Walmart EPIC

EPC-17-008

BASIS OF DESIGN REPORT

FINAL SUBMITTAL

P2S ENG

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INTRODUCTION

The scope of this project includes the integration of several pre-commercial energy efficiency technologies to an existing Walmart Supercenter located in Covina, CA. The primary goal of the project is to demonstrate the ability of these pre-commercial technologies to deliver electricity savings of 20% or greater. The energy efficiency technologies will include upgrades to several systems with pre-selected technology partners and vendors.

- Mechanical HVAC systems
    - Integrated Comfort Inc. (ICI): Evaporative outside air and condenser inlet air pre-cooling
    - Software Motor Company (SMC): Smart DX rooftop unit controls and switched reluctance motor replacement
        - Note: as of July 2020 SMC rebranded their name to Turntide Technologies. For the purposes of this document, the SMC reference will remain to maintain consistency of current project documents with previously submitted documents.

- Water monitoring system
    - Saya: Water consumption monitoring and water leak detection for ICI Evaporative pre-cooling system

- Lighting systems
    - i2 Systems California: Auto Switching AC/DC LED lighting fixture replacement.

- Refrigeration systems
    - Software Motor Company (SMC): high efficiency switched reluctance condenser fan motor replacement.

- Central building level cloud control system for monitoring data for all above systems and energy optimization.
    - Locbit

The successful implementation of these technologies will serve as a case study for other similar facilities in California to also consider similar strategies to achieve similar results. In addition to the energy savings benefits, the project will also evaluate how the technology upgrades affect human comfort, building operational efficiency, water consumption and maintenance costs.

This Walmart site already has several energy efficiency systems on site, including a rooftop PV system and recently installed a Tesla battery energy storage system (BESS) sized for peak shaving. The EPIC project M&V will ensure separation of the actual impact of the EPIC project measures.

MECHANICAL HVAC SYSTEMS

Rooftop units (RTUs) are the most common types of mechanical system installed in large commercial buildings since they are inexpensive, require minimal engineering design and are easy to install. However, due to their low cost, they generally just meet code minimum requirements for energy efficiency and often have inexpensive components that frequently need to be replaced, which leads to higher maintenance and energy costs. Building owners therefore typically want more efficient systems, but it does not make financial sense to replace existing RTUs before their useful life of 15-20 years has been reached. There are several newer technologies now available to improve the efficiency of existing RTUs.

The design of the HVAC system shall include the integration of several pre-selected energy-efficiency technologies to the existing rooftop units (RTUs) and associated dedicated outdoor air handling units (AHUs). The mechanical upgrades will address the overall objective of improving the energy efficiency of the existing building while also maintaining a comfortable environment for occupants, minimizing maintenance costs, and preserving the operational efficiency of the business. One of the technology upgrades will be a retrofit evaporative pre-cooling system installed at four of the existing RTUs and the two existing AHUs, which will include the addition of water meters to monitor water use of the evaporative cooling systems. The RTUs selected for evaporative pre-cooling are units already dedicated for building IAQ. The evaporative cooling system, water meters, and existing RTUs and AHUs will be integrated into an overall building control system to monitor, control and optimize energy usage. The HVAC system additions will provide heating, ventilation, and air conditioning in conformance with applicable codes and specific requirements of the design criteria.

Applicable Codes

1. California Building Standards Administrative Code (Title 24, Part 1), 2019
2. California Building Code (Title 24, Part 2), 2019
3. California Mechanical Code (Title 24, Part 4), 2019
4. California Plumbing Code (Title 24, Part 5), 2019
5. California Energy Code (Title 24, Part 6), 2019
6. California Fire Code (Title 24, Part 9), 2019
7. California Referenced Standards Code (Title 24, Part 12), 2019

Reference Standards and Guidelines

1. ASHRAE Standard 52.2-2012
2. ASHRAE Standard 62.1-2016
3. ASHRAE Standard 55-2016
4. SMACNA
5. UL: Underwriters Laboratories, Inc.

HVAC Climate Design Conditions

1. Project Location: Covina, CA
2. Latitude: 34.102525°
3. Longitude: 117.9094°
4. Elevation: 575 Feet
5. CEC Climate Zone: 9

The technology upgrades will be sized in collaboration with the technology partners considering the statistical weather data from the California Energy Commission's 2016 Joint Appendix 2 (JA2) for Covina, CA. The summer design conditions will be based on the 1% Design Conditions and the winter will be based on Winter Median of Extremes.

