

Empowering Energy Efficiency in Big-Box Retail (The Big-Box Efficiency Project)



California Senate Bill 350 aims to double statewide electricity and gas end use savings from energy efficiency and conservation measures by 2030. This is equivalent to a 20% reduction in projected statewide building energy use. Meeting this aggressive target will require the commercial building industry to install holistic energy efficiency technology packages, specifically those that leverage emerging, precommercial products.

According to the California Public Utilities Commission's [2013 California Energy Efficiency Potential and Goals Study](#), aging commercial buildings, particularly in inland communities, present the greatest energy savings potential. However, many building owners operate in a resource-constrained environment and lack the ability to perform the rigorous evaluation required to vet the technologies and technology packages that would provide deep energy savings.

The Big-Box Efficiency Project is funded by a \$2.8 million California Energy Commission grant, in partnership with Walmart, Southern California Edison, Center for Sustainable Energy and other partners, to evaluate the impacts of installing an integrated suite of precommercial energy efficiency technologies at an existing 134,733-square-foot, 24-year-old Walmart Supercenter in Southern California (Store 2292), with the goal of achieving greater than 20% savings in electric consumption at the site, in support of California and Walmart's ambitious greenhouse gas reduction goals.

For a complete analysis of the Big-Box Efficiency Project, see the [Final Project Report](#), available on the project website.

Site Characteristics

Walmart Supercenter 2292 sits between the I-210 and I-10 freeways in Los Angeles County, just south of Azusa, in California Climate Zone 9. It includes standard retail space with several in-store centers including auto care, photo, vision, garden and pharmacy and a grocery sales area with a deli and bakery and a McDonald's restaurant. Originally constructed in 1997 as a standard Walmart, it was renovated to a supercenter in 2010, adding the grocery section.

A 500-kW-AC solar photovoltaic (PV) system was installed in 2007 to help reduce electric consumption from the grid. The PV panels cover about 60% of the roof's surface and generate about 867,437 kWh annually. Battery storage was installed in 2019 using Tesla's Powerpack 5.3 model. It has a 300-kW power rating and a 510-kWh energy capacity. While combining on-site PV with battery storage was not directly incorporated into this project due to contractual limitations, a future iteration of this project could integrate on-site generation and storage to further expand upon grid-interactive capabilities and associated demand reduction savings.

Energy Efficiency Measures

Walmart Supercenter 2292 was outfitted with energy efficiency measures (EEMs) and evaluated in conjunction with existing solar panel production to evaluate system performance, market viability and energy savings.

Prior to the installation of the EEMs, Walmart 2292 consumed 3,447,959 kWh/year in electricity, with the annual peak in summer months to meet increased cooling loads. After installation, electric use is forecasted to be reduced by 20.36% percent by project installed measures, with an additional 9.87% savings from unidentified end uses and 2.12% in potential savings from DC lighting, for a gross site total savings of 32.35%.



Project Facts

Project Site Walmart 2292 Covina, CA

Timeline Q1 2018 – Q1 2022

Savings Goal > 20% electric energy savings

Actual Annual Project-Attributable Savings 20.36% electric energy savings
701,913 kWh/year saved
\$110,902 electric consumption savings

Project Team

Funders California Energy Commission
Southern California Edison
Walmart (site host)

Project Management Center for Sustainable Energy

Modeling National Renewable Energy Laboratory

Design P2S Inc.

General Contractor TRC

Installation Emily Grene

Commissioning DAVenergy Solutions

M&V Center for Sustainable Energy

Technology Partners i2Systems
Turntide
Saya Life
Integrated Comfort Inc.
Locbit

System Design & Performance

Five different precommercial technology EEMs were evaluated through this project.



DC-Ready LED Lighting

The store's existing fluorescent lighting fixtures were retrofitted to DC-ready light-emitting diodes (LEDs) manufactured by i2Systems. DC lighting has the potential to save an additional 4-8% in electricity over traditional AC LED fixtures.



