Enhancing Savings By Design Program; Technical Reviewer's Perspective

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ABSTRACT

The Savings By Design (SBD) Program is administered by four of California's Investor-Owned Utilities — Pacific Gas & Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), Southern California Gas Company (SCG), and Southern California Edison Company (SCE) in their respective territories. The SBD program encourages high-performance design and construction of new commercial buildings. The primary goal of this study is to provide useful information to SBD stakeholders to enhance program participation, reduce project turn-over time, and improve overall cost effectiveness.

This study is based on the review of over one hundred SBD project applications and installations completed between 2015-2018 for various non-residential building types and sizes. Various whole-building energy modeling tools were utilized in these projects including EnergyPro, IES-VE, CBECC-Com, and eQuest to determine energy savings and compliance margins. This study identifies and documents common reasons that result in changes between submitted and approved energy savings and incentives. An energy savings and compliance margins gap analysis was also completed to support study findings. Finally, the study outlines several recommendations to expedite the utility technical review process and reduce gaps between the submitted and approved energy savings.

Introduction

California is ranked as the second largest energy-consuming state in U.S. as per the 2015 US Energy Information Administration report. The state's commercial sector ranks third in energy end-use sectors.[1] In 2015, the commercial sector in California used 1,465 trillion British thermal units (Btu) of energy equivalent to 19% of total energy consumption in the state. With a share of 8.1% of overall U.S. commercial energy use, the commercial sector in the state of California is the second largest in terms of energy consumption nationwide (U.S. Energy Information Administration 2015). Due to the size of energy consumption in California's commercial sector the promotion of energy efficiency in this sector is extremely important. Through implementation of energy efficiency programs dating back to the 1970s, California energy use per capita has remained flat, while the rest of the U.S. has increased by about 33% (CalEPA 2018).

Since 1975, the California Energy Commission has been responsible for reducing the state's electricity and natural gas demand primarily by adopting new Building and Appliance

[1] The energy consumption in commercial sector is mostly building related but it also includes energy consumption for street and other outdoor lighting, and for water and sewage treatment. These energy uses are relatively small contributors to the commercial sector's total energy consumption.

Energy Efficiency Standards that have contributed to keeping California's per capita electricity consumption relatively low. These standards − coupled with the California Public Utilities Commission (CPUC)'s Energy Efficiency programs − are saving consumers money, reducing energy use and greenhouse gas (GHG) emissions, and creating clean energy jobs in California (California Public Utilities Commission 2008).

The CPUC has oversight over Electric Program Investment Charge (EPIC), with investments administered by the California Energy Commission and the state's three large electric investor-owned utilities (IOUs). In 2014, over $1.7 billion was budgeted for energy efficiency programs within the state. A wide variety of energy efficiency programs, which are supported by public purpose funds, are administered by the state's IOUs including the Savings By Design (SBD) Program. All California IOUs currently offer the SBD Program and provide two incentive tracks for integrating energy efficiency measures (EEMs) into new constructions and major renovations: whole building and systems. For the Whole Building Approach, in which majority of applications are submitted, the SBD program offers building owners and their design teams a range of services including design assistance, owner's incentives (up to $0.40 per annualized kWh, $150 per kW demand reduction during peak hours, and $1.00 per annualized therm savings), and design team incentives (up to $50,000). Owner Incentives include a separate 10% bonus for incorporating end-use monitoring. The maximum total incentive per project is $150,000 (Energy Incentive Programs, California 2015).

SBD uses the applicable California Building Energy Efficiency Standards (Title 24, Part 6) as a reference baseline for comparison. When appropriate, the program uses other industry standards to determine reference baselines. It encourages building design and construction practices for buildings to perform better than mandated by Title 24. SBD Program design also provides detailed technical and financial assistance that allows building owners and design teams to make informed decisions (California Public Utilities Commission (CPUC) 2018).

Customer interface with utility program teams begins during the project design phase and continues through construction completion. Design assistance can range from a simple plan review and efficiency upgrade recommendations to a more detailed computer simulation analysis that compares several alternative systems and integrated building design options. Financial incentives to help offset increased design interaction and potential costs of construction are available for projects that exceed the thresholds established by the Program. Participation in the Program offers additional benefits including:

1. Reduced long-term operating costs
2. Greater comfort, health, and productivity for occupants
3. Conservation of natural resources and cleaner air due to avoided power generation.

