

Baby, It's Cold Outside: 2014 Polar Vortex Impacts on Residential Dynamic Electricity Pricing Programs

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ABSTRACT

During the winter of 2014, the Polar Vortex created extreme and sustained cold weather that greatly affected the electricity markets in the Midwest. For residential participants in market-based pricing programs, the extreme winter weather drove electricity prices to a record high of almost \$2 per kilowatt hour. These participants are typically accustomed to shifting electricity away from peak hours during summer months, but what happens when winter prices spike at unpredictable times and remain high throughout the cooler months? How does this affect participant behavior and retention, and what can administrators do to protect participants from high winter prices going forward?

This paper takes a deep dive into the impacts of the 2014 Polar Vortex by analyzing household type, hourly interval usage and billing data, and high price alert settings to determine what types of residential customers are able to reduce or shift load during high winter prices and what impacts this could have on the need for system voltage reduction. This paper highlights specific participant behaviors, including response to high prices over a long duration of time and at different times of the day. This paper also looks at seasonal and weather-related factors such as how price elasticity in the winter months compares with summer months, and whether there is any overall conservation effect from sustained high winter prices.

As extreme weather events occur with greater frequency, it is imperative to continuously evaluate and innovate to deliver the best program offering to participants. The 2014 Polar Vortex greatly affected participant enrollment discussions and ongoing education on the variability of market-based pricing, as well as the development of tools to support participants going forward. As such, this paper will also focus on the administrative changes made to accommodate future extreme weather events and dynamic pricing administration in the age of increasing climate volatility.

Background

In 2007, an Illinois law went into effect that required the states' two utilities, Commonwealth Edison (ComEd) and Ameren Illinois, to offer an hourly electricity pricing option to all residential customers. ComEd created the Residential Real-Time Pricing (RRTP) program (the Ameren Illinois program is Power Smart Pricing) which bills customers based on the PJM real-time hourly market prices. The law requires a third-party administrator to provide program support and marketing, which is currently being administered by Elevate Energy. ComEd RRTP participants pay a monthly participation fee (currently set at \$0.39) and are required by state law to remain on the program through 12 consecutive billing periods before returning to the ComEd fixed-price rate. There are currently 10,000 RRTP participants and the savings on the electricity supply portion of the bill has averaged 20 percent since the program began in 2007.

Because RRTP participants are subject to the PJM real-time hourly market prices, they take on a certain amount of risk that accompanies market rates. To help manage this risk, participants can opt to receive different types of price alerts via three different communication channels. The day-ahead price alert is based on day-ahead market prices and is sent when prices meet or exceed 14 cents per kilowatt hour (kWh). Participants can receive this alert via e-mail, text message or automated phone call. The

day-ahead price alerts include complete pricing information on the e-mail alerts only. The real-time price alert is based on the real-time market prices and is sent when the previous 30 minutes meet or exceed either 10 cents/kWh and/or 14 cents/kWh. Participants can receive these alerts via e-mail or text message. Since the exact price of the current hour is not known, these alerts do not contain detailed pricing information, but direct participants to tools that contain the current hour's real-time average price and the 5-minute prices. Once participants receive a real-time price alert, they will not be alerted for another four hours.

There is no cap on prices in the PJM real-time markets. Typically, market rates are highest during the times of 12 p.m. to 4 p.m. during the summer months (June, July, August, and September). The fall, winter, and spring months are typically the periods of the year when RRTP participants pay the lowest costs per kWh, as shown in the graph below.

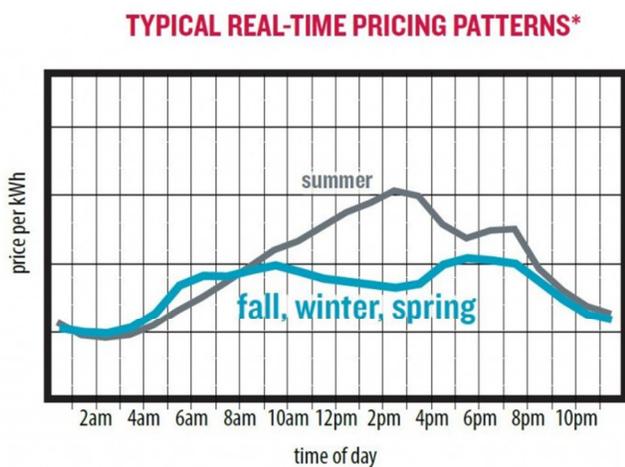


Figure 1. Average RRTP Hourly Prices

The weather effects of the Polar Vortex had a significant impact on prices in 2014. During January and February, the extreme cold weather throughout PJM territory pushed market rates to historically high levels; levels that were above the historically high summer prices. These high winter market prices were unprecedented for RRTP participants who are accustomed to shifting usage based on high summer afternoon prices, not on high winter prices.

