Applying Value at Risk Analysis towards Energy Efficiency Investments

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Abstract

Value at Risk (VaR) is a measure of risk for potential losses within a portfolio of investments. Investments in energy efficiency in a manufacturing environment compete in terms of payback period, ease of investment, and transaction costs with other investments (production, safety, engineering, etc.). Because manufacturers have limited amounts of capital to allocate, investments in productivity tend to be prioritized over energy efficiency projects that offer similar paybacks. Value at Risk (VaR) can be used to quantify how risk-weighted expenditures change over time. Energy efficiency investments are often believed to offer relatively stable payoffs compared to changes in production and other assets, particularly when evaluated using methodologies such as simple payback. Incorporating methodologies such as VaR can provide a stronger business case for energy efficiency investments by quantifying value beyond what is captured in other Return on Investment calculations.

In this paper we outline a methodology for applying VaR in the context of the variety of investments made by manufacturing organizations. Additionally, we profile the stability of energy efficiency (EE) and renewable energy (RE) investments compared to other types of investments made in manufacturing. By applying VaR to these investments, energy managers can better translate the financial benefits of energy-related capital projects in a way that is more compelling to Corporate Finance and Treasury departments. This common language also allows Corporate Finance and Treasury departments to support large, strategic deployments of capital for such projects based on a targeted objective – the management of financial risk for the organization's shareholders.

Introduction

Value at Risk ("VaR") is a measure of risk for potential losses within a given portfolio over a defined period of time. Historically, the metric has been used in financial circles to measure the collective risk of a portfolio comprised of various securities. The goal of the calculation is to measure the greatest potential loss under normal market circumstances at a specified confidence level. In other words, VaR seeks to determine the probability of a certain outcome happening (generally of financial losses). Typically, a probability of 5% is most often used, e.g. there is a 5% probability of losing a given amount of money over a specified time horizon.

Based on new technology advances and an increasingly competitive marketplace, the VaR methodology is gaining traction with corporations seeking to identify opportunities to improve cash flow from operations, optimize allocation of scarce capital and maximize profitability.

Within a manufacturing environment, capital investment decisions are generally centered on the simple payback, ease of investment, and transaction costs with other investments (production, safety, engineering, etc.).

As other suggestions for improvement, energy projects are often highly scrutinized by Finance and Treasury staffs as well as management, because manufacturers have limited amounts of capital to allocate. However, this decision-making process is often impacted by two key constraints. First, the interplay between supply procurement and capital projects can be difficult to quantify. This has become particularly acute as more corporations are pursuing renewable energy power purchase agreements ("PPA" or "VPPA"). Quantifying this interplay is critical to establishing the actual financial risk that companies have related to energy requirements. The second key constraint is based on methodology for how (i) cost and (ii) financial risk are each represented internally within an organization. Many capital projects have historically been evaluated based on a premise that electricity rates will either repeat themselves or will grow at an assumed escalation rate – often between 2% - 5%. However, based on all of the fundamental changes occurring in energy markets, technology advances and new products (e.g. renewable PPAs), that escalation rate is not an appropriate assumption for managing capital efficiently. By embracing these dynamics and translating the value of capital projects into a framework most often used by Finance and Treasury personnel, energy management professionals can improve the financial justification of energy efficiency projects and illustrate the true business case for such initiatives on a similar playing field as other strategic decisions that are made within their organization.

Value at Risk can be used to quantify the range of what an organization may spend on energy over the business planning cycle, and how this range may change over a specified period based on various scenarios of how electricity prices may evolve over time. By creating this financial profile for each facility, business unit and geography, organizations receive two strategic benefits. First, capital dollars can be directed toward specific locations that demonstrate high levels of unwanted financial volatility ("variability") or exposure ("extreme high"). Secondly, the value provided by the efficiency projects is centered on reducing financial risk for the organization rather than technical metrics (kWh reduction) or a simple payback based on a single-point forecast of near-term energy rates. This paradigm is being implemented by market leaders to achieve both financial targets as well as sustainability goals.

In this paper we outline a methodology for applying VaR in the context of energy efficiency and/or renewable energy investments made by manufacturing firms. Additionally, we profile the stability of such investments compared to investments in other facets of manufacturing operations.

Energy efficiency investments in manufacturing entail inherent risks: energy price risk, project risk, product price risk, etc. Effectively quantifying and comparing the risks of investments in industrial energy efficiency allows plant managers and owners to make investments that match their needs and fit within long-term plans. Several different methods of quantifying risk in manufacturing exist but comparisons to other kinds of investments are usually difficult. VaR models can be used effectively to quantify risks.

Investment decisions impact a variety of metrics governing firms' success including profit margin, average cost of production, and the firm shutdown condition. Firm shutdown occurs when price is lower than average variable costs. Investments in manufacturing typically widen the gap between price and average variable cost of production due to decreases in the average cost of production. In manufacturing, energy efficiency is analogous to investing in equipment with lower variable cost (utilizing fewer inputs to produce a unit of output) although it has a different risk profile than other investments.

Background

Risk management is a core component to investment decisions and has long been a core aspect of investments made in the financial industry. Value at risk models were initially created for use in comparing and evaluating the risk of a portfolio of financial assets (stocks, bonds, etc.) (Holton, 2004). Value at risk, at its core, is the likelihood of an asset falling in price by a certain margin over a specified period. This value is typically expressed as a chance or likelihood of a given event occurring (a number between 0 and 1).

