.126663769	48.56352742	0.976322662	-0.023677338				
34	0.294770493	48.02008918	0.988746663	-0.011253337				
35	0.754478279	48.72392231	1.014550679	0.014550679				
36	0.21541939	47.93189309	0.983610982	-0.016389018				
37	0.732524421	48.56396081	1.013100599	0.013100599				
38	0.21768867	47.79575871	0.984055197	-0.015944803				
39	0.583501551	48.00810776	1.004433003	0.004433003				
40	0.680295481	48.48461985	1.009876723	0.009876723				
41	0.242103611	47.78344585	0.985432627	-0.014567373				
42	0.395748658	47.51991934	0.994469719	-0.005530281				
43	0.856486875	48.60535972	1.022584829	0.022584829				
44	0.860395074	49.734118645	1.022958746	0.022958746				
45	0.618073715	50.04959871	1.006321935	0.006321935				
46	0.589514016	50.2883163	1.004758282	0.004758282				
47	0.862615102	51.46732573	1.023174385	0.023174385				
48	0.939195417	53.19443359	1.033006605	0.033006605				
49	0.947381235	55.06531498	1.034566267	0.034566267				
50	0.909684	56.65625504	1.028482371	0.028482371				
51	0.58044159	54.84858216	0.96757394	-0.03242606				

52 0.937893068 56.67595803 1.032773763 0.032773763 0.032773763 52 0.20310409 0.33135706  
53 0.279037777 55.98808912 0.987788874 -0.012211126 -0.00755721 \$91.37 0.020203341 53 0.19111347 0.34213222  
54 0.308098105 55.4052705 0.989540381 -0.010459619 0.00644523 \$90.68 -0.00755721 54 0.18345275 0.32095531  
55 0.70131144 56.02626091 1.01141171 0.011141171 0.006866104 \$90.10 -0.00644523 55 0.17823766 0.32597952  
56 0.256014363 55.26613988 0.986339897 -0.013660103 0.00961441 \$90.72 0.006866104 56 0.20191882 0.33450702  
57 0.770766532 56.13917058 1.015673374 0.015673374 0.009658279 \$89.96 -0.00961441 57 0.20805937 0.33537556  
58 0.96863049 58.41921434 1.039811052 0.039811052 0.024792656 \$93.11 0.024792656 58 0.20568765 0.34034153  
59 0.450905098 58.26867682 0.997419825 -0.002580175 -0.00161809 \$92.96 -0.00161809 59 0.18768569 0.32438472  
60 0.318834893 57.69866212 0.990169313 -0.009830687 -0.005615079 \$92.99 -0.005615079 60 0.15783901 0.30452571  
61 0.880112161 59.157302168 1.024966057 0.024966057 0.003630134 \$93.85 0.003630134 61 0.18464768 0.33047606  
62 0.431181202 58.94294303 0.996369866 -0.003630134 -0.00228674 \$93.63 -0.00228674 62 0.19090142 0.34517104  
63 0.191129227 57.8821086 0.981838423 -0.018161577 -0.01139438 \$92.57 -0.01139438 63 0.20019495 0.3175261  
64 0.7379332501 58.6659824 1.013451711 0.013451711 0.003451711 \$93.36 0.003451711 64 0.20560159 0.34632507  
65 0.607546896 59.00379393 1.005741703 0.005741703 0.003612 \$93.69 0.003612 65 0.19535509 0.31771158  
66 0.757831363 59.88224395 1.014778287 0.014778287 0.009332075 \$94.57 0.009332075 66 0.1776114 0.32583851  
67 0.312547499 59.27467362 0.989802093 -0.010197907 -0.00644513 \$93.96 -0.00644513 67 0.21600082 0.3461175  
68 0.918517955 60.31657077 1.029699029 0.029699029 0.008837141 \$95.75 0.008837141 68 0.18897334 0.30938038  
69 0.278014352 60.31657077 0.987725717 -0.01274283 -0.00780998 \$95.01 -0.00780998 69 0.19012752 0.3177432  
70 0.089141995 58.66043649 0.972158633 -0.027841367 0.001758551 \$93.35 -0.001758551 70 0.18799479 0.32425973  
