Constellation
An Exelon Company

America's energy choice®

Evaluating Power Purchasing Strategies for Your Business

How Power Purchasing Strategies Perform Across Varying Market Conditions

A Constellation Whitepaper—August 2018

Principal Author: Richard Spilky

When and how to buy power for your energy needs is a common question for energy buyers. There are a host of considerations that play into the purchase decision: weather, economy, market prices, your appetite for risk, and time you wish to allocate to the process. The following whitepaper evaluates 73 different power purchasing approaches and how they can help you manage both volatility (risk) and power supply costs (price) over time.

The Benefits of a Blended Strategy

A key benefit for customers in states that support retail competition among suppliers is choice. Commercial, industrial and government energy users in competitive states[1] have a variety of choices in how they structure their power procurement. Energy buyers can select retail supply contracts that range from monthly to multiyear agreements and come in an array of structures to meet their unique needs.

However, businesses that are fortunate to have a choice of supplier are also faced with challenging questions they must answer to create an effective energy management strategy:

- When is the best time to buy?
- How will market fluctuations impact my business' budget?
- Are certain months more important to manage than others to achieve a more stable price?
- What percentage of my business' power supply should be secured with a fixed price and what percentage should 'float' at an index to take advantage of potentially lower costs?

These questions can all be summarized by asking **"Which power purchasing strategy is right for my business?"**

While not all energy purchasing needs are created equal, neither are power purchasing strategies. The research detailed in this paper has found that certain strategies perform much better compared to others, but only in specific market conditions. When the market conditions move from one market extreme to the other, the performance of the strategies also changes. Whether you're in a thriving economy with rising summer volatility or a recession facing polar vortex events, a combined strategy will help to mitigate your risk and manage your energy costs to the mean. Despite the changes in market conditions, one truth remains constant: **A blended strategy is the better way to purchase power for most businesses.**

Taking a New Approach

In 2013 Constellation released the first whitepaper evaluating purchasing strategies within the retail power space (A Study of Electricity Procurement Strategies, by John Domagalski, et. al). This paper builds upon what was written in 2013 by expanding the number of solutions, the number of timing variations and the number of years reviewed, and adding a few layering (or dollar-cost averaging) methods. Constellation believes that this information can be utilized to inform an energy buyer's purchasing strategy. By focusing on the components an energy buyer can control, companies can consider multiple energy purchasing strategies to find the one best suited for their needs and success.

Examination of the Purchasing Strategies

This paper is designed to provide an overview of the simulated outcomes of purchasing strategies over an extended period and draw insights from the results. The 13-year time frame from 2005 to 2017 is long enough to incorporate a steady period of rising and falling forward prices, significant and relatively flat locational marginal pricing (LMP) index volatility, as well as a major recession and the recovery, pre- and post-shale gas boom, a few weather events, and more. The 2005-2017 timeframe is subsequently broken down as:

- 2005-2010
- 2011-2017

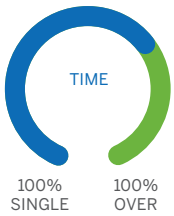
To get started, a load profile for a standard baseline customer was used as a representative load shape to simulate the expected price and volatility for different power strategies[2]. The variables considered are:

- Solution Types: This represents the months of the customer's load that were managed,
  - All months (for both on- and off-peak periods[3])
  - Only on-peak periods for all months[4]
  - Only summer months (June – September) for both the on- and off-peak periods
  - Only winter months (January – February) for both the on- and off-peak periods

- The percentage of the load that was managed—25%, 50% and 100% as applied to the different solution types above.
- The time at which the final purchase was made—i.e., two months prior to the first delivery month or twelve months prior to the first delivery month[5].
- The increments or 'layering' in which the load was purchased—i.e., the entire load purchased all at once, in twelve equal purchases, or in three equal purchases, all prior to the delivery month[6].

Table 1 summarizes the different solution parameters for the purchasing strategies in terms of price navigation and time navigation components. Using this process, there were a total of 73 strategies which were simulated over this 13-year period. The average $/MWh price for each purchasing strategy in each year was obtained and compared. Finally, the standard deviation was derived for each purchasing strategy to measure the budget risk a buyer might incur.

TABLE 1: PURCHASING STRATEGY COMPONENTS AS MEASURED IN THIS PAPER

	Solution Types (4)	• All months fixed • On-peak only fixed • Summer months fixed • Winter months fixed
	Percentage Fixed (3)	• 100% • 50% • 25%
	Timing of Purchase (2)	• Last purchase ending 2M before flow date • Last purchase ending 12M before flow date
	Frequency of Purchases (3)	• All-at-once • In three equal 1/3 increments • In twelve equal 1/12 increments
	Manual or Automatic Layering of Purchasing Percentages	• Manual or straight-line percent purchases • Purchasing percentages derived by MVPe algorithm

This paper primarily evaluates the price and time scenarios with a manual execution. There are additional navigation options such as automation that are not discussed in this paper. The options in this chart led us to 73 power purchasing strategies.

The Gap Between High and Low Price for Power Purchasing Strategies

How did these 73 power purchasing strategies compare over this 13-year time period? Figure 1 on the following page shows the annual average prices (red line graph) of all the strategies and overlays the range of lowest- to highest-priced strategies in each year (blue bars). This shows us that the average price outcome over the period was $53.44/MWh, while the highest price strategy in each year averaged $67.83/MWh. Meanwhile, the lowest price strategy over the same period averaged $45.36/MWh. **Therefore, the overall average price variance between the highest- and the lowest-performing purchasing strategies compared to the average was over 41%.** As you can see, the right power purchasing strategy makes a big difference. See Table 2 for a summary of these key outcomes.

Annual Comparative Price Performance of the Purchasing Strategies

There is a large gap between the highest- and lowest-priced purchasing strategies averaging over $22/MWh for all 13 years. But how do these purchasing strategies stack up against each other?

To begin evaluating how these purchasing strategies rank versus one another on a year-by-year basis, let's look at Figures 2A and 2B on the following page. Figure 2A illustrates the annual ranking of nine sample purchasing strategies from a high to low price over the 13-year period. Meanwhile, Figure 2B shows the average price and risk (volatility) performance of these same nine sample purchasing strategies over the period. These strategies were selected as examples to illustrate the differences in price performance between specific solutions from year-to-year.