Polar Vortex Impact on PJM Market Prices

To better understand how the recent extreme cold temperatures affected PJM market prices, Elevate Energy worked with Klos Energy Consulting, LLC on an impact study. From electricity demand to weather variables to energy prices, there is a notable difference between the 2013 winter and the Polar Vortex of 2014. Several findings of the impact study are summarized here.

First, the 2014 Polar Vortex was a challenge for much of the U.S. energy industry, especially the electricity and natural gas sectors. Grid operators saw increased uncertainty and stressed power supplies as the prolonged periods of cold temperatures drove up electricity demand. Locally, eight of the ten highest winter demands for electricity on the PJM system occurred in January 2014. On some days, even the lowest hours of demand were 10,000 megawatts (MW) higher than typical winter peak demands of recent years. For PJM, the highest ever winter peak demand of 141,846 MW occurred on January 7, 2014. Other factors, like wind chill temperature, also demonstrate the significant impact of the 2014

Polar Vortex. The Klos study suggests that the comparison of wind chill temperatures between the two winters confirms that the 2014 winter was indeed very cold compared to the previous year. Wind chill temperatures were nearly 10 degrees lower than the year before, and this is consistent across all hours of the day as detailed below in Figure 2. (Klos 2014)

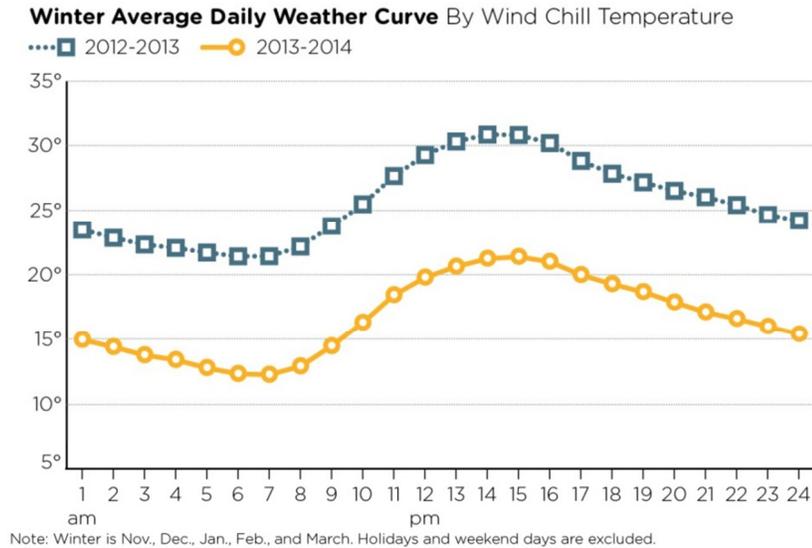


Figure 2. Wind Chill Temperature Comparison

Energy prices also increased during the winter of 2014. The Klos study finds there was a significant difference in electricity prices between the two winters. While average hourly prices ranged between 2.5 and 4 cents per kWh during the 2013 winter, Figure 3 shows the average prices ranged between 3 and 7 cents per kWh during the 2014 winter. The study also finds a noticeable increase in prices during certain times of the day. While prices were relatively flat throughout the day in winter 2013, prices nearly doubled during the peak morning (5 a.m. to 11 a.m.) and evening (4 p.m. to 8 p.m.) in winter 2014. (Klos 2014)