HVAC and Refrigeration Smart Motor System

Turntide's Smart Motor System replaced the existing supply fan motors across 28 rooftop units. Additionally, the six refrigeration condensers serving the medium- and low-temperature refrigeration systems were retrofitted with 24 smart motors. These smart motors feature advanced controls and analytics to improve savings and operations.



Direct and Indirect Evaporative Cooling

Integrated Comfort's DualCool system pre-cools air coming into the HVAC system to reduce energy use in HVAC units by approximately 20%. This was coupled with Saya's Smart Water System to optimize the trade-offs between saving energy and increasing water usage in heating and cooling.



Smart Water Management System

Saya Life's Smart Water Management System assessed water use for heating and cooling the store.

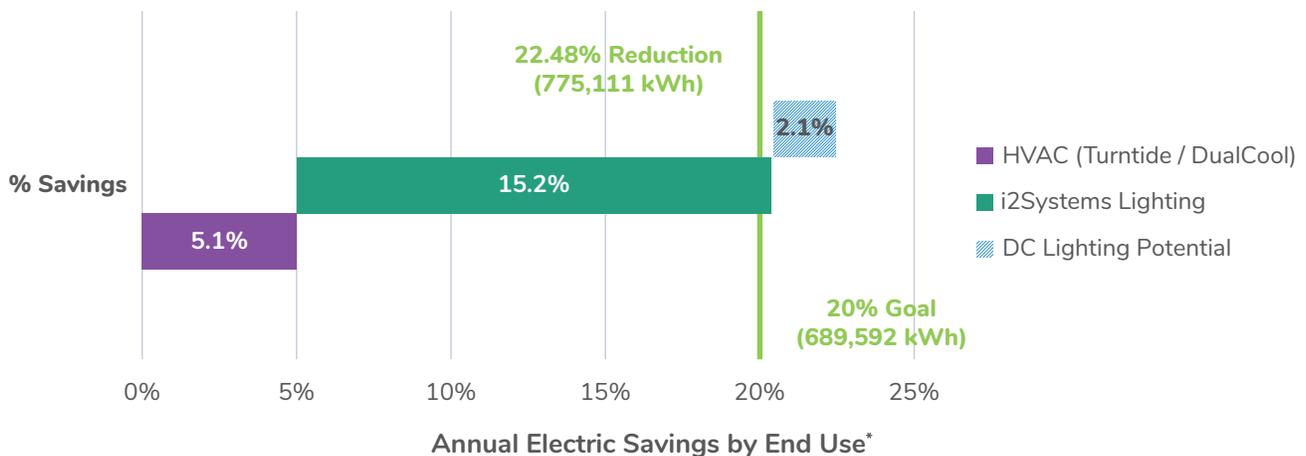


Locbit Internet of Things Platform

This cloud-based platform integrated all data from the different energy efficiency technologies and building control system.

The following graph shows how the installed measures exceeded the reduction goal.

Breakdown of Annual Electric Savings by End Use



*Saya Life's water management system did not have any anticipated electric savings but was used to evaluate water consumption by the ICI DualCool technology. While Locbit was able to integrate data from all partners on the project, due to delays in the integration of the Walmart legacy control system, Locbit did not contribute any savings during the M&V period.

Project Results

Energy & Emissions Savings

From the installed technologies (lighting and HVAC measures), Walmart 2292 is forecasted to save 701,913 kWh/yr., \$110,902 in electric consumption costs per year and 300.4 mtCO₂e in displaced greenhouse gas emissions. An additional 73,198 kWh/year (\$11,565 in costs and 31.3 mtCO₂e) would be saved from fully realizing the DC lighting potential. The table below summarizes the key savings from the project.