The available studies in the literature to enhance the SBD Program are limited in number, span, and point of view. In 2009, Southern California Edison published a report process and market study of the SBD Program based on staff and customer feedback to further refine and develop Program design and implementation plans (HESCHONG MAHONE GROUP, INC. 2009). The Energy Division of the CPUC published a report in 2013 that evaluates the impact of California program administrators' 2013 Non-Residential New Construction (NRNC) programs. This study recommends California IOUs, as program administrator, to improve project documentation and tracking data to increase consistency between project files. It also recommends design, implementation, and test program features and procedural changes focusing on increasing program-induced savings to mitigate free ridership. In 2014, Navigant published historic market penetration and savings potential for each of the California IOUs, with the goal of determining the two market sectors with the highest savings potential (Navigant 2014). In addition to the studies mentioned above, several studies were carried out by consulting companies for CPUC, or individual IOUs to evaluate the Program penetration and evaluate the market player factors. Some of these studies are gathered by California Measurement Advisory Council.

This study is different from the work discussed above for three main reasons. First, it includes analysis based on a broader set of data; second, the results are based on data from the last four years reflecting the current environment; and third, it includes the perspective of utility technical reviewers that were not considered in any of the previous studies.

Data Collection and Analysis

This study is based on reviewing over one hundred SBD project applications/installations completed between 2015-2018 for various non-residential building types and sizes. Due to continuous changes in program policies, calculation methodology, nature of projects, applicable code cycles, and available/eligible measures, this study was limited to projects from last three years. It should be noted that this represents a sample of SBD projects in California and some of the findings may not be applicable to other projects.

Program Participation and Achieved Energy Savings

This study includes 116 project applications and spans a wide range of customers and 7 building types. Out of 116 SBD projects studied, 79.3% of them were using the Whole Building approach and the rest were done using the Systems approach. The main reasons for the predominance of Whole Building approach include:

- Higher incentive rate
  - The incentive rate per kWh for a Systems approach project with lighting EEM is $0.08/kWh, and for HVAC EEM is $0.15/kWh. However, the incentive rate for Whole Building projects starts at $0.10/kWh for all EEMs and increases linearly with the compliance margin.
- Additional incentive allocations
  - Several incentive adders such as a Design Team Incentive (which is one-third of the customer incentive), a $0.10/kWh incentive added for higher education customers, and an End Use Monitoring Incentive (10% of the project's Owner incentive) is only allocated to projects with Whole Building Approach.
- Design team participation
  - When there is a design team involved in the design and construction phase of the project, the program influence becomes more significant and the relation between the administering utility and project stakeholders becomes more enhanced due to the potential prior participation of the design team in SBD Program.

The Table 1 outlines a summary of allocated incentives for the acceptable approaches in the SBD program based on the most recent SBD Participants Handbook:

Table 1: Summary of allocated incentives in the SBD program (California Public Utilities Commission (CPUC) 2018)

Approach	Base Incentive	Design Team	Incentive Adder
Whole Building	$0.10-$0.40 per kWh $150/kW $1.00 Per therm	1/3 of the owner incentive	$0.10 per kWh for UC/CSU/CCC Partnerships 10% of the total Owner incentive for End Use Monitoring
Systems	HVAC, Refrigeration, Envelope, and Service Hot Water Systems $0.15 / kWh $1.00 / therm $150.00 / peak kW Lighting and other Systems $0.08 / kWh $1.00 / therm $150.00 / peak kW	-	-

The SBD projects analyzed for this study were submitted by a wide range of utility customers. To understand the penetration of the SBD market, the submitted applications were classified by building type and shown in the Figure 1. As the Figure 1 shows, the office and university building types are the most common participants in the study sample.