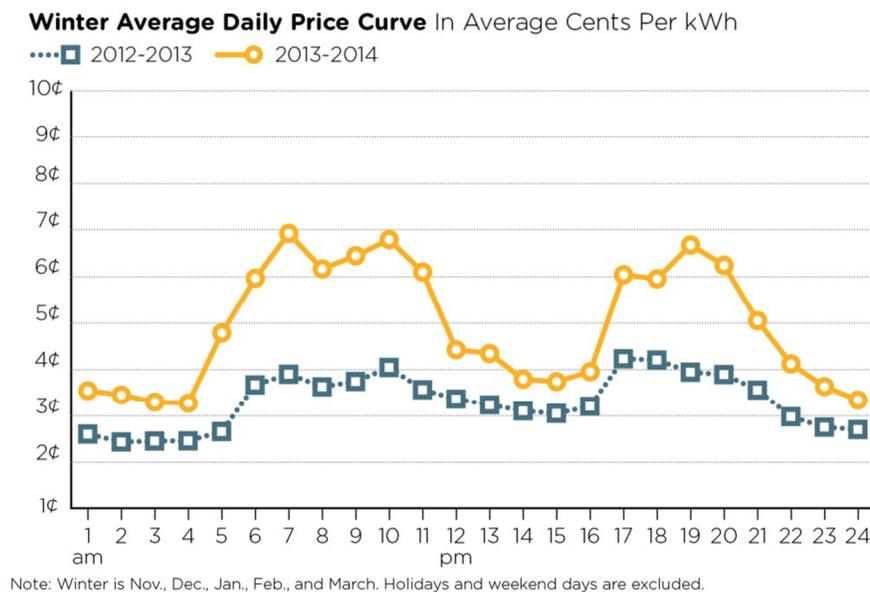


Figure 3. Winter RRTP Price Comparison

The Polar Vortex of 2014 also saw extreme price spikes on specific days. The highest price spike was \$1.81 per kWh between 7 a.m. to 8 a.m. on January 7, 2014. In fact, there were 33 hours spread over 11 different days in which the hourly price exceeded 30 cents per kWh. Thirteen of these high price hours occurred on January 7, 2014. On other days, the high price hours were most likely to occur between 5 a.m. to 7 a.m., between 9 a.m. to 10 a.m., or between 5p.m. to 7 p.m. (Klos 2014)

The frequency of day-ahead price alerts changed from winter 2013 to winter 2014. There were no day-ahead price alerts during the 2013 winter. That year, the real-time price exceeded 10 cents for a total of only fourteen hours, and the price was greater than 14 cents for only half of that time with a maximum price of 33 cents per kWh. Comparing this to January and February 2014, there were 14 day-ahead price alerts, 54 real-time alerts at 10 cents per kWh, and 30 real-time price alerts that reached or exceeded 14 cents per kWh.

Polar Vortex Impact on RRTP Program Savings

For the first time since the program launched in 2007, the 2014 Polar Vortex caused unusual market conditions that resulted in an average annual net loss for RRTP program participants, as compared to the ComEd fixed-price rate. This was primarily due to the high market prices during the first three months of the year. On average, participants paid 28 percent more in January 2014, 24 percent more in February 2014 and 15 percent more in March 2014, as compared to the ComEd fixed-price rate. These results do not take into account the reductions in electricity usage during this time, but analysis shows that the additional reductions in electricity usage did not offset the extremely high market prices during this period. Despite the higher average bills early in 2014, the RRTP program still provided savings opportunities for some participants across the entire year. Of the 10,847 distinct accounts that billed on RRTP during 2014, 4,101 accounts (38 percent) saved money on the program when considering total bill savings. The Klos study found that savings ranged from a minimum of \$0.01 to a maximum of \$2,498. From the perspective of percent savings, the minimum percentage saved was 0.01 percent, and the maximum was 26.8 percent.

Conversely, there were 6,746 accounts (62 percent) that paid more on their bills during the year of 2014. Losses ranged from a minimum of -\$0.03 to a maximum of -\$486. From the perspective of percent losses, the minimum percentage lost was 0.01 percent, while the maximum was 83.3 percent. In 2014, RRTP participants lost a combined \$34,612 on total bills compared to the ComEd fixed-price rate. During the same period, the average of individual participants' supply charge savings was -4.7 percent as compared to the ComEd fixed-price rate. Despite the negative savings for RRTP participants in 2014, the average savings on RRTP since the program began in 2007 is 19.4 percent (See Figure 4 below).

