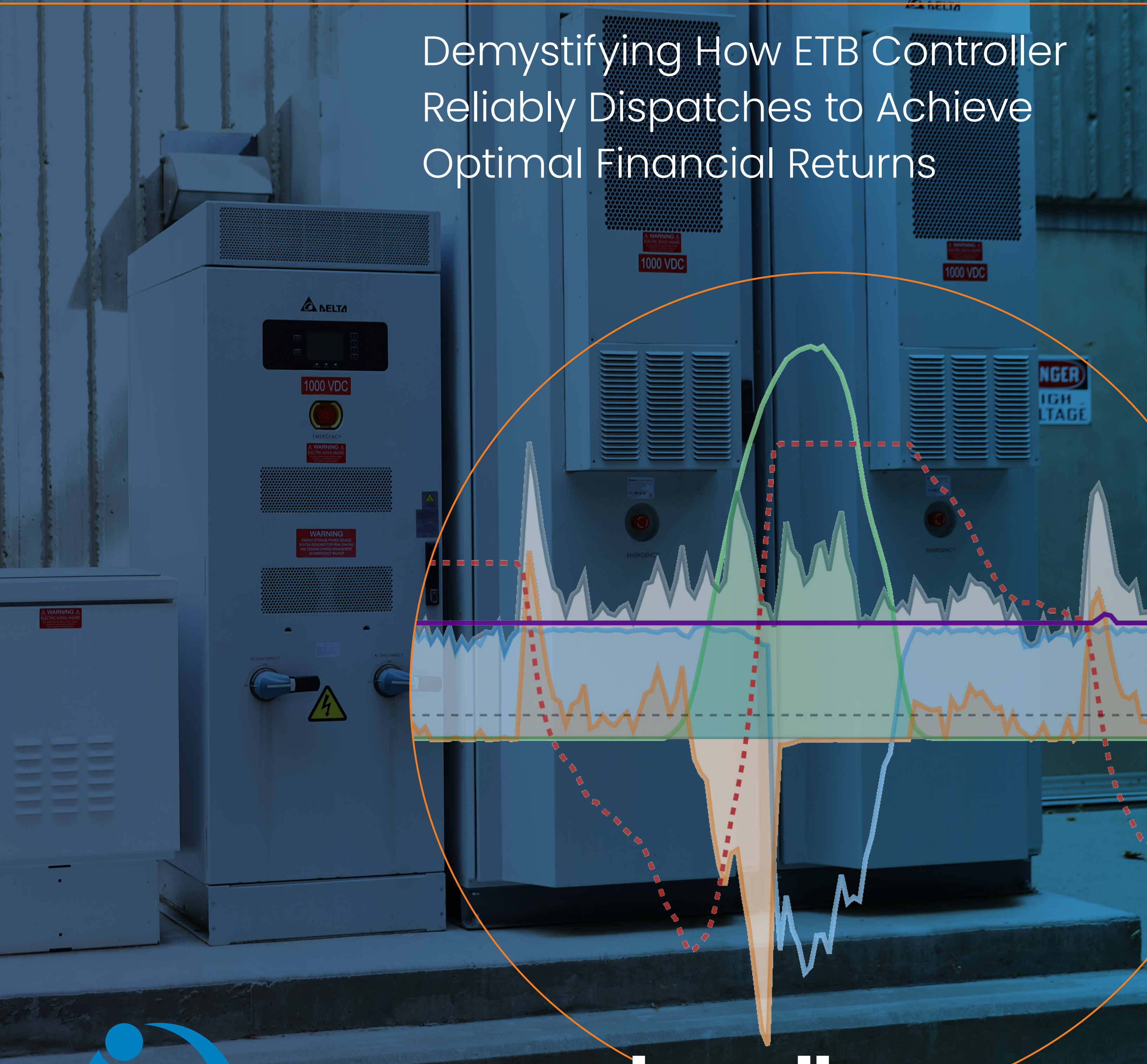
Monetize Your Energy Storage Asset

Demystifying How ETB Controller Reliably Dispatches to Achieve Optimal Financial Returns



energy toolbase

By Adam Gerza, Enrico Ladendorf & Quinn Laudenslager

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Software that reliably models and controls energy storage and solar-plus-storage assets is mission critical for a project's return on investment. In high-stakes use cases, energy storage system performance is only as good as the system's modeling, forecasting and control capabilities. As a result, software qualification and specification can make or break your projects.

Software drives return on investment (ROI) in energy storage applications. Project stakeholders cannot design and deploy an energy storage system (ESS) without effective software. Moreover, project developers, financiers and host customers require robust and sophisticated prediction, control and monitoring capabilities to monetize an energy storage investment reliably. This is especially true when the stakes are highest, as is the case with monthly demand charge management or application stacking scenarios.

While it can be challenging to monetize an energy storage asset, it is possible given quality data inputs and intelligent software. Many inverter and battery vendors have simple software that provides an energy storage asset with an operating interface or a monitoring system. However, Energy Toolbase is one of the few companies that provide a higher-level energy management system (EMS). ETB Controller provides flexible options to suit any project needs: a straightforward fixed-schedule dispatch for simpler setups, and advanced EMS software powered by Acumen AI for maximizing the economic performance of any system.

In this paper, we explain how next-level software platforms, such as Energy Toolbase's ETB Controller with Acumen AI, dispatch an ESS for maximum value and validate and improve real-world performance over time. In addition to providing an overview of representative use cases for energy storage, we present project- and fleet-level data from operational projects. Last but not least, we share lessons learned from real-world projects and best practices for mitigating performance risk.

> *"Software is a key component in the new business models for energy storage—there will be no future of energy without software."*
>
> **—Miguel Sepúlveda Garcia, FRV**

DISPATCHING AN ESS FOR MAXIMUM VALUE

Whereas software is generally a passive observer in solar applications—monitoring fielded system performance only—the opposite is true for an ESS. In typical on-grid operations, software controls independently dispatch a battery to achieve an optimal ROI based on specific use cases. Since it is impossible to generate financial returns without this active software control layer, project developers, financiers and host customers require robust and sophisticated monitoring, prediction and control capabilities to monetize an energy storage investment.

"Software is a key component in the new business models for energy storage," says Miguel Sepúlveda Garcia, FRV's new business development manager for Latin America. "There will be no future of energy without software."

When considering the challenges associated with dispatching an ESS for maximum value, it is crucial to recognize that a battery management system (BMS) or a storage monitoring system is not the same as an EMS. Moreover, the economic performance of an energy storage asset will vary according to the quality of the field operational algorithms used to dispatch the system and the perfect foresight algorithms used to validate system performance. Last but not least, software vendors need to customize and train EMS software on an application-by-application basis.

AI and Machine Learning are often essential for monetizing an ESS investment. Acumen AI relies on a combination of field operational and proprietary foresight algorithms to continuously make the quick decisions required to dispatch an ESS for maximum economic value.

Battery vs. Energy Management Dispatching an ESS requires multiple software layers. The first layer is the *battery management system*. The BMS is a relatively simple input/output (I/O) interface that serves as an operating system for the battery. Conceptually, the BMS is analogous to a car's steering wheel, transmission lever and floor pedals. Every automobile has these rudimentary operating system components, but this I/O interface alone cannot pilot a vehicle down the road.

The second essential software layer is the *energy management system*. EMS software not only integrates an I/O interface for the battery but also acts as the system operator. In other words, an ESS controlled by a full-featured EMS is functionally equivalent to a self-driving car. This higher-level EMS software, which works in harmony with the BMS, is the key to value creation in ESS applications.