71 0.462041386 58.54341144 0.99800305 -0.00199695 \$93.23 -0.0012544 71 0.19504979 0.31669356  
72 0.149473159 57.29513188 0.978447107 -0.021552893 0.00377041 \$91.64 -0.00377041 72 0.20740834 0.34703132  
73 0.385994223 56.9496311 0.993939821 -0.006060179 0.002924291 \$91.41 -0.002924291 73 0.20081479 0.33877306  
74 0.423116576 56.71823345 0.995940254 -0.004059746 0.005623322 \$92.01 0.005623322 74 0.18399617 0.33322796  
75 0.588597879 56.98592893 1.00470864 0.00470864 0.00404361 \$91.64 -0.00404361 75 0.20353076 0.32039885  
76 0.609019788 57.31870187 1.005822597 0.005822597 0.00882785 \$92.14 0.00882785 76 0.19832372 0.3292444  
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78 0.662387362 57.45235558 1.00882785 0.00882785 0.005455164 \$92.14 0.005455164 78 0.18533496 0.32531321  
79 0.985175536 60.19759282 1.046676359 0.046676359 0.007863659 \$95.64 0.007863659 79 0.20213423 0.33124829  
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82 0.063166536 57.83395015 0.968440658 -0.03159342 0.001099983 \$90.93 -0.001099983 82 0.19754841 0.29243659  
83 0.533387998 57.93578088 1.001759195 0.001759195 0.00977618 \$91.02 0.00977618 83 0.20460047 0.32881052  
84 0.07377947 56.24409706 0.970365923 -0.029634077 0.00478185 \$90.59 -0.00478185 84 0.19162951 0.34144725  
85 0.525998863 56.33303933 1.001580113 0.001580113 0.001608706 \$90.73 0.001608706 85 0.20827709 0.34067635  
86 0.35575194 55.89881968 0.992262058 -0.007737942 0.003579205 \$87.54 -0.003579205 86 0.1722245 0.30458119  
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92 0.938677703 53.58335015 0.976522373 -0.023477627 0.007981777 0.007981777 92 0.2192468 0.38109276  
93 0.134615874 52.36973083 0.97709038 -0.02290962 0.007981777 0.007981777 93 0.21256931 0.38768775  
94 0.128700795 51.1545346 0.999335721 -0.00664279 0.007981777 0.007981777 94 0.18931219 0.32041925  
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96 0.625799276 51.46684871 1.006751024 0.006751024 0.00407323 0.00407323 96 0.19702336 0.33661199  
97 0.273417674 50.65851193 0.984169385 -0.015830615 0.00521886 \$85.35 -0.00521886 97 0.21714804 0.32934105  
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101 0.11959416 46.67155484 0.975611973 -0.024388027 0.00521886 \$81.36 -0.00521886 101 0.18423654 0.3211969  
102 0.017029072 44.56322828 0.953774166 -0.04625834 0.00521886 \$79.25 -0.04625834 102 0.21323548 0.33572946  
103 0.17628361 43.71173896 0.980707651 -0.019292349 0.00521886 \$78.40 -0.019292349 103 0.18731478 0.32495522  
104 0.638197119 44.03843057 1.007445983 0.007445983 0.004158235 \$78.73 0.004158235 104 0.20700954 0.33832966  
105 0.925075364 45.409977 1.030669164 0.030669164 0.017272124 \$80.10 0.017272124 105 0.22658344 0.33280313  
106 0.517692182 45.45227436 1.000931022 0.000931022 0.000527918 \$80.14 0.000527918 106 0.22643496 0.3499006  
107 0.189823746 44.62982498 0.981739497 -0.018260503 0.000527918 \$79.32 -0.018260503 107 0.19191102 0.3314134  
108 0.676312597 45.0621968 1.009641329 0.009641329 0.00543619 \$79.75 0.00543619 108 0.19223698 0.33953706

109	0.121841858	43.98658412	0.975840995	-0.024159005	\$78.58	-0.01357871	109	0.18058969	0.31959927