Calculating VaR is generally done through various approaches: 1) historical data approach 2) variance-covariance approach (Hull, 1998 3) Monte Carlo approach and 4) other proprietary techniques developed in the private sector. The simplest of these approaches is the historical data approach, which utilizes historical price changes to calculate the likelihood of future price changes. The variance-covariance approach assumes that price changes are normally distributed around a mean. This method requires an estimate of two factors, an expected (or average) change and a standard deviation from that change. This enables the normal distribution to be plotted along a bell curve. The Monte Carlo approach involves developing a model for future price changes and performing multiple hypothetical simulations in the model. The intent of the Monte Carlo approach is to generate random, probabilistic results in which the outcomes differ. The approach is successful if the differences converge as the number of simulations increase. Each of these approaches have their own set of pros and cons depending on the context they are being applied to.

Energy supply and forward contracts are often evaluated utilizing price forecasting based, in part, on price history (Mehdi and Saeed, 2006). Value at risk was first applied to energy investment decisions after the Organization of the Petroleum Exporting Countries (OPEC) agreements in the 1970s as a means of dealing with sudden increases in petroleum price volatility (Mehdi and Saeed, 2006). In the context of manufacturers, due to the fundamental changes occurring in the energy markets (e.g. retirements of coal-fired power plants/boilers, energy storage, and renewable build-outs), market volatility in future years could deviate widely from actual historical data. One key example is with the California Independent System Operator (ISO or "CAISO"), where the magnitude of new solar capacity (as a result of regulatory incentives) has contributed to a collapse of on-peak pricing. Similarly, the magnitude of renewables being built in Texas (the ERCOT region) is creating significant impacts to how companies approach managing energy price volatility. When thinking about allocating capital, organizations are now asking how to risk-adjust the returns based on these types of market dynamics. Depending on the approach used to calculate VaR, the resulting insight can deviate widely, so thinking through the use case and the associated pros and cons of each approach is important prior to taking action.

One of the principal benefits of applying VaR models in investment decisions is the ease of communication. Because VaR is based on a probability distribution, the conversation is organized around recognizing that volatility exists and can be managed based on the audience's risk tolerance. This helps to paint a more robust picture of risk, reward and opportunity cost for any given decision. Once these parameters are defined, the process can easily be incorporated into existing workflows and investment decision-making models. (Mehdi and Saeed, 2006).

When making investment decisions, plant managers and owners can suffer from typical investor issues such as myopia, inability to assess avoided cost, and the irreversibility of energy efficiency investments (Jackson, 2010). Unlike most investments, energy efficiency serves to reduce risk inherently by reducing the volume of energy supply required to operate (Jackson, 2010), which serves as an added benefit to plant managers and owners.

Risk in energy efficiency investments falls into four primary areas:

1. Energy price risk
2. Project risk
3. Market risk
4. Weather Risk (depending on the technology of interest)

Energy price risk is the natural fluctuation of energy prices in the market. If energy prices fall, the payoff period for an investment in simple energy efficiency will be lengthened because energy cost savings will be lessened. Similarly, if energy prices rise, savings from an energy efficiency investment will be amplified. Understanding how a capital project's marginal efficiency compares to potential efficiencies (and inefficiencies in the market) are critical to making good decisions. This lowers plant exposure to potential energy market fluctuations, which can be driven by market factors ranging from commodity prices to weather events and technology changes, as well as political or other non-market forces such as decisions made by governments, regulators, or other groups (Mehdi and Saeed, 2006). A VaR approach can help decision makers understand the impacts of these risks on operations and investment decisions by quantifying the range of opportunity costs from doing nothing.

Figure 1: Example Market Factors

Project risk entails risks in the engineering of energy efficiency solutions and the compatibility of those solutions with existing manufacturing processes. When considering energy efficiency investments, it is necessary to consider the potential energy savings (Jackson, 2010). Calculating these savings is risky because engineering calculations can be inaccurate and behaviors of users can change in response to energy efficiency installations (Jackson, 2010).

Conversely, market risks occur outside of internal plant operations. As such, these forces are outside the control of plant decision-makers and typically affect the availability of manufacturing inputs or the demand of manufacturing outputs. For example, output quantity due to market fluctuations affects the potential payoff for an energy efficiency investment because plants typically dedicate a portion of energy consumption to baseload use and a portion to variable use. The amount of energy in a plant dedicated to variable use fluctuates with production patterns. If market conditions impose low demand for the plant's output immediately after an energy efficiency investment, savings will be lower than an alternative scenario where plant production had remained constant. Conversely, energy (and cost) savings would be higher if demand for a manufacturing output were suddenly increased after an energy efficiency investment.

Weather risk is a risk specific only to certain types of energy efficiency investments in the manufacturing setting. In settings where manufacturing inputs need to be dry or cooked, humidity and precipitation can affect energy use significantly. This especially affects variable use of energy because the processes are generally product/input-dependent and these processes (dryers, ovens, dehumidifiers, etc.) need to be run until the input/product meets a certain metric such as humidity, water content, etc.

Combined, these risks all affect the way Finance and Treasury teams in industrial firms consider financial planning, capital allocation processes and operational decision-making. The core goal for manufacturing is to stay profitable, and therefore operational. To do so, decision makers invest in assets and processes that either lower average variable costs of production or increase product price. The four risk components outlined above typically affect the average variable cost of production when applied in an energy efficiency context. The goal of an energy efficiency investment is to lower the average variable cost of production while keeping product quality constant. This is also the goal of investments in manufacturing processes or capital that will lower the average cost of production by producing a unit of output with fewer units of input. Quantifying these risks in a clear and concise way enables decision-makers to avoid failures described above by incorporating risk into investment decisions.