"I consider these advanced control capabilities to be the core competence of a competitive energy storage software company," notes Michael Liu, senior director of energy storage at BYD. "Moreover, having a competent software company as part of an energy storage team can demonstrate the competitiveness of your energy storage project."

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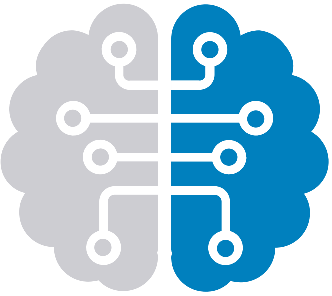
>
> **—Michael Liu, BYD**

Monitoring vs. Control A third software layer in an ESS is the monitoring system, which provides real-time insights into the operational performance and savings of an ESS. Though system monitoring is vital in energy storage applications, some monitoring companies do not offer the advanced control capabilities required to monetize a battery. In other words, simple storage-monitoring platforms do not necessarily provide advanced control capabilities.

"It is interesting how many companies claim to be in the 'storage monitoring' space," notes Chuck Rames, North American director of energy storage marketing at Socomec. "In and of itself, monitoring storage may not have a lot of value. Say I do not know how to drive, but I sit in the front seat of a car and monitor the driver. Observing the driver is not very useful. Similarly, storage monitoring does not unlock a lot of value absent an operational engine."

Energy Toolbase's ETB Controller provides advanced system control capabilities while ETB Monitor effectively serves as the user interface (UI) layer, providing robust monitoring capabilities. Project developers and host customers with ETB Controller–controlled assets can use ETB Monitor to view real-time system performance. This UI also provides a detailed breakdown of the precise utility bill savings associated with both energy storage and solar.



"Every 15 minutes, Acumen AI makes site demand and renewable energy generation forecasts for the next 24 hours."

—Prudhvi Tella, Energy Toolbase

Field Operational Algorithms The event-based dispatch of an EMS requires artificial intelligence (AI) and machine learning. Operational algorithms are forward-looking and make real-time decisions based on the results of time-series forecasting. These forecasts predict the future value of two weather-dependent quantities: site power demand and on-site renewable energy generation. The difference between these two values determines the site's forecasted net power demand.

"Those forecasts become the inputs to our optimization logic," says Prudhvi Tella, Acumen Engine Architect at Energy Toolbase. "Every 15 minutes, Acumen EMS makes site demand and renewable energy generation forecasts for the next 24 hours. By periodically generating these new forecasts, the control system can optimize the battery asset's charge and discharge schedule."

Machine learning models allow the control software to identify patterns based on time and weather. Time-correlated parameters include time of day, day of the week, day of the year and holidays. Weather-related parameters—especially ambient temperature—are also relevant. Additionally, the software must account for technical aspects of the battery and its state of charge (SOC).

Perfect Foresight Algorithms Operational algorithms must dispatch an EMS based on an unknowable future. Conversely, perfect foresight algorithms have complete information about the future, allowing them to determine the mathematically optimal dispatch profile. Prior to introducing the revolutionary Acumen Engine, the only way to model was using foresight algorithms on the ETB Developer sales and modeling platform to simulate ESS savings estimates by factoring in battery efficiency degradation.

"Ideally, we work with a year of historical data. However, Acumen's model performs quite well with as little as three months of site data."

—Prudhvi Tella, Energy Toolbase

"The intention with perfect foresight algorithms is to determine the maximum potential savings," explains Prudhvi Tella, Energy Toolbase's Acumen Engine Architect in charge of Acumen AI control strategies. "Predictions based on a perfect forecast essentially provide the maximum upper bound for the theoretical savings. Without the insights offered by perfect foresight algorithms, we cannot improve the accuracy of time-series forecasts over time or produce realistic simulations for sales proposals."

Perfect foresight algorithms provide an optimal performance baseline for continuous process improvement as well as proof and verification. For example, in recently deployed field assets, Energy Toolbase conducts 3-, 6- and 12-month performance reviews based on perfect forecasts to validate customer savings. By looking backward, we can learn from the past and improve performance in the future. ETB Developer ESS modeling capabilities have been vastly enhanced with the release of the Acumen Engine which now integrates the same operational algorithm indicating real-world results directly in the simulation platform.

Customizing and Training the Model Studying the past is also the best way for AI and machine learning models to predict the future. Since every site is unique, Acumen AI generates forecasts based on historical data that effectively train the model for operations. This training process starts with customer-provided historical usage data as well as location-specific third-party weather data.

"Our data science team uses these raw input streams to encode features that Acumen AI uses to create a forecast based on historical patterns," explains Tella. "Ideally, we work with a year of historical data. However, Acumen's model performs quite well with as little as three months of site data."

"We also have techniques for addressing the 'cold start' problem," adds Tella. "Historical data is unavailable for new buildings or facilities. Also, some customers do not have interval data. In these cases, we can leverage our extensive database of building load profiles to maximize forecast performance and accuracy in the face of missing or incomplete data."

SYSTEM RELIABILITY To support its mission-critical control software, ETB Controller runs on a ruggedized industrial computer edge device, such as the OnLogic Karbon 300, shown here. Assuming sites maintain Internet connectivity, ETB Controller has a fleet-level uptime average above 99.2%.

> *"Software is not something you can leave out of an energy storage system to save a penny per watt."*
>
> **—Chuck Rames, Socomec**

UNDERSTANDING ESS USE CASES

The centrality of software to ESS applications is a marked departure from how solar photovoltaic (PV) power systems operate. "Software is not something you can leave out of an energy storage system to save a penny per watt," says Socomec's Rames. "With solar, passive monitoring is a luxury, as solar generates returns without software. With energy storage, active software controls are a necessity."

Advanced software controls are essential for energy storage use cases that involve a higher degree of complexity or seek to capture multiple value streams concurrently.

Solar vs. Storage Applications At a fundamental level, a grid-tied PV system has one power production source and only one job to do. This job is the same in customer-sited behind-the-meter applications as it is in front-of-the-meter applications on the bulk power system. By comparison, an ESS asset can integrate multiple power production sources and perform numerous jobs. Moreover, these jobs will vary depending on the ESS's location on the electrical power system.

For example, in a demand charge management application, the primary job is to shave peaks and reduce demand charges. In an energy arbitrage application, by contrast, the job of an ESS is to monetize differences in the time value of energy associated with specific time of use (TOU) rates. In a frequency regulation application, the job of an ESS is to provide ancillary services such as capacity firming or frequency regulation.

Application and Resource Stacking Multitasking is common in ESS applications. "Some people think these different applications must be mutually exclusive," observes Socomec's Rames. "That is not the case. Energy storage can be used for backup power or to provide economic returns or it can do both. Energy storage can be used to do demand charge management or to move solar-generated energy in time or to do both."

While application stacking is counterintuitive for some customers, it is also a primary way in which ETB Controller with Acumen AI dispatches an ESS asset for optimal financial returns. Stacking multiple applications creates multiple opportunities for savings from avoided costs. Similarly, integrating multiple power production sources—such as solar plus energy storage—can increase opportunities to create value compared to systems utilizing solar only or energy storage only.

"When you have multiple assets and applications, you need software to forecast, predict and make operational decisions," says FRV's Sepúlveda Garcia. "When do we buy or sell energy? How aggressively can we charge or discharge a battery according to the warranty? A person cannot make these decisions. These are decisions for software."

High-Stakes vs. Best-Effort Applications Not all ESS applications are created equally in terms of risk and reward. TOU arbitrage, for example, is a best-effort type of scenario with minimal performance risk. If the system goes offline and is unavailable to move solar energy generated during an off-peak pricing period to an on-peak period, the stakes are relatively low. The result is that the owner has lost the opportunity to avoid cost for that subperiod; however, avoided costs are still available for the remainder of the billing period. Given the low stakes and simple time-based logic, it is straightforward to implement an energy arbitrage control algorithm.