110	0.120432249	42.93049525	0.975697737	-0.024302263	\$77.62	-0.01351407	110	0.17243815	0.30448229
111	0.639273712	43.25397534	1.007506726	0.007506726	\$77.94	0.004158797	111	0.22013988	0.36181749
112	0.779606983	43.96487782	1.016301939	0.016301939	\$78.65	0.009079343	112	0.21076517	0.32855767
113	0.776297394	44.67687434	1.016064931	0.016064931	\$79.37	0.009011435	113	0.20540981	0.32412444
114	0.699590399	45.1736558	1.011058065	0.011058065	\$79.86	0.006239797	114	0.18680402	0.32095895
115	0.188374991	44.3513574	0.981629234	-0.018370766	\$79.04	-0.01034965	115	0.19490408	0.33198228
116	0.677114392	44.78314899	1.009688615	0.009688615	\$79.47	0.005447989	116	0.1725083	0.31413256
117	0.297070544	44.28981869	0.988522894	-0.011077106	\$78.98	0.00622686	117	0.15551814	0.30614017
118	0.564074507	44.44019327	1.00338949	0.00338949	\$79.13	0.001902152	118	0.18446142	0.32257612
119	0.42369595	44.26151132	0.985971167	-0.004028833	\$78.95	-0.00226063	119	0.18320903	0.32257612
120	0.331965484	43.8617452	0.990927052	-0.009072948	\$78.55	-0.0050763	120	0.18865761	0.34215686
121	0.11590403	42.78861029	0.97522942	-0.02477058	\$77.48	-0.01375568	121	0.21317482	0.33959112
122	0.404187002	47.5720287	0.994925482	-0.005074518	\$77.26	0.00279929	122	0.1992498	0.34270001
123	0.696122177	43.03538533	1.010825257	0.010825257	\$77.73	0.005979298	123	0.19150636	0.31528498
124	0.633032273	43.34443053	1.007155526	0.007155526	\$78.03	0.003968233	124	0.206164	0.32337444
125	0.751597618	43.97119361	1.014356511	0.014356511	\$78.66	0.007999795	125	0.17827342	0.30764795
126	0.07386417	42.67549057	0.970900035	-0.029909965	\$77.37	-0.01660912	126	0.21562821	0.34635139
127	0.55707856	42.80439995	1.003016136	0.003016136	\$77.49	0.001664852	127	0.18663885	0.3522213
128	0.780415191	43.5104544	1.016360134	0.016360134	\$78.20	0.009069669	128	0.18418035	0.32020811
129	0.437088284	43.3663899	0.99668368	-0.00331632	\$78.06	-0.00184383	129	0.2050791	0.35853764
130	0.586330056	43.56571955	1.004585877	0.004585877	\$78.26	0.001550407	130	0.20226794	0.34448236
131	0.518862625	43.60898825	1.000997689	0.000997689	\$78.30	0.000552761	131	0.17695325	0.30580558
132	0.113894805	42.53302475	0.975017545	-0.024982455	\$77.22	-0.01383702	132	0.16857848	0.31558771
133	0.062273577	41.20560929	0.968293568	-0.031706432	\$75.90	-0.01733883	133	0.18216019	0.318672619
134	0.209250952	40.51801503	0.983172296	-0.016827704	\$75.21	-0.00910103	134	0.1580948	0.30095238
135	0.76730113	41.14808983	1.015430816	0.015430816	\$75.84	0.008342863	135	0.18297375	0.32004425
136	0.318283014	40.74424917	0.990137199	-0.009862801	\$75.43	-0.00533927	136	0.21845339	0.33262119
137	0.630395584	41.03077618	1.007007719	0.007007719	\$75.72	0.003791172	137	0.22121182	0.33953058
138	0.342546785	40.68468975	0.991529425	-0.008470575	\$75.37	-0.00458104	138	0.22159076	0.35100993
139	0.590764179	40.88151148	1.00482607	0.00482607	\$75.57	0.002607841	139	0.17275327	0.33373304
140	0.658777753	41.23540276	1.008619259	0.008619259	\$75.93	0.004671936	140	0.14555793	0.2920507
141	0.966100415	42.8776917	1.039054506	0.039054506	\$77.57	0.021399681	141	0.20908897	0.3418642