Implementing Portfolio Management and VaR metrics in Practice

The thrust of this paper is to look at utilizing energy risk concepts and metrics like VaR to show the impact that investments in energy efficiency (and other energy supply procurement programs) have on managing the cost volatility for large energy end users such as manufacturers.

Step #1: Quantify the probabilistic range of what energy expenditure could be over the next business planning cycle.

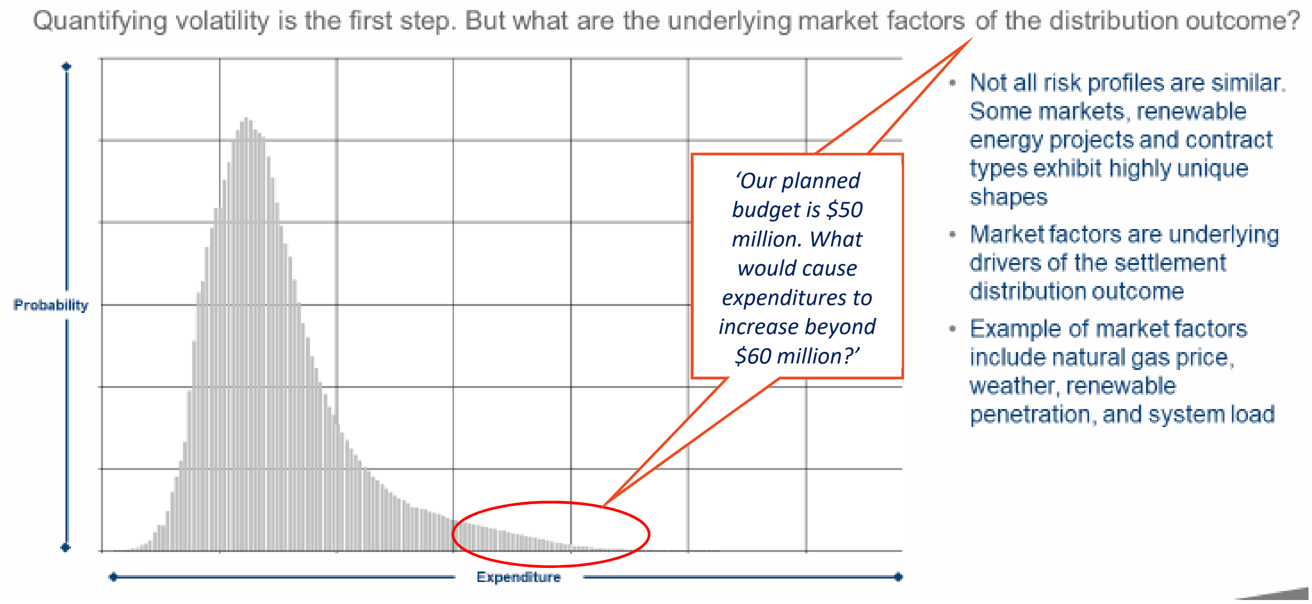


Figure 2: Quantifying Volatility

Table 1: Probability of Exceedance

Table 1 illustrates the existing financial exposure profile and associated probability of exceedance (represented by p1-p99), as measured by the cumulative expenditure over the coming business planning cycle. Specifically, we have quantified the probabilistic range of what energy expenditure could be over the next business planning cycle (years 1-5) for Company X and the likelihood of exceeding the planned budget due to exposure to market factors and associated risk. For example, Company X's 3-year budget has a 5% probability of being missed by at least $28 million. With an internal cost of capital of 10%, the cost of forgone earnings on that $28 million over the 3yr period is $9.3 million. This means the total impact to Company X is $37.3 million.

$USD	p1	p5	p25	p50	p75	p95	p99
1yr	$79M	$83M	$89M	$91M	$93M	$99M	$102M
3yr	$228M	$242M	$261M	$270M	$278M	$298M	$304M
5yr	$386M	$407M	$431M	$444M	$459M	$501M	$512M
10yr	$784M	$819M	$851M	$875M	$907M	$1.1b	$1.2b

Step #2: Understand the underlying drivers to the expenditure risk. Said differently, what are the things that are most impactful to costs increasing or decreasing over the planning cycle? This insight can be used to select the best sites and projects to mitigate the risk.