TABLE 2: SUMMARY OF PURCHASING STRATEGY OUTCOMES SHOWN IN FIGURE 1

13-Year Average	Average Cost ($/MWh)	$/MWh from Average	% from Average
Highest Priced Strategy	67.83	14.39	26.9%
Average Purchase Strategy	53.44		
Lowest Priced Strategy	45.36	-8.08	-15.1%

FIGURE 1: ANNUAL AVERAGE, HIGH, LOW RANGE IN PRICES OF THE 73 PURCHASING STRATEGIES BY YEAR

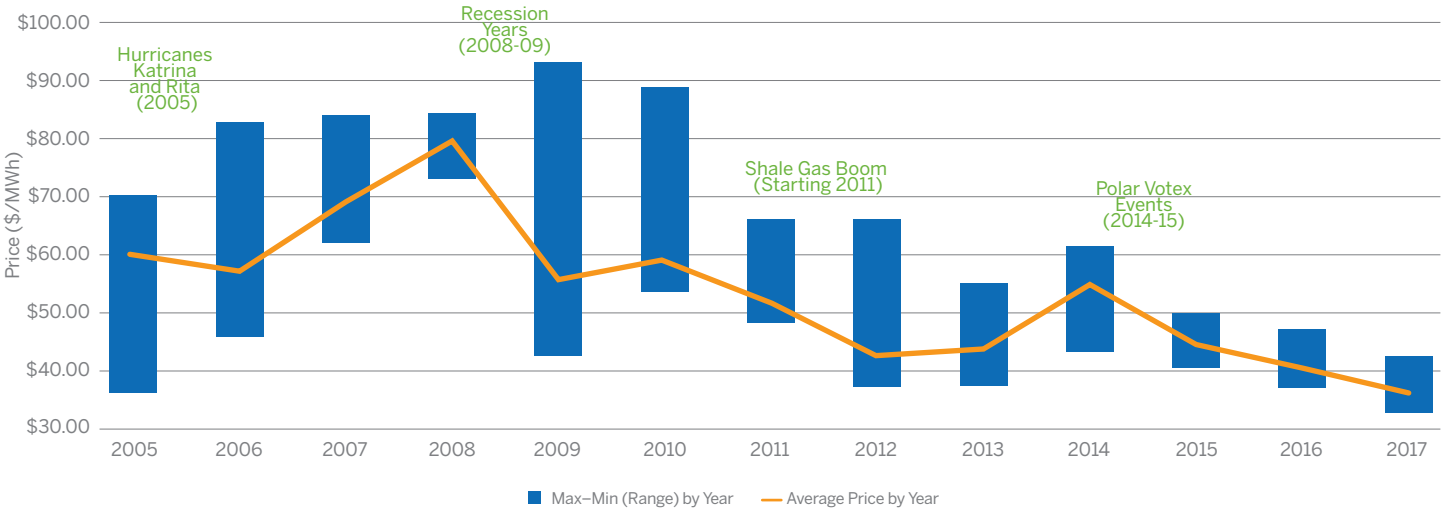
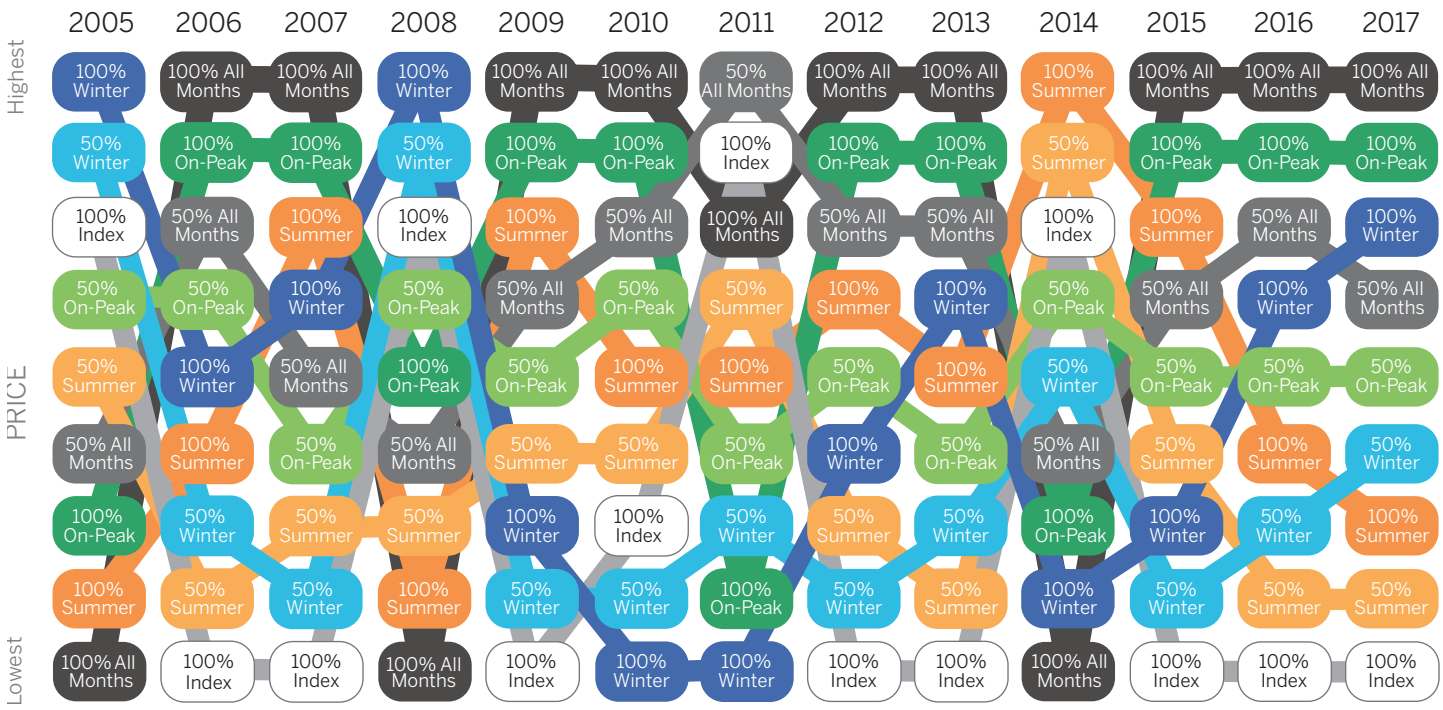