142	0.947437764	44.38623403	1.034577693	0.034577693	\$79.08	0.019261378	142	0.19532759	0.35272979
143	0.273771197	43.83322381	0.987462687	-0.012537313	\$78.52	-0.00701795	143	0.19345742	0.34072094
144	0.042306679	42.30321945	0.964471129	-0.035528871	\$76.99	-0.01967707	144	0.18277431	0.33370118
145	0.89070907	43.42378403	1.026144117	0.026144117	\$78.11	0.014449174	145	0.20528265	0.33713881
146	0.618977982	43.70136431	1.006372011	0.006372011	\$78.39	0.003547239	146	0.19409401	0.32991622
147	0.65298771	44.06499591	1.008286493	0.008286493	\$78.75	0.004627994	147	0.20484635	0.32679283
148	0.06857811	42.73273837	0.969299519	-0.030700481	\$77.42	-0.01706125	148	0.18512486	0.32476407
149	0.716160171	43.25121222	1.012059928	0.012059928	\$77.94	0.006674338	149	0.18140783	0.32920841
150	0.284493939	42.74056298	0.988123161	0.011876839	\$77.43	-0.00657328	150	0.20206397	0.33409028
151	0.386728489	42.48403053	0.993979831	-0.006020169	\$77.17	-0.00331856	151	0.17988824	0.32538728
152	0.545703806	42.58659858	1.002411364	0.002411364	\$77.28	0.001328166	152	0.19767572	0.333062
153	0.274147853	42.05699535	0.987486114	-0.012513886	\$76.75	-0.00687694	153	0.19989507	0.33629069
154	0.065387766	40.7650653	0.968799742	-0.031200258	\$75.46	-0.01697692	154	0.19039915	0.33404696
155	0.304283206	40.33179821	0.989314723	-0.010685277	\$75.02	-0.0057586	155	0.17175608	0.31933451
156	0.246978018	39.7612861	0.985753532	-0.014246468	\$74.45	-0.00763368	156	0.20257336	0.31760275
157	0.733191565	40.28734654	1.01314371	0.01314371	\$74.98	0.007040988	157	0.33288997	0.34192755
158	0.72867232	40.80849216	1.012852763	0.012852763	\$75.50	0.006926663	158	0.17961531	0.32566146
159	0.73598662	41.35590198	1.013324943	0.013324943	\$76.05	0.007224447	159	0.17465227	0.31038584
160	0.994051931	43.65830304	1.054178339	0.054178339	\$78.35	0.029827179	160	0.2148898	0.34608008
161	0.082680889	42.42391292	0.971318704	-0.028681296	\$77.11	-0.01588059	161	0.1964316	0.34050197
162	0.844467924	43.34490312	1.021476934	0.021476934	\$78.03	0.011872485	162	0.24269812	0.34296297
163	0.262485626	42.77451664	0.986753399	-0.013246601	\$77.46	-0.00733622	163	0.20773541	0.33034132
164	0.223478798	42.10287922	0.984173609	-0.015826391	\$76.79	-0.00870806	164	0.18780674	0.317933
165	0.832526446	42.97969955	1.070431913	0.070431913	\$77.66	0.01253773	165	0.21956686	0.3524033

166	0.300490292	42.50565842	0.989089165	-0.010910835	\$77.20	-0.00602247	166	0.20211848	0.32076932
167	0.902944373	43.69573555	1.027613306	0.027613306	\$78.39	0.015298749	167	0.19127914	0.33141465
168	0.292858894	43.20179552	0.988631545	-0.011368455	\$77.89	-0.00632134	168	0.19242579	0.31613925
169	0.177920808	43.3809919	0.9808179	-0.0191821	\$77.07	-0.01059366	169	0.17236845	0.32328728
170	0.695331673	42.84026894	1.010778566	0.010778566	\$77.53	0.005941457	170	0.20065687	0.32545709
171	0.192517965	42.07365356	0.981943215	-0.018056785	\$76.76	-0.00993716	171	0.17155816	0.30554642
172	0.296579122	41.60737554	0.988855277	-0.011144723	\$76.30	-0.00609296	172	0.20369745	0.31836398
173	0.666796302	41.98703517	1.009083869	0.009083869	\$76.68	0.004963947	173	0.18276493	0.3361867
174	0.029556997	40.388435	0.961182597	-0.038817403	\$75.08	-0.02106889	174	0.17007694	0.32055724
