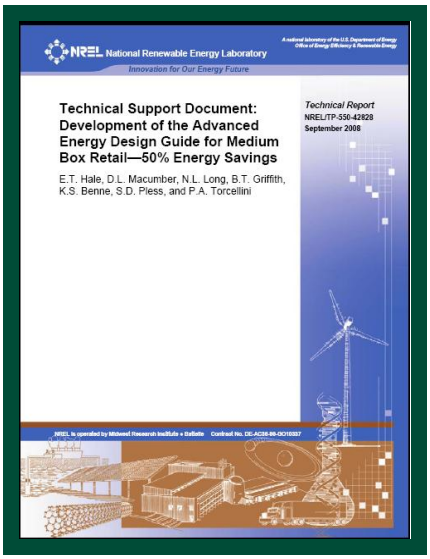
ZERO NET ENERGY (ZNE) BUILDINGS - TECHNICAL AND MARKET POTENTIAL REVIEW

ET10SCE4020 Report



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Southern California Edison's Design & Engineering Services (DES) group is responsible for this project. It was developed as part of Southern California Edison's Emerging Technology program under internal project number ET10SCE4020. DES project manager Teren Abear conducted this technology review with overall guidance and management from Edwin Hornquist. For more information on this project, contact *Teren.Abear*@sce.com.

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ABBREVIATIONS AND ACRONYMS

AFUE	Annual fuel utilization efficiency
ASHRAE	American Society of Heating, Air-Conditioning and Refrigeration Engineers
BTU	British thermal unit
CEC	California Energy Commission
CLTEESP	California Long Term Energy Efficiency Strategic Plan
CFL	Compact fluorescent lamp
DCV	Demand controlled ventilation
DES	Design and Engineering Services
DOAS	Dedicated outside air system
DOE	Department of Energy
DR	Demand response
D/S	Demonstration Showcase
EE	Energy efficiency
EF	Energy factor
EER	Estimated energy requirement
ETP	Emerging Technologies Program
EUI	Energy use intensity ($kBtu/ft^2$)
HERS	Home Energy Rating System
HSPF	Heating Seasonal Performance Factor
HVAC	Heating, Ventilation, and Air-Conditioning
NREL	National Renewable Energy Laboratory
IDSM	Integrated demand side management

IECC	International Energy Conservation Code
kW	Kilowatt
kWh	Kilowatt hour
LED	Light emitting diode
LEED	Leadership in Energy & Environmental Design
NC	New Construction
NREL	National Renewable Energy Laboratory
PNNL	Pacific Northwest National Laboratory
PV	Photovoltaic
SCE	Southern California Edison
SEER	Seasonal Energy Efficiency Ratio
SMUD	Sacramento Municipal Utility District
ZNE	Zero net energy

TABLES

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EXECUTIVE SUMMARY

Southern California Edison (SCE) conducted this Zero Net Energy (ZNE) technical and market potential review as part of its Emerging Technologies Program (ETP) to identify the business segments and building types best suitable for ZNE new construction and retrofits in SCE's service territory. This report proposes a method for scoring and prioritizing potential ETP Demonstration Showcase (D/S) ZNE projects to advance the objectives of the California Long Term Energy Efficiency Strategic Plan (CLTEESP). The scoring method applies to the six business segments and building types that have the highest potential to achieve reliable ZNE results (high "ZNE potential") and the associated opportunities and obstacles are outlined in this report. Finally, this report identifies any D/S ZNE projects that correspond to the selected business segments and building types.

DESCRIPTION OF METHODOLOGY

This project used the following approach:

1. Developed a screening method to determine which business segments and building types have the highest ZNE potential.

   The screening method considered several parameters including cost, to ensure application of maximum cost-effective building-energy use reduction, before applying alternative energy generation in accordance with the California Energy Action Plan loading order.

   The screening method also identified the standard baselines, such as the American Society of Heating, Air-Conditioning, and Refrigeration Engineers (ASHRAE) Standard 90.1-2004, for consistent and replicable energy reduction for a wide range of business segments and building types against which to measure energy savings toward ZNE.
2. Reviewed building science literature and interviewed prominent ZNE and low-energy building practitioners in order to identify business segments and building types that have potential for achieving ZNE performance.
3. For the selected business segments and building types, discovered published data on corresponding low-energy buildings and building simulations for the climate zones of SCE's service territory.
4. Used these building examples and simulations as a proxy for potential ZNE projects, applied the screening method to assess the ZNE potential for the selected business segments, and building types in SCE's service territory.
5. Used the synopses of proposed and on-going SCE D/S projects that address the selected business segments and building types, compared the D/S project approaches with those in the screened building examples and simulations in order to identify the D/S potential opportunities and pitfalls.
6. Summarized the results from this technical and market potential review, and then identified key recommendations for future study of unresolved issues.