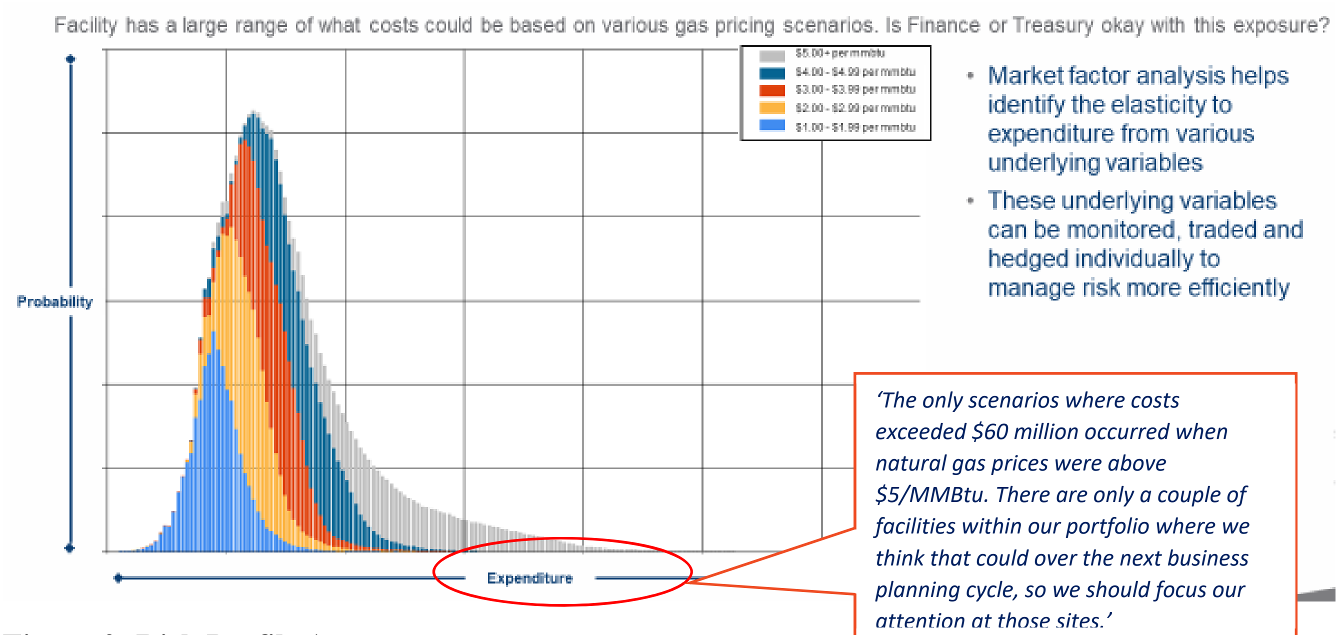
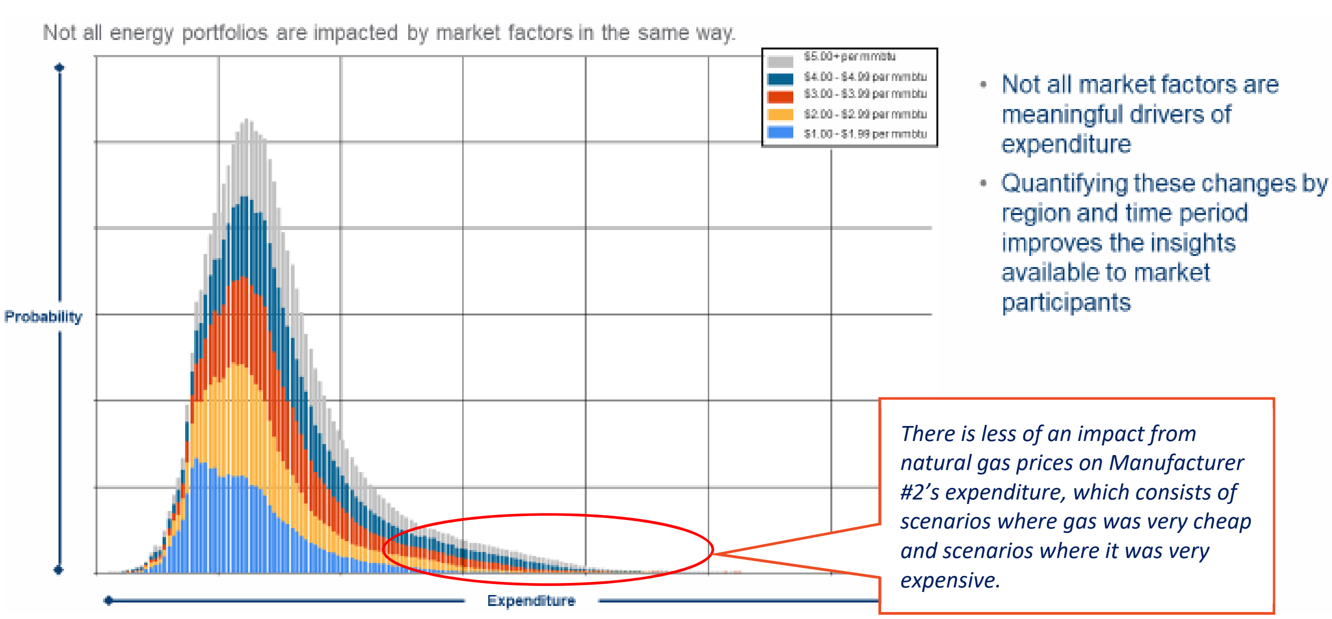


Figure 3: Risk Profile 1

As shown in below graph, depending on the facilities, regions and contracts in place, the portfolio risk profile will vary drastically between organizations, so the shape of the distribution will look drastically different. However, let's ignore that for the time being and assume a second manufacturer happens to have the same financial risk profile (same shape of their expenditure distribution). For this second manufacturer, there is less of an impact from natural gas prices on their expenditure, as seen by the right tail, which consists of scenarios where gas was very cheap and scenarios where it was very expensive. For this manufacturer, we would need to look at other underlying drivers to their costs to formulate an investment strategy.



Step #3: Prioritize opportunities by the metrics most important to success of the plant, business and overall organization. This can include (i) expenditure variability (ii) maximum exposure or (iii) carbon footprint.

Figure 4: Risk Profile 2

For manufacturer #1, we can then focus on the specific facilities that we believe are most exposed to natural gas prices (or other underlying factors we identify). By understanding how each facility compares to the other, we can be more specific with how we prioritize our capital deployment. In this example, Facility #2 demonstrates a relatively stable cost profile when compared to Facility #1. This means the efficiency projects can create more value for Facility #1 than Facility #2.