175	0.576684475	40.55297215	0.985258847	-0.014741153	\$75.24	0.002189139	175	0.21417787	0.33821773
176	0.239485247	39.95955912	0.985258847	-0.014741153	\$74.65	-0.00791789	176	0.18151588	0.31199167
177	0.57189591	40.11202867	1.003808335	0.003808335	\$74.80	0.002040388	177	0.17315342	0.33413616
178	0.550926239	40.22002346	1.002688712	0.002688712	\$74.91	0.0014427	178	0.18889933	0.33386802
179	0.115805318	39.23558197	0.975219071	-0.024780929	\$73.93	-0.01322877	179	0.18792592	0.31855535
180	0.772361539	39.85985845	1.015785725	0.015785725	\$74.55	0.008409204	180	0.18949845	0.33173619
181	0.692480191	40.28482309	1.010605036	0.010605036	\$74.97	0.005684223	181	0.17964437	0.333865826
182	0.278199109	39.79383203	0.987737126	-0.012262874	\$74.48	-0.00657028	182	0.19030096	0.34032835
183	0.247737993	39.23288088	0.985803267	-0.014196733	\$73.92	-0.00755968	183	0.16942164	0.31249431
184	0.796328889	39.9268195	1.017533073	0.017533073	\$74.62	0.009343545	184	0.17818458	0.30723533
185	0.393014025	39.70073791	0.994321509	-0.005678491	\$74.39	-0.0030345	185	0.20574313	0.32448336
186	0.882811033	40.7162991	1.025258707	0.025258707	\$75.41	0.01355937	186	0.19015659	0.33885358
187	0.45670694	40.6226405	0.997721694	-0.002278306	\$75.31	-0.00122955	187	0.19323396	0.35895051
188	0.140813784	39.72648012	0.977667795	-0.022332205	\$74.02	-0.00530588	188	0.17576972	0.32911974
189	0.316576985	39.33268101	0.99003778	-0.00996222	\$74.52	0.006690365	189	0.1922713	0.33388841
190	0.723992583	39.87958011	1.012554104	0.012554104	\$75.08	0.007479408	190	0.18079705	0.30419887
191	0.745482985	40.38903201	1.013948408	0.013948408	\$74.40	-0.00903299	191	0.19315345	0.33706731
192	0.208841584	39.71389736	0.983142923	-0.016857077	\$74.40	-0.00903299	192	0.19090779	0.33197502
193	0.116311681	38.74389828	0.975272094	-0.024727906	\$73.43	-0.01312267	193	0.16211535	0.31276905
194	0.630906983	39.01747515	1.007036347	0.007036347	\$73.71	0.003718562	194	0.18603338	0.33549557
195	0.735483783	39.53956796	1.013292264	0.013292264	\$74.23	0.00705834	195	0.20413875	0.32437519
196	0.728460392	40.05049656	1.012839181	0.012839181	\$74.74	0.006859507	196	0.17965221	0.32842262
197	0.334128717	39.69367457	0.991050772	-0.008949228	\$74.38	-0.00478558	197	0.20800378	0.33311704
198	0.896667313	40.77362191	1.026843506	0.026843506	\$75.46	0.014414221	198	0.21713272	0.32421137
199	0.383922772	40.52269496	0.993826836	-0.006173164	\$75.21	-0.00333068	199	0.21120999	0.34388949
200	0.137155595	39.61434435	0.977329097	-0.022670903	\$74.30	-0.01215061	200	0.17082253	0.31335822
201	0.365302936	39.33027196	0.992803218	-0.007196782	\$74.02	-0.00383042	201	0.17250472	0.3228485
202	0.43683867	39.19953697	0.996670433	-0.003329567	\$73.89	-0.00176777	202	0.21682414	0.33927189
203	0.081383573	38.08456888	0.971144249	-0.028855751	\$72.77	-0.01520467	203	0.17020436	0.3160164
204	0.400904671	37.88509103	0.994748474	-0.005251526	\$72.58	-0.00274448	204	0.20089714	0.33148442
205	0.739799267	38.40284144	1.013573794	0.013573794	\$73.09	0.007108669	205	0.18593006	0.31006308
206	0.612196945	38.63385095	1.005997407	0.005997407	\$73.32	0.003155511	206	0.20439226	0.34234402