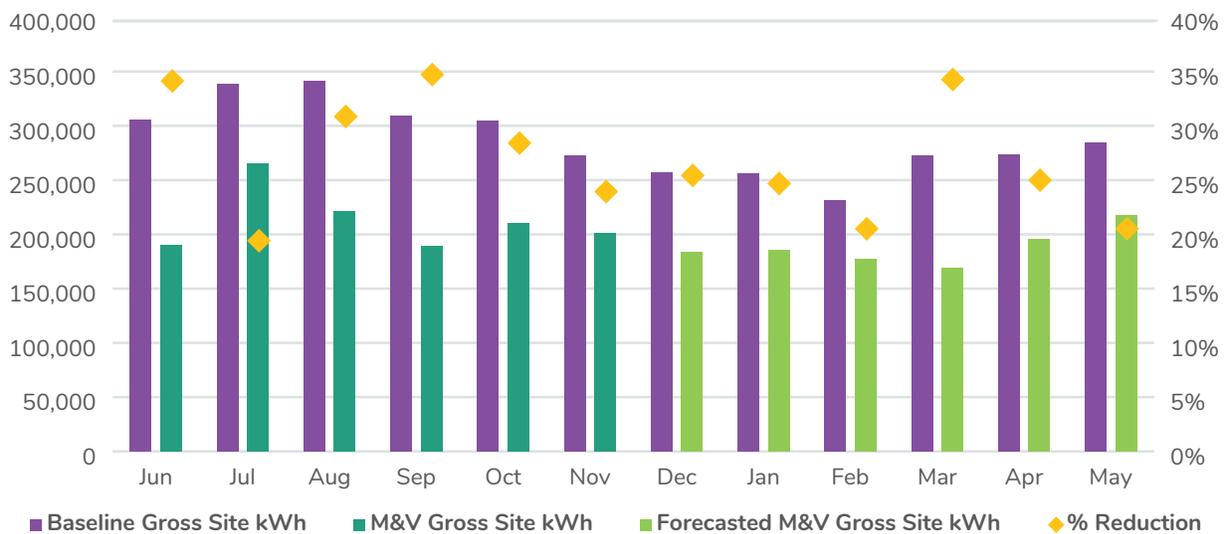
Walmart Supercenter (Store 2292) Estimated End-use and Gross Site Electric Savings

Efficiency Measure	NREL Estimated % Reduction	NREL Estimated kWh Reduction	M&V Forecasted % Reduction	M&V Forecasted kWh Reduction
Locbit IoT Platform	1.90%	64,405	-	-
i2Systems Lighting	10.90%	374,726	15.22%	524,737
HVAC (Turntide / ICI)	8.90%	306,035	5.14%	177,176
DC Lighting Potential	-	-	2.12%	73,198
Unidentified End Uses	-	-	9.87%	340,364
Gross Site Total	21.70%	745,166	32.35%	1,115,475

The chart below details the monthly site electric consumption and PV production during the measurement and verification (M&V) period (June 2021 – May 2022) as compared to the baseline year (February 2017 – January 2018).

Monthly Gross Site kWh & % Reduction

Whole - Building Baseline (Feb 2017 - Jan 2018) vs M&V Period (June 2021 - May 2022)



In addition to the savings listed, the project team evaluated the water consumption required per kWh savings for the DualCool evaporative pre-cooling technology. On average, it took 0.13 gallons of water per kWh saved, which was below the project’s goal of 3.4 gallons consumed per kWh saved.

Cost Savings

The following table shows the cost per measure, technology and the total engineering and construction costs. Installation of each technology requires design engineering, permitting and a licensed contractor to complete. Overall costs are best shown with the entire suite of technologies for a comprehensive project because that is the most cost-effective way to approach deep holistic energy savings as demonstrated by the Big-Box Efficiency Project.

Overall, the payback period for the project was 16.23 years in Covina, CA. In other areas with higher electricity rates, such as SDG&E, the project would have a lower payback period. However, the project team anticipates that project financial performance could be significantly improved in future iterations of the project as certain aspects of the project did not show savings in the demonstration at Store 2292 but could show savings in future project iterations, such as with Locbit's IoT platform and Turntide's refrigeration motors. Additionally, when these precommercial technologies move toward commercialization and scale, costs potentially could be reduced further.