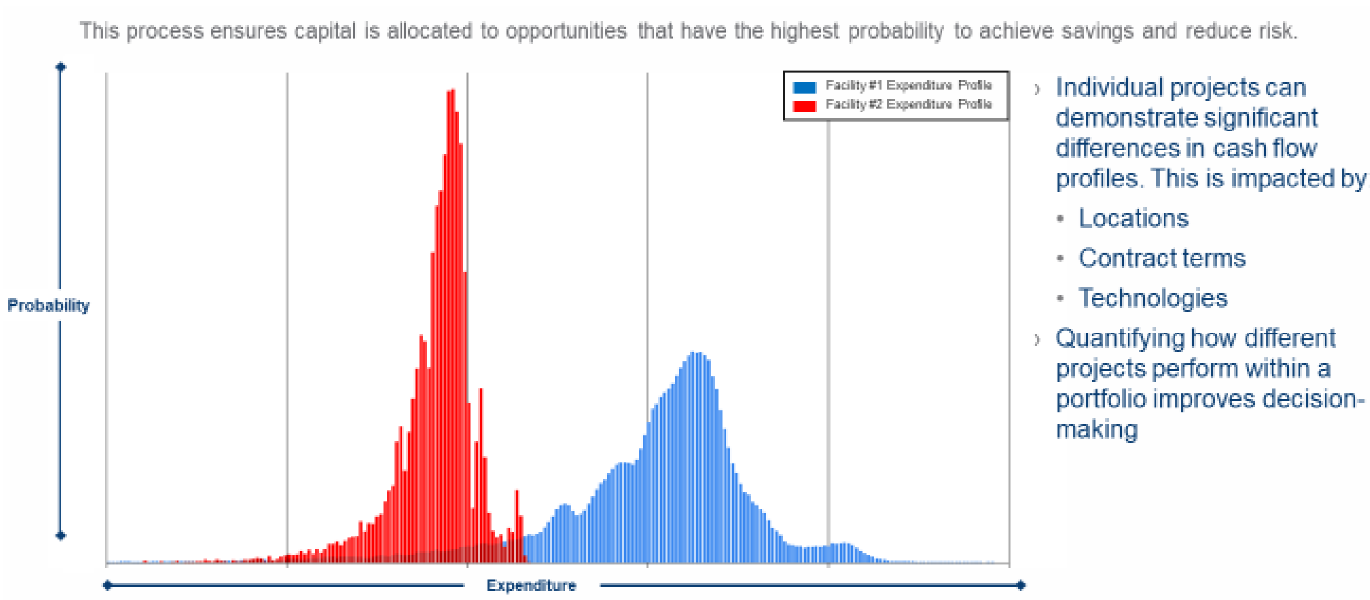


Figure 5: Proper Capital Allocation

Step #4: Based on the knowledge gained through the first three steps, and internal preferences for financial risk management and sustainability targets, allocate the optimal set of technologies in the highest impact regions. Edison refers to this as the optimized Energy Investment Playbook.

An action plan of changes to an organization’s portfolio based on the financial, environmental and operational goals of a company. The end result is a clear path to goal achievement with increased budget certainty and

Portfolio Design: Supply & Capital Programs

- Two (2) strategic adjustments to portfolio reduce likelihood of $2.2b exposure by 20% over 10 year period
- Increase annual capital budgeting from $15M to $25M for 2019 – 2021
- Execute large-scale renewable energy purchase in Illinois or Ohio by 4Q 2019; $25M in credit support

Supply Program	Capital Program	Sustainability Value	Risk Value
› Introduce 100MW of wind capacity › Increased allocation to index procurement during winter months	› Introduce 30MW capacity of combined heat & power (“CHP”) › Eligible facilities within AEP Dayton territory	› Increase to 40% renewable energy › Long-term procurement of RECs	› Reduce or remove $1.0b exposure by 2025 › Reduce or remove $1.0b exposure by 2030
Financial Analysis			
$133 million in capital expenditure	Sensitivity pro-formas	‘Simple-Savings’ of Programs ~$50M by 2030	‘Risk-weighted Savings’ of Portfolio ~$200M by 2030

Figure 6: Energy Investment Playbook Example 1: Portfolio Design

Strategic Value: Of the 9 potential markets for U.S. offsite procurement, PJM wind projects provide a number of unique values to Company’s existing portfolio. First, such projects typically produce most during winter months, when Company’s facilities in Illinois, New Jersey and Ohio have above-average electricity requirements to power heating systems at the facilities required to maintain operational performance.

KEY COMMERCIAL TERMS:

Products:	Power, RECs
Market:	PJM
Contract Type:	Financially-settled, fixed-for-floating contract for difference
Project Size:	100MW nameplate capacity
Volume:	Unit-Contingent
Settlement Indices:	Northern Illinois Hub, AEP Dayton Hub, Western Hub
Target PPA Price:	$22 - $25 per MWh (no escalation)
Guaranteed COD:	December 2019

Action: In order to obtain RECs, reduce carbon footprint and meet the 2025 corporate sustainability goal, the best renewable energy opportunity available for Company is to pursue an offsite power purchase agreement by Q4 2019 for approximately 350,000 MWh per year of volume5, equivalent to approximately 40% of total PJM load. As a financially settled instrument, Company is able to execute offsite power purchase agreements throughout the U.S. regardless of whether the project is sited in a market where PJM operates.