FIGURE 2A: PRICE COMPARISON OF 9 SAMPLE STRATEGIES EMPHASIZING PRICE NAVIGATION



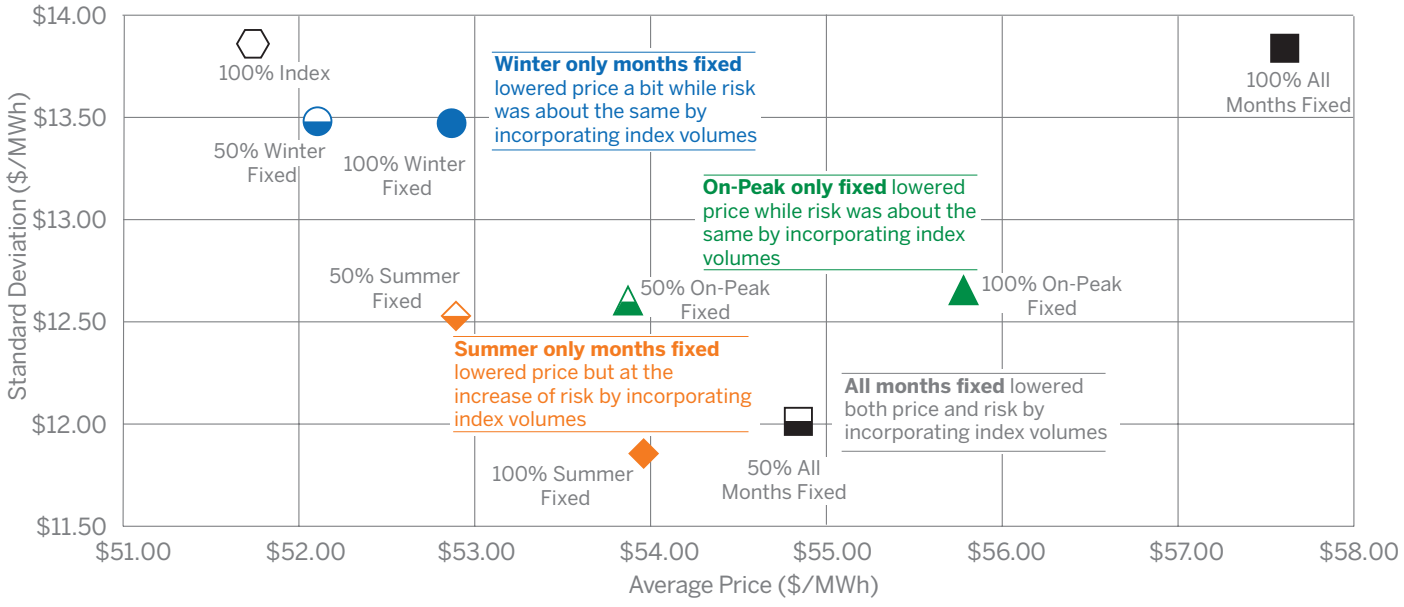
KEY FOR FIGURE 2B

		Price Navigation		Time Navigation	
Name	Symbol	Solution Type	Percent Fixed	Timing of Last Purchase	Frequency of Purchases
100% All Months Fixed	■	All Months Fixed	100	2m	All-at-Once
50% All Months Fixed	▬	All Months Fixed	50	2m	All-at-Once
100% On-Peak Fixed	▲	On-Peak Only Fixed	100	2m	All-at-Once
50% On-Peak Fixed	△	On-Peak Only Fixed	50	2m	All-at-Once
100% Summer Fixed	◆	Summer Months Fixed	100	2m	All-at-Once
50% Summer Fixed	◇	Summer Months Fixed	50	2m	All-at-Once
100% Winter Fixed	●	Winter Months Fixed	100	2m	All-at-Once
50% Winter Fixed	◒	Winter Months Fixed	50	2m	All-at-Once
100% Index	⬡	100% Index	0	N/A	N/A

Figure 2A indicates that the purchasing strategy with all months purchased, all at once, two months before contract flow date ■ was usually the highest-priced. Not surprisingly, this "all months purchased all at once" approach has high volatility and risk associated with it. Meanwhile, the purchasing strategy with on-peak period purchased all at once, two months before contract flow date ▲ came in as the second highest-priced strategy in nine of the 13 years. Purchasing strategies for summer-only ◆ and winter-only ● purchased respectively all at once, two months before contract date were both generally found in the middle during most of the 13-year period. Purchasing strategies with 50% purchased at index of the same respective strategies usually performed better than their fully-purchased counterparts, likely due to the higher percentage of index-based pricing in the mix. **The bottom line is that no single strategy consistently produced the lowest price over the 13-year period.**

Figure 2B shows that all four solution types (All months fixed, Summer only months fixed, Winter only months fixed and On-peak periods only fixed each benefited (price-wise) by incorporating 50% index into the mix (shown by the corresponding shapes that half-filled in the Figure). Only the summer-months fixed solution went up in risk by doing so. In fact, the All-months hedged solution actually went down in risk and price by incorporating 50% index into the mix.

FIGURE 2B: PRICE AND RISK COMPARISON OF NINE SAMPLE STRATEGIES EMPHASIZING PRICE NAVIGATION (PRODUCT AND PERCENTAGE)



A Tale of Two Time Periods: 13 Years of Dramatic Price Volatility

The period of 2005-2017 covers a full range of different economic and market conditions. From an economic point of view, this period includes the end of a prosperous time in the mid-2000s, economic weakness and a recession in 2008-2009, followed by a steady recovery. From a power market perspective, this period included weather events, their aftermath, and most importantly, the shale gas boom. Therefore, our research can be broken into two distinct periods to review.

2005 to 2010: A Thriving Economy, Rising Prices and Summer LMP Volatility

The first period under examination is from 2005-2010, when the economy was growing and natural gas and forward power prices were rising for the first several years. This period was followed by a steep drop-off in prices caused by an economic recession in 2009-2010. Figure 1 indicates that the average purchasing strategy outcome went from about $59/MWh in 2005-2006 to a much higher price of over $80/MWh in 2008, and then dropped steeply to below $60/MWh in 2009-2010. Figure 8 in the appendix shows the average LMP prices in each season over this initial six-year period.

2011 to 2017: Economic Recovery, Shale Gas Boom, Polar Vortex Events and More

The shale gas boom had a profound effect on market fundamentals during this period, as did the two polar vortex events. Shale gas production increased sharply during this period causing the average purchasing strategy price outcomes to drop steadily to around $52/MWh in 2011, and continued their downward trajectory to around $36/MWh in 2017. The exception to this declining price trend was driven primarily by the polar vortex event in 2014 (see Figure 1). Other significant energy market changes that occurred during this period were a general decline in volatility overall with abrupt volatility in winter 2014-2015. Figure 8 in the Appendix shows the generally lower LMP prices in the second period compared to the first. In summary, inexpensive gas prices and new gas-fired generation put downward pressure on forward power prices and LMPs while forward prices against winter volatility began trading at a premium to reflect price volatility during cold winters. These changing market dynamics had a significant impact on the purchasing strategy outcomes.