By contrast, the control algorithms required to monetize many other ESS cost-saving opportunities are considerably more complicated and consequential. For example, in monthly demand charge management applications, every missed peak erodes avoided-cost savings. If the ESS system goes offline and misses the highest monthly peak demand, all other actions for the billing period are rendered moot. We designed ETB Controller and Acumen AI with these high-stakes applications in mind.

USING SOFTWARE TO SIMPLIFY COMPLEXITY

The following case studies demonstrate how properly implemented software masks many complexities inherent in representative ESS applications and maximizes savings from avoided costs. In most cases, project stakeholders used Energy Toolbase's industry-leading ETB Developer software modeling platform to right-size systems for optimal returns and estimate ESS performance based on the customer's load profile and rate structure.

Once deployed, Acumen AI leveraged its sophisticated machine learning models to predict each site's optimal charge and discharge schedules. To ascertain how well Acumen AI delivered financial returns, we used perfect foresight analyses to compare actual performance to the maximum theoretical savings.

USE CASE

STAND-ALONE STORAGE DEMAND CHARGE MANAGEMENT

American Faucet and Coatings Corporation operates a 60,000-square-foot manufacturing facility in San Diego County, California. Served by San Diego Gas & Electric (SDG&E), the American Faucet factory is subject to the utility's AL-TOU rate schedule, which features some of the highest demand charges in the state.

SDG&E's AL-TOU rate subjects customers to some of the highest non-coincident (NC) demand charges in California. Since project commissioning in mid-2019, American Faucet's NC demand charges have ranged from $25 to $30 per kilowatt. Reducing these NC demand charges is a high-stakes application.

In this scenario, each 15-minute interval has the potential to set the NC demand charge for an entire billing cycle. ETB Controller with Acumen AI must reliably dispatch stored energy to reduce each billing cycle's highest demand peaks, as shown in the monthly and key day data graphs. In this particular stand-alone storage application, where demand reduction is not supplemented by solar PV, Acumen AI is able to efficiently reduce demand with limited battery cycling, as illustrated in the monthly data image. The billing period results demonstrate that ETB Controller with Acumen AI is able to achieve a high level of success, as measured by the percentage of perfect, even in an application with a small battery capacity relative to the site load.

PROJECT DETAILS

FACILITY TYPE: Metal finishing and plating

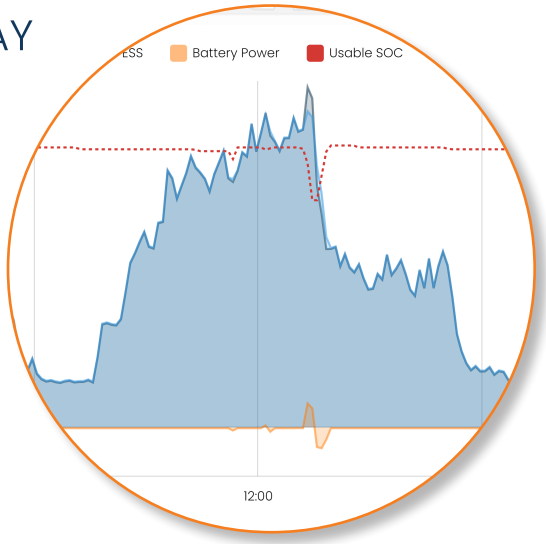
LOCATION: San Diego County, CA

COMMISSIONED: May 2019

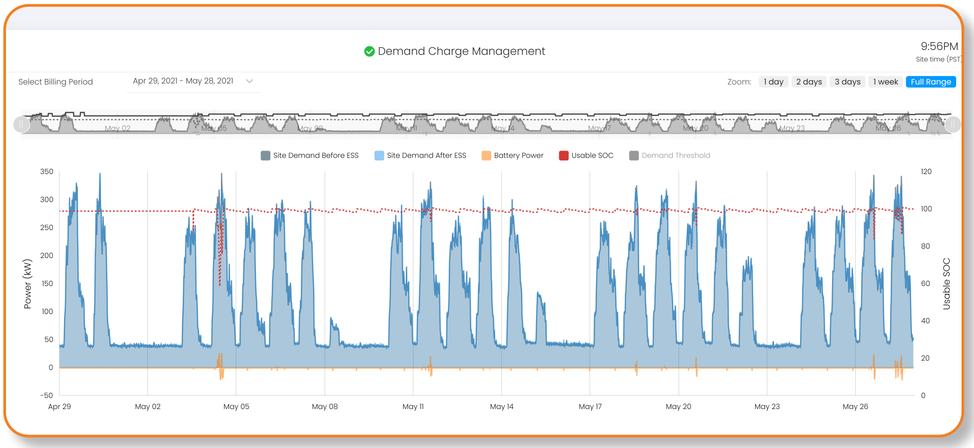
UTILITY: San Diego Gas & Electric

AVAILABLE ESS CAPACITY: 29.4 kW/57 kWh

KEY DAY DATA



MONTHLY DATA



The monthly data (left) for the American Faucet factory are punctuated by relatively narrow and extreme peaks. While the ESS capacity is just 7.6% of the peak load, ETB Controller with Acumen AI is highly successful at dispatching stored energy to offset NC demand. The daily data (above) shows the maximum NC demand with and without ESS. On this key day, the 29.4 kW–rated battery shaved the midday peak demand by 28 kW.

BILLING PERIOD RESULTS

Billing Period	Max. Demand Before ESS	Max. Demand After ESS	Non-Coincident Demand	
Month	Non-Coincident	Non-Coincident	kW Shaved	Percentage of Perfect
May 2021	387 kW	359 kW	28 kW	95%

For the illustrative month, ETB Controller with Acumen AI shaved American Faucet's NC demand by 95% of perfect.

USE CASE

SOLAR-PLUS-STORAGE DEMAND CHARGE MANAGEMENT

Tennsco is an office equipment manufacturer with seven manufacturing facilities and warehouses in Dickson, Tennessee. Through its local public utility, Tennsco is one of over 750,000 businesses served by the Tennessee Valley Authority (TVA). Leveraging feed-in tariffs offered by TVA, Tennsco began installing on-site solar at its manufacturing facilities in 2012 to reduce its energy costs and carbon footprint.

Energy costs represent a fraction of Tennsco's monthly electricity bills. In 2020, Tennsco began adding on-site energy storage at manufacturing plants that already host solar to reduce its demand charges. To date, it has deployed five ETB Controller with Acumen AI–managed energy storage assets across its facilities.

To optimize solar-plus-storage demand charge savings, control software needs to anticipate the site loads, estimate solar generation based on day-ahead weather forecasts, and dispatch to reduce the after-solar peak demand. The billing period results demonstrate the level of success that Acumen AI is able to achieve in this complex, multi-variable application. As illustrated in the monthly data image, a peak-demand threshold, after solar and ESS, is set early in the billing cycle, which limits subsequent battery cycling. Once this ceiling is established, ETB Controller with Acumen AI shaves to this set point, dispatching only when peak demand exceeds this threshold.