RECOMMENDATIONS

- ETP to adopt a ZNE potential evaluation system similar to the one developed for this Technical and Market Potential Review report, to provide support for SCE decisions on proposed or potential ZNE projects in their preliminary stages of development.
- Pursue all planned SCE D/S projects, with particular emphasis on the Single Family Home – New Construction project due to its strong potential.
- Consider additional projects for Medium Box Commercial - New Construction and Low-Rise Office Building – New Construction as the opportunities and ETP budget allow.
- Pursue the Sports and Recreation Center – Retrofit project with an awareness of its unique and challenging characteristics as a ZNE project.
- Develop a universal ZNE energy savings metric as recommended[1] by Charles Eley of Architectural Energy Corporation. This is valuable for the SCE D/S ETP program element, and can potentially make a durable contribution toward the ZNE goals of the CLTEESP and to ZNE activities elsewhere.
- Update energy models of prototype baseline and ZNE buildings by replacing Department of Energy (DOE), International Energy Conservation Code (IECC), and ASHRAE climate zones with California Energy Commission (CEC) climate zones to obtain better resolution.
- Update the prototype baseline building models to reflect American Society of Heating, Air-Conditioning and Refrigeration Engineers (ASHRAE) 90.1-2010, 2008 Title 24 and pending 2011 requirements.
- Cautiously extrapolate data on completed low-energy buildings and simulations to address related segments/building types for which examples and data are lacking. Follow up by developing prototype-building simulations for these additional segments/building types.
- Perform energy modeling of proposed ZNE D/S buildings as early as possible during the project initiation phase to determine how close energy efficiency (EE) measures will bring the building(s) to ZNE and how much on-site generation is necessary to achieve ZNE.
- Investigate using owner return on investment (ROI) as an alternative to payback period when performing detailed project analysis and decision-making.
- Address the five ZNE potential evaluation parameters not used in this report for detailed project decision-making, and consider the challenges and advantages of adding the sixth parameter – SCE Systemwide Savings Potential - for an in-depth analysis of project impacts.

INTRODUCTION

Southern California Edison (SCE) conducted this Zero Net Energy (ZNE) technical and market potential review as part of its Emerging Technologies Program (ETP) to identify the business segments and building types best suitable for ZNE new construction and retrofits in SCE's service territory. This report proposes a method for scoring and prioritizing potential ETP Demonstration Showcase (D/S) ZNE Projects to advance the objectives of the California Long Term Energy Efficiency Strategic Plan (CLTEESP). The scoring method applies to the six business segments and building types that have the highest potential to achieve reliable ZNE results (high "ZNE potential"). The associated opportunities and obstacles are outlined in this report. Finally, this report identifies any D/S ZNE projects that correspond to the selected business segments and building types.

SELECTION METHODOLOGY

The steps below outline the method used to select the business segments and building types with ZNE potential and find the published data that corresponds to the buildings and building simulations for the climate zones in SCE's service territory.

1. Developed a screening method to compare ZNE potential across a wide range of business segments and building types.

   In addition to other parameters, this review measures cost-effectiveness in order to ensure that optimal building energy efficiency (EE) approaches are in use before applying alternative energy generation, in accordance with the California Energy Action Plan loading order. For example, as described in the Selection Parameters and Definitions section of this report, this SCE review measures the parameters, Percent Energy Savings over Baseline, excluding on-site renewable generation, as well as CLTEESP Alignment and several market transformation parameters. To ensure consideration of alternative energy generation, a parameter that addressed practical on-site renewable generation potential is included.

   Identified the following standard baselines for consistent and replicable energy reduction for a wide range of business segments and building types against which to measure energy savings toward ZNE:

   - For commercial new construction (NC), this report uses American Society of Heating, Air-Conditioning, and Refrigeration Engineers (ASHRAE) 90.1-2004 as the baseline. This is the baseline used in the majority of applicable examples and simulations of near-ZNE commercial buildings[2,3] available as of the date of publication of this report.
   - For commercial retrofit, this report uses the applicable Title 24 standards for the year the previous building construction permit was issued as the baseline. This applies to most commercial retrofits except historic rehabs, which require a case-by-case approach.
   - For residential new construction, this report uses 2005 Title 24 (effective October 1, 2005 through December 31, 2009) as the baseline. This is the baseline used in the majority of applicable examples and simulations of near-ZNE residential buildings for California climates available as of the date of publication of this report.
   - For residential retrofit, this report uses the Home Energy Rating System (HERS) Index to establish the baseline and proposed energy consumption. This is the index used in the majority of applicable examples and simulations of near-ZNE residential building retrofits for California climates[4].

     The Selection Parameters and Definitions section describes the screening method used in this report, and outlines it in the ZNE Potential Evaluation Matrix **–** proposed score sheet**.**

2. Reviewed the building science literature and interviewed selected ZNE and low-energy building practitioners to identify business segments and building types with the greatest potential of achieving ZNE performance.