Best (and Worst) Price and Risk Performers

2005 to 2010: A Thriving Economy, Rising Prices and Summer LMP Volatility

Table 3A shows us the three purchasing strategies with the lowest price and the lowest risk during 2005-2010. The summer-only managed strategies and 100% LMP index strategy are the lowest-priced. Both summer-only strategies utilized a layering strategy that ended 12 months before the flow date. These strategies succeeded during this period in large part because they purchased their power well in advance of rising market prices. The bottom half of Table 3A shows us that from a risk point of view, the summer-only strategies came out on top again. These purchasing strategies avoided much of the summer LMP index price risk that occurred during this period.

The differences between the three summer-only, lower-risk purchasing strategies from the lowest-priced group are:

- Those strategies in the risk group each managed all of their summer load (compared to just a percentage).
- Those strategies secured their final summer load only two months before the flow date.

The three highest-priced strategies during this period managed their entire load two months before the flow date and the strategies that managed their entire load also produced the most risk. Since the entire load was managed, these strategies did not benefit from having exposure to LMP index pricing.

Now let's turn our attention to the poorest-performing purchasing strategies from 2005-2010. The top half of Table 3B shows us the three highest prices were found in the purchasing strategies that fixed their entire load two months before the flow date. These purchasing strategies were affected by waiting until two months before the flow date in a forward market that was generally rising. Not to mention the fact that since all the load was fixed, these strategies did not benefit from having any exposure to LMP index pricing which was generally lower than forward prices during this period.

The bottom half of Table 3B shows that, once again, from a price volatility (risk) measurement point of view, the strategies that fixed their entire load produced the most risk. The only difference between the highest-priced group of purchasing strategies and the highest-volatility group (as shown in Table 3B) is that the highest-priced group each completed their hedging two

months before the flow date, while the highest-volatility group completed their last hedging purchase twelve months before the flow date. By way of comparison, the difference between the two month before flow date versus the 12 month before flow date purchasing strategies resulted in slightly better pricing outcomes for the 12 month before date group while incurring more volatility (risk) during this time frame.

TABLE 3A: BEST THREE PRICE AND RISK PERFORMERS (2005–2010)

	Price Navigation		Time Navigation	
	Solution Type	% Fixed	Timing of Last Purchase	Frequency of Purchases
Lowest Three Prices	Summer Only Fixed	25	12m	12 x 8.33%
	Summer Only Fixed	50	12m	12 x 8.33%
	100% Index	0	N/A	N/A
Lowest Three Risk (Volatility)	Summer Only Fixed	100	2m	All-at-Once
	Summer Only Fixed	100	2m	3 x 33.33%
	Summer Only Fixed	100	2m	12 x 8.33%

TABLE 3B: WORST THREE PRICE AND RISK PERFORMERS (2005–2010)

	Price Navigation		Time Navigation	
	Solution Type	% Fixed	Timing of Last Purchase	Frequency of Purchases
Highest Three Prices	All Months Fixed	100	2m	All-at-Once
	All Months Fixed	100	2m	3 x 33.33%
	All Months Fixed	100	2m	12 x 8.33%
Highest Three Risk (Volatility)	All Months Fixed	100	12m	All-at-Once
	All Months Fixed	100	12m	3 x 33.33%
	All Months Fixed	100	12m	12 x 8.33%

2011 to 2017: Economic Recovery, Shale Gas Boom, Polar Vortex Events and More

Table 4A shows the three lowest-price and lowest-risk strategies during 2011-2017. The winter-only managed strategies take up all three of the best price performance spots. Two of the three winter-only purchasing strategies yielding the lowest prices during this time period each managed all of their winter-only load (the third winter-only was 50%), and all three of these low-priced strategies utilized the all-at-once method. These lowest-price purchasing strategies succeeded in large part during this second time frame because they were benefiting from the lower LMP index prices that were occurring while largely avoiding the winter LMP index volatility.

From a risk point of view, the winter-only purchasing strategies outperformed again with an on-peak only strategy in this low volatility grouping. These purchasing strategies also avoided much of the winter LMP index risk that occurred during this period, and as a result exhibited low volatility measures. One difference that emerged was that the lowest-volatility grouping includes a winter only strategy that layers in its hedges in three steps.

On the opposite side, the top half of Table 4B shows the three highest prices that were found in the purchasing strategies that procured their entire load 12 months before the flow date. These purchasing strategies were affected in this period by buying their power too far ahead in a market with generally falling forward prices. These strategies also did not benefit from having any exposure to LMP index prices, which again tended to be significantly lower than forward prices.

The bottom half of Table 4B shows that from a price volatility (risk) measurement point of view, the strategies that either purchased only a portion of just their summer months during this period or were on 100% index incurred the most risk.

TABLE 4A: BEST THREE PRICE AND RISK PERFORMERS (2011-2017)

	Price Navigation		Time Navigation	
	Solution Type	% Fixed	Timing of Last Purchase	Frequency of Purchases
Lowest Three Prices	Winter Only Fixed	100	2m	All-at-Once
	Winter Only Fixed	100	12m	All-at-Once
	Winter Only Fixed	50	12m	All-at-Once
Lowest Three Risk (Volatility)	On-Peak Only Fixed	100	2m	All-at-Once
	Winter Only Fixed	100	2m	All-at-Once
	Winter Only Fixed	100	2m	3 x 33.33%

TABLE 4B: WORST THREE PRICE AND RISK PERFORMERS (2011-2017)

	Price Navigation		Time Navigation	
	Solution Type	% Fixed	Timing of Last Purchase	Frequency of Purchases
Highest Three Prices	All Months Fixed	100	12m	All-at-Once
	All Months Fixed	100	12m	3 x 33.33%
	All Months Fixed	100	12m	12 x 8.33%
Highest Three Risk (Volatility)	Summer Only Fixed	25	12m	3 x 33.33%
	Summer Only Fixed	25	12m	12 x 8.33%
	100% Indexed	0	N/A	N/A

Best Practices: Balancing Price and Risk

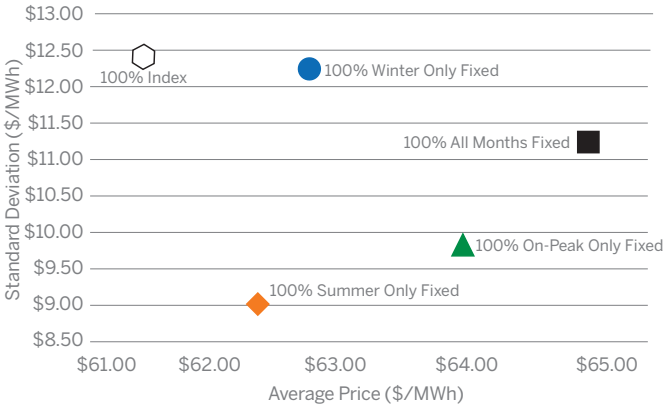
Looking back at Table 1, there are a variety of solution types, percentages of load, timing and frequency of purchases utilized in this study.