PROJECT DETAILS

FACILITY TYPE: Metal forming and stamping

LOCATION: Dickson, TN

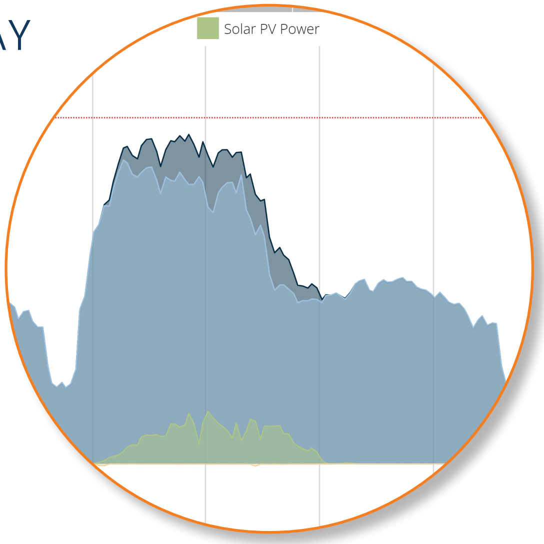
COMMISSIONED: July 2020

UTILITY: Dickson Electric System

AVAILABLE ESS CAPACITY: 117 kW/342 kWh (at Plant 2)

SOLAR PV CAPACITY: 545.5 kW (at Plant 2)

KEY DAY DATA



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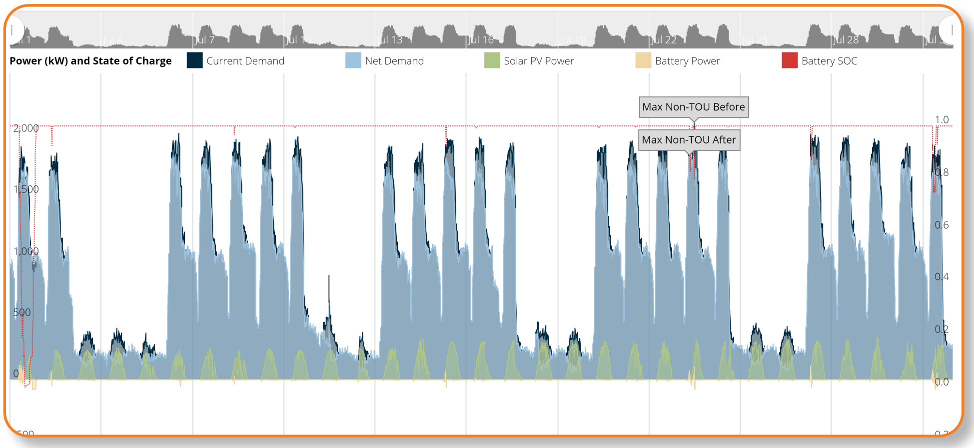


As shown in the monthly data (left), peak demand at Tennsco's Plant 2 occurs Monday through Friday during first-shift operations. While the load profile is relatively broad, peak solar generation is largely coincident with peak demand, as shown in the daily data (above). Anticipating the load and forecasting weather-dependent solar generation, Acumen EMS effectively dispatches stored energy to manage the after-solar peak demand.

BILLING PERIOD RESULTS

Billing Period	Max. Demand			ESS Performance	
Month	Before PV & ESS	After PV, Before ESS	After PV & ESS	Demand Shaved	Percentage of Perfect
July 2020	2,099 kW	1,928 kW	1,836 kW	92 kW	79%

ETB Controller with Acumen AI shaved peak demand at 79% of perfect in this given month.

USE CASE

APPLICATION STACKING WITH SOLAR AND STORAGE

A global food and beverage industry leader is targeting a companywide 40% reduction in greenhouse gas emissions by 2030. In mid-2021, the Fortune 500 company opened a 125,000-square-foot warehouse and distribution center in Lakeside, California. This state-of-the-art facility includes an ETB Controller with Acumen AI–controlled solar-plus-storage system developed by HES Solar.

The host customer deployed a 436 kW roof-mounted SunPower solar PV system paired with a 240 kW/532 kWh BYD Chess ESS. Using ETB Developer, HES Solar estimates that the combined system has a 3-year payback period, after incentives, and will capture $6.4 million in electric bill savings over its 25-year service life. As shown below, the site load is volatile and spiky, with numerous short-duration load bursts that are generally advantageous for peak-shaving applications.

At the time of commissioning, in January 2022, the warehouse facility was subject to SDG&E's AL-TOU rate. However, rate-switch analyses conducted in ETB Developer indicate that a move to SDG&E's solar-friendly DG-R rate will provide the host with the best economic returns. Once the planned rate change is completed, Acumen AI will enhance the host's long-term avoided costs by co-optimizing two distinct applications: demand charge management and time-of-use energy arbitrage.

PROJECT DETAILS

FACILITY TYPE: Beverage distribution warehouse

LOCATION: Lakeside, CA

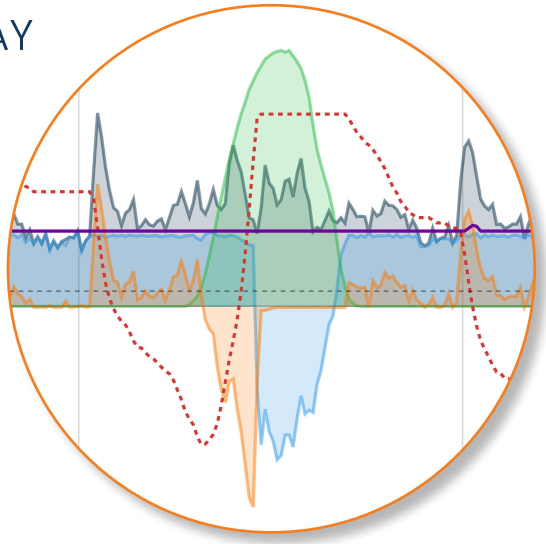
COMMISSIONED: January 2022

UTILITY: San Diego Gas & Electric

AVAILABLE ESS CAPACITY: 240 kW/532 kWh

SOLAR PV CAPACITY: 435.6 kW

KEY DAY DATA



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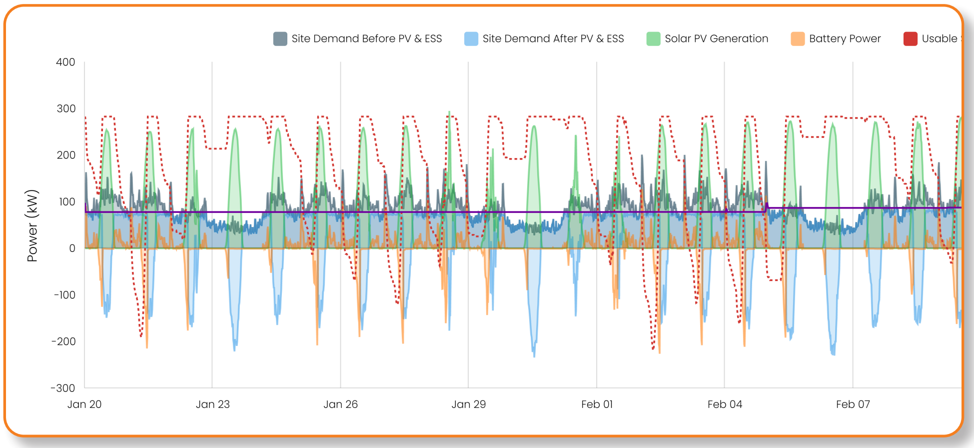


During the workweek, the beverage distribution warehouse facility experiences multiple daily load spikes, as shown in the monthly data (left). While solar production is coincident with some load spikes, as shown in the daily data (above), others occur in the early morning or evening hours. ETB Controller with Acumen AI dispatches as needed to shave the peak and maintain the demand set-point threshold.

BILLING PERIOD RESULTS

Billing Period	Max. Before PV & ESS	Max. After PV	Max. After PV + ESS	NC Demand Reduced by ESS	
Month	Non-Coincident (NC) Demand			kW Shaved	Percent of Perfect
January 2022	202 kW	201 kW	89 kW	112 kW	86%

In new construction, little historical data is available for training an ESS control model. Despite the inherent "cold start" challenges, Acumen AI was 86% of perfect at reducing the host's NC demand charges in its first monthly billing cycle of operation.