   During this task, the following sources were referenced, including the National Renewable Energy Laboratory (NREL) Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector[2] and the United States Department of Energy (DOE) Zero Energy Building Database[5]. David Hewitt (New

Buildings Institute), Ann Edminster (Design AVEnues), Mike Keesee (Sacramento Municipal Utility District (SMUD)), and Rob Hammon and Brian Kennedy (ConSol) were interviewed during this task.

3. For the selected business segments and building types, published data on corresponding buildings and building simulations for the climate zones in SCE's service territory were discovered.

   For this task, the National Renewable Energy Laboratory (NREL) and Pacific Northwest National Laboratory (PNNL) 50% Energy Savings Technical Support Documents[3] for commercial new construction and interviews with Ann Edminster (Design AVEnues), Mike Keesee (SMUD), Rob Hammon and Brian Kennedy (ConSol), and Amy Sims (LivingHomes) for residential new construction and retrofit examples and simulations were referenced.

   The standard source used for SCE climate zone information was the International Energy Conservation Code (IECC)/ASHRAE 90.1 Thermal Climate Zones[6] as expanded by NREL for DOE commercial building benchmarking[7]. This report focuses on climate zones 3B-CA, which represents the majority of SCE's customer base, and includes climate zones 3C (Ventura County), 4B (Inyo County) and 6B (Mono County).

4. Using these building examples and simulations as a proxy for potential ZNE projects, a screening method was applied to assess the ZNE potential for the selected business segments and building types in SCE's service territory.

   The resulting ZNE potential scores are reported in the Executive Summary and the Selected Business Segments and Building Types sections of this document.

SELECTION PARAMETERS AND DEFINITIONS

The first step in this Technical and Market Potential Review was identifying the parameters to compare the ZNE potential among different business segments and building types. To develop these parameters, SCE staff proposed criteria based on previous ZNE and ETP project screening experience. Definitions were developed for each criterion, and then the criteria were checked for consistency, duplication, and overlaps. Redundant criteria were combined or eliminated, resulting in the 15 parameters shown in the leftmost column of the ZNE Potential Evaluation Matrix in this document.

The 15th parameter, SCE System Wide Savings Potential, was eliminated from further consideration due to the complexity of making a meaningful estimate at the ZNE project portfolio planning stage. This parameter has potential for future use after specific projects are selected, possibly as part of the ETP final reports or as a stand-alone market study based on details that become available as detailed project designs are developed; it is shown in the last, grayed-out row of the ZNE Potential Evaluation Matrix.

An additional five parameters were included in the list below and in the ZNE Potential Evaluation Matrix, but were not used when reviewing the business segments and building types for this report. It was determined that these parameters are highly project specific and therefore unsuited for high-level comparison of business segments and building types. These parameters are bulleted but not numbered in the list below, and are included in the light shaded rows of the ZNE Potential Evaluation Matrix.

The remaining nine parameters are numbered, listed and defined below, and included in the dark shaded rows of the ZNE Potential Evaluation Matrix. These are used throughout this report to evaluate and compare the six selected business segments and building types for ZNE project consideration.

Finally, the list below and the ZNE Potential Evaluation Matrix group the parameters into three families indicating the aspect of the project decision-making process to which each contributes: Feasibility, Portfolio Fit, and Market Transformation potential.

FEASIBILITY PARAMETERS

- **Percent energy savings over baseline towards ZNE:** How much energy savings can an aggressive, systematic application of current technology to this building type/business segment achieve over baseline performance towards ZNE?

  For this report, the energy savings baselines are ASHRAE Standard 90.1-2004 (Commercial New Construction), Title 24 for the year when the previous building construction permit was issued (Commercial Retrofit), 2008 Title 24 (Residential New Construction), and the HERS Index (Residential Retrofit).

  It is important to note that this parameter favors commercial building types with inherently low energy use indexes (EUIs) such as non-refrigerated warehouses, over those with high EUIs, such as, restaurants. Inclusion of other parameters such as payback period for owner and market acceptance ensures that a low baseline EUI will not skew the ZNE screening process.

- **On-site renewable generation potential:** How significant is the potential for on-site electric or hot water generation for this building type/business segment?

  Assuming that photovoltaic (PV) and solar thermal applications will be the most widespread and cost-effective on-site energy sources for near-term ZNE projects, this parameter refers to unobstructed roof square footage with non-shaded

southern exposure. Future project-specific analysis can include wind generation potential if there is clear evidence that neighbors will not object. For this report, other on-site or locally based renewables, such as low-head hydro, wave, and tidal generation are not considered.

- **Payback Period for Owner:** How many years are required for energy savings over baseline to offset the incremental cost of measures selected to achieve ZNE?