During the fall of 2014, RRTP participants were surveyed and asked about why they chose to remain on the program despite the extremely high winter prices. Of the 2,302 survey respondents (24% response rate), 67 percent decided to remain because they are still saving money overall, 14 percent still appreciate the environmental and community benefits, 8 percent stated "other" reasons, and six percent still enjoyed gaining access to their electricity usage data. Only five percent stated they would opt out once the 12-month commitment was fulfilled.

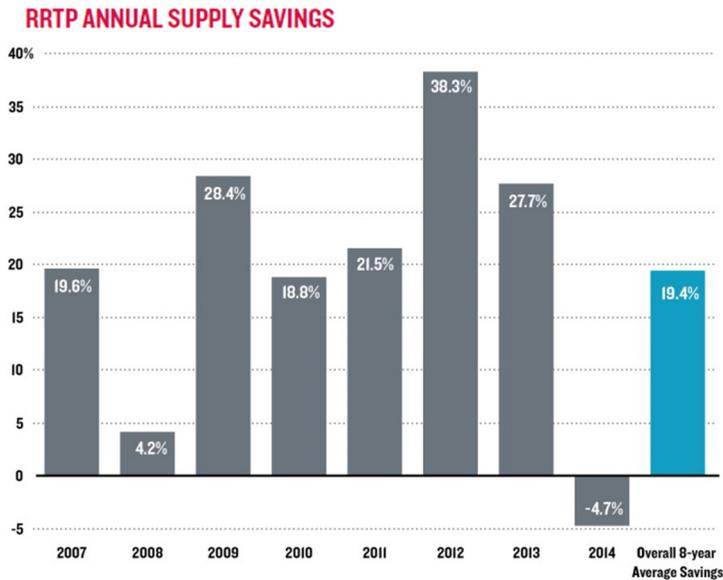


Figure 4. RRTP Annual Supply Savings

ComEd RRTP Participant Response to High Winter Prices

Since 2007, the RRTP participant response to high prices has been measured during the summer months. During the fall, winter, and spring, the prices of electricity have historically remained flat, and therefore, price response for participants was minimal during this time. However, for the first time in eight years, the price volatility during the 2014 winter was greater than in summer months due to impacts of the Polar Vortex. This provided a unique opportunity to determine how participants adjust their electricity consumption based on higher prices in the winter months.

During the summer, the air conditioner is the primary load source participants shift usage of based on high market prices. Participants are encouraged to “precool” their homes by lowering the temperature setting on the air conditioner during morning hours when prices tend to be low. This allows participants to increase the temperature setting during the afternoon hours when prices are often high, driving down the total cost of operating the air conditioner.

During the winter months, however, the majority of homes do not have a central appliance, such as an air conditioner, to shift usage of when market prices are high. As administrator of the RRTP program, Elevate Energy wanted to determine whether participants were able shift usage during high winter prices, and if those prices encouraged a larger conservation effect. Elevate Energy also wanted to compare the price elasticity in the summer versus the winter to determine if there was persistence in response to sustained high prices or if participants exhibited pricing fatigue.

Price Elasticity

Navigant Consulting conducted an evaluation of the RRTP program and analyzed the price elasticity for participants in both the medium-run and short-run during the summer months of 2007 to 2010. The medium-run price elasticity looked at price response to “average” hourly prices, while the short-run price elasticity looked at shifts in usage on an hour-to-hour basis. The evaluation determined that the medium-run price elasticity ranged from -0.05 to -0.15, meaning an increase in the average price in an hour by 10 percent reduces average consumption in the hour by 0.5 percent to 1.5 percent. (Navigant 2013)

The short-run price elasticities are influenced by the time of the price spike and the participants' awareness of high prices. Therefore, the analysis focused on hours when participants received a high price alert notifying them of higher prices, and categorized elasticity by time of day. Estimates of short-run price elasticities ranged from a low of -0.16 during the hours of 9 a.m. to 2 p.m. to a high of -0.31 during the hours of 3 p.m. to 4 p.m. So, an increase of 10 percent in hourly prices from 3 p.m. to 4 p.m. that results in a high price alert would result in a 3.1 percent reduction in electricity consumption. (Navigant 2013)