	Summer	Winter
Ambient Design Temperature:	95°F / 69°F (dB / MCwB)	29°F

Evaporative Pre-Cooling System

The building is served by 27 existing packaged rooftop units (RTUs) and 2 existing 100% outside-air air-handling units (AHU's). The RTUs consist of a DX cooling coil, gas heating section, and supply fan. The AHUs consist of supply fan, DX cooling coil, and gas heating/reheat section to allow cooling and heating of outside air and to serve as the building's main dehumidification units. The 2 AHU's and the 4 primary RTUs equipped with CO_2 sensors serving the main retail area will be supplied with a retrofit evaporative cooling system called DualCool as manufacturer by Integrated Comfort Inc. Water will be piped from the building's main cold-water supply line to each of the 4 RTUs and 2 AHUs. The DualCool system essentially acts as a miniature cooling tower by supplying water over an evaporative media section attached to the condenser intake to pre-cool the condenser air. The water cools as it passes over the media and is then pumped to a coil that is attached to the outside air intake, which pre-cools the outside air. The water continues back to the condenser section and the cycle repeats. The DualCool system consists of the following components:

- Direct Evaporative Condenser Pre-Cooler.
    - This is a stainless-steel enclosure that is attached to the condenser air intake section of the RTU or AHU. The enclosure contains the direct evaporative cooling media and an integrated water reservoir, as well as a submersible pump that pumps the water through the system. This component of the pre-cooling system cools the air entering the condenser while also cooling the water that will be used in the outside-air cooling coil.
- Outside Air Cooling Coil.
    - This is a water coil that is attached to the outside air intake section of the RTU or AHU. Cool water is pumped through this coil from the reservoir to pre-cool the outside air. The water warms up as it travels through the coil, where it then flows to the distribution pipe at the top of the evaporative media section.
- Bleed System.
    - This system limits the concentration of hard minerals by draining water out before minerals can build on the media and in the coil. The bleed rate is determined in the field by measuring the hardness content of the supply water. A filter upstream of the bleed valve protects the system against clogging, and the filter needs to be cleaned regularly.
- Controls.
    - A thermostat is supplied with the system, which activates the DualCool pump when the outdoor air temperature exceeds a preset value. The evaporative cooling system will be locked out when the ambient air dewpoint exceeds 58°F, which will help avoid increased latent loads from bringing in ventilation air with high moisture content.
    - Typical changeover value to operate DualCool may be 70°F, however exact controls sequences and setpoints must be tested for this specific site condition to ensure proper operations and prevent buildup on the evaporative media.

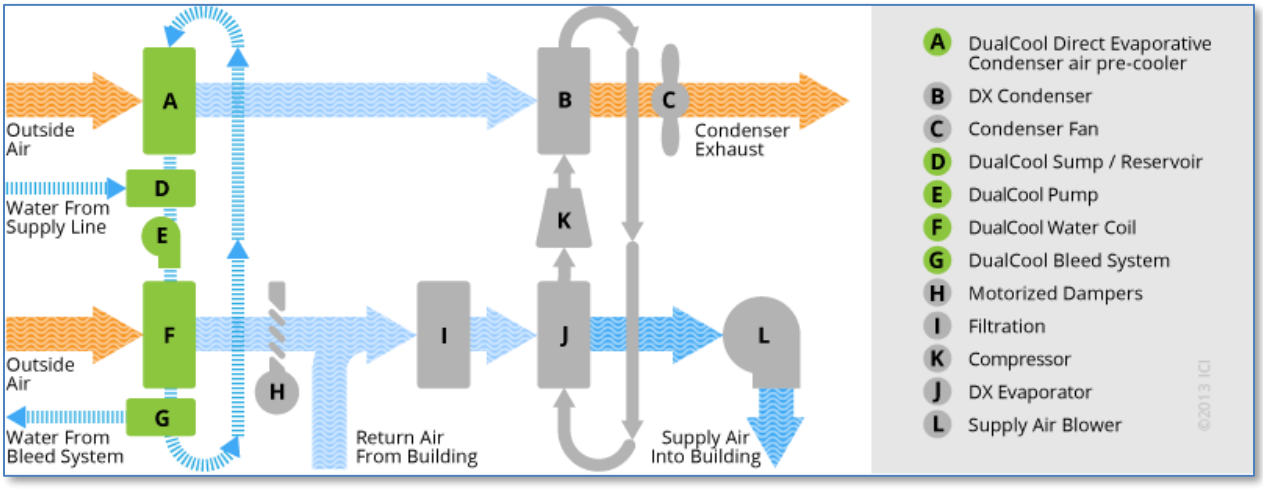

Figure 1: Evaporative System Schematic Diagram

The DualCool system will require minimal electric power for the circulation pump, and water to be consumed for both evaporation and bleeding. SCE report ER13SCE1040 estimates approximately 3.4 gallons of water may be used to save 1 kWh. The report also indicates up to 2.76 gallons of water is required to generate 1kWh of energy, therefore the net total water consumption is lower than what will be measured at the site. This project's site conditions and results will vary.

Smart RTU and AHU Retrofits and Controls

All of the existing RTUs and AHUs will be retrofitted with switched reluctance motors and smart control systems to help reduce energy usage, as manufactured by Software Motor Company (SMC). Some of the existing RTUs and AHUs have constant speed supply fans, which waste energy as the fans run at full speed even during part-load conditions. Other units have multi-speed fans which may or may not be operating in multi-speed mode. The smart retrofit solution shall upgrade each of the following areas of the existing RTUs and AHUs:

- Provide variable speed operation to the supply fan motor by replacing existing motor with switched reluctance motors. Fan speed to modulate to maintain supply air temperature setpoint. Energy savings for this component may result in 60% or more in energy savings.
- Update and commissioning economizer controls for fixed dry-bulb economizing logic and monitoring outdoor air humidity levels to avoid introducing unnecessary moisture into the space.
- Maintain the store's demand control ventilation logic, which is limited to four (4) units serving the retail sales area. Purpose of this system is to maintain IAQ for overall store. Coordinate operations of these units with Evaporative Pre-Cooling system to minimum energy use impact if these units need to increase ventilation during non-economizer hours.
- The previously mentioned DualCool evaporative cooling system will also be controlled by the SMC system to maximize RTU and AHU efficiency.
- Smart RTU and AHU controls will coordinate with Locbit energy optimization for temperature reset of up to 2°F after business hours. Coordinate with Walmart required for final reset schedule.

WATER MONITORING SYSTEM

Although the DualCool system will result in kW demand reduction and an increase in energy savings, a significant amount of water will be used to run the evaporative cooling system. A water consumption monitoring system, as supplied by Saya, will be installed to provide water consumption data for each of the 4 RTUs and 2 AHUs planned to have the DualCool evaporative pre-cooling systems installed. This data will be utilized by the RTU and AHU controller and central energy optimization systems to maximize overall system efficiency. Evaporative cooling system will operate only when payback can be realized. The data may also be used in a fault detection capacity to determine if the water usage is reasonable for the given conditions.

The water meters shall be ultrasonic type flow meters with integrated pressure sensor that will provide data to single gateway. This system will consist:

- One water meter on the main water line serving the RTUs
- Two water meters at each RTU and AHU equipped with DualCool: one on the supply line one on the bleed-off line at each unit. The differential reading is the amount of water evaporated. Flow meters may be installed outdoors with weather cover.
- The information from all the meters will be sent via one gateway back to the Locbit central energy optimization system for trending, monitoring and controlling water usage. Gateway to be installed indoors or in area able to maintain manufacturer's operating temperature range.
- Communications to central Locbit building control and optimization system will be through available 4G/LTE wireless network to Saya's cloud-based network, then transmitted back to local control systems. Direct connection to local controls and proposed Locbit Energy Optimization system is currently not available.

Figure 2: Flow Meters

Figure 3: Data Gateway

REFRIGERATION SYSTEMS

The building has six existing refrigeration systems that serve the cooling needs for the various refrigerators, freezers and walk-in coolers in the building. The systems consist of vertical scroll compressor racks located indoors and air-cooled condensers located on the roof. Refrigeration systems in supermarkets account for a significant portion of overall energy usage, so substantial savings can be realized by increasing the efficiency of these systems.

Refrigeration Racks

The main upgrades to the refrigeration rack systems will include:

- Replacement of the existing air-cooled condenser fan motors with switched reluctance motors, as manufactured by Software Motor Company (SMC) – see Smart RTU Retrofit and Controls section above for additional information on SMC motors. Condensing fan motors will continue to be controlled for head pressure by existing refrigeration control system.
- Refrigeration system will coordinate with Locbit energy optimization system for walk-in freezer system temperature reset during non-business hours may be allowed up to 2°F after business hours. The acceptable period to be confirmed with Walmart, however this period is assumed to be between 1AM and 5AM.

LIGHTING SYSTEMS

With lighting systems shifting towards controllability and efficiency, light emitting diodes LEDs have emerged to be the main light source in the commercial lighting market. In the past, LEDs were limited to applications such as traffic signals, exit signs, automobiles and electronics. Today's LEDs are more efficient and longer-lasting, allowing for growth into areas long dominated by more traditional light sources. LEDs are solid state light sources that are resistant to vibration and offer significantly longer operating lifetimes than most other sources while using much less energy than fluorescent and incandescent type fixtures.

The proposed lighting upgrade will involve retrofitting the existing fixtures from linear fluorescent fixtures to LED fixtures. The project will replace approximately 1050 8ft fluorescent fixtures with 2100 4 ft LED fixtures serving the Retail Sales floor and the common back of house areas, including the stock room and circulation areas to the employee breakrooms/offices/restrooms. Retrofit fixtures will be carefully chosen with high color rendering index values for better color consistency and with efficient diffused lenses for reduced glare. The lighting upgrades will also improve visual acuity by providing higher perceived brightness throughout the space.

DC Ready Fixtures

The planned lighting installation at Walmart in Covina will be with a DC ready LED lighting product developed by i2 Systems. This lighting product uses a hybrid approach with an LED driver that automatically detects whether incoming power is 277 VAC or 380 VDC and switches to drive the LED based on the incoming current. This approach allows for a retrofit solution that can be broadly implemented with minimal changes to existing electrical distribution wiring in Walmart's stores, while maintaining future compatibility with DC based electrical distribution systems that could be installed with Solar PV and/or Energy Storage Systems.

The lighting fixtures will be powered from the existing AC voltage electrical infrastructure already present in the store. To demonstrate the DC capability of the lighting product and the benefits of a DC lighting system, one area of the store, the "Grill Center" will be retrofitted to DC electrical distribution.

- The light fixtures in this area will be powered by an AC to DC power rectifier supplied by the i2 Systems. The voltage converter will be powered by the AC voltage infrastructure that already serves the store's lighting system.
- The installation will allow the project team to monitor this demonstration area to determine the energy input to the DC lighting in Watts-DC, the conversion efficiency of the rectifier, and confirm that the lighting product provides the required illuminance when operating on DC voltage.
- This data will be used to estimate the potential savings resulting from all lighting in the store being powered from a DC bus that is energized by a battery energy storage system or other DC source.

Lighting Controls

The drivers used can switch from incoming AC or DC power, allowing the results from the demonstration area to be directly compared to the same lighting product operating in other areas of the store and extrapolated to demonstrate the savings and advantage of a storewide DC lighting system.

The lighting system will be controlled by the existing Walmart Novar executive building control system. If the lighting fixtures will connect directly to the Novar system, the integration shall meet Walmart

information technology security standards. The lighting fixtures will communicate with each other through a Bluetooth wireless mesh network, with hard wired controls only required for final connection to control system. Lighting controls will uniformly dim all retail sales floor fixtures to approximately 60% of normal foot-candle levels after business hours. The retail sales floor lights need to support store stocking and maintenance activities after hours, therefore they cannot be dimmed further or shut off completely.

Lighting Design Criteria

Horizontal and vertical foot-candles will meet, improve or exceed those specified for retail lighting as stated in the Recommended Practices for retail lighting provided by the IESNA (Illuminating Engineering Society of North America) and per Walmart design guidelines. By being point sources, LED light sources perform especially well in areas where specific products are highlighted.

Space Type	Color Temperature	Vertical Foot Candle Level	Horizontal Foot Candle Level @ 3 ft above finished floor
Standard Retail Area	3500K	25 F.C.	60 F.C.
Grocery Sales Area	3500K	TBD	TBD

Applicable Codes

The codes and standards listed below are minimum requirements.

- California Building Standards Administrative Code (Title 24, Part 1), 2019
- California Building Code (Title 24, Part 2), 2019
- California Electrical Code (Title 24, Part 3), 2019
- California Energy Code (Title 24, Part 6), 2019
- CALGreen Building Code (Title 24, Part 11), 2019
- California Fire Code (Title 24, Part 9), 2019
- California Referenced Standards Code (Title 24, Part 12), 2019

Reference Standards and Guidelines:

- UL: Underwriters Laboratories, Inc.

Figure 4: LED Retrofit Lighting Fixtures

ENERGY OPTIMIZATION SYSTEM

All the energy efficiency upgrades and technologies will be tied back to a cloud-based control system accessible through authorized local, remote, and mobile devices. The control system will monitor all connected building systems and detect energy waste, equipment malfunctions and other operational problems using a fault detection and diagnostics engine. The system will then recommend setpoint adjustments to operating equipment to achieve increased operating efficiency.

- The system will dynamically provide suggested setpoints for the building's electrical and mechanical system parameters to meet changing environmental conditions and operational requirements which will lead to substantial energy savings and operational cost reduction.
- The system shall be compatible with all the technologies proposed in this project and with existing building systems.
- The system shall provide graphical data visualizations for identified electric utility end uses for easier understanding of Big Data collected.
- Where the individual systems are to remain in local control of their functions, i.e. the Smart RTU control system or existing legacy building systems, the Energy Optimization system shall still be able to provide actionable fault detection and diagnostics reporting to the building maintenance staff.
- The system shall communicate with the building's existing NOVAR building management system and lighting control system to achieve actual setpoint changes in the operating equipment. This integration is expected to be customized to the specific building configuration requirements. All recommended resets will require Walmart authorization for implementation through the NOVAR building management system.
- System will communicate to the cloud through 4G/LTE wireless gateway to maintain Walmart data security protocols.

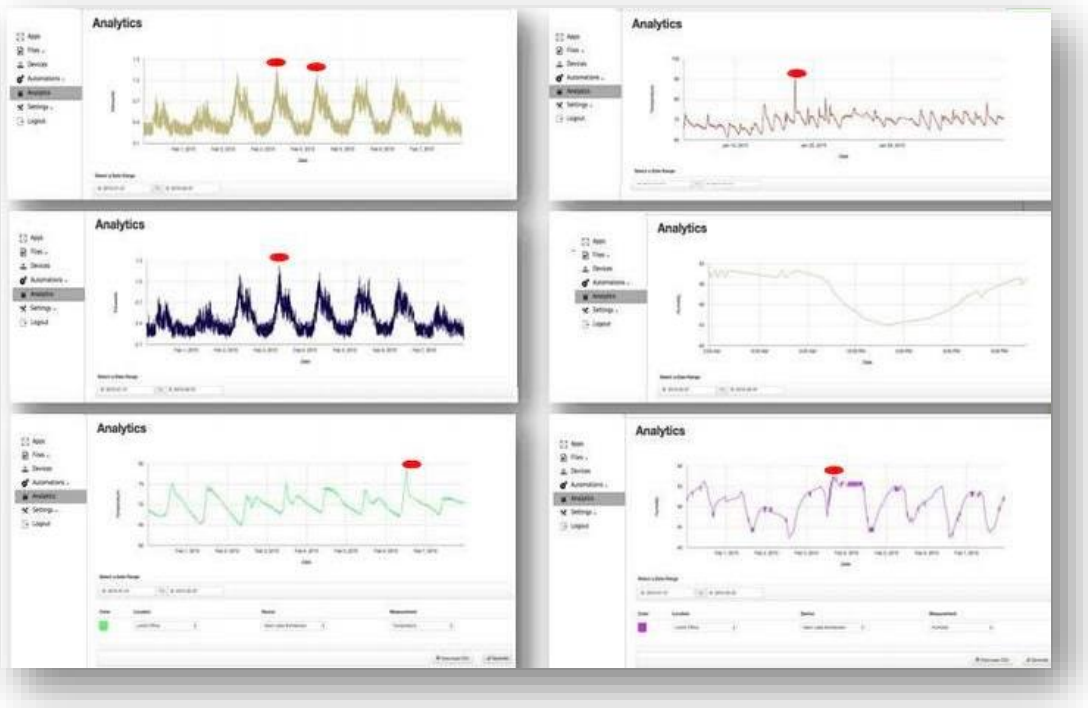

Figure 5: Example of Custom Analytics available from Locbit platform