Figure 14

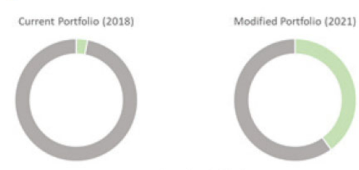


Figure 7: Energy Investment Playbook Example 2: Recommendation of Offshore Wind PPA

Due to existing incentives for wind energy projects it is common for development projects to sell fixed-price electricity for between 12 and 15 years at prices that are competitive with traditional power prices. Additionally, because winter pricing in PJM is subject to high levels of volatility, short-term traders and market-makers charge significant premiums for short-term strips of electricity to compensate them for the risk to cover their position. Because wind projects generally do not maintain open positions, the contract prices do not contain premiums. As a result, the project provides 90% of Company’ s corporate renewable energy commitment while also mitigating a key market risk in an economically efficient manner relative to current practices.

Case Study 1: Renewable Energy Project Analysis and Design Applying VaR Proprietary Technique

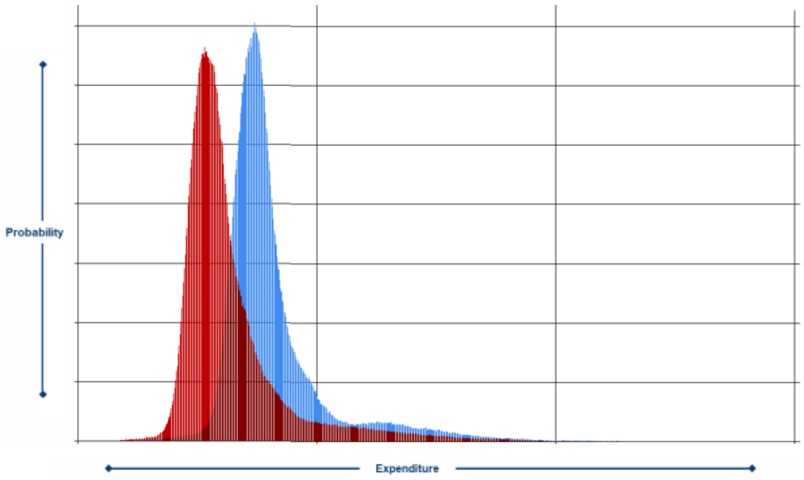
A large corporation (“Company”) with a baseload electricity profile repeatedly saw its peers announcing transformative energy programs. In parallel, Company’s external stakeholders began voicing concerns over the lack of progress achieved in the existing renewable energy program that was publicly announced. Given the significant changes occurring in the market and purchasing structures that exist, Company did not want to make a long-term financial commitment without proper due diligence. As such, Company contracted Edison Energy to as a partner to design the optimal path forward utilizing proprietary VaR techniques.

In order to find the right solution for Company, it was critical to incorporate what we knew about Company’s risk tolerance and energy goals. The right combination of solutions was highly dependent on how the different available options reduced the tail risk in Company’s regional portfolio. The Edison Energy team evaluated options with the below parameters and identified the best-fit solution based on its ability to reduce expected costs:

- Drive scale to renewable energy targets
- Quantify the impact to financial risk profile from the installation
- Avoid impact to revenue generating activities / requirements of decreased electric consumption

Based on previous research, Company believed onsite solar projects would increase budget certainty because the contract prices are fixed, and thus believed the first opportunity to achieve savings and make progress on sustainability was to install rooftop solar at multiple facilities. The Edison team analyzed both options for Company (facility expenditure with onsite solar and without), stress testing both projects against thousands of real-world market scenarios.

The outcome is depicted in the below graph. The solar projects created ‘expected’ savings, as shown by the distribution shifting left, however the tail risk remained.



Surprisingly, the onsite solar projects **actually *reduce*** budget certainty because the reliance on grid power is now dependent upon the weather (sunshine). This means that while the facilities would expect to achieve cost reductions, the projects did not functionally remove exposure to scenarios where expenditure levels increase substantially (despite these being a low likelihood).

Figure 8: Distribution of Risk from Solar PV

This visibility helps plant managers, energy managers, finance professionals and treasury officers view decisions in a single framework. This common language then allows for faster, strategic decisions to be made. For example, now that:

- Treasury sees the tail risk, does this change their stance on hedging?
- Finance sees the variability, does this change their perspective on budgeting or approvals for additional capital projects?
- Energy sees the financial implications of onsite generation, does this impact their portfolio strategy for other regions?

Case Study Two: Department of Energy, Better Plants Challenge Partner Case Study (Volvo Trucks) Applying VaR

In 2017 the Volvo Group's Mack and Volvo Trucks divisions participated in a DOE Better Plants Energy Treasure Hunt Exchange In Plant training involving two of their plants: the New River Valley (NRV) Volvo Truck assembly plant in Dublin, Virginia, and the Lehigh Valley Operations (LVO) Mack Truck assembly facility in Macungie, Pennsylvania. The Energy Treasure Hunt Exchange training involves a collaborative approach towards energy efficiency in which mixed teams of employees from multiple plants and business units go through one or more plants to identify energy savings opportunities. This approach has been found to yield more energy-saving opportunities than when individuals from one plant work alone. The first phase at the NRV plant included employees from the NRV, the LVO plant, corporate Health, Safety and Environment (HSE), Volvo Group Trucks Operations, Volvo Construction Equipment and Prevost Bus. In the second phase, held one week later, many of the same personnel conducted an energy treasure hunt at the LVO plant. In both phases, at least one employee from both sites received specialized instruction so that they could serve as facilitators and perform internal energy treasure hunts in the future.