USE CASE

SOLAR SELF-CONSUMPTION

23 Ammonoosuc is a small private company in Littleton, New Hampshire, focused on the arts and education. Tenants at 23 Ammonoosuc Street include White Mountain Science, which develops and delivers science, technology, engineering and mathematics (STEM) educational programs. The site is also home to Littleton Studio School, a community arts center.

To restore the old three-story commercial building, 23 Ammonoosuc hired Garland Mill, a design-build firm specializing in high-performance, heavy timber–framed buildings. In addition to making deep energy-efficiency upgrades to the building, the owners also installed a behind-the-meter solar-plus-storage system. The primary application of the ESS is to increase solar self-consumption and prevent exports to the grid.

Solar self-consumption and non-export applications are becoming increasingly common. In high-penetration solar markets, such as Hawaii or Australia, there are regulatory restrictions and strong price signals in place to prevent solar exports to the grid. As solar penetration increases, and successor net energy metering (NEM) tariffs are adopted, strong price signals in the form of low export rates will become more prevalent.

In a self-consumption application, ETB Controller monitors the building load relative to on-site solar production. As shown in the data, when solar production exceeds the building load, ETB Controller uses excess solar generation to charge the battery; after sunset, it dispatches stored energy reserves in proportion to the building load. After this discharge cycle, the batteries are at a low state of charge and ready to store excess solar generation the next morning.

PROJECT DETAILS

FACILITY TYPE: Commercial office space

LOCATION: Littleton, NH

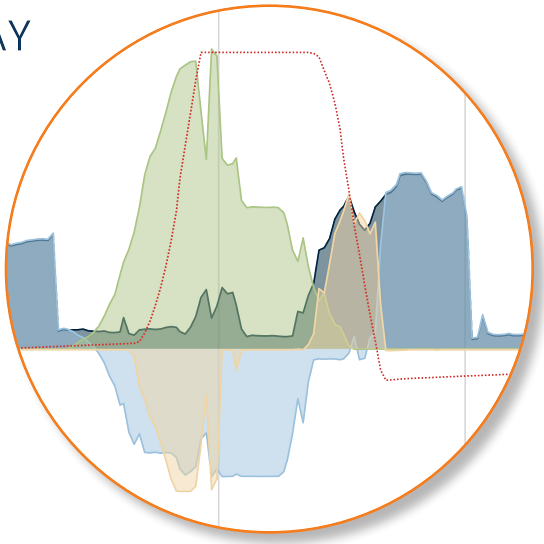
UTILITY: Littleton Water & Light

COMMISSIONED: March 2019

AVAILABLE ESS CAPACITY: 15 kW/39 kWh

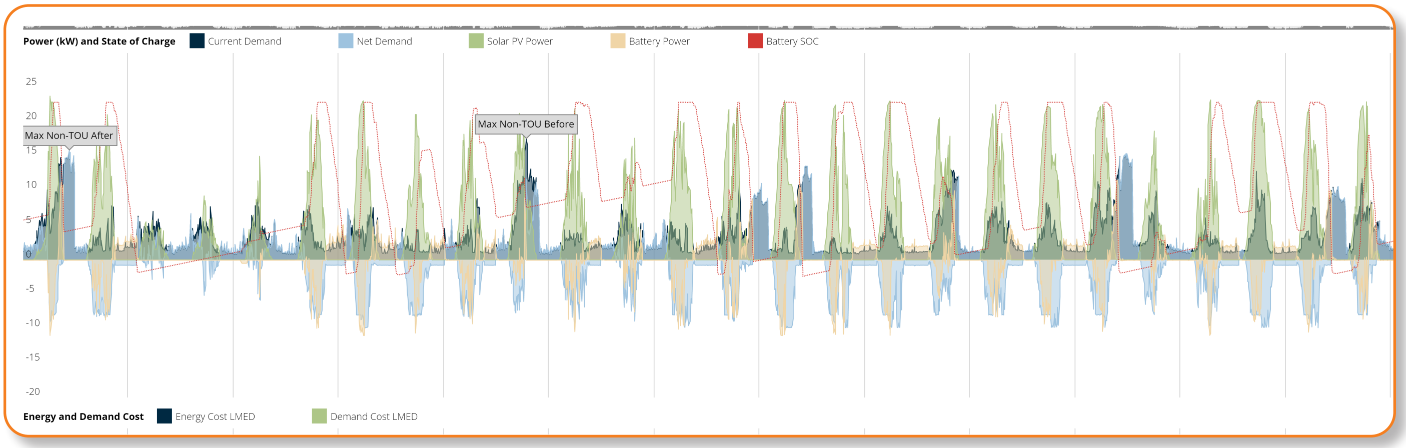
SOLAR PV CAPACITY: 22 kW

KEY DAY DATA



In self-consumption applications, ETB Controller is charging the ESS with solar in order to prevent generation from being exported back to the grid, as shown in the monthly data image (below). At 23 Ammonoosuc, the building load is smallest on weekends, when offices and classrooms are unoccupied, causing some PV to export once the battery is at a full state of charge, as shown in the key day data (above).

MONTHLY DATA



USE CASE

FRONT-OF-THE-METER ESS

Today's Power is a renewable energy development company formed by the 17 locally operated, customer-owned electric distribution cooperatives in Arkansas. A subsidiary of Arkansas Electric Cooperative Corporation, Today's Power allows its member cooperatives to offer community solar projects, energy storage systems, electric vehicle charging stations and other emerging technologies to their customers.

In June 2020, Today's Power announced a solar-plus-storage partnership with Ouachita Electric Cooperative Corporation (OECC)—one of its 17 cooperative members—and aerospace and defense company General Dynamics. Spit evenly across two sites in Calhoun County, Arkansas, Today's Power installed 2.4 MW of solar capacity to provide clean energy to General Dynamics, as well as 4.8 MW/9.6 MWh of energy storage capacity for OECC. Under the terms of the agreement, OECC leases and operates the battery systems to offset a portion of its peak demand.

In this front-of-the-meter application, OECC uses ETB Controller to dispatch the stored energy when the utility's forecasted peak is expected to occur. Using manual controls designed by Energy Toolbase, OECC can log into the ETB Monitor interface to schedule dispatch commands and override events for its ETB Controller-controlled front-of-the-meter asset. By scheduling a maximum discharge in the expected peak window, as shown in the monthly data. OECC is able to shave its systemwide peak, minimize wholesale power costs and increase grid stability, which benefits stakeholders up and down the value chain.