In an effort to compare the price elasticity exhibited in the summer months to the price elasticity exhibited during the winter, the Klos study analyzed participant usage during the winter of 2014. It was determined that there was no evidence of medium-run or short-run price elasticities, for RRTP participants, even during the days with the highest price spikes. This means that participants did not reduce load in direct response to the variation of prices on individual winter days. One potential explanation for this finding is due to the structure of real-time hourly market prices. Since the current hour's price is not known until after the hour has passed, RRTP participants are not provided specific pricing information in the high price alert. Therefore, it is not likely the majority of participants knew that the price on January 7, 2014 topped out at \$1.81 cents per kilowatt hour, until hours or days later. This caused a delay in the participants' response to these extremely high prices. It wasn't until after January 7 that participants reduced overall usage. In addition, for most households, there is not a large load source to shift during the winter months, therefore, there is less opportunity to immediately shift load in response to the real-time hourly prices. (Klos 2013)

Conservation Effect

The Navigant evaluation for program years 2007 to 2010 determined that RRTP participants reduced overall annual electricity usage by 4 percent. This conservation effect ranged from 2.4 percent to 5.0 percent throughout the year, with the summer months showing the greatest effect and the winter months exhibiting a reduction of 3.2 percent. However, the Navigant evaluation also showed that during the winter months, reduced usage in response to price "appears to diminish or even reverse in the winter", indicating that participants responded to lower winter prices by not conserving, and in some cases, increasing their usage. (Navigant 2013)

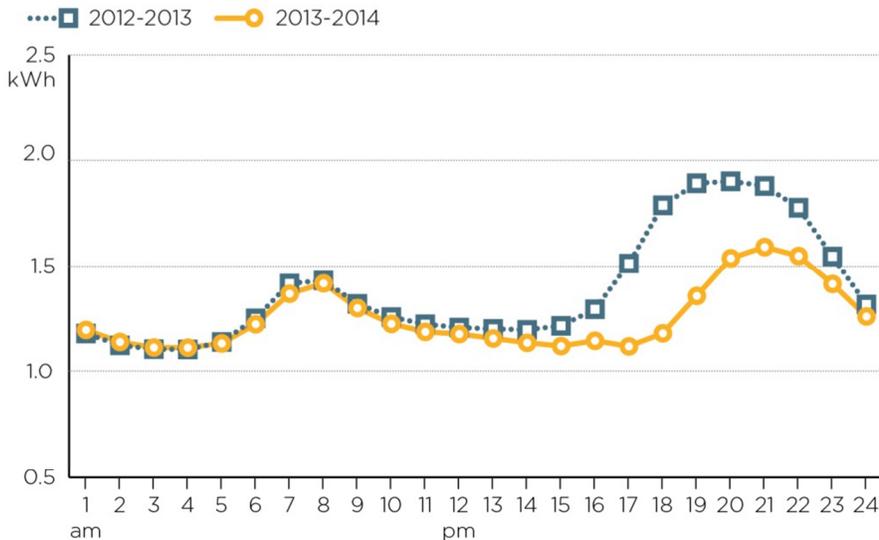
For comparison, the conservation effect during the 2014 winter was examined to determine if the higher winter prices encouraged additional reductions in electricity use. The study looked at the overall conservation effect for RRTP participants since they joined the program, for all dates ranging from 2008 to 2013. For a control group, the usage data for RRTP participants prior to joining RRTP was utilized for comparison.

The Klos study showed that RRTP participants did not reduce overall usage in the month of December and from January 1 to January 6, 2014. The winter prices leading up to January 7 remained low, which is consistent with previous winter prices, and there were no high price alerts in November and December 2013. But, on January 6 and 7, 2014, this pattern abruptly changed. The extreme cold weather on these days pushed the hourly prices on RRTP up to \$0.86 per kWh on January 6 and up to \$1.81 per kWh on January 7. Prices this high were unprecedented, not just in the winter months, but during all times of the year.