Project Category	Total Category Cost	Total Category Cost Savings per Year
HVAC	\$176,980	\$27,994
Technology - ICI DualCool	\$59,576	
Technology - Saya Water Meters	\$50,080	
Technology – Turntide Smart Motors	\$67,324	
IoT	\$101,304	\$0
Technology - Locbit IoT	\$101,304	
Lighting	\$593,652	\$82,908
Technology - i2Systems Lighting	\$593,652	
Refrigeration	\$148,087	\$0
Technology – Turntide Smart Motors	\$148,087	
Engineering & Construction	\$779,685	\$0
Commissioning	\$47,600	
Construction (MEP)	\$352,372	
Design	\$110,660	
General Contracting	\$264,677	
Permit Fees	\$4,376	
Grand Total	\$1,799,707	\$110,902

Conclusions

Key Successes

The Big-Box Efficiency project achieved 20.36% reduction in electric energy consumption at Walmart 2292, for a total of approximately 701,913 kWh/year and \$110,902 in estimated direct electric consumption charge savings a year.

Lessons Learned

The path to California SB 350's goal of doubling statewide electricity and gas savings by 2030, equivalent to a 20% reduction in projected statewide building energy use, still has many opportunities for growth. The lessons and findings from this project can better inform future deep energy savings retrofit projects. Lessons learned from this project include the following.

System Submetering

Due to budget and technical constraints, HVAC units were submetered at the panel level, which did not provide granularity on a unit-by-unit basis. With additional budget, submetering could be performed at an individual HVAC unit level. Additionally, since there were some units that received both the DualCool and smart switch reluctance motor technologies, the project had to evaluate the combined effects of these measures.

As subsequently noted, in future iterations of the project, it is recommended that any submetering systems (e.g., DENT submeters) have data recovery features that are accessible remotely, versus having to be recovered on-site.

i2Systems DC-Ready LED Lighting

i2Systems created an innovative, brand-new AC/DC autosensing light fixture for this project in less than a year. In the implementation phase, i2Systems identified lessons learned in four main areas.

- ▶ **Mechanical Fit** — i2Systems didn't account for an interference with the fit of their fixture. Once i2Systems realized the issue, they made an accommodation in the housing design.
- ▶ **Red Indicator Lights** — In certain situations, the i2Systems fixtures were signaling a fault even when one did not exist. This was due to an over sensitivity in the circuit design that caused false failures to be reported in the system.
- ▶ **Balancing of Circuits in the Store** — In a few circumstances, the original electrical wiring in the store couldn't accommodate the draw of the i2Systems fixtures as configured, requiring a change in the number of fixtures per circuit.

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“The Center for Sustainable Energy has collaborated with Walmart every step of the way in a demonstration project to help validate the savings potential of precommercial energy efficiency technologies. We value CSE's deep expertise and experience in guiding the project and identifying key lessons that can be applied to similar projects as we work toward a zero-emissions future.”

—Bob Stone,
Senior manager,
Renewable Power &
Energy Efficiency,
Walmart Energy

- ▶ **Signal Propagation** — Initially, i2Systems had some instances of the wireless signal not propagating properly and fixtures not reacting to commands; however, i2Systems was able to make firmware modifications to correct this.

ICI DualCool Evaporative Pre-Cooling

While the installation itself was straightforward for ICI, the following would have reduced issues found in the commissioning of the systems.

- ▶ Ensuring each HVAC unit receiving DualCool retrofit was level pre- and post-install and confirming the roof could accommodate the extra weight.
- ▶ Conducting pre-project “commissioning” of HVAC units receiving retrofits to ensure the units operated correctly. A few existing HVAC units had economizer dampers requiring repair in order to realize the full savings from the DualCool technology.

Saya Smart Water Management System

One issue was that the original iteration of Saya Life water meters were not waterproof and required an in-field solution. Saya Life now has IP68 water meters rated for outdoor use.

Additionally, Saya Life had to adjust for a 5V power requirement for their water meters by installing low voltage wiring in conduits.

Turntide Smart Switch Reluctance Motors

Turntide encountered the following issues with implementation of their technology and implemented a robust root cause analysis and corrective process.