207	0.249706255	38.09414398	0.985931709	-0.014068291	\$72.78	-0.00738782	207	0.20197302	0.33147248
208	0.34361242	37.7751047	0.991589711	-0.008410289	\$72.47	-0.004393	208	0.1937857	0.31196664
209	0.817776097	38.50765056	1.019206658	0.019206658	\$73.20	0.010058193	209	0.23125663	0.36805139
210	0.783801981	39.15242355	1.016605388	0.016605388	\$73.84	0.008770087	210	0.17700537	0.30737315
211	0.3579349	38.85575084	0.992393768	-0.007066232	\$73.55	-0.00402574	211	0.19623563	0.33733868
212	0.61762401	39.10041698	1.006277039	0.006277039	\$73.79	0.003321199	212	0.16698477	0.30418198
213	0.343257405	38.77217171	0.991569634	-0.008430366	\$73.46	-0.00445827	213	0.19497316	0.3144893
214	0.053027047	37.50102419	0.966665479	-0.033334521	\$72.19	-0.01745488	214	0.18384705	0.32712449
215	0.507562754	37.51594374	1.000397765	0.000397765	\$72.21	0.000206466	215	0.18968653	0.32504178
216	0.678920501	37.88522596	1.009795316	0.009795316	\$72.58	0.005101313	216	0.21052605	0.36353402
217	0.3416762	37.5638236	0.991480123	-0.008519877	\$72.25	-0.00443843	217	0.18919468	0.30854162
218	0.850139785	38.39908619	1.021992213	0.021992213	\$73.09	0.011493809	218	0.2410095	0.37124214
219	0.850115201	39.25283276	1.021989952	0.021989952	\$73.94	0.011613208	219	0.18402137	0.313737007
220	0.403918264	39.05358261	0.994911002	-0.005088998	\$73.74	-0.00268829	220	0.19096514	0.3308153
221	0.124268715	38.1306964	0.976085021	-0.023914979	\$72.82	-0.01259377	221	0.18164265	0.31871191
222	0.017257317	36.51207163	0.956623298	-0.043376702	\$71.20	-0.02247829	222	0.19509374	0.32868856

223	0.683032408	36.88247056	1.010393222	0.010209222	571.57	0.005160653	223	0.192525304	0.333684646
224	0.605544839	37.08876343	1.005631893	0.005631893	571.78	0.002906092	224	0.20813171	0.35089616
225	0.939386273	38.33468335	1.030410066	0.033041006	573.02	0.017208554	225	0.19773698	0.327532434
226	0.713435977	38.79318954	1.011889647	0.011889647	573.48	0.006259154	226	0.19141353	0.34125447
227	0.725774372	39.28777383	1.012667509	0.012667509	573.98	0.006707413	227	0.19498925	0.34010581
228	0.798848195	39.99076329	1.017723794	0.017723794	574.68	0.009451765	228	0.22400642	0.3515082
229	0.0003374	37.33030916	0.931169568	-0.068830432	572.02	-0.03627679	229	0.17839668	0.30859693
230	0.326549252	36.98163759	0.990615933	-0.009384067	571.67	-0.00485305	230	0.20338071	0.32979968
231	0.379314299	36.74478722	0.993574863	-0.006425137	571.43	-0.003331013	231	0.20121692	0.33879168
232	0.28842407	36.31967272	0.988363171	-0.011636829	571.01	-0.00596886	232	0.18335913	0.32664582
233	0.863279116	37.17360236	1.023239933	0.023239933	571.86	0.011953807	233	0.2154337	0.333559177
234	0.848487456	37.98190677	1.021511013	0.021511013	572.67	0.011184972	234	0.22012492	0.31937303
235	0.616170484	38.21865732	1.006213899	0.006213899	572.91	0.003252505	235	0.21843472	0.34742068
236	0.340485545	37.89186447	0.991412623	-0.008587377	572.90	-0.0044923	236	0.17943049	0.31505477
237	0.656145826	38.21408456	1.008467722	0.008467722	572.90	0.004429577	237	0.20071722	0.34727906
238	0.405786441	38.02393264	0.995011614	-0.004988386	572.71	-0.00261166	238	0.20513579	0.35566456