So, how did RRTP participants respond? They took cover. From January 8 to March 31, RRTP participants reduced overall usage, not just on the extremely cold days, but on all weekdays. This reduction in use was not in response to specific hourly price changes between January 8 and March 31, but rather in response to the extreme prices from January 7th and the potential for high prices in the future. There was no significant shifting of load during this time, just an overall reduction in use. Single family and multifamily households, without electric space heat, both showed an additional conservation

effect above and beyond the basic conservation effect of general program participation. Single family households observed an additional nine percent conservation effect (14 percent total) and multifamily households observed an additional seven percent conservation effect (11 percent total). During this time, there was no sign of pricing fatigue, where participant usage returns to levels prior to January 7th, due to the sustained high prices. Even as the high prices fluctuated sporadically throughout the winter, RRTP participants continued to conserve electricity above and beyond the pre-existing conservation effect from general program participation (See Figure 5 below). However, for electric space heat accounts, both single family and multifamily households did not exhibit a statistically significant change in their usage in response to the high winter prices that accompanied the Polar Vortex of 2014.

Customer Use On Modeled Normal Winter Day In Average Kwh Per Customer



Note: Winter is Nov., Dec., Jan., Feb., and March. Holidays and weekend days are excluded.

Figure 5. Participant Response Following January 7, 2014

In the 2014 fall survey, participants were asked about load shifting and reduction during the winter. Although there was no significant measured price response, 75 percent of participants surveyed reported running appliances during off-peak hours. To conserve electricity, 64 percent reduced the temperature setting on the thermostat, 59 percent turned off lights, and 17 percent invested in energy efficiency. Only 9 percent of survey respondents reported doing nothing to reduce or shift usage during the 2014 winter.

Potential Impact on Grid Operations

The Klos study determined that if there were 50,000 participants in the RRTP program, the total load reduction during winter peak load could top out at 37 megawatts, due to the additional energy conservation. The kW impact per participant ranged from -0.29 kW to -0.74 kW, depending on the hour of the day. However, in order to directly affect the real-time markets, the study highlighted a need to improve the alert system to drive immediate participant response. Elevate Energy is in the process of refining the RRTP high price alert options and communication to simplify and provide more specific pricing information during hours with extremely high prices.

The Impact of the Polar Vortex on the Call Center

Elevate Energy maintains a dedicated call center to assist potential and existing participants. During January and February 2014, there was a significant increase in calls due to the Polar Vortex. However, there was no discernible influence on the number of participants leaving the program.

While call volumes before the Polar Vortex weather averaged 15 calls per day, the volume spiked to 56 calls per day on January 7, the first full day of extreme high prices (see Figure 5). This volume moderated to about 20 calls per day over the next month, and then reached a new height of 92 calls on February 10. This increase in calls was caused by RRTP participants receiving their January bill, which was an average of 28 percent higher than the ComEd fixed-price rate. For the next month, daily calls stayed at this new, higher volume, reaching a peak of 119 calls on March 3. The number of live chats on the RRTP website also rose dramatically to a total of 90 unique chats during the week of January 7 2014. For comparison, no other *month* reached more than 80 chats during the entire year of 2014.

Outside of the quantitative results, the largest challenge for the call center was assuaging RRTP participants who were struggling to make a payment on extremely high bills. Once enrolled in RRTP, participants must remain on the program for 12 months, and there is no emergency fund set aside to help participants manage extreme pricing events. In addition, the majority of the customers who were impacted the greatest were those who heat their homes with electric heat. Many of these participants had recently enrolled in the program after they were informed of the historically strong savings for customers who heat their homes with electricity. From 2009 to 2013, the February savings for all RRTP participants ranged from 19 percent to 50 percent, with electric space heat customers at the higher end of the spectrum. However, in 2014, the average savings in February was *negative* 24 percent. These participants felt misinformed, and it was evident that a new communication approach around savings was necessary as the program continued to move forward.