In both plants the mixed teams of employees identified multiple opportunities for improving energy performance at each plant. In some instances the teams identified opportunities that were similar at each plant. One of the opportunities found in both plants was to replace pneumatic paint agitators (depend on compressed air) with explosion-proof electronic units. This type of analysis – identifying pneumatic equipment that can be replaced reliably with electric or mechanical devices that perform the same task – is one of the best practices that has been identified and promoted by the DOE's Advanced Manufacturing Office (DOE, 2003).

At NRV, the team that focused on processes found a pneumatic paint agitator that needed to operate continuously to ensure the consistency of the paint. The team assessed the agitator and found that it consumed approximately 107,000 kWh per year. They then researched various electric agitators and found that the plant could replace the pneumatic device with an electric agitator that would be just as safe and effective as the existing unit. The team estimated that the plant would save just over 84,000 kWh annually with a cost savings of $7,400/year. With a project cost of $12,000 the simple payback was 1.62 years.

For the LVO plant a team with a similar focus discovered and analyzed two paint agitator applications. The team found a small unit that was using 15 Cubic Feet per Minute (CFM) and a larger application served by two agitators that served a 350-gallon tank. The small pneumatic agitator consumed 60,400 kWh and if replaced with a 1.5-hp electric unit would save approximately 48,000 kWh and $3,400 per year. With project costs of $18,000 the simple payback for the small agitator was more than 5 years. The second pneumatic agitator application consumed 222,000 kWh and if replaced with electric units would save 177,000 kWh and $12,500 per year. With total project costs of $26,000 the simple payback for both applications came out to 2.1 years.

Using the energy treasure hunt information provided by Volvo Group Trucks Operations and commercial/industrial utility rates for Southwestern Virginia and Central/Eastern Pennsylvania we performed a rudimentary VaR analysis on the pneumatic agitator replacement projects using the historical approach.

<u>Results for NRV</u>

We examined NRV's agitator project by using historical commercial/industrial electricity price rates in the state of VA for the past ~40 years and calculated the annual logarithmic percent change from each year to the next. We then looked at the pre-project energy consumption (converted from kWh to MMBtu and then to dollars using the historic commercial energy price EIA data) and the post-project estimated energy consumption (converted from kWh to MMBtu and then to dollars using the EIA data). Doing this gave us a clear picture of two main elements of risk: 1) the risk of energy prices impacting potential savings and 2) the change in VaR induced by the investment in the new paint agitator.

Utilizing historical data, we compiled annual price changes per unit of energy consumption. When displayed in a histogram, these results appear with price losses on the left and price gains on the right. The tails of this distribution indicate years in which there was particularly high volatility in price risk. Of chief concern in a VaR model is the chance of hitting a certain threshold of price overrun in the coming year, meaning that price increase tail events (the left side of the graph) are of particular interest.

To calculate percent change in price we utilize a logarithmic percent calculation which accounts for the difference between base devisor options (i.e. calculating percent decrease or increase) by approximating a percent change between the potential decrease and increase outcomes. This allows for ease of interpretation of results. This approach also allows us to apply a VaR model to either positive or negative tail event scenarios (though in this paper we only examine positive tail event scenarios as seen in Figure 9) without additional interpretation and calculation. The formula is given by:

$$\ln\left(\frac{Base\ energy\ price}{Comparison\ energy\ price}\right) = Approximate\ percent\ change\ in\ price$$

Where ln is the natural logarithm of the percent calculation between the base energy and the comparison energy prices in this case the difference in average annual energy prices for commercial/industrial customers in Virginia and Pennsylvania.