PROJECT DETAILS

FACILITY TYPE: Utility-controlled ESS

LOCATION: Hampton, AR

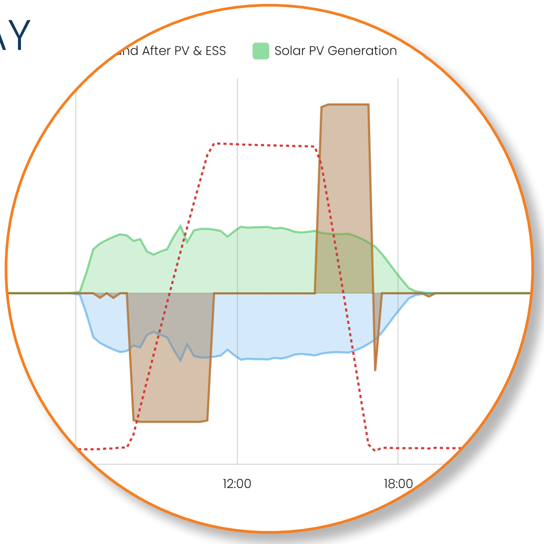
UTILITY: Ouachita Electric Cooperative Corporation

COMMISSIONED: June 2021

AVAILABLE ESS CAPACITY: 2.4 MW/4.8 MWh (at Site 2)

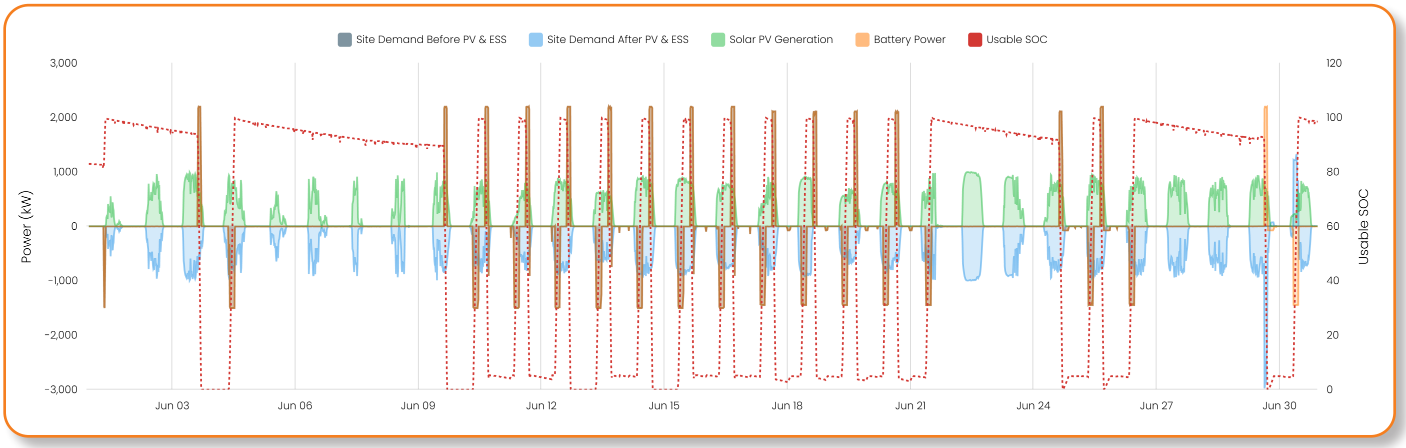
SOLAR PV CAPACITY: 1.215 MW (at Site 2)

KEY DAY DATA



OECC pays a demand charge to a larger electric generation and distribution cooperative. To reduce its systemwide peak, OECC uses ETB Controller to strategically dispatch front-of-the-meter ESS assets, as shown in the monthly data (below). The key day data (above) show a typical utility-controlled dispatch, which effectively shifts off-peak solar generation in time to offset the late-afternoon peak demand.

MONTHLY DATA



ANNUAL & FLEET-LEVEL PERFORMANCE

In the previous use cases, we see that ETB Controller performs admirably on key days and illustrative months in a variety of applications. Zooming out from these case studies, we can analyze project-level performance over a longer period of time. Additionally, we can review key performance indicators (KPIs) across an entire fleet of assets.

Annual Project-Level Performance To evaluate the performance of ETB Controller over a calendar year, we analyzed a full year's worth of operational data for American Faucet. As described in the detailed use case, the facility hosts a 29.4 kW/57 kWh ESS that is used to shave peak demand, which exceeds 400 kW at certain times of the year.

As shown in the site-level annual results table, ETB Controller with Acumen AI was highly efficient at dispatching American Faucet's on-site ESS to reduce NC demand. Looking at the bottom line, we see that Acumen AI achieved 82% of perfect across an entire year, despite a suboptimal month of performance in April, in which peak shaving was only 31% of perfect. Reviewing the monthly data, Acumen AI eclipsed 90% of perfect in six of 12 months.

The annual data set also demonstrates how Acumen's in-field performance tends to improve over time. For example, Acumen AI averaged 92% of perfect over the last five months of the year. This incremental improvement is a direct result of a longer operating history. Informed with more historical data, Acumen AI is able to make more accurate predictions and dispatch more efficiently.

Historical Fleet-Level Performance Zooming out further, we reviewed KPIs (p. 12) across the entire fleet of ETB Controller–managed ESS assets through January 2022.

In the last eight years since the platform's first pilot deployment, our ETB Controller EMS software has logged more than 1.2 million run-time hours. In applications where host customers have met our minimum Internet connectivity standards, ETB Controller has maintained an impressive 99.2% uptime. In August 2024, Energy Toolbase rebranded Acumen EMS as ETB Controller to align more closely with our brand identity and better reflect the full capabilities of our EMS. We are confident that ETB Controller, powered by Acumen AI, will continue to deliver exceptional performance and fully optimize our customers' storage assets.

The Energy Toolbase team has had to contend with a lack of uniformity in our initial deployments. As of January 2022, ETB Controller is currently deployed or contracted across 132 sites that are located in 21 US states and four countries. To date, ETB Controller has been integrated with 14 different energy storage, inverter or power conditioning system hardware vendors. We have implemented nine unique control strategies across this fleet of projects, which represents 73 MWh of storage capacity.

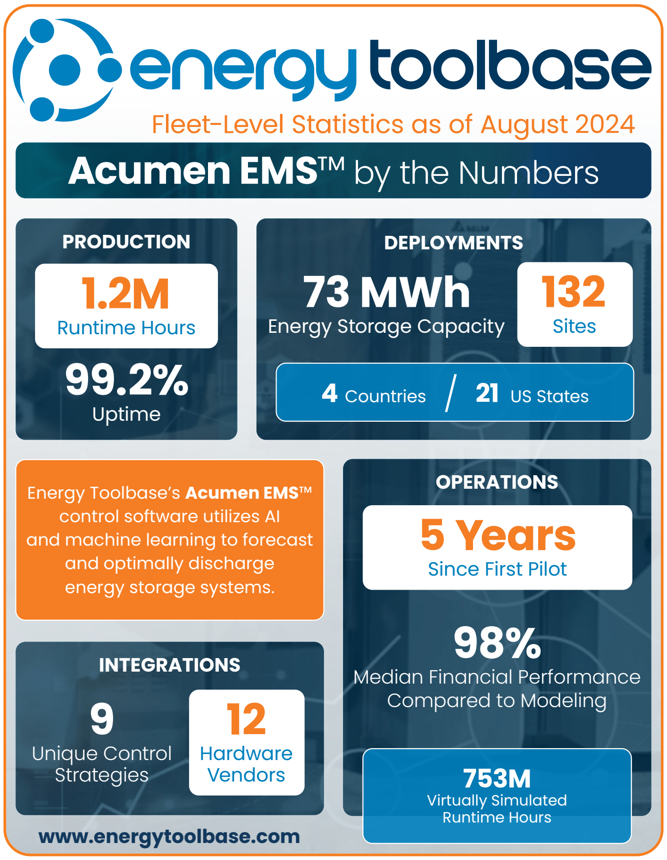
BEST PRACTICES & LESSONS LEARNED

Given this extensive and varied field experience, Energy Toolbase has learned many valuable lessons about how to mitigate operational performance risk. With that in mind, here are some best practices and pro tips to help ESS developers and host customers extract the maximum value out of an energy storage investment.