239	0.667552906	38.37260183	1.009127943	0.009127943	573.06	0.004783621	239	0.18537047	0.33162967
240	0.738170533	38.89287076	1.013467252	0.013467252	573.58	0.007095632	240	0.18676794	0.30922706
241	0.994632365	41.09086151	1.054974786	0.054974786	575.78	0.02943351	241	0.20461348	0.32147946
242	0.933891646	42.4305598	1.032083104	0.032083104	577.12	0.017524135	242	0.19578746	0.31168541
243	0.077719216	41.20321467	0.970647427	-0.029352573	575.89	-0.01604263	243	0.16805727	0.32180341
244	0.616537445	41.461	1.006236947	0.006236947	576.15	0.003390929	244	0.18882219	0.33290102
245	0.803084159	42.21610614	1.018048584	0.018048584	576.91	0.009867066	245	0.17871112	0.32846056
246	0.015319345	40.38538063	0.955666004	-0.044333956	575.08	-0.02409259	246	0.21794125	0.33743026
247	0.458634334	40.29757287	0.997823387	-0.002176613	574.99	-0.00117028	247	0.16419619	0.3048035
248	0.349638959	39.97365671	0.991929414	-0.008070586	574.66	-0.00432895	248	0.20853498	0.35449766
249	0.616428217	40.2235065	1.006230909	0.006230909	574.91	0.003340751	249	0.18770601	0.32054573
250	0.274257527	39.71910972	0.987380862	-0.012619138	574.41	-0.00675582	250	0.19499586	0.31537164
251	0.43728638	39.58802279	0.996694193	0.0033305807	574.28	-0.00176326	251	0.21352773	0.35146559
252	0.5231485	39.63629461	1.001218611	0.001218611	574.33	0.000649669	252	0.24194046	0.34188496
253	0.925620633	40.87415572	1.030752745	0.030752745	575.36	0.016517253	253	0.21382774	0.32109096
254	0.312132405	40.45845789	0.989777743	-0.010222257	575.15	-0.00551644	254	0.18570987	0.32159947
255	0.543106106	40.5505488	1.002273598	0.002273598	575.24	0.001224703	255	0.21693251	0.34605885
256	0.730234267	41.07921799	1.012953034	0.012953034	575.77	0.007001817	256	0.20817909	0.32979413
257	0.844271311	41.97027585	1.021459301	0.021459301	576.66	0.011691543	257	0.20080038	0.34620986
258	0.804036526	42.73776286	1.018121256	0.018121256	577.43	0.009961751	258	0.20465174	0.33919212
259	0.672371649	43.1418078	1.00940964	0.00940964	577.83	0.0095204779	259	0.17818945	0.33646338
260	0.033083307	41.54116424	0.9621923	-0.0378077	576.23	-0.02077983	260	0.20499755	0.32403991
261	0.733524003	40.91694337	0.984859395	-0.015140605	575.61	-0.00822224	261	0.18641134	0.31969209
262	0.148841605	40.04425813	0.978391109	-0.021608891	574.73	-0.01163629	262	0.17965473	0.33940365
263	0.585538591	40.22458693	1.004543074	0.004543074	574.91	0.002436789	263	0.19188041	0.32025113
264	0.704540457	40.68329146	1.011339055	0.011339055	575.37	0.006104364	264	0.19117535	0.32342606
265	0.377071931	40.41776533	0.993451945	-0.006548055	575.11	-0.00352903	265	0.16695562	0.31965174
266	0.147193554	39.54796763	0.978244755	-0.021755245	574.24	-0.01164831	266	0.18797411	0.33852948
267	0.090619483	38.46922453	0.972344379	-0.027655621	573.16	-0.01463742	267	0.17602817	0.3217311
268	0.223868932	37.86620834	0.984200555	-0.015799445	572.56	-0.00827667	268	0.20111706	0.33463516
269	0.093635317	36.8471436	0.972718988	-0.027281012	571.54	-0.01414474	269	0.17537999	0.31875616
270	0.224824199	36.27059327	0.984229209	0.0015770791	570.96	-0.00809211	270	0.18377365	0.32436082
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