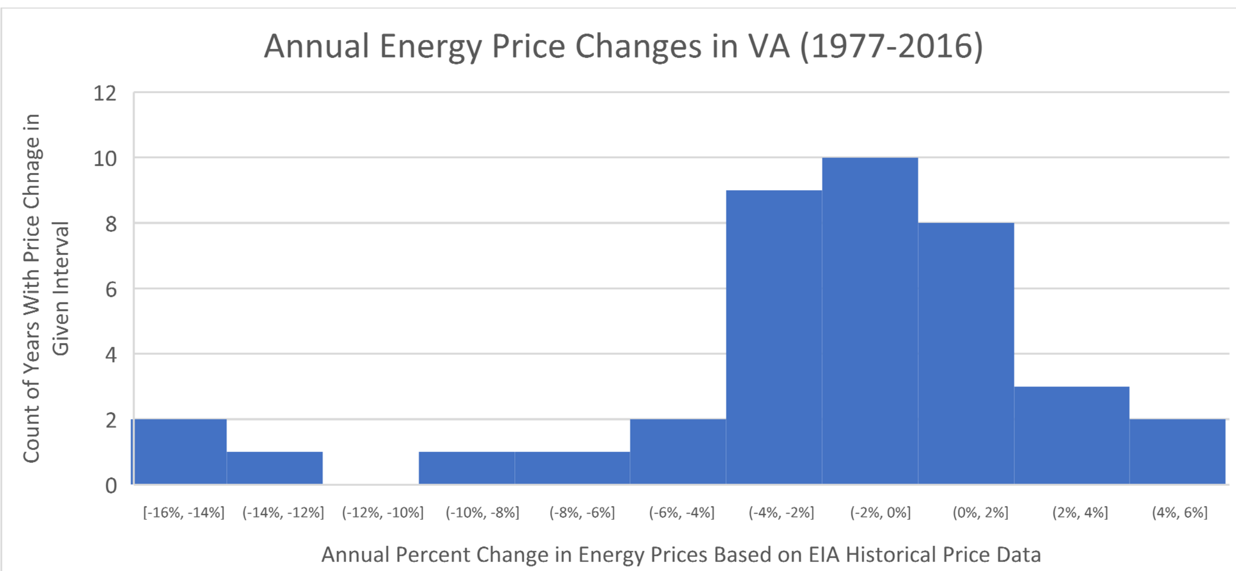


Figure 9: Distribution of Annual Energy Price Changes in Virginia

VaR calculations typically use fixed probabilities to determine the magnitude of an adverse event occurring. In this analysis 5th and 10th percentile price increases were identified and applied to Volvo investment decisions. This means that based on historical price volatility in local electric markets, Volvo can expect some change (identified in Tables 2 and 3 below) in the magnitude of its possible adverse event (either at the 5th or 10th percent likelihood). The results from the analysis are shown below:

Table 2: VaR Results for NRV

Project	Paint Shop Redesign	
Pre vs Post	Pre	Post
Location (EIA historic data)	VA	
5% Chance Event (dollars in cost overrun)	$ 50.77	$ 10.83
50% Chance Event (dollars in cost overrun)	$ 5.51	$ 1.17

These results for the first row signify:

1. There is a 5% chance that the pre-project expected savings will net $50.77 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the paint shop.

2. There is a 5% chance that the post-project expected savings will net $10.83 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the paint shop.

These results for the second row signify:

1. There is a 50% chance that the pre-project expected savings will net $5.51 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the paint shop.

2. There is a 50% chance that the post-project expected savings will net $1.17 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the paint shop.

The main takeaway is that the energy price risk is small – there is only a 5% chance of cost overruns around $10.83 annually when the investment is made, e.g. the company will save $10.83 less than anticipated if electricity prices spike. This 5% scenario represents the likelihood of a rare price spike on the order of magnitude of the late 1970's energy crisis. Essentially, in the event of a massive energy price shock, the company will be less exposed than if they had not made the capital investment as indicated by the decreased pre- and post-project price risk.

<u>Results for LVO</u>

We examined the both agitator projects for the LVO plant by using historical commercial/industrial electricity price rates in the state of PA for the past ~40 years and calculated the annual logarithmic percent change from each year to the next. We then looked at the pre-project energy consumption (converted from kWh to MMBtu and then to dollars using the EIA data) and the post-project estimated energy consumption (converted from kWh to MMBtu and then to dollars using the EIA data). Again, this gave us a clear picture of two main elements of risk: 1) the risk of energy prices impacting potential savings and 2) the change in VaR induced by the investment in the new paint agitator. The results from the analysis are shown below:

Table 3: VaR Results for LVO

Project	Agitator, 2 units <200 gal/tank		Agitator >350 gal	
Pre vs Post	Pre	Post	Pre	Post
Location (EIA historic data)	PA		PA	
5% Chance Event (dollars in cost overrun)	$ 517.03	$ 103.41	$ 1,895.76	$ 379.14
50% Chance Event (dollars in cost overrun)	$ 43.13	$ 8.63	$ 158.13	$ 31.62

These results for the first row signify:

1. There is a 5% chance that the pre-project expected savings will net $517.03 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 2-unit agitator.

2. There is a 5% chance that the post-project expected savings will net $103.41 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 2-unit agitator.

3. There is a 5% chance that the pre-project expected savings will net $1,895.76 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 350-gal agitator.

4. There is a 5% chance that the post-project expected savings will net $379.14 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 350-gal agitator.

These results for the second row signify:

1. There is a 50% chance that the pre-project expected savings will net $43.13 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 2-unit agitator.

2. There is a 50% chance that the post-project expected savings will net $8.63 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 2-unit agitator.

3. There is a 50% chance that the pre-project expected savings will net $158.13 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 350-gal agitator.

4. There is a 50% chance that the post-project expected savings will net $31.62 fewer dollars saved annually than is expected given historical energy price volatility for the investment in the 350-gal agitator.

Once again, the principal conclusion is that the energy price risk is small – there is only a 5% chance of cumulative cost overruns around $103.41 and $379.14, respectively. In this case, the investment in the 2-unit agitator will yield the smallest financial risk to the company due to its efficiency of energy use. In the event of a massive energy price shock, the company will be less exposed than if they had not made the investment.

Conclusion

Value at Risk (VaR) is a well-understood framework and widely used as a measure of risk for potential losses in financial investing. However, it has yet to be widely applied to projects that fund the installation of onsite generation assets or energy efficiency upgrades across a portfolio of facilities. Because these types of projects can also be considered investments this paper sought to investigate the applicability of VaR analysis in these types of projects, particularly in a manufacturing context. The results show that VaR models not only work, e.g. they can accurately estimate project risk for these investments, but that they can also display the risk exposure of not implementing such projects. For companies that receive an energy assessment that yields multiple energy-saving recommendations, the VaR approach can help understand which of the recommendations are riskiest. When added to the payback or ROI calculations this will provide a better understanding of where to allocate financial capital.

For energy management staffs in manufacturing companies and organizations having the ability to calculate VaR on suggested projects is important in order to provide senior management and finance teams with a comprehensive picture of the benefits of doing energy efficiency and renewable energy projects. This could enable a more efficiency allocation of capital into investments in energy efficiency and renewable energy.

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