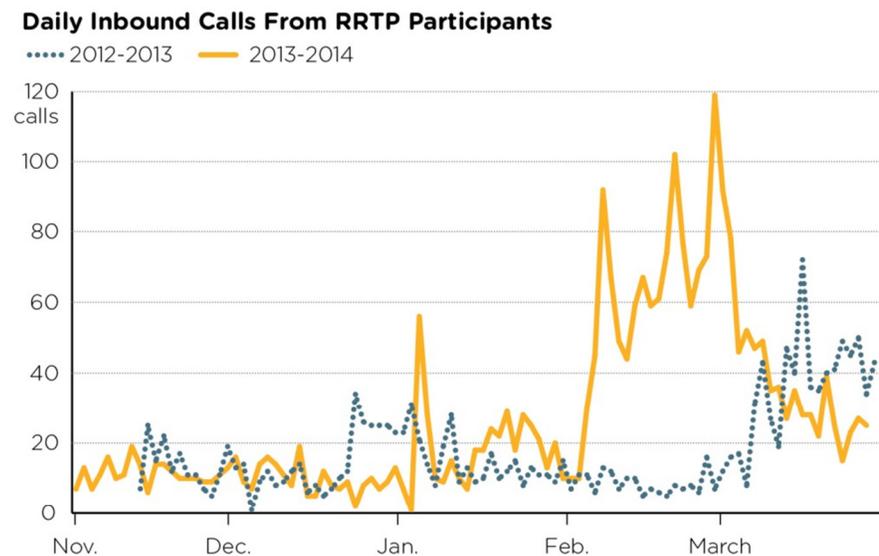


Figure 6. Daily Inbound Calls from RRTP Participants

Program Support and Marketing Improvements

Following the 2014 Polar Vortex and subsequent high winter prices, the ComEd Residential Real-Time Pricing program administrator, Elevate Energy, adjusted program communications for both non-participants and participants and improved overall program support.

Polar Vortex Communications

Emergency email communications were developed and sent to participants during the height of the extreme prices starting in January 2014. When prices remained high into February, Elevate Energy sent an update to participants that acknowledged concerns and shared tips to manage electricity costs. Over the remainder of the year, additional resources and infographics were developed to help participants understand the market effects of extreme cold on their program performance. These resources also serve as preparatory material in advance of future potential cold weather events.

Winter Readiness Communication

In preparation for the possibility of a reoccurrence of extreme weather impacts on hourly prices, Elevate Energy developed and sent a series of three targeted email communications to participants. The first email included general education on typical winter price patterns with a call to action to update high price alert settings. It also promoted the RRTP enhancement to the ComEd mobile app and reminded participants of the option to sign up for budget billing. Some general home energy efficiency tips were shared, as well as lessons learned from the Polar Vortex the previous winter. The first installment was emailed to participants in December 2014 and the subsequent installments were released in February and March of 2015.

RRTP Enhancement to the ComEd Mobile App

An RRTP enhancement to the ComEd mobile app was launched in May 2014 to provide participants with easier access to important program information. The exclusive RRTP section on the ComEd mobile app is only visible to program participants and allows them to check hourly prices and monthly bill comparison results. Participants can also track how their individual savings compare to other participants on the program.

My RRTP Account Update

In an effort to provide better clarity into the day-to-day costs for program participants and to leverage the smart meter platform, Elevate Energy redesigned the online participant portal. Participants with a My RRTP Account username were surveyed specifically on their current use of the tool and improvements they would like to see. A redesign of the tool began in 2014 and launched in April 2015. The My RRTP Account update includes a dashboard view for participants to better understand their program performance, Advanced Metering Infrastructure (AMI) data visualized for day-by-day electricity use information, and a single sign-on referral tool to make it easier for participants to take part in the referral program.

Live Chat

Live Chat was originally implemented on the RRTP website in November 2013 and proved to be a valuable communication channel, especially during the Polar Vortex. RRTP participants had questions around the abnormally high prices which were answered by live chat agents using content directly from the “Prices” page of the website. This was a quick and efficient way for participants to get answers and helped reduce call volume during a period of increased activity. In total, there were 783 live chats in 2014.

General Program Communications

As the program administrator for RRTP, Elevate Energy remains focused on ensuring that participants benefit from the program. During the enrollment process, the dedicated call center filters those customers who are not a good fit for the program, primarily due to low electricity usage or an inability to shift electricity use to off-peak hours. The primary goal of the call center is to help customers make an informed decision based on historical performance of the program and the customers’ own individual preferences. Following the events of the Polar Vortex, more attention is now spent discussing the potential for high prices during both the winter and summer months. Although the potential for savings is still the primary motivator for new participants, RRTP marketing materials and participant communications are increasingly highlighting the potential community and environmental benefits that derive from program participation.

A Snapshot of the 2015 Winter

In 2015, the weather in PJM and ComEd territories returned to historical norms. There was no significant Polar Vortex or other weather event that led to sustained low temperatures or high amounts of snowfall. Therefore, it was expected that the winter market prices for RRTP participants would return to pre-2014 levels. For the month of January 2015, this expectation held true: The average supply percent savings was 19 percent. For February 2015, however, colder weather drove higher prices and the average participant savings dipped down to -3.8 percent. Other than 2014, this was the only other year when RRTP participant savings in February were negative.

In January 2015, there were no day-ahead price alerts, 3 real-time alerts at 10 cents/kWh, and only one real-time price alert that reached or exceeded 14 cents per kWh. In February 2015, these numbers jumped to 3 day-ahead price alerts, 17 real-time alerts at 10 cents per kWh, and 10 real-time price alerts that reached or exceeded 14 cents per kWh. Although less than 2014, the number of price alerts during January and February 2015 was higher than previous winters.

Based on the electricity market prices during the winter of 2014 and 2015, it is possible that high electricity prices during the winter months may become more prevalent in future years. A variety of trends across the PJM market territory may influence the hourly market prices during winter, including a changing use of natural gas. As natural gas use continues to increase and is used as both a heating fuel and for electricity, there will be greater demand for natural gas which could drive up hourly electricity prices. Natural gas is also increasingly utilized for base load as coal plants throughout PJM are phased out. This could also drive up the demand and cost for natural gas. Lastly, natural gas is increasingly utilized during peak times, which could drive up the price of electricity during times of highest demand. In addition to the changing uses for natural gas, renewable energy, distributed generation, and electricity storage technology could also impact market prices in future years.

Conclusion

For seven years, participants in the ComEd Residential Real-Time Pricing (RRTP) program have shifted electricity use during peak summer hours to manage electricity costs. At the same time, these participants relied on low hourly market prices during the winter months to bolster their overall savings on the program. This all changed following the extreme and sustained cold weather delivered by the 2014 Polar Vortex. For the first time since the program began in 2007, the hourly market prices during the winter months were higher and more volatile than during the summer months. This provided a rare opportunity to determine the extent to which residential customers shift and/or reduce electricity load in response to high hourly prices in the winter, much like they are prepared and expected to do during summer months.

Based on data analysis conducted by Klos Energy Consulting, it was determined that following the winter peak price of \$1.81 per kilowatt hour on January 7, 2014, RRTP participants reduced overall electricity load during weekdays by an additional nine percent beyond the typical usage reductions due to participating in the program. This additional load reduction was not in response to specific hours on certain days, but rather across all weekday hours. Instead of shifting use, RRTP participants rather reduced usage during all hours of the day throughout the entire winter season. This reduction was similar in size to hourly load reductions on hot summer days and was sustained through the end of March 2014. This is an important finding as it highlights the impact that a residential hourly pricing program can have on customer behaviors, including desired behavior modifications that drive energy efficiency.

Although participants reduced overall electricity usage (and therefore costs) during winter 2014, most RRTP participants still saw higher bills as a result of the Polar Vortex. On average, for the first time in program history, the annual average of individual participants' supply charge was 4.7 percent higher during 2014. Despite overall average losses, 4,101 participants (38 percent) managed to save money during 2014. Regardless of the negative savings and extremely high winter prices, there was no discernible increase in the number of participants opting to leave the RRTP program. Based on participant survey responses, the majority of participants opted to stay on RRTP due to the overall average positive savings since initial enrollment.

As a result of the high 2014 winter prices, the RRTP program administrator, Elevate Energy, made changes to accommodate the likelihood of high winter prices in future years. The first ever "Winter Readiness" communications were sent to participants in 2015 to provide awareness of the potential of high winter prices and to educate participants on how best to avoid higher costs. General program communications were also updated to reflect the potential for high winter prices and to emphasize program benefits other than bill savings. Elevate Energy also launched a new smart phone app, updated the "My RRTP Account" online portal, and integrated Live Chat on the website to better support RRTP participants and provide quick and easy access to pricing information. In combination, these innovations and efforts help Elevate Energy focus on ensuring that participants benefit from the RRTP program, especially during upcoming potential cold weather events.

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