- ▶ **Site Connectivity** — The original RMK (antenna) design encountered communication dropouts , requiring new equipment to reduce the problem.
- ▶ **Modbus Communication** — A firmware flaw was discovered related to RS-485 Modbus communication and was corrected with newer firmware.
- ▶ **Motor Controller Reliability** — A high number of P04 motor controllers for the V01 series motors failed, leading to development of a next generation motor controller.
- ▶ **RTU Motor Noise** — An unacceptable level of motor noise was emitted in the retail space from Turntide’s V02 motor series. Noise isolating motor mounting feet were installed.
- ▶ **Condenser Fan Motor Noise** — At certain motor operating frequencies, an unacceptable noise level came from the condenser rack. Problematic operating frequencies are now being “skipped.”

Post-project, Turntide is continuing to work with the Walmart team to monitor the installed motors to ensure any remaining communication and noise issues are identified and promptly resolved.

Locbit Internet of Things Platform

Due to delays in the integration of the Walmart legacy control system (NOVAR) into the Locbit platform, Locbit was unable to propose specific triggers and corresponding energy saving actions and did not contribute savings during Q1-Q3 of the M&V period. This was due to a combination of factors, including the following.

- ▶ Locbit did not have full direct control of Walmart’s legacy control system (read-only access), so it could not automatically adjust setpoints.

- ▶ Many data points in Walmart’s legacy system weren’t clearly labeled by subsystem (e.g., sensor says Sensor 1 HVAC instead of Sensor 1 RTU 8).
- ▶ Locbit’s team faced staffing challenges during the COVID-19 pandemic, which delayed integration of the NOVAR system.

The system did provide non-energy benefits through fault detection and diagnostics, such as allowing visibility when the on-site solar generation went offline and identifying when there were communication issues with any installed technology.

One key lesson learned is to vet cybersecurity requirements and integration requirements upfront to ensure that the provider can meet the site hosts’ security requirements and vetting process in order to fully integrate into existing legacy systems on the site hosts’ internal network.

Another key lesson is that if energy savings are to be based on data from a legacy control system’s sensors, then it is imperative that the system’s data is accessible to the IoT platform and is usable, in that all components of the legacy control system can be accessed using current communications protocols.

Finally, in selecting an IoT platform for future projects it is important to consider the project needs such as dashboards, M&V requirements for proving savings for incentives and adequate data, communication and computing infrastructure to support multiple communication protocols and quickly resolve issues when integrating into existing systems.

Next Steps

Walmart is committed toward its goals of being 100% renewable by 2035 and achieving zero emissions across global operations in 2040. Walmart will be leveraging the findings of this project in several ways:

- ▶ **Lighting**
Walmart is looking at how new lighting products, like i2Systems DC-ready LED lighting, can be aligned with current LED end-of-life cycles to streamline the timing of upgrades. Walmart is working with i2Systems to further test their products in a store in Florida.
- ▶ **Smart Switch Reluctance Motors**
Walmart will continue to work with Turntide to monitor operations at Store 2292 to ensure communications issues with the supervisory controllers are resolved. They are also working on doing additional testing with other units at other Walmart stores.
- ▶ **Smart Water Meters**
Walmart is exploring the opportunity to further expand on smart water meter testing by exploring the ability to measure mineral content in blowdown and the possibilities for on-site water reuse.
- ▶ **Evaporative Pre-Cooling**
ICI’s DualCool evaporative pre-cooling technology has been installed in over 280 Walmart stores across the United States. Walmart and ICI are in talks on how to further leverage the data from the DualCool performance to further drive savings in its stores.
- ▶ **Internet of Things**
Over the past few years, Walmart has developed an in-house Internet of Things team that is working on taking the findings of demonstration projects like Store 2292 to further streamline data integration from various building system vendors at Walmart stores.

› **Battery Storage Interconnection to DC Loads**

Based on the findings of this project, Walmart will have conversations with battery energy storage manufactures to better understand battery technology and how they can integrate the technology at stores with solar and DC-based building loads (like lighting), with the ultimate goal of achieving a building that can be self-sufficient with on-site energy generation and storage, increasing power reliability and resiliency.

› **Future Research Opportunities**

Walmart is open to exploring additional research opportunities to further drive building energy efficiency savings, increase store resiliency and look toward the future of on-site distributed energy resources, demand response and electric vehicle-to-grid integration.

For more information visit
EnergyCenter.org/bigbox



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