SITE-LEVEL ANNUAL RESULTS

Billing Period	NC Demand (kW)			
Month	**Before ESS**	**After ESS**	**ESS Shaved**	**% of Perfect**
Jan	326	306	20	68%
Feb	320	297	23	78%
Mar	329	301	28	95%
Apr	370	361	9	31%
May	387	359	28	95%
Jun	369	341	28	95%
Jul	377	358	19	65%
Aug	399	371	28	95%
Sep	380	352	28	95%
Oct	400	374	26	88%
Nov	376	350	26	88%
Dec	407	380	27	92%
Average	**370**	**346**	**24**	**82%**

AVERAGED OVER A CALENDAR YEAR, ETB Controller with Acumen AI shaved American Faucet's NC demand by 82% of perfect. Note that Acumen eclipsed 90% of perfect in six of 12 months and averaged 92% of perfect from August to December.



KEY PERFORMANCE INDICATORS This infographic presents KPIs for Energy Toolbase's ETB Controller software. Acumen's AI and machine learning models forecast site loads and renewable energy generation based on historical site data and dispatch fielded ESS assets for optimal financial returns.

Maximize System Uptime System reliability and availability are mission critical in energy storage applications. If hardware is not functionally available or software is offline, ESS investments will not provide the expected ROI. Qualifying and procuring the highest-reliability hardware or best-performing software is rarely the most economical path in terms of upfront CapEx. This is why savvy developers often take a pound-wise approach to improving system availability and reliability and to mitigating performance risk.

One of the most important lessons from one of our early project deployments is that ESS hardware can and will go offline for a variety of reasons. In some cases, outages result from a fault related to the power conversion system, the BMS or the battery packs or cells. In other cases, outages result from communication issues between these components. While many hardware faults are out of our control, they directly affect customer savings, which we take accountability for. Out of necessity, our operations team has become adept at remotely diagnosing errors and determining the requirements to bring systems back online at full capacity.

As the EMS software provider, Energy Toolbase takes a very hands-on approach to resolving problems, coordinating directly with hardware vendors, project developers and host customers to resolve issues. In addition to working on the frontline of projects during commissioning, our operations team is the first to respond in terms of monitoring assets and troubleshooting issues.

Reviewing key statistics from our fleet-level monitoring data, summarized here in an infographic (right), we see that ETB Controller software averages 99.2% uptime in production deployments where hosts meet our Internet connectivity requirements. This impressive statistic is partly due to the fact that ETB Controller runs locally on a ruggedized industrial computer. It also reflects our operations team's ability to quickly identify and remedy any faults and errors in fielded assets.

As a result of our extensive firsthand experience, Energy Toolbase chooses its ESS hardware partners judiciously. We encourage project developers to do the same. Given that inverter and battery failures are considerably more common and consequential than software or communications outages, simple hardware reliability improvements can materially and positively impact project returns.

Validate and Retrain the Model Because site usage patterns and utility price signals change over time, it is necessary to retrain the software model periodically to learn these new patterns. Utilities routinely make changes to rate tariffs, while NEM rules generally change over longer periods of time. Additionally, new customer usage patterns can be significant, such as the installation of new manufacturing equipment or electric vehicle chargers. From 2020 through 2022, we saw multiple examples of new usage patterns emerge due to Covid-related changes in occupancy behavior.

PRO TIPS FOR ESS DEVELOPERS

1. Optimize ESS capacity based on site-specific parameters such as load profile, rate tariff, NEM rules and available incentives.
2. Only present end customers with ESS savings and financial analyses that are validated, defensible and realistic.
3. Demand that your ESS and EMS vendors provide complete transparency into operational performance and savings.

"With Energy Toolbase, the company that models your economic returns is the same company that delivers those returns."

—Chuck Rames, Socomec

Retraining the model allows Acumen AI to holistically understand new usage patterns and avoided cost opportunities and to dispatch an ESS for optimal ROI. To ensure that Acumen AI is optimizing financial returns, Energy Toolbase conducts 3-, 6- and 12-month performance reviews for new deployments. By comparing actual system performance to the best possible performance, Energy Toolbase can adapt its control algorithms and incrementally improve economic performance over time.

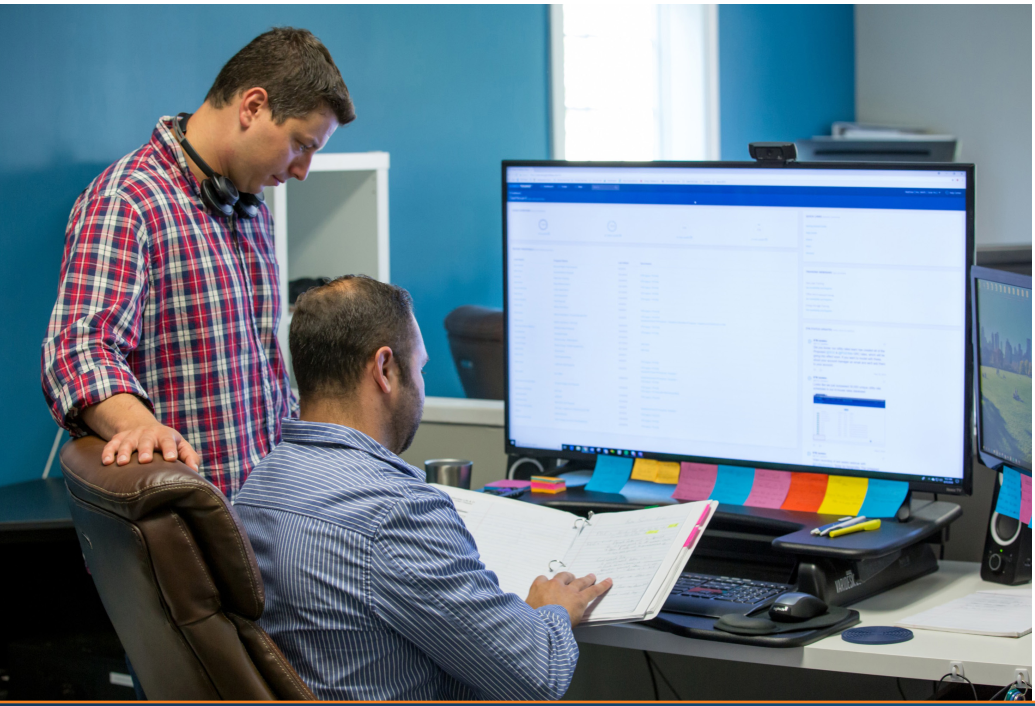
ETB Monitor serves as ETB Controller's user-interface layer. It enables developers and host customers to transparently track utility bill savings over time. This UI allows stakeholders to determine whether a decrease in savings is due to new customer usage pattens, changes in utility rate structures or suboptimal ESS algorithm performance. ETB Monitor also answers this fundamental question: How is the system performing relative to the original estimate?

In addition to verifying that systems are working correctly and meeting investor expectations, Energy Toolbase's proof process also helps users gain a deeper understanding of ETB Controller and its many capabilities. It also helps project stakeholders better understand the correlation between site loads and avoided cost opportunities. While AI is very powerful, it does not solve every problem; the best approach to some problems is a combination of machine learning and human intervention. For example, if asset owners inform us when they anticipate adding shifts or staff, Energy Toolbase can proactively take steps to make ETB Controller with Acumen AI more resilient to these changing load patterns.

Start with Quality Rate Data It is impossible to optimally monetize an ESS asset without first understanding utility rates and NEM frameworks. During the sales process, project developers rely on quality rate data to produce precise financial analyses that inform customer proposals. During project operations, AI and machine learning models rely on accurate rate data to dispatch stored energy for maximum returns.

Utility rates have been a core competency at Energy Toolbase since its founding in 2014. Today, our data team maintains a database of over 100,000 unique rate schedules globally. The data team also tracks and indexes incentive programs and detailed NEM specifications, including export rates, nonbypass charges and true-up schedules.