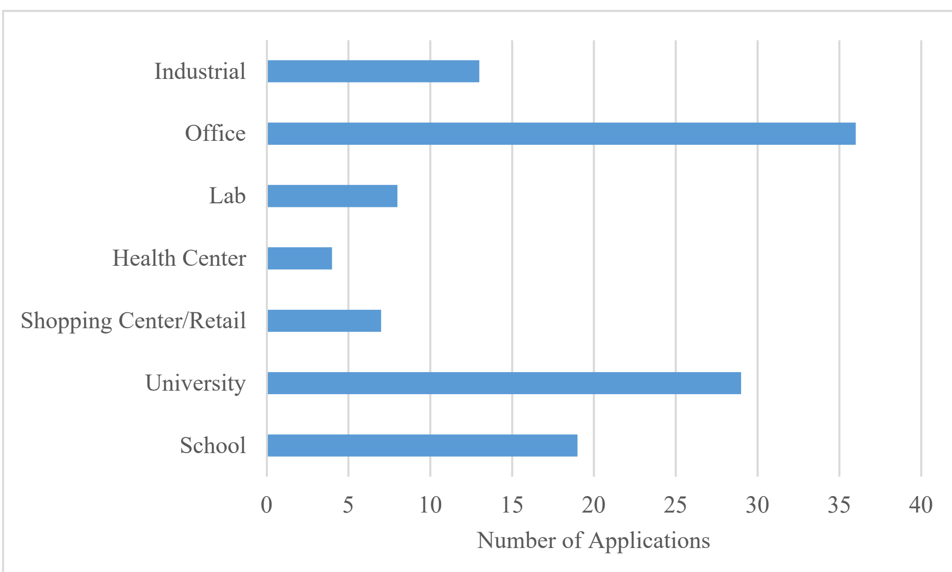

Figure 1: Applications by building type

Figure 2 outlines the share of the approved energy savings by building type and Figure 3 shows the average approved energy savings per project for each building type. Please note that the presented energy savings are annualized and are the summation of kWh and therms savings by converting to Btu.

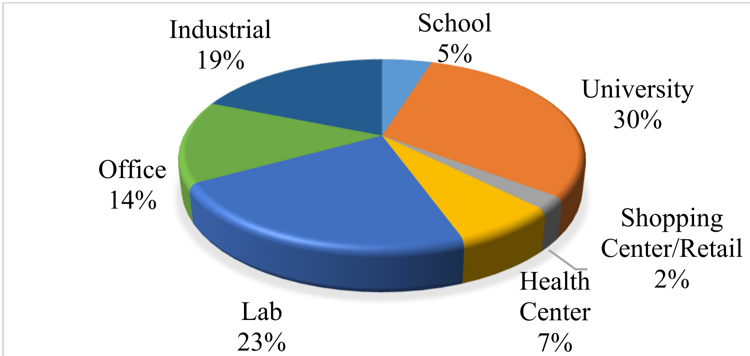

Figure 2: Percent energy savings by building type

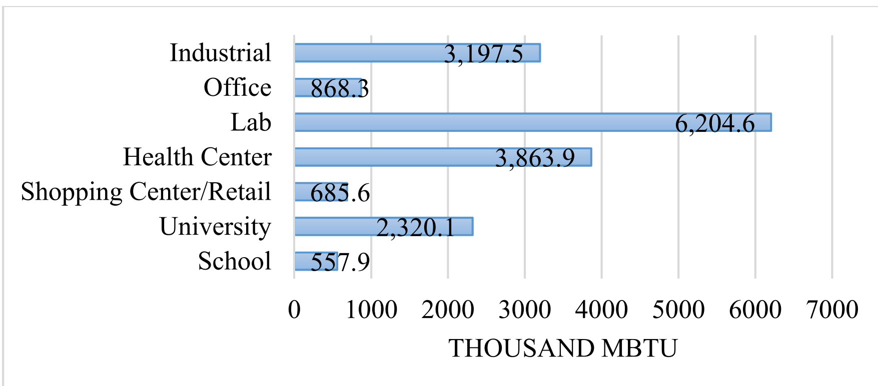

Figure 3: Average energy savings per project by building type

The study findings show that the share of the energy savings for each building type differs from the population share. As an example, while the K-12 school building category had 16% of all applications, it only contributed 5% to the approved savings. In contrast, laboratory buildings were only 4% of the population, but had 17% of the savings. The following reasons explain why the energy savings of building types does not follow the program participation for each category:

- The size of the office buildings varies significantly, and the majority of the applications are small office buildings with limited savings opportunities.
- The majority of the university buildings are served by a central plant to meet the heating and cooling load. In other words, chilled water and heated hot water are supplied by chillers and boilers in the central plant, and adding new efficient buildings only increases the load. Typically, energy savings at the central plant do not qualify for Program incentive unless separate calculations are provided. Therefore, these projects do not receive any credit to meet the heating and cooling load efficiently.
- The number of laboratory buildings and healthcare facilities that participated are small; however, their energy savings are significant. This is mainly due to the HVAC load and high ventilation energy usage for these buildings. The baselines for these building types which uses 100% outside air due to the air quality requirements, provides an opportunity

for the design teams to incorporate creative and sophisticated HVAC measures and achieve significant energy savings. (EnergySoft 2016) and (Rumsey Engineers 2010).

This study suggests that there is a great energy savings opportunity in new laboratory buildings since this building type has the highest energy savings per building among SBD program building types. Due to typically higher amount of savings for laboratory applications, a more detailed analysis of energy savings opportunities was done as part of this study. The only code guidance on laboratory air change rates is for Class H6 areas and a section regarding flammable liquids in a Class B space, which requires six air changes per hour, while current lab standards recommend a minimum of 4-6 ACH (Pacific Gas and Electric Company 2011). Among the studied cases, the common EEMs for laboratory buildings with medium to high cost-effectiveness can be listed as:

- Air change per hour optimization
- Adjusting design to the proper load knowing that typical open lab measured load is between 2-5 W/sf
- Decoupling the cooling and ventilation systems to reduce energy needed for conditioning that requires 100% outside air
- Installation of a low-pressure drop air delivery system which can be accomplished through many design strategies such as low-face-velocity air handling units and low-pressure drop ductwork.

Energy Simulation Tools

An SBD application in Whole Building approach comes with an energy model. The energy savings of each project are calculated by one the approved simulation tools using the energy model. Table 2 outlines the frequency simulation software tools used by building type for SBD projects using a Whole Building approach. Among the SBD projects that underwent the technical review process, EnergyPro (Version 5, 6, and 7) has the most applications with 84%. It was followed by IES VE (9%) and CBECC-Com (5%). It is important to note that all of the applications with IES VE models were submitted in 2017 and 2018.

Table 2: Simulation software tools used by building type

Building Type	EnergyPro	CBECC-Com	IES VE	eQuest
K-12 School	16	0	0	0
University	22	1	2	2
Shopping Center/Retail	3	0	0	0
Healthcare Center	3	0	0	0
Lab	1	0	5	0
Office	25	4	1	0
Industrial	7	0	0	0
Total	77	5	8	2

As indicated in the table above, IES VE was recognized to be the most preferred software tool to simulate the energy savings in the laboratory buildings. The following list presents the most common HVAC design EEMs that are incorporated in the IESVE models used for laboratory buildings:

- Minimizing ventilation requirement to 6 ACH occupied and 4 ACH unoccupied
- Meeting the HVAC load using passive strategies (natural ventilation) and direct/indirect evaporative coolers.
- Water-side economizer control strategy
- Radiant heating and cooling systems
- Volatile Organic Compounds sensor and lighting occupancy sensor-BAS interface for lab ventilation setback
- Proximity sensors for fume hood face velocity setback
- Geo-exchange system for seasonal heat rejection and absorption

Enhancing The Technical Review Process

In the technical review process, there are important guidelines and steps that if underestimated can add additional time and costs to the process, reducing overall program cost-effectiveness. In this section, the common reasons for these oversights and delays are listed and recommendations are provided to mitigate these issues.

Establishing Compliance Baseline

Several factors should be considered when establishing the SBD Program's approved baseline. For commercial buildings, an appropriate version of the Title-24 standards or applicable baseline study should be used as the baseline. Table 3 outlines the effective dates for the most recent code cycles. Accordingly, if the application for the building permit is submitted on or after the effective dates below, the corresponding standards must be used as the baseline.

Table 3: Recent California Title 24 Standards and corresponding effective dates

Standards	Effective date
2016 Building Energy Efficiency Standards	January 1, 2017
2013 Building Energy Efficiency Standards	July 1, 2014
2008 Building Energy Efficiency Standards	January 1, 2010

Currently, the submission date for permit documents is not among the required documents on SBD applications. The technical reviewer needs to contact the design team/customer to receive the date.

In addition, the building area (in square feet) and occupancy type are key factors in establishing the baseline HVAC system type. Tables 4-7 of the 2016 Non-residential Alternative Calculation Method Reference Manual outlines the HVAC system map that needs to be used in establishing the SBD baseline (California Energy Comission 2015). The building area includes all conditioned spaces and unconditioned spaces in a building. In Title 24, Part 6, "Conditioned Floor Area" is defined as the floor area (in square feet) of the enclosed conditioned space on all floors of a building, as measured at the floor level of the exterior surfaces of exterior walls enclosing the conditioned space. Therefore, areas of interior wall framing/structural columns and exterior wall façade need to be considered when establishing the baseline. Often, applications are submitted for review while the above-mentioned areas are excluded from the model. This issue adds another model revision step, hence requiring additional resources.

To expedite the review process and eliminate the gap between submitted and approved energy savings, procedure of defining applicable code baseline, using the correct building area from the architectural plans, and selecting the appropriate occupancy type can be added to the future versions of the SBD Participants Handbook, or alternatively, be included in a submission documents checklist.

Compliance Run and Non-compliance Run

The California Energy Commission regulates which computer compliance programs are approved for the 2016 Building Energy Efficiency Standards in accordance with the California Code of Regulations: Title 24, Part 1, Article 1, Section 10-109 (California Energy Commission 2018). SBD uses approved non-residential compliance programs such as EnergyPro, CBECC-Com, IES, and Simergy to determine savings. However, EnergyPro (Version 6.7 and after) is the only simulation software to have the above approach built in, which can be accessed with the Non-residential SBD Performance Run option. All other simulation tools must manually follow the methodology outlined above, but in practice, this may be difficult.

Zhang et al. (Zhang, Kanungo and Jacobs 2014) showed the differences between the compliance and non-compliance runs as well as its impact on energy savings. Additionally, this study recommends a methodology that generates standard and proposed DOE2.1E input files by combining the input files created by EnergyPro.

Energy saving measures in the SBD Program, as a part of energy efficiency programs administered by California IOUs, are evolving rapidly as new technologies are introduced into the market. While EEMs become more sophisticated, more elaborative energy modeling tools are needed to simulate baseline and measures accurately. Two of these new energy modeling tools, which are receiving more attention lately are IES VE and CBECC-Com.

Since the default baseline generated by the IES VE complies with the ASHRAE 90.1 guidelines, modifications are required to match it to the California Title 24 Standards. Implementation and documentation of baseline adjustment requires an extra step and adds cost to the application preparation and technical review processes. This additional cost can be mitigated if the SBD baseline creation could be incorporated into the software capabilities, similar to recent versions of EnergyPro.

With the market transitioning to new software tools such as IES VE, the need to develop similar methodologies becomes crucial. Although a detailed description of this methodology is beyond the scope of this study, it may require a number of changes in the ASHRAE 90.1 baseline model generated by IES VE. Some of the common changes include:

1. Assigning appropriate Climate Zone weather file,
2. Modifying simulation year to 2009 and applying DEER Design conditions,
3. Modifying baseline envelope to match Title-24 requirements,

4. Modifying baseline lighting power densities to match Title-24 requirements,
5. Incorporating Title-24 space use schedules and set points,
6. Modifying baseline inputs from NR ACM Section 5.

Operating Conditions

Discrepancies between the presumed operating conditions, hours of operation, HVAC set-points in the pre-install review process, and actual building operation at the post-install stage adds both delays and costs to the review process. At the post-install review stage, energy models need truing up to calculate the energy savings based on the actual building operation. For verification purposes, screenshots of Building Management System (BMS), if available, or customer/design team statements are needed and should be collected during the site visit when possible. It is required that the final approved model be adjusted to physical "as-built" conditions observed during the verification site visit.

Calculation Methodology

Common issues in the calculations include incorrect DEER peak demand reduction analysis, incorrect weather file, using Title-24 compliance run instead of the SBD run, calculating the compliance margin using a non-compliance run, claiming savings from chilled water and hot water equipment for buildings served by a common central plant, and claiming energy savings from the Variable Refrigerant Flow (VRF) system. Often, technical reviewers need to spend time during their meetings with design teams to elaborate the approved calculation methodology in the SBD Program.

Providing Hourly Grid Impact Analysis

Program applicants are required to provide an assessment of "coincident savings" (also referred as "non-IOU" fuel analysis) for sites with non-IOU fuel supply sources. Coincident savings is defined as savings associated with EEMs that coincide with periods that the customer is purchasing energy from utility and thus reducing impact on the grid/system. The time period is hourly for electricity and monthly for natural gas. If this extra assessment requirement is not conveyed to the design team, additional resources would be needed in the technical review process to revise the calculations. Since it may impact the energy savings and customer incentive adversely, if this step is fulfilled in the technical review process, a gap would be imposed between the submitted and approved energy savings.

SBD Applications with Inappropriate Baselines

Often, automatically-generated baseline models need to change to reflect applicable Title 24 or ACM guidelines for establishing standard/baseline model characteristics. The recommended modeling adjustment process detailed above is a time-intensive process and can cause delays in the review process. For instance, technical review of SBD projects with IES model (which require baseline adjustment) take about 30% more time than a similar project modelled through EnergyPro. We recommend that Program administrators explore modifications to the common software tools to automate the recommended modeling process and automatically generate Program-eligible energy savings.

Uncontrollable and Unpredictable Factors

There are instances when delays are imposed into the review process due to uncontrollable and unpredictable factors. Some examples are changes made to the scope of work in the construction phase which includes adding/changing/removing EEMs; delays in receiving a response from the design teams and customers; discrepancy between the submitted version of the simulation tool and appropriate version; etc. While many of the unpredictable and uncontrollable factors are inevitable, enhanced communication between Program administrators and technical review teams can help mitigate these factors.

Conclusions

Energy use in the commercial sector of California accounts for a significant portion of the state's total energy consumption. The IOU-administered SBD Program makes an essential and considerable contribution to California's energy efficiency portfolio. However, program-level participation and improvement methods of this statewide Program have not been comprehensively discussed in recent studies.

In this study, SBD Program participation was examined for a sample of 116 applications that went through the third-party technical review process during the period between 01/2015 - 02/2018.This study presented the findings concerning program participation, energy savings per application, and simulation methodologies. In addition, the authors provided a list of common deficiencies in these applications and several recommendations to increase the overall program cost-effectiveness.

The highest number of applicants were for office buildings, followed by university buildings. In terms of approved energy savings per building, laboratory buildings have shown the highest energy savings amount which can be recognized as an indicator for energy savings potential for this building type. During the study period, IES VE, as recently approved and emerging energy simulation tool in the SBD Program, had the most number of applications in simulation of laboratories due to its capabilities and flexibilities. Design teams have used IES VE simulation to model the innovative EEMs such as using passive heating and cooling strategies, implementation of water-side economizer, radiant heating and cooling systems, and more.

Common deficiencies in the study's applications can be listed as a flaw in establishing the proper baseline mode, discrepancy between the proposed and actual operating conditions, incompatibilities between applied calculation methods and Program guidelines, and a lack of supplemental calculations such as grid impact analysis. Following list outlines some examples of recommended steps to improve the cost-effectiveness of the technical review process and minimize the project turnaround time:

- Including a "Required Documents Checklist" for SBD projects. This checklist can be a part of the SBD Participants Handbook, or a standalone document and would be shared with design teams in SBD kick-off meetings.
- Adding an appendix to the SBD Participants Handbook to define compliance run and non-compliance run and discuss their applications and differences. This section would emphasize that the operating conditions and hours of a building should be defined in a SBD model.

- Conveying the most recent SBD-specific policy decisions and approved calculations, such as VRF calculation methodology, to the SBD design teams prior to or during kick-off meetings.
- Defining a path for energy savings calculations of SBD projects with “non-IOU” fuel sources. This would include the most recent incentive policies for ZNE and non-ZNE projects and would be shared with design teams. Design teams need to be informed about claimable energy savings of a building with non-IOU fuel sources.
- Providing a technical memo or a white paper on how to define a Title 24 compatible baseline energy model for SBD projects with IES VE energy models.

It is important to note that the list above is not an exhaustive list and is limited to the findings of projects subject to this study. Although the discussions provided in this study focus on California’s Statewide Savings By Design Program, it can offer valuable insight to decision makers and managers of non-residential new construction programs in other states and countries.

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