  This parameter excludes costs and benefits for on-site generation, as well as rebates and tax credits. This is intended to allow a level playing field comparison between bundles of EE measures in various building types and business segments.

  Project-specific analysis should also examine on-site renewable generation costs and benefits, both separately from and in conjunction with EE costs. This will ensure that comparisons between ZNE projects respect the California Energy Action Plan loading order and make financial sense for all stakeholders.

- **Technology Risk*:** Is this complete building system likely to succeed in a predictable way?

  This parameter is reserved for project-specific reviews, where the details of the building systems are known and an analysis of the specific risk factors is possible.

  This criterion is not used when reviewing business segments/building types for this report.

- **Other Benefits for Utility & Customer*:** What specific, non-energy impacts is this project expected to produce for the customer, and what benefits not directly tied to EE and Integrated demand side management (IDSM) can the project provide for the utility?

  This parameter is reserved for project-specific reviews, where details that may impact the utility and the building owner or occupant are known.

  This criterion is not used when reviewing business segments/building types for this report.

PORTFOLIO FIT PARAMETERS

- **California Long Term Energy Efficiency Strategic Plan (CLTEESP) Alignment:** How well does this building type/segment comply with CLTEESP vision and requirements for ZNE?

  CLTEESP ZNE requirements are complex, making this parameter difficult to assess in detail without project specifics. However, due to its importance, it is applied on a preliminary basis in reviewing business segments and building types for this report.

  A more detailed evaluation is recommended for specific projects as they are defined sufficiently for in-depth analysis. This detailed evaluation should address the critical success factors identified in the California Public Utilities Commission (CPUC) ZNE Action Plan[8] that includes business planning cycles, market leadership, financial viability, statewide coordination, technological improvement, and commercial viability.

- **Underserved Sector*:** How well does this building type/segment or project satisfy regulatory equity expectations?

This parameter is reserved for project-specific reviews, where details such as location, owner and occupant demographics, and other factors that address equity considerations are known.

This criterion is not used in reviewing the business segments/building types for this report.

- **Importance of Utility Involvement*:** Does the project participant have a history of SCE program involvement?

  This parameter is reserved for project-specific reviews, where details about the project participant's prior involvement in SCE programs are known.

  This criterion is not used in reviewing business segments/building types for this report.

- **Opportunities for Collaboration*:** How well does this project satisfy internal and external expectations for collaboration among entities in order to achieve ZNE?

  Collaboration is required in order to achieve regulatory goals for statewide ETP coordination, assure optimum IDSM integration, and secure adequate project funding, particularly for on-site generation, which is ineligible for ZNE EE funding. Because these factors vary significantly from project to project, this parameter is reserved for project-specific reviews.

  This criterion is not used in reviewing the business segments/building types for this report.

MARKET TRANSFORMATION PARAMETERS

- **Overcomes Barriers:** To what extent does aggressive, systematic application of current EE technology in projects similar to this one help overcome barriers and address gaps to broaden market penetration of ZNE construction?

  This is one of several qualitative parameters used to gauge the ZNE market transformation potential for specific business segments and building types. Below are some potential barriers a ZNE building project may help to overcome[9]:

  - **Information or search costs:** The value of time spent identifying, evaluating, and locating EE measures.
  - **Performance uncertainties:** The difficulties and costs of acquiring the information needed to evaluate performance claims for EE measures.
  - **Organizational practices or customs:** The behavior by companies, departments, professional groups, and government entities that has been institutionalized may discourage forward thinking and proactive implementation of EE measures.
  - **Product or service unavailability:** Limited supply and/or distribution of EE measures.

- **Replicability (Retrofit projects only):** What is the expected frequency of similar retrofit projects (ranging from one every three or more years to many per year) in this building type/business segment?

  This parameter is important because certain types of ZNE retrofits may occur rarely so their ability to transform the construction market is limited (for example, sports stadiums are relatively few in number and infrequently retrofitted.) Because these tend to be highly customized projects, with multiple years between

occurrences, the limited replicability of such a project makes it a weak option for ZNE retrofitting when the goal is broad transformation of the construction market.

- **Future Growth Potential (New Construction projects only): ** What is the expected frequency of similar new construction projects (ranging from one every 3 years or more to many per year) in this building type/business segment?

  This parameter addresses ZNE new construction projects and corresponds to replicability for retrofit projects. As with replicability, future growth potential varies among business segments and building types, and may vary due to climate or other factors in SCE's service territory. For instance, skating rinks and bowling alleys are rarely constructed in SCE's service territory, so the future growth potential associated with a single ZNE project of this type is low.

- **Market Acceptability:** To what extent are building designers, contractors, and owners of this building type/business segment expected to support and advocate building/buying ZNE?