Having this expertise in-house provides a significant advantage. Energy Toolbase does not have to rely on third-party application programming interfaces in order to simulate ESS projects on the ETB Developer platform or to operate projects using ETB Controller. The ability to define the data structures for different types of utility billing methodologies allows our control algorithms to optimally dispatch for any type of price signal.



DOMAIN EXPERTISE Active asset management for solar-plus-storage solutions requires a unique combination of core competencies. In addition to maintaining an industry-leading utility rate database, Energy Toolbase and its parent company, Pason Systems, have expertise in real-time data acquisition at the grid edge, AI controls and industrial process monitoring, hardware integration and software development, telemetry and wireless communications—all of which are mission critical in ESS applications.

Energy Toolbase is directly responsible and accountable for the accuracy of its rates database. Our rates team is continuously improving our quality assurance and validation processes for updating rates all over the world. On average, our data team updates more than 1,000 rates per month, and supports our customers with rate-related inquiries including custom rate creation. Moreover, we have designed and standardized our data structures to be compatible with all of our products—ETB Developer, ETB Controller and ETB Monitor. This enables us to simulate and backtest to confirm that ETB Controller with Acumen AI is optimizing correctly based on current price signals.

In a presales context, comprehensively understanding utility rate structures, NEM frameworks and incentive program requirements is essential for project planning purposes and setting customer expectations. After the sale, closely monitoring utility rate updates ensures that ESS controls are optimizing for the current price signals. Furthermore, it is important to track rate-switching eligibility to ensure that customers are always on the most advantageous rate schedule.

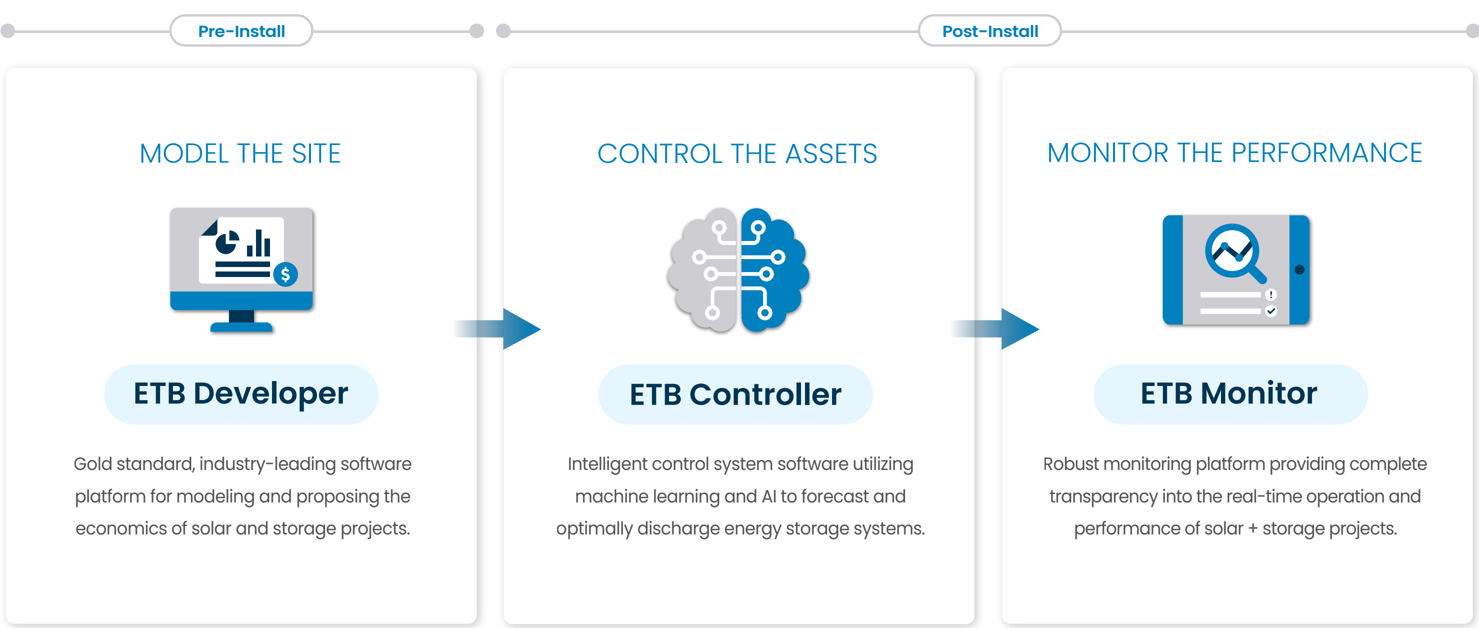
CHOOSING ENERGY STORAGE SOFTWARE

The ability to simplify complexity while maximizing ROI separates different software vendors. "If you look at all of the independent software vendors," concludes Socomec's Rames, "Energy Toolbase is at the top of the list. It has all of the capabilities you are looking for—from the rate database to the modeling software to the sales proposals to the operational engine to the monitoring platform to the customer support services. It is also backed up by a bankable balance sheet."

Energy Toolbase's Model-Control-Monitor product suite gives project developers and asset owners all of the tools required to confidently deploy energy storage projects for optimal financial performance. Our modeling capabilities and professional proposals allow developers to explain to potential customers how an ESS asset is going to produce value. Informed by a comprehensive and accurate rate database, our control capabilities dispatch an ESS to realize these savings. Last but not least, our monitoring platform empowers owners to verify that assets are performing according to the original proposal and to hold vendors accountable.

"As ESS software matures," Rames observes, "the aspiration is that the analytical engine and the operational engine are much the same. To the extent that this is the case, performance modeling is less of an abstraction and more concrete because it is based on real world operational data. With Energy Toolbase, the company that models your economic returns is the same company that delivers those returns."

ENERGY TOOLBASE'S MODEL-CONTROL-MONITOR PLATFORM



PRODUCT LINEUP Energy Toolbase offers three separate but interrelated ESS software products: ETB Developer, ETB Controller and ETB Monitor. In combination, this Model-Control-Monitor platform allows project developers to produce site-specific economic models and proposals, control fielded assets and monitor real-time solar-plus-storage system performance.

ABOUT THE AUTHORS

Adam Gerza is the vice president of business development at Energy Toolbase. He has worked in the solar-plus-storage industry for 14 years in various executive, project development and policy-related roles. Adam currently leads business development and product marketing for Energy Toolbase and serves on the board of the California Solar and Storage Association (CALSSA). He has a Bachelor of Science in finance from the University of Southern California.

Enrico Ladendorf is the vice president of technology and product operations at Energy Toolbase. He has a 20-plus-year career in software development. As the co-founder of Pason Power, Enrico was instrumental in developing Pason's original energy storage optimization algorithms that evolved to become Acumen EMS. Enrico's team is responsible for the deployment, commissioning and operational performance of fielded storage systems.

Quinn Laudenslager is Energy Toolbase's senior product manager for Acumen EMS. He has a 15-plus year career in the electrical construction industry and is a certified master electrician. Quinn has directly designed, installed and operated thousands of solar, energy storage and solar-plus-storage systems throughout the US. Quinn acts as a liaison across the product, engineering, data science and sales teams at Energy Toolbase.

ABOUT ENERGY TOOLBASE

Energy Toolbase is a pioneer in energy storage software that is dedicated to simplifying the complexity of energy storage and solar-plus-storage applications for both developers and downstream customers. Since its founding in 2014, Energy Toolbase has developed an industry-leading software platform to provide project stakeholders with a cohesive suite of project modeling, energy storage control and asset monitoring products. In September 2019, Energy Toolbase merged with Pason Power, which had been developing EMS controls software since 2016. Energy Toolbase is backed by its parent company, Pason Systems Inc. (TSX: PSI), a worldwide leader in energy data management and controls automation software.

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