Solution Type: Price Versus Risk

When the power purchasing strategy outcomes are **grouped together to examine the differences between the solution types**, there are some consistencies and distinctions. Figure 4A shows the price versus standard deviation results for each of the purchasing strategies clustered by solution type—each of these outcomes is derived from the average of 18 separate purchasing strategy outcomes—for each solution-specific data point. For 2005-2010 we find that:

- The **100% index solution** exhibited the lowest price, but also possessed the highest risk.
- The **100% Winter Fixed solution** exhibits nearly the same amount of risk as the 100% index solution with a slightly higher price.
- The **100% All Months Fixed solution** exhibits the highest price outcome, with just a little less risk than the 100% LMP index and the winter-only solution types.
- The **100% Summer Fixed solution** offers both the lowest risk as well as nearly the lowest price. As was discussed, this is due to the dual benefits derived from avoiding high summer LMPs while benefiting from the low LMP prices in the non-summer months.

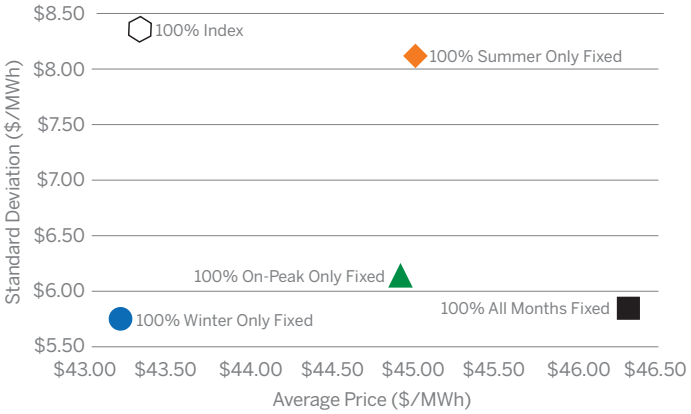
FIGURE 4A: PRICE AND STANDARD DEVIATION (RISK) BY SOLUTION (2005-2010)



Meanwhile, Figure 4B portrays the price versus standard deviation results for each of the purchasing strategies **grouped by solution type.** During 2011-2017 we find that:

- The **100% index solution** again exhibits the lowest price, but also possesses the highest risk just as it did during 2005-2010.
- The **100% Winter Fixed solution** exhibits both the lowest price and the lowest risk.
- The **100% All Months Fixed solution** again exhibits the highest price outcome as it did during 2005-2010, but this time has relatively lower risk than before and is nearly even (risk-wise) with the on-peak only and winter-only fixed solution types.
- The **100% Summer Fixed solution** demonstrates both the second-highest price and the second-highest risk. Purchasing in the summer months was not as beneficial during the 2011-2017 as it was in 2005-2010 since the LMP price volatility shifted to the winter months during the second period.

FIGURE 4B: PRICE AND STANDARD DEVIATION (RISK) BY SOLUTION (2011-2017)

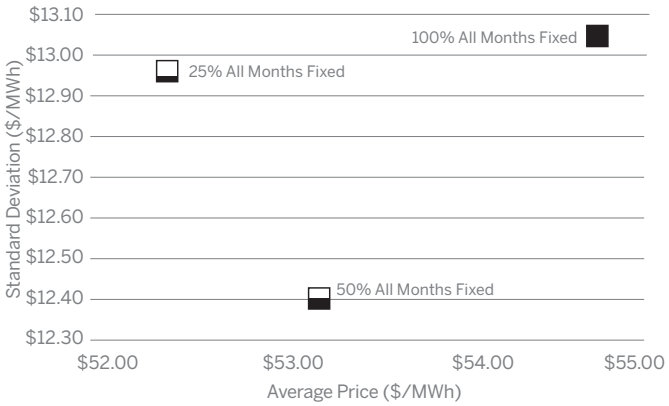


Percentage Purchased: Price Versus Risk

Figure 5 shows the price versus standard deviation results for each of the purchasing strategies **grouped by percentage purchased**—each of these outcomes is derived from the average of 24 separate purchasing strategy outcomes. During 2005-2017:

- The **100% All Months Fixed parameter** produces both the highest price and the highest risk.
- The **50% All Months Fixed parameter** produces both slightly lower price and risk. The lower price outcome is due to the exposure to the (generally) lower LMPs that the 100% load fixed solution does not have, while the lower risk feature is a welcome bonus.
- The **25% All Months Fixed** has the lowest price of these three, with just a bit less risk than the 100% load fixed, but more risk (lower price, somewhat closer to a 100% index solution) than the 50% load fixed parameter.

FIGURE 5: PRICE AND STANDARD DEVIATION (RISK) BY PERCENTAGE FIXED (2005-2017)

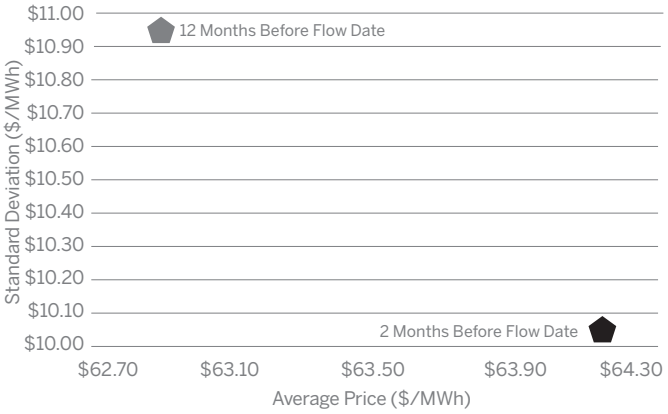


Last Purchase Made End Date: Price Versus Risk

When the purchasing strategy outcomes are grouped together with the purpose of examining the differences between the last purchase end date, we find very different outcomes across the two periods. Figure 6A shows the price versus standard deviation (risk) results for each of the purchasing strategies clustered by last purchase end date based on the average of each of the purchasing strategies using that respective method—there are 36 separate purchasing strategy outcomes for each last purchase end date. During 2005-2010:

- Making the last purchase 12 months prior to the flow date produced a lower price outcome compared to making the last purchase two months before the flow date. This is not surprising since the forward curve was rising during this time period and consequently, buying earlier rather than later was generally a good idea.
- Making the last purchase 12 months prior to the flow date also produced more risk than making the last purchase two months before the flow date. This is also not surprising since forward curves a year or more before the flow date can be more volatile than those closer to the flow date.

FIGURE 6A: PRICE AND STANDARD DEVIATION BY LAST PURCHASE END DATE (2005-2010)



Meanwhile, Figure 6B portrays the price versus standard deviation results for each of the **purchasing strategies clustered by final purchase end date** for 2010-2017:

- Making the final purchase 12 months prior to the flow date produced a higher price outcome than making the last purchase two months before the flow date. This is not surprising since the forward curve was falling during this time period and subsequently, buying later rather than earlier was generally a good idea.
- However, making the final purchase 12 months prior to the flow date again produced more risk than by making the last purchase two months before the flow date. This is the same outcome as in the 2005-2010 period, and is again due to the volatility of forward curves a year or more before the flow date as compared to those closer to the flow date.

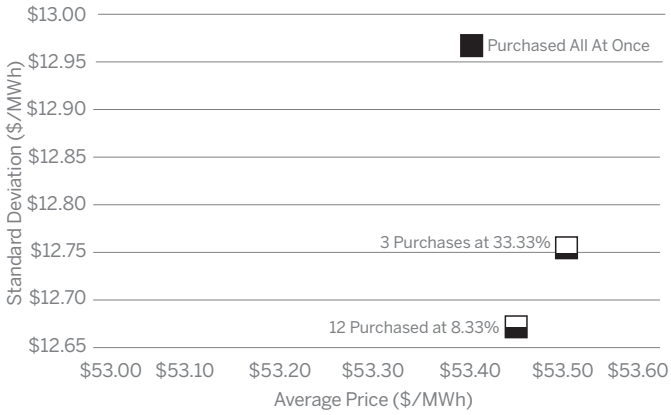
FIGURE 6B: PRICE AND STANDARD DEVIATION BY LAST PURCHASE END DATE (2011-2017)

Frequency of Purchases (Layering): Price Versus Risk

Figure 7 shows the price versus standard deviation results for each of the **purchasing strategies grouped by frequency of the purchases**—each of these outcomes is derived from the average of 24 separate purchasing strategy outcomes. Looking at 2005-2017, while all three hedging frequency methods resulted in nearly the same price, the more purchases (or layering) that occurred decreased the standard deviation (or risk) measure.

The principles of dollar-cost averaging, time diversification and asset allocation that are used in the finance industry are very similar to the outcomes illustrated here. Just like a dollar-cost averaging investment strategy—which allows purchasers to buy a fixed dollar amount of an investment on a regular schedule, regardless of the share price—an energy purchasing strategy can be similar. Rather than purchasing a company's energy requirements all at once, risk can be mitigated by utilizing an energy strategy that buys over time.

FIGURE 7: PRICE AND STANDARD DEVIATION (RISK) BY LAYERING STRATEGY (2005-2017)



Future Paths

The key takeaway from this study is how blended purchasing strategies have effectively reduced both budget risk and price over the last 13 years in dramatically different market conditions. Price navigation (solution and percentage), time navigation (timing and frequency) and execution navigation (manual or automated) settings can impact the performance of different purchasing strategies, and each can have a significant impact to a customer's realized energy costs.

About the Authors

Richard Spilky

Richard transitioned to Constellation in June 2015 through its merger with Integrys Energy Services, where he had served as a Product Development Manager and Senior Regulatory Analyst since 2011, and Director of Power Deal Management prior to that. Richard initially worked for Constellation in 2000 as the Director of Electric Pricing and Products for four years before moving to MidAmerican Energy as the Director of Electric Services. His retail energy career began in 1990, where he worked for ten years at Alliant Energy in various consulting, marketing and customer service roles. Richard has 30 years of experience in supporting business growth initiatives, both in regulated and competitive businesses across the U.S. His current role is primarily advising customers and channel partners on how to navigate complex policies and regulations against their energy needs and in a cost-effective manner. He also supports the company in advising state legislative bodies and regional regulatory commissions on how the political landscape affects customers and competitive retail energy markets at large.

Fadwa Dababneh

Fadwa Dababneh, who conducted many of the calculations that derived the results presented in this paper, is a Ph.D. student in the Department of Mechanical and Industrial Engineering at the University of Illinois at Chicago. She earned her B.S. and M.S. degrees in Industrial Engineering from the University of Illinois at Chicago in 2014 and 2016 respectively. Her research interests are in operations research, sustainable manufacturing and demand side energy management.

About Constellation

Constellation, an Exelon company, is a leading competitive supplier of power, natural gas, renewable energy and energy management products and services for homes and businesses across the continental U.S. We provide integrated energy solutions that help customers strategically buy, manage and use their energy. Our customers, including two-thirds of the Fortune 100, rely on our commitment to innovation, reliability, transparency and service. That is the kind of value you and your communities can expect from Constellation.

Endnotes

[1] The 14 competitive jurisdictions for purposes of this paper are those states (and Washington, D.C.) that enable full retail choice for all customers and in which the utilities for the most part do not own any generation assets (and in that way might be described as 'wires-only' delivery service utilities). Those 14 competitive jurisdictions are: CT, DC, DE, IL, MA, MD, ME, NH, NJ, NY, OH, PA, RI, and TX. Other states that allow limited retail choice are CA, OR, WA, MT, NV, AZ VA, and MI. These eight states are, for the most part, still vertically integrated. Customers in both groups can benefit from the concepts described in this paper, although only those limited customers enabled to choose their retail supplier can do so in the second group of states.

[2] A hypothetical 10,000 MWh per year customer exhibiting a monthly on- and off-peak load shape (Figure 9 in Appendix). This was derived using the average of a large sample of existing Constellation commercial and industrial customers. Each purchasing strategy's outcome was measured with respect to calendar years. Historical forward curves (for fixed power) and LMP prices (for indexed power) were obtained and incorporated into the calculations [both from the Baltimore Gas & Electric (BGE) PJM Interconnection LLC (PJM) zone]. The study did not examine non-supply components such as capacity, transmission or ancillary costs.

[3] The On-Peak definition used in the context of this paper is the NERC definition, namely, usage hour-ending 7:00 a.m.-10:00 p.m. Monday through Friday on non-holidays. Off-Peak periods are all other hours.

[4] Figure 7 in the Appendix clarifies by way of color coding the on- and off-peak percentages, the summer months and the winter months.

[5] See Figures 10A and 10B in the Appendix for illustrations showing the timing variable for the purchasing strategies

[6] Figures 11A and 11B in the Appendix illustrate layering strategies.

[7] In the Appendix, the "S.M.–N" nomenclature on the horizontal axis on these charts indicates the number of months prior to the first power flow month. For example: S.M.-12 means 12 months prior to the first flow month.

Appendix

FIGURE 8: LMP AVERAGES DURING THESE TIME PERIODS

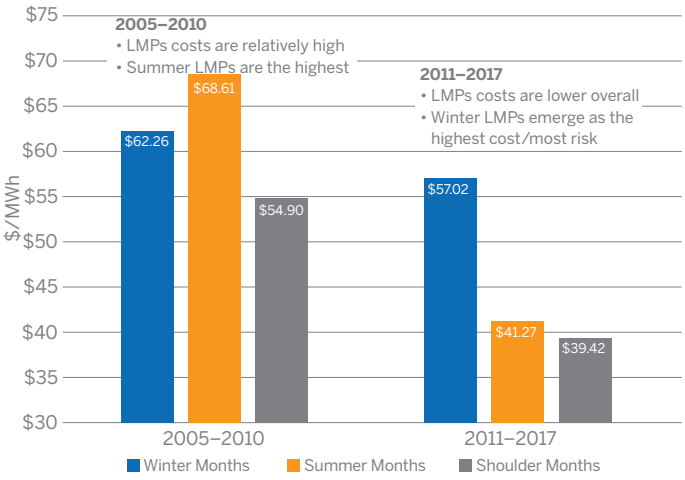


FIGURE 9: BASELINE CUSTOMER LOAD PROFILE BY MONTH

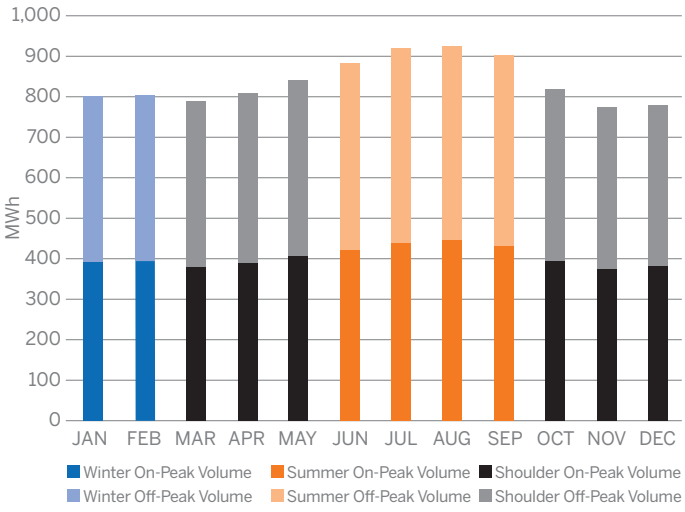


FIGURE 10A: PURCHASING 100% OF THE LOAD, ALL-AT-ONCE, 2M BEFORE FLOW DATE[3]

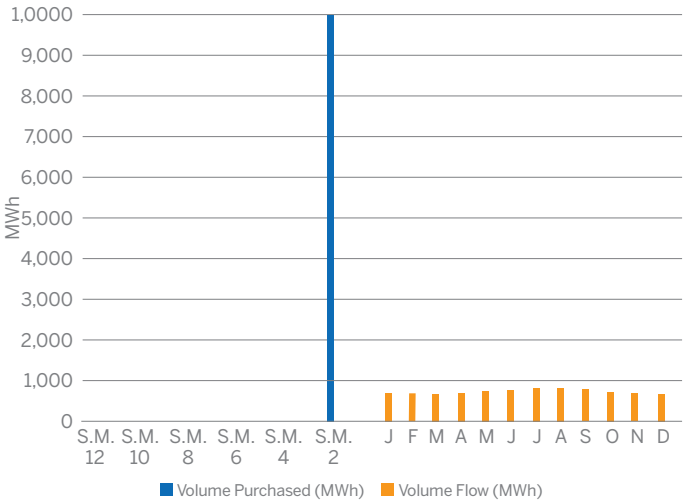


FIGURE 10B: PURCHASING 100% OF THE LOAD, ALL-AT-ONCE, 12M BEFORE FLOW DATE[3]

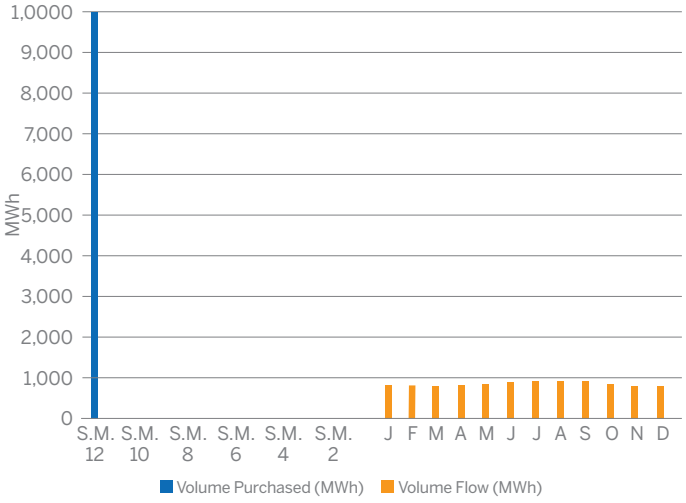


FIGURE 11A: PURCHASING 100% OF THE LOAD IN 1/3 INCREMENTS, ENDING 12M BEFORE FLOW DATE[3]

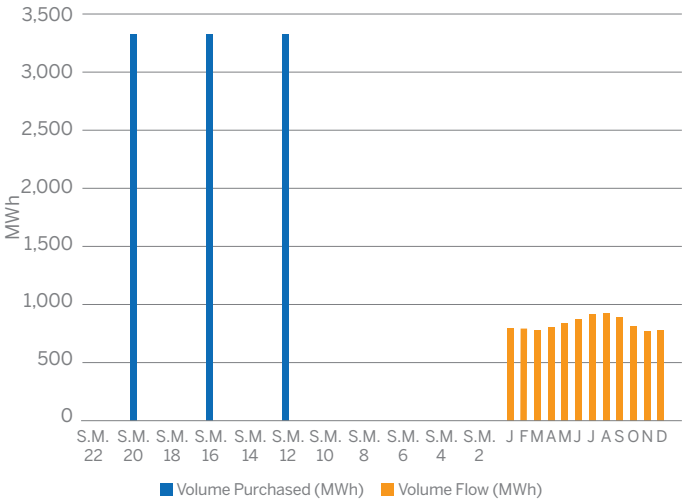


FIGURE 11B: PURCHASING 100% OF THE LOAD IN 1/12 INCREMENTS, ENDING 2M BEFORE FLOW DATE[3]

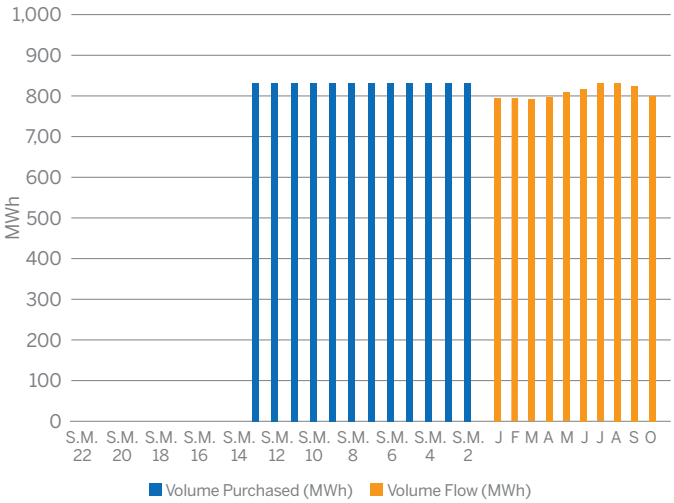


Figure 8 shows how the summer LMPs became much less expensive relative to the non-summer month LMPs that occurred during the second period. Meanwhile, Figure 8 also shows the volatility of the LMPs during the summer months in the first period and contrasts that by illustrating the steep LMP volatility that occurred during the winter months in the years 2014 and 2015 on the right hand side of this figure.

Examples

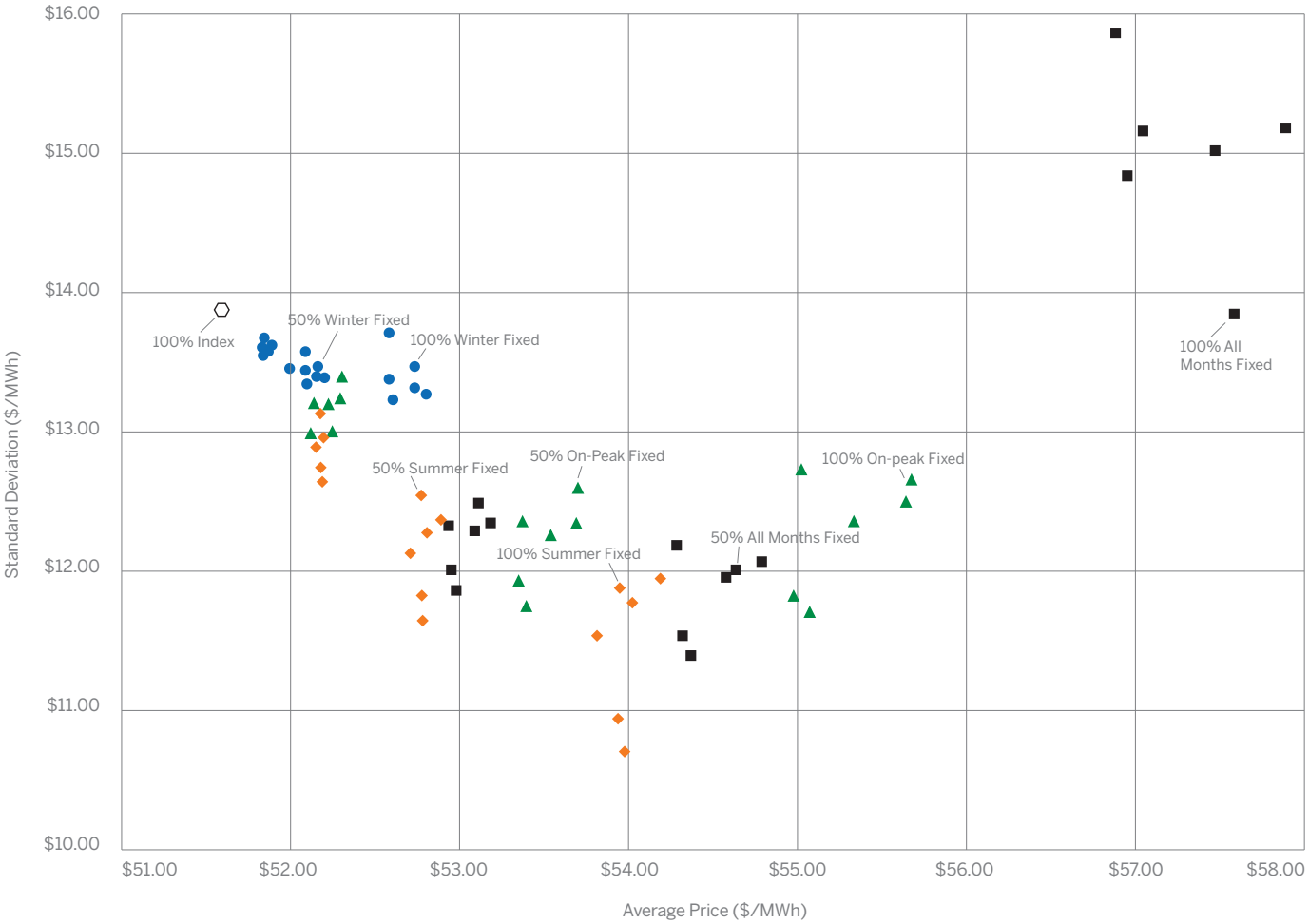
This first table illustrates the meanings of the solution abbreviations and shapes. For example, the first purchasing strategy listed in this table represents the 'all months fixed' solution and is abbreviated with the letter "A" in its name and utilizes a square as its symbol.

Abbr.	Product	Color and Shape	Ex.
A	All Months Fixed	Black Square	
OP	On-Peak Only Fixed	Green Triangle	
S	Summer Only Fixed	Orange Diamond	
W	Winter Only Fixed	Blue Circle	
X	100% Indexed	Hexagon	

Figure 12 shows all 73 purchasing strategies across the 13-year period with respect to their average price outcome and standard deviation. The nine solutions that are illustrated in Figures 2A and 2B are called out individually on Figure 12 to show their relative positions compared to the others. It is interesting to note several things about Figure 12:

- The 100% index solution does garner the lowest price position, but with that comes a significant amount of risk.
- The worst six performing strategies (highest prices and highest risk) in the upper right hand corner of Figure 12 are each the 'all months fixed' solution type.
- The summer-only and on-peak only blended strategies that contain a portion of index and a portion of fixed price tend to have both lower risk and better pricing outcomes.

FIGURE 12: PRICE V. STANDARD DEVIATION (2005–2017)



Notes

Notes

Constellation®

An Exelon Company

America's energy choice®