  This is one of two parameters that address the potential impact of a ZNE project on the building design and construction industry, and the impact on building owners. This parameter focuses on key stakeholders' impressions and intentions with regard to undertaking ZNE construction projects for this business segment/building type.

- **Difficulty Level:** How challenging is it to achieve ZNE in this particular building type/business segment (as compared conceptually with other types/segments) for building designers, contractors, and owners?

  This parameter addresses the actual and practical challenges of achieving ZNE performance for key stakeholders who are dealing with this building type/business segment. This differs from cost-effectiveness, although there is some overlap between ZNE projects that are difficult to realize and ZNE projects that have long payback periods. Similarly, there is some overlap between difficult projects and the projects that have low market acceptability.

All 15 parameters, with proposed weights, are included in the ZNE Potential Evaluation Matrix. Only the parameters numbered 1 through 9 above, and shown in dark-shaded rows of the ZNE Potential Evaluation Matrix, will be used in the remainder of this report.

ZNE POTENTIAL EVALUATION MATRIX – PROPOSED SCORE SHEET

	PARAMETER	WEIGHT	1	2	3	4	5	RAW SCORE	REASON FOR SCORE	WEIGHTED SCORE
FEASIBILITY	% Energy Savings Over Baseline Towards ZNE	4	Minimal <15%	Low 15% - 30%	Medium 30-50%	High 50% - 70%	Very High >70%			
	On-site Generation Potential	4	Poor	Fair	Good	Excellent	Outstanding			
	Payback Period for Owner	3	> 8 years	6 - 8 years	4 - 6 years	2 - 4 years	< 2 years			
	Technology Risk	3	High	Medium - High	Medium	Low - Medium	Low			
	Other Benefits for Utility & Customer	1	Low	Low - Medium	Medium	Medium - High	High			
PORTFOLIO FIT	CEELTSP Alignment	3	Minimal	Low	Medium	High	Very High			
	Underserved Sector	2	Low	Low - Medium	Medium	Medium - High	High			
	Importance of Utility Involvement	3	Not Essential	Not Important	Limited Impact	Very Important	Essential			
	Opportunities for Collaboration	2	Poor	Fair	Good	Excellent	Committed			
MARKET TRANSFORMATION	Overcomes Barriers	4	Low	Low - Medium	Medium	Medium - High	High			
	Replicability (Retro.)	3	Low	Low - Medium	Medium	Medium - High	High			
	Future Growth Potential (New Const.)	3	Low	Low - Medium	Medium	Medium - High	High			
	Market Acceptability	3	Low	Low - Medium	Medium	Medium - High	High			
	Difficulty Level	2	High	Medium - High	Medium	Low - Medium	Low			
	SCE Systemwide Savings Potential		<0.5 MWh	0.5 - 5 MWh	5 - 10 MWh	10 - 50 MWh	>50MWh			
									TOTAL SCORE	

The parameters in the dark boxes are used in this report. The parameters in the light boxes are intended for detailed project selection. SCE System Wide Savings Potential is reserved for possible future use.

SELECTED BUSINESS SEGMENTS AND BUILDING TYPES

There are six business segments and building types with high potential for achieving ZNE performance. These segments and business types were selected based on a thorough review of relevant building science literature as well as by conducting interviews with leading ZNE and low-energy building practitioners and technical experts.

The literature review included the NREL Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector[2] and the U.S. DOE Zero Energy Building Database[5]. The interviewees included David Hewitt (New Buildings Institute), Ann Edminster (Design AVEnues), Mike Keesee (SMUD), and Rob Hammon and Brian Kennedy (ConSol).

A brief summary of building characteristics for each segment and building type, based on published data and the corresponding low-energy building or building simulation for the climate zones of SCE's service territory was provided.

The ZNE Potential Evaluation scoring results for each building or prototype as a proxy for the corresponding business segment/building type was provided. The eight ZNE Potential Evaluation parameters used in this report can generate a maximum score of 130 points.

Following the score for each building or prototype, opportunities and obstacles to achieving ZNE with this business segment/building type were identified. Finally, any relevant demonstration showcase (D/S) ZNE projects, based on information from SCE D/S ZNE project synopses were identified and briefly described.

SINGLE FAMILY HOME - NEW CONSTRUCTION

DEFINITION AND SCOPE

This segment describes the construction of any single family detached residence that is under the jurisdiction of the California Building Standard Code (Title 24). For the purpose of this report, the term 'new construction' represents a building that is new from the ground up, or involves at least 75% by square footage of new construction, for major renovation projects.

BUILDING CHARACTERISTICS

The selected prototype new construction house is SMUD's Home of the Future[10], a 1,921 square foot (ft^2), two-story single-family house with a detached 740-ft^2 guesthouse located above the garage. The main house has a roughly square footprint; uses advanced "stack" wood-frame construction, and resembles a craftsman-style bungalow. Walls are insulated with R-29 insulation, the floor is insulated with R-21, and the attic is insulated with R-38, backed up by quality insulation inspection throughout the house.

All fenestration is spectrally selective, exceeds ENERGY STAR® ratings for low U-factor and low solar heat gain coefficient, and is equipped with automated shades. The main house heating, ventilating, and air-

conditioning (HVAC) system consists of a Phoenix hydronic heating system (0.95 annual fuel utilization efficiency (AFUE)), an AquaChill water-cooled air conditioner (Energy Efficiency Ratio (EER) 15), and a night ventilation system to pre-cool the house when night-time temperatures are suitable. The guesthouse HVAC is supplied by a ductless mini-split heat pump (Heating Seasonal Performance Factor (HSPF) 10, EER 12.5).

Domestic hot water for the main house is provided by a 97% thermally efficient Phoenix gas-fired boiler with a solar thermal collector providing 0.49 solar fractions. The guesthouse is supplied by a tankless gas water heater (0.82 Energy Factor (EF)). All appliances are ENERGY STAR rated, if available, and lighting is a light emitting diode (LED) or ENERGY STAR rated compact fluorescent lamp (CFL).

Simulation of the house as constructed with its highly efficient features reveals a 60% savings relative to a 2005 Title 24 compliant baseline version. A 3.9-kilowatt (kW) rooftop-mounted photovoltaic (PV) system is projected to generate 6,300-kilowatt hours (kWh) per year and export approximately 2,000 kWh per year, qualifying the house as ZNE. The total utility cost savings is estimated to be $1,400 per year, with utility bills under $24 per month.

A whole house energy-management system allows the homeowner to monitor and control the lighting, heating and air conditioning, solar electric system, window coverings, skylight, and irrigation systems.

ZNE Potential Evaluation

Table 1. ZNE Potential Evaluation For Single Family Home - New Construction

Parameter	Scoring
Percent of Energy Savings Over Baseline Towards ZNE	16
On-site Generation Potential	20
Payback Period for Owner	6
CLTEESP Alignment	12
Overcomes Barriers	16
Future Growth Potential	3
Market Acceptability	9
Difficulty Level	8
TOTAL	**90**

ZNE Opportunities and Obstacles

Single Family Home – New Construction is the highest scoring of the six business segments/building types examined in this report. It is rated 'outstanding' for
On-site Generation Potential, since orientation and shading are likely not significant obstacles in residential new construction. It is rated 'high' for Percent Energy Savings Over Baseline, CLTEESP Alignment, Overcomes Barriers, and 'low' for Difficulty Level.

The lowest parameter scores for this segment/building type are on Future Growth Potential, due to near-term uncertainties in the residential new construction market, and on Payback Period. However, the overall score for this segment/building type is still the highest of all considered.

SCE D/S Relevance and Commentary

SCE has proposed a ZNE D/S New Homes Project. No quantitative details on this project are available as of the date of publication of this report, but because of the high ZNE potential score for this segment/building type, we recommend a concerted D/S effort to assess and validate the opportunity for new construction of ZNE single-family homes.

The SMUD's Home of the Future described above, as well as planned additional homes in Sacramento, can provide useful data and insights for the D/S New Homes project. Another resource for near-ZNE new homes is LivingHomes[11], based in Santa Monica, which has recently completed modern, modular pre-fabricated homes in Newport Beach, near their offices, and in Northern California.

Single Family Home – Retrofit

Definition and Scope

This segment encompasses the remodel of a single-family detached residence, including but not limited to projects that are under the jurisdiction of the California Building Standard Code (Title 24). For the purpose of this report, the term 'retrofit' represents a building that is modified, renovated, or remodeled, or involves less than 75% by square footage of new construction.

Building Characteristics

The prototype low-energy single-family home retrofit is based on simulation results from the Building American Retrofit pilot program for a Sacramento, CA single-story home built in 1970 with 2,000 square feet of conditioned space. This prototype house is designed to achieve near-ZNE performance, using about 50% less energy than the baseline, pre-retrofit house as indicated by the HERS Index.

The low-energy home retrofit package includes R-38 attic insulation, spectrally selective dual-pane windows with a U-factor of 0.3 and solar heat gain coefficient of 0.3, and complete home envelope air sealing.

The HVAC system upgrades include a seasonal energy efficiency ratio (SEER) 16 air conditioner, a 0.95 AFUE furnace, and comprehensive duct system testing and sealing. The domestic hot water system includes a solar thermal system with the backup storage water heater upgraded to 0.65 and hot water pipe insulation throughout the house.

All lighting will be upgraded to CFL where compatible with existing fixtures.

The combined, installed cost of the low-energy features is approximately $29,000, with about half the cost attributed to replacing fenestration and installing the solar hot water system. Based on an estimated pre-retrofit monthly energy expenditure of $250 ($3,000 per year), the estimated payback period for adding the low-energy features is 24 years, excluding any applicable energy efficiency subsidies, rebates, or tax credits.

Additional energy efficiency measures to achieve ZNE performance include wall insulation, cool roofing in applicable climate zones, ENERGY STAR smart appliances with demand response capability, and an energy management system for miscellaneous electric loads (plug loads). The addition of a 3.0 to 3.5 kW PV will qualify the house as ZNE.

ZNE Potential Evaluation

Table 2. ZNE Potential Evaluation of Single Family Home Retrofit

Parameter	Scoring
Percent of energy savings over baseline towards ZNE	12
On-site generation potential	12
Payback Period for Owner	3
CLTEESP Alignment	12
Overcomes Barriers	16
Replicability	12
Market Acceptability	6
Difficulty Level	6
TOTAL	**79**

ZNE Opportunities and Obstacles

Single Family Home – Retrofit is among the lowest scoring of the six business segments/building types examined in this report. The variation among scores for the six segments/building types is moderate, ranging from 72 to 90 out of a possible 130 points.

Although Single Family Home – Retrofit scored lower than Single Family Home – New Construction for most parameters, it generally scored only one level lower. The notable exception is that it scored two levels lower for On-site Generation Potential (solar PV), receiving a rating of 'good'. This reflects the overall SCE climate with some mitigation due to variations in home orientation and shading.

The single greatest obstacle to achieving ZNE in the residential retrofit market is cost. The long payback period identified for the Building America Retrofit project also impacts market acceptability, which is low to medium. Builders and homeowners are open to the idea of ZNE retrofits, with some contractors skeptical of packaging performance improvements prior to evaluating individual homes, or attempting to

achieve ZNE as part of a retrofit package. The cost of implementation further impedes market acceptability.

SCE D/S Relevance and Commentary

SCE has a committed ETP D/S project with the San Bernardino Green Alliance that may include similar features to those proposed in the low-energy prototype. The Building America Retrofit prototype for Sacramento described in the Single Family Home – Retrofit section, as well as planned Building America Retrofit prototypes for Anaheim, can provide valuable insight for the D/S project.

Single Family Home - Multi-Home Retrofit in a Planned Development

Definition and Scope

This segment encompasses the remodel of a group of at least four single family detached residences, including but not limited to projects that are under the jurisdiction of the California Building Standard Code (Title 24) and were constructed based on a common house plan and model.

The individual houses in a planned development are assumed to meet the same criteria as for Single Family Home - Retrofit with the expectation that the project costs are reduced because of common construction details and solar access is improved, assuming common height and orientation, reducing the likelihood of shading.

Building Characteristics

The prototype low-energy single-family home retrofit is based on simulation results from the Building American Retrofit pilot program for a Sacramento, CA single-story home built in 1970 with 2,000 ft^2 of conditioned space. This prototype house is designed to achieve near-ZNE performance, using approximately 50% less energy than the baseline, pre-retrofit house as indicated by the HERS Index.

The low-energy home retrofit package includes R-38 attic insulation, spectrally selective dual-pane windows with a U-factor of 0.3 and solar heat gain coefficient of 0.3, and complete home envelope air sealing.

The HVAC system upgrades include a SEER 16 air conditioner, a 0.95 AFUE furnace, and comprehensive duct system testing and sealing. The domestic hot water system includes a solar thermal system with the backup storage water heater upgraded to 0.65 and hot water pipe insulation throughout the house.

All lighting will be upgraded to CFL where it is compatible with existing fixtures.

The combined, installed cost of the low-energy features is approximately $29,000, with about half the cost attributed to replacing fenestration and installing the solar hot water system. Based on an estimated pre-retrofit monthly energy expenditure of $250 ($3,000 per year), the estimated

payback period for adding the low-energy features is 24 years, excluding any applicable energy efficiency subsidies, rebates, or tax credits.

Additional energy efficiency measures necessary to achieve ZNE performance include wall insulation, cool roofing in applicable climate zones, ENERGY STAR smart appliances with demand response capability, and an energy management system for miscellaneous electric loads (plug loads). The addition of a 3.0 to 3.5 kW PV will qualify the house as ZNE.

ZNE Potential Evaluation

Table 3. ZNE Potential Evaluation For The Single-Family Home – Multi-Home Retrofit

	Scoring
Percent of energy savings over baseline towards ZNE	12
On-site generation potential	16
Payback Period for Owner	6
CLTEESP Alignment	12
Overcomes Barriers	16
Replicability	12
Market Acceptability	6
Difficulty Level	8
TOTAL	**88**

ZNE Opportunities and Obstacles

The Single Family Home – Multi-Home Retrofit scored relatively high among the business segments/building types examined in this report. This distinguishes it from the Single Family Home – Retrofit segment/building type, against which the Multi-Home Retrofit scored one level higher in several categories.

The Single Family Home – Multi-Home Retrofit received a higher score for On-site Generation, assuming that a planned development will provide better opportunities for solar PV orientation and unshaded locations. A higher score was also given for Payback Period and Difficulty Level, assuming that some economies of scale will reduce the cost and complexity for Multi-Home Retrofits in a planned development. This assumption warrants further analysis to determine if such economies of scale will be realized and have a significant impact.

SCE D/S Relevance and Commentary

SCE has committed the ETP ZNE D/S Tract Homes Retrofit Project for the University Hills community in the city of Irvine, CA. This project may include similar features to those proposed in the low-energy prototype. The Building America Retrofit prototype for Sacramento as well as the planned Building America Retrofit prototypes for Anaheim provides insight for the D/S project.

MEDIUM BOX RETAIL STORE – NEW CONSTRUCTION

DEFINITION AND SCOPE

This segment encompasses the construction of any medium size (average of 50,000 ft^2) single-story "box" style retail store that is under the jurisdiction of the California Building Standard Code (Title 24). For the purpose of this report, the term 'new construction' represents a building that is new from the ground up, or involves at least 75% by square footage of new construction, for major renovation projects.

BUILDING CHARACTERISTICS

The prototype building is based on EnergyPlus modeling of a 50,000 ft^2, one-story rectangular medium box retail business building with a 1.25 aspect ratio, as described in the NREL Technical Support Document for Medium Box Retail - 50% Energy Savings[12].

NREL assumes 1,000 ft^2 of glazing on the façade, which gives a 20% window-to-wall ratio for that wall, and a 5.6% window-to-wall ratio for the entire building. The prototype building has masonry wall construction and a roof with all insulation above deck. HVAC equipment consists of 10-ton packaged rooftop units with natural gas furnaces for heating, and electric direct-expansion coils with air-cooled condensers for cooling.

The low-energy version of the medium box retail store includes the following energy efficiency features not present in the baseline version (minimally compliant with ASHRAE 90.1-2004) of the building:

- **Lighting technologies:** Reduced lighting power density (LPD), daylighting sensors, and controls throughout the building, and occupancy sensors and controls in active storage, office, lounge, restroom, and electrical/mechanical spaces.
- **Plug loads:** Reduced density and nighttime loads. Plug loads are significant drivers of energy use for this building type and vary considerably by business segment, with stores displaying consumer electronics with high-energy use. Achieving ZNE depends on smart and comprehensive application of controls as well as other strategies to minimize plug loads at all times while promoting robust sales of the products on display.
- **Fenestration:** Reduced square footage of façade glazing and use of spectrally selective, low solar heat gain coefficient glazing products throughout the building. Provide overhangs for solar shading of all south-facing windows.

  Optimize skylight size, location, glazing type, and construction details so resulting daylighting energy benefits more than offsetting any incremental air conditioning (AC) energy requirements.
- **Envelope:** Opaque envelope insulation, air barriers, cool roofing materials, and vestibules.

- **HVAC Equipment:** Higher efficiency equipment and fans, economizers, demand control ventilation (DCV), energy recovery ventilators (ERVs), and indirect evaporative cooling.

  Additional HVAC energy savings options not analyzed include packaged variable air volume systems and variable refrigerant flow systems, radiant heating and cooling; solar thermal technologies for service water heating and space conditioning; direct and indirect evaporative cooling; and decreased fan pressure drop via improved duct design.

The baseline building has a EUI of 43.9 to 84.2, and the low-energy building has a EUI of 19.2 to 42.1, with the two-fold variation due to the magnitude of plug loads and the associated AC energy use. Construction costs necessary to achieve a 50% energy savings in the low-energy building range from 17% – 22% higher than for the baseline building, with the variation driven primarily by PV installations covering from 2% - 5% of building roof area, and secondarily by additional energy saving measures to offset plug loads.

ZNE Potential Evaluation

Table 4. ZNE Potential Evaluation For Medium Box Retail Store – New Construction

Parameters	Scoring
Percent of energy savings over baseline towards ZNE	16
On-site generation potential	16
Payback Period for Owner	3
CLTEESP Alignment	12
Overcomes Barriers	16
Future Growth Potential	9
Market Acceptability	9
Difficulty Level	8
TOTAL	**89**

ZNE Opportunities and Obstacles

Medium Box Retail Store – New Construction is the second highest scoring of the six business segments/building types examined in this report. It received a rating of 'excellent' for On-site Generation Potential. Since most buildings of this type are single-story, available surface area, as well as orientation and shading, will not be significant obstacles. It also received high ratings for Percent Energy Savings Over Baseline, CLTEESP Alignment, Overcