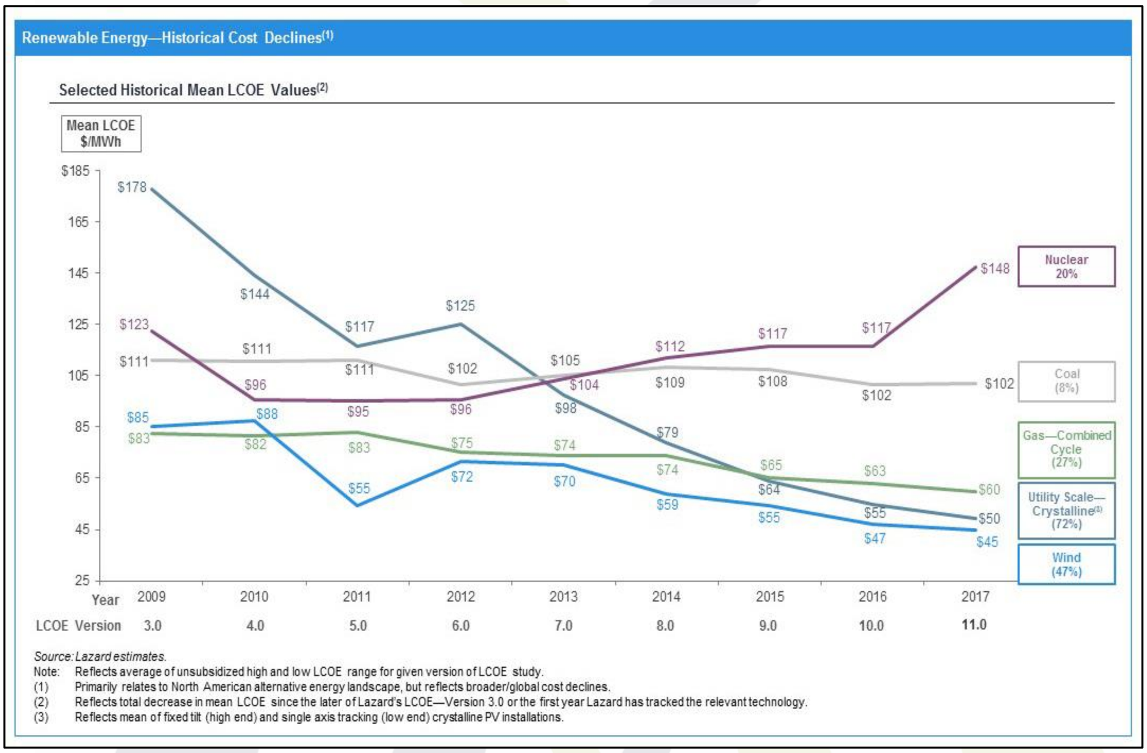
Quantifying the Value of Electricity Storage in Dynamic Use Environments:

Modeling for Optimizing Acquisition and Execution

Part 2

The intent of this paper, which builds on the previously released White Paper "Quantifying the Value of Electricity Storage in Dynamic Use Environments," is to present some solutions to the problems presented. In particular this is written to address a portion of the technological and demand changes that have been realized throughout the U.S. electricity industry. The current disruption in the industry highlights a number of challenges for companies that produce and distribute power throughout the country. There is little doubt that the need to meet peak demand during a time in which demand curve tails are lengthening is, and will continue to be, a challenge for all types and sizes of electricity providers. The previous paper discussed some of the demand changes, but providers are also impacted by changes in generation. A portion of these dynamics can be viewed in the analysis of production costs from various sources from the investment firm Lazard, as seen in the chart below.



Source: Lazard's Levelized Cost of Energy Analysis, Version 11.0

Problem Statement and Solution Approach

The growth of volatility, realized and potential, in the demand of electricity has been brought about by some of the factors discussed in this and the previous paper. The need to manage this variability is well understood by electric companies, although previously the tools to do so have been limited, as have the ability to optimize the timing when mitigation efforts make economic sense. The economics involve undertaking the initial cost of controlling the volatility as well as the optimal time is to deploy such solutions.

The optionality of storage, which this paper limits to that offered through the use of batteries, provides a unique solution to address the volatility of the variables that contribute to electricity demand. However, understanding the dynamic value of this solution is paramount in assessing the acquisition of the batteries, as well as optimizing the value of the batteries storage capacity. We have developed a modeling capability to value both the initial purchase of specific storage capacity as well as usage optimization based on the unique attributes of the producer's environment.

In both cases, initial purchase and point in time use, the value is directly related to the implied volatility of the environment. Having the best understanding of the value, relative to the specific environment, is paramount when considering the acquisition of storage capacity (i.e. batteries) and the ability to understand exactly what the parameters this solution addresses at time of acquisition and the future probabilities.

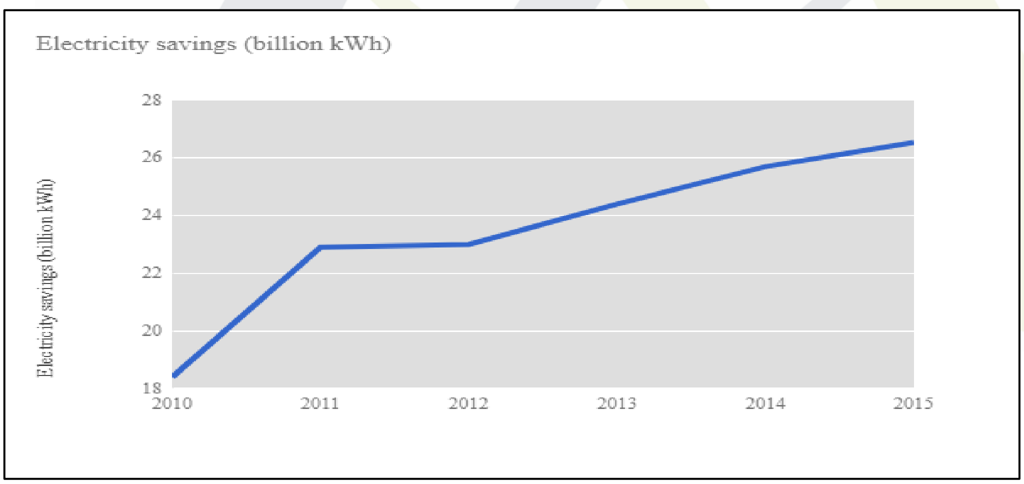
The second part of the model allows for (as short as) intraday understanding of the optimum application of the batteries' storage capacity usage point in the demand cycle. The model provides the recalibration flexibility to incorporate variables (e.g. weather) to optimize usage. This optimization is unique to the different environments and schemas of the electricity generators.

The unique nature of every organization that generates and distributes electricity is well understood, and this precludes a "one size fits all" generalized approach. In some cases, the utilization of storage to augment electricity produced by alternative and/or traditional means may not make economic sense, but may instead be an approach to reduce specific generation capabilities for other purposes. The approach articulated here respects the multitude of electricity generation organizational aspects and is fashioned in such a way so as to tailor the solutions.

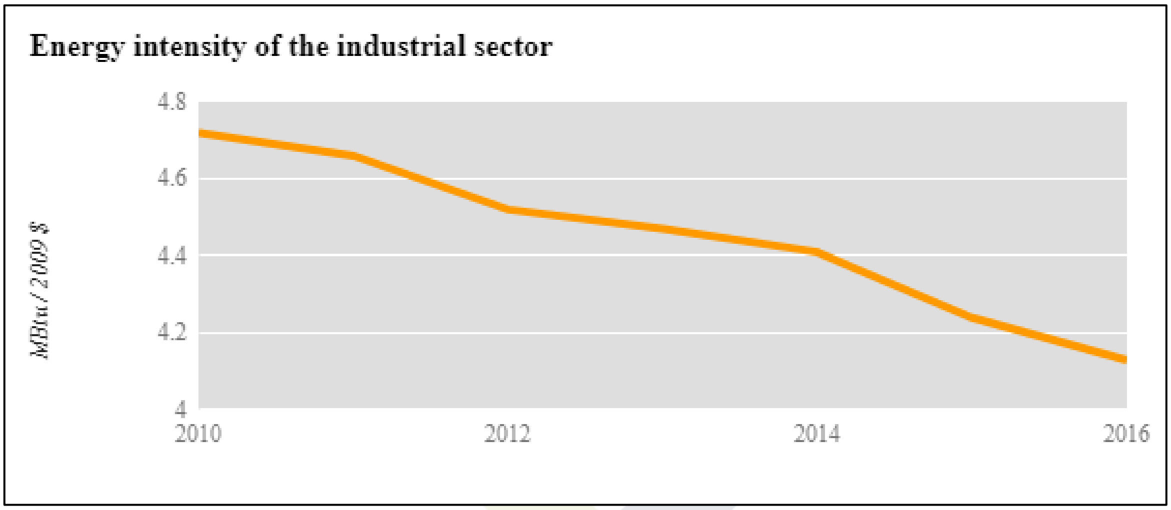
Additionally, the economic approach to storage is considered in terms of alternatives (i.e. solar and wind power) to provide a complete solution. The modeling approach taken by FRG was developed after an in-depth review of storage facilities and the probable economic impact that may be realized when a complete system is modeled in terms of regressions and forecasts.

Factors

The adoption of wind and solar as alternatives has been boosted by the increasing efficiency ratios enjoyed by both of these sources. Improvements in the technology, materials, and manufacturing of both wind and solar generation equipment promises to continue, diminishing returns have yet to be experienced to date. According to the WWEA, installed wind power capacity has increased by 20% per annum from 2010-2016, at the same time wind power prices have decreased by 64% (per megawatt hour). During the same period installed solar capacity in the U.S. has risen some 1700%, continuing an exponential growth pattern.



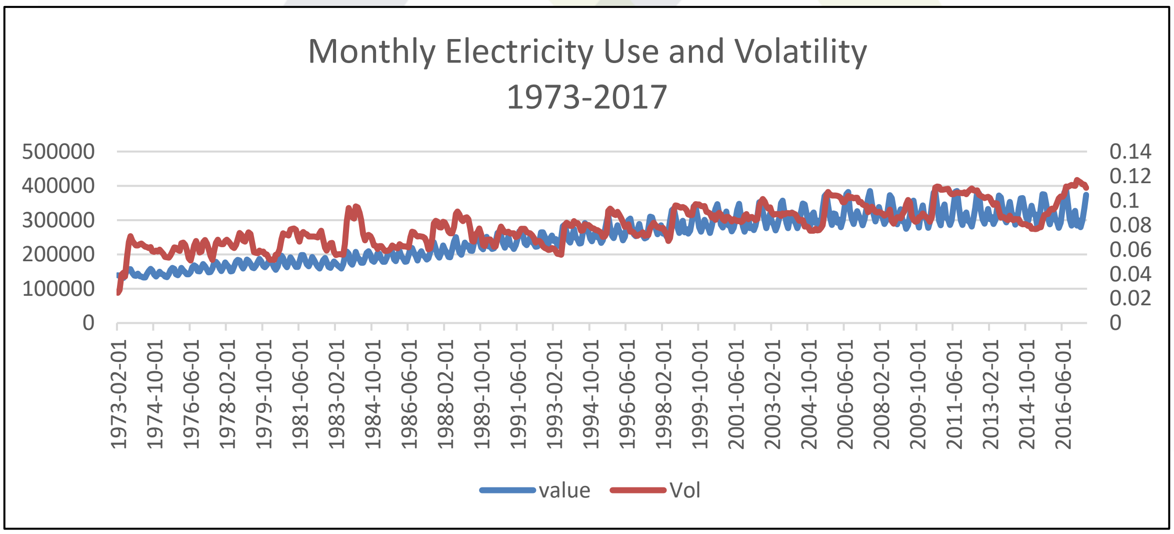
The inverse of the power generation equation is usage and trends in efficiencies currently being realized in the environments. Below is a chart from the American Council for an Energy Efficient Economy (ACEEE) that illustrates the first-year electricity savings attributed to efficiency efforts. It's important to note that this chart highlights only first year savings, which of course will continue to impact the demand into the future. Both residential and industrial efforts to improve the efficiency of appliances and equipment, as well as construction techniques, will likely allow this trajectory to continue.



Perhaps the best illustration is this graph from ACEEE that demonstrates the energy used per dollar of goods produced.

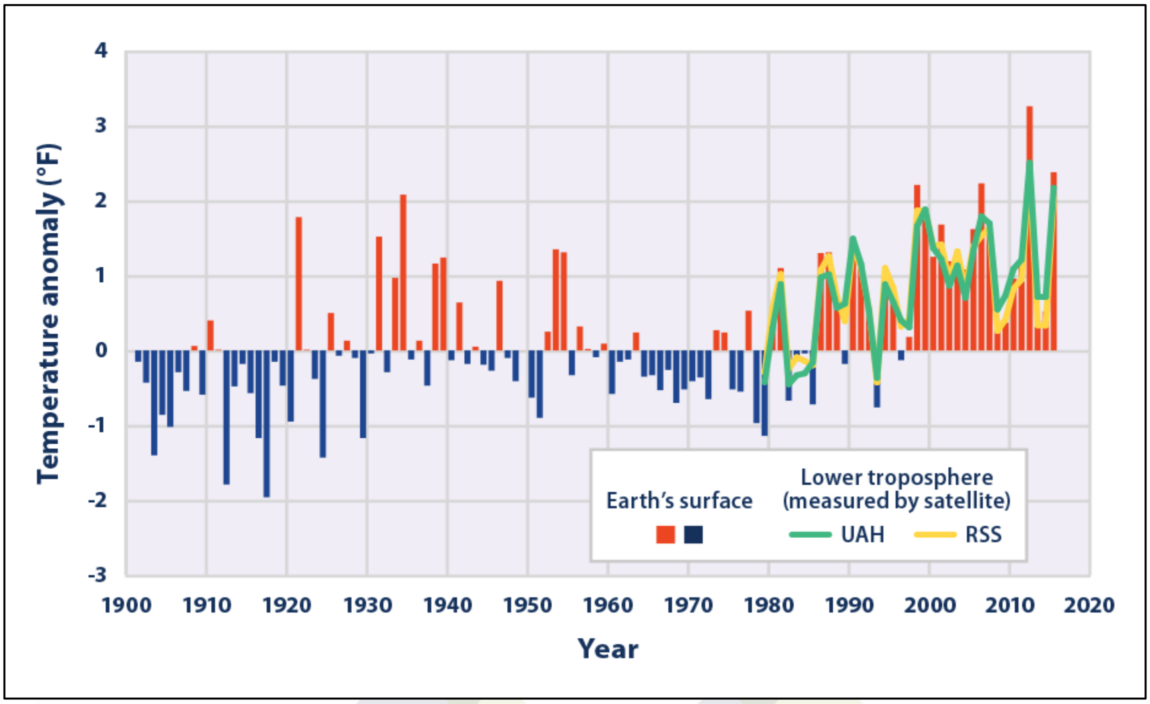
There are, of course, a number of variables that will affect these trends going forward, but the trajectory is unmistakable. Given this challenge, the need to continue to meet demands that have a correlated volatility function while reducing costs is primary to any type of power generation organization.

At the same time there has been a steady, albeit cyclical rise in the volatility of electricity usage. The volatility has risen from about 6% in the mid 1970's to about 11% more recently, on a 12-month rolling basis. While energy usage is decreasing, the volatility of the demand, which power companies must be prepared to satisfy, is increasing and adding to an already complex equation.



The decreasing per capita usage of electricity, along with the increasing adoption of alternatives, an increasing U.S. population, and increasing building and equipment efficiencies provide some of the dynamic variables that will continue to face electric power generators and distributors. The ability to understand the relationship between these and other variables, in specific environments, allows for probability curves to be developed that will reflect the future environment.

The need to address the increasingly volatile demand for electricity is well understood by the power generation industry, and efforts are being made to address the business and service needs. The primary issue revolves around volatility of demand, which on a micro level is primarily determined on time of day and weather. The chart below illustrates the annual volatility of the U.S. surface temperatures in a historic perspective.



Source: U.S. Environmental Protection Agency

While the warming trend is apparent over the past 40 years, of greater interest to electric power producers is the year-to-year volatility in surface temperatures. Because of the effect of both known daily cyclical demand and the unknown weather variable on demand, both of these factors are instrumental to solving for demand function mitigates.

Other Considerations

As this report has illustrated the changes that have *already* been realized are substantial, and as such there is no reason to believe that this cycle has run its course, in fact it has anything but. Distributed integrated resource planning has been utilized but the depth to which this can be used, in particular with more finite forecasting, will continue to mature. As forecasting and computational skills are applied this will become much more useful and specific to the environment served.

More controversial is the future of electricity pricing landscape changing from the traditional kilowatt hours (kWh) that have become a mainstay, not only in billing but in many of the measurement metrics, to kilo Volt Amperes (kVA). The growth of equipment (e.g. electric vehicles) has exceeded forecasts and may potentially exert pressure on existing electricity generation, in particular during peak hours. A recent article in the Financial Times of London quotes a Think Tank that suggests charging as few as six electric vehicles on the same street during peak demand hours could lead to shortages. Billing in kVA would address this new generation of electric devices and incentivize other behaviors such as off-peak charging.

Conclusion

The Financial Risk Group has a long history of modeling various aspects of the (foreign and domestic) electricity generation economic and operational environment, with the goals of minimizing cost and maximizing efficiencies. The rapidly changing demand for electricity, and the ability to forecast the probable changes, will continue to be issues for all types of electricity suppliers. FRG's experience in all types of organizations, including the firm's deep financial and capital markets work around the globe has allowed for the development of solutions that are reflective of the dynamics of unique electricity markets. While there is no doubt that electricity storage and alternative generation technologies will continue to develop, there are opportunities to leverage the options afforded through these technologies in the current environment if they are well understood, modeled correctly, and the usage is optimized. The fact that modeling and optimization will need to be reflective of the environment is a core understanding, as is the regular calibration of these tools.

FRG would welcome the opportunity to speak with you concerning the findings of this paper, as well as how the approaches developed may fit into specific environments. For more information contact the FRG Research Institute at Research@frgrisk.com or 919.439.3819.