**SCE Findings**
February 2016

# DR12.20: Evaluation of Permanent Load Shift Technologies and Development of Pre-Feasibility Tool

## DEMAND RESPONSE USING ENERGY STORAGE TECHNOLOGY

This project was funded by the Emerging Products program at Southern California Edison (SCE) to investigate emerging technologies for energy storage, with particular relevance to Demand Response and Permanent Load Shift (PLS) programs. The state of the technology and policy has evolved significantly in the last four years, with emergence and significant advancement of battery storage technologies, as well as new thermal energy storage technologies. Many of these technologies are focused on the customer side of the meter, where they are being installed to provide customer services such as demand charge management, backup power and, in some cases, self-sufficiency, so as not to export excess generation at certain times of the day. This market is an evolving market that is being closely monitored.

With the new regulatory requirements in California supporting energy storage, Southern California Edison (SCE) along with other Investor Owned Utilities (IOUs) has set up procurement of megawatt-scale energy storage installations. Within SCE's related procurements, two of four awardees are focused on customer side storage; one supports customer storage with a thermal storage solution and one supports storage with a demand response (DR) plus storage controls platform for commercial buildings. The statewide Permanent Load Shift Program (PLS) has developed incentives for thermal storage technologies that focus on larger commercial and industrial buildings. In parallel, the Self Generation Incentive Program (SGIP) provides incentives for battery storage systems. These programs help to accelerate market transformation of battery storage technologies, especially tied to photovoltaic (PV) generation.

The project had three main objectives: (1) to provide a market characterization and technology review of energy storage and load shift technologies, (2) to review and advance existing EnergyPlus™ building simulation models used for predicting thermal energy storage savings, and (3) to develop a free, open-source, cloud-based tool based on EnergyPlus to estimate energy savings and implementation costs for thermal energy storage systems used in buildings. The second and third objectives peripherally support the building industry by advancing predictive energy tools, yet the primary intent of these two tasks are to support participation in the statewide PLS Program, by providing customers and program implementers with a quick yet accurate pre-feasibility tool for assessing thermal energy storage systems.

# INTRODUCTION

## What Is This Technology?

### PERMANENT LOAD SHIFT

Permanent Load Shifting refers to the shifting of energy usage from one period of time to another on a recurring basis, often by storing energy produced during off-peak hours and using the energy during peak hours to support loads. Permanent load management technologies have undergone significant evolution in the last decade, especially in the area of customer side systems. Previously, the only viable systems were cold thermal storage systems for large commercial and industrial buildings and lead acid batteries. However, recently the technology choices have significantly expanded and now include:

- Packaged ice storage systems.
- High efficiency electrical storage technologies such as Li-Ion and zinc oxide batteries.
- Flow batteries promising much lower cost of electrical energy storage.
- Advances in building controls that can enable latent storage systems in buildings with minimal customer discomfort.

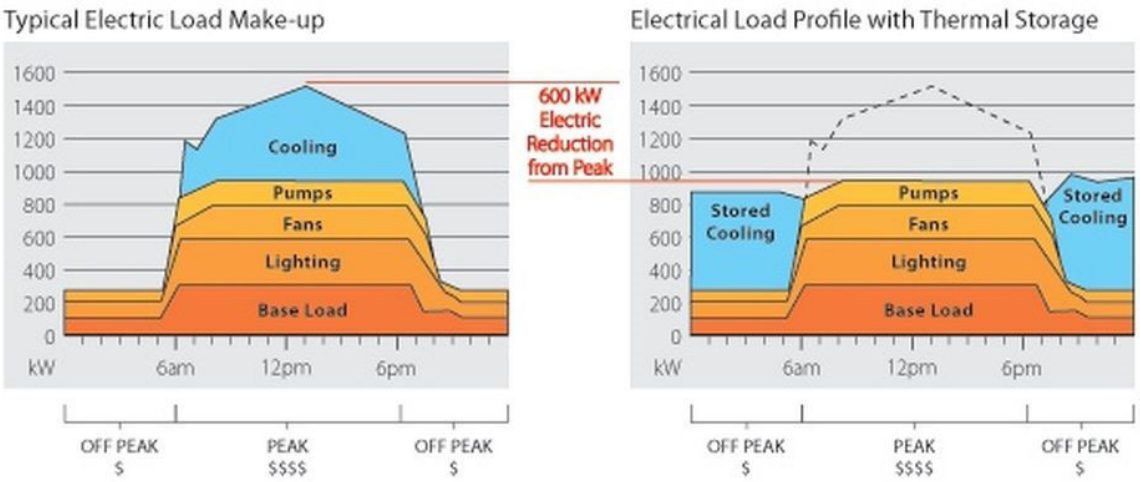
## What We Did?

### MARKET REVIEW AND FEASIBILITY TOOL DEVELOPMENT

The project conducted an extensive investigation into Permanent Load Shift (PLS) programs and technologies, as well as developing an online software tool that can utilize AMI data to provide an initial analysis of feasibility of PLS application. The technology review became an evolving document through the project due to advancements in energy storage technology through the course of the project. The review included both a technical review as well as interviews with a limited set of product providers on their strategy and technology.

The study also details the process of developing EnergyPlus models both for baseline cases and with incorporation of TES systems. Lastly, a PLS predictive tool was developed called the Thermal Energy Storage Screener (TESS) tool. The TESS tool was created to support the existing statewide PLS Program by helping to quickly evaluate thermal energy storage (TES) systems at no cost.

#### COMPARISON OF TYPICAL BUILDING LOADS WITH AND WITHOUT THERMAL ENERGY STORAGE



## REVIEW OF EXISTING TECHNOLOGIES AND ENERGYPLUS MODELING

The study starts with a review of the PLS program followed by a review of multiple types of load shift technologies. The load shift technologies include traditional thermal energy storage systems and battery storage systems as well as newer technologies, such as refrigeration storage and controls enabled load shifting technologies, which can be utilized for renewables balancing and fast response requirements. From this, the capabilities of EnergyPlus building simulation models were reviewed, specifically for integrating TES systems.

Research of EnergyPlus was conducted in collaboration with the National Renewable Energy Labs (NREL) and is one of the first implementations of the Thermal Energy Storage module incorporated by NREL into EnergyPlus in 2013. The research revealed bugs in the controls systems with chiller operations, some of which have been corrected and incorporated back into EnergyPlus.

## CAPABILITIES AND PURPOSE OF TESS TOOL

A PLS predictive tool was developed called the Thermal Energy Storage Screener (TESS). The TESS tool was created to support the existing statewide PLS Program by helping to quickly evaluate thermal energy storage (TES) systems at no cost. The tool is completely open-source and was calibrated using real data provided by SCE's PLS Program. The overall objective of this work is to increase participation in the statewide PLS Program by providing customers and program implementers with easy to use resources.

Analytica is a modular and flexible software program that can be easily adapted to provide additional outputs without custom coding. Future efforts can extend the tool to provide other functions such as predicting DR availability using AMI data and DR program targeting using AMI data.

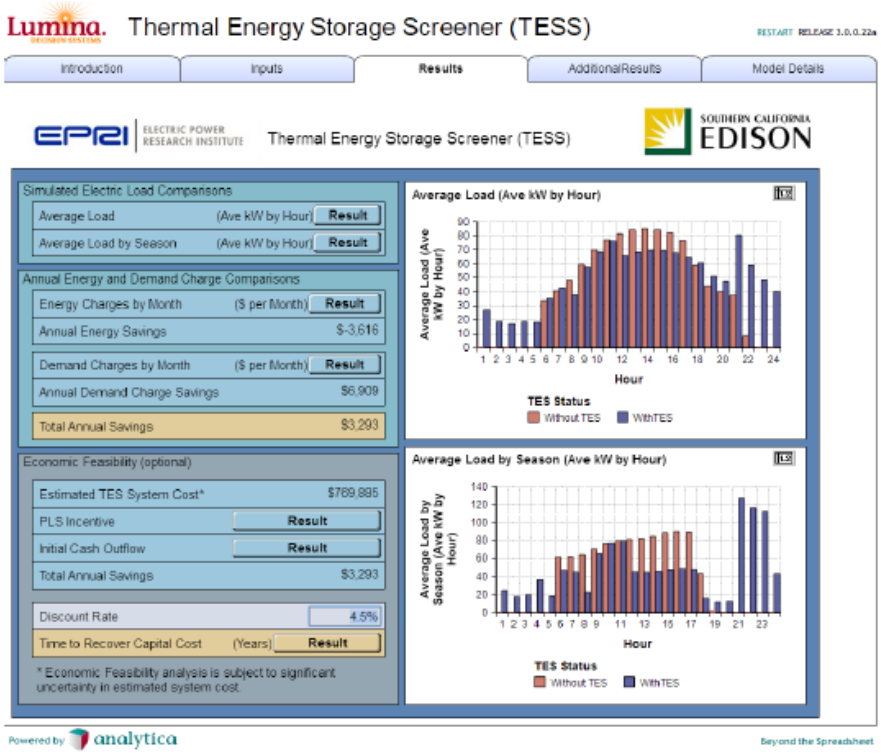



Figure 1: TESS Results Page Showing Comparison with TES

# CONCLUSIONS

## RESULTS

The development of the TESS tool was planned as a multi-step process. The difficulty in assessing potential for PLS application (or for DR) is that while there is AMI data available at the whole building level, there is not sufficient knowledge of energy use of HVAC system and other loads. Building energy models can provide breakdown of energy-use by load, but modeling every single building is not a feasible approach. EnergyPlus, the most common and most detailed modeling tool, was utilized due to its open availability and its capability to model thermal energy storage. To bridge the gap between models and real operations, the project adopted a unique approach where a database of EnergyPlus models and their output was developed to cover a spectrum of building sizes and types. The models were developed and run for both the TES and non-TES cases. This meta-database could then be extrapolated and interpolated for a variety of sizes and even multiple TES options.

These Findings are based on the report "Evaluation of Permanent Load Shift Technologies" which is available from the ETCC program website, https://www.etcc-ca.com/reports.

## MOVING FORWARD

There are additional opportunities for determining demand response and permanent load shift capabilities for various technologies and building types through the use of software modeling tools.

### FURTHER CAPABILITIES OF MODELING AND TESS TOOL

To extend EnergyPlus models to real buildings and to provide a user-friendly interface, Analytica software was utilized to provide the analysis engine. Given the need for access for both SCE personnel and subcontractors, the software is set up as a cloud-based access, with a limited set of user licenses. The software currently can analyze educational and office buildings, ranging from 50,000 sq.ft. to 2 million sq.ft. (the size seen as most probable by SCE for PLS system integration). The user can select building size and the type of TES system and run it either as a building without data (only modeled performance) or use available building energy data (calibrated to actual building operations). The building data can be monthly, daily, hourly or 15 minute intervals, with or without peak load. The results can be obtained both for cost savings and energy-use in operations and can be visualized in many different variations, including tables and graphs.

One of the unintended benefits of tool development was that it showed a pathway to actually understand DR potential of buildings using measured AMI data. The same philosophy as used for PLS evaluation can be extended to estimate lighting, plug and process loads, which can provide a better understanding of the DR capabilities, and required technologies. The tool can also be extended to other types of buildings beyond the limited building set targeted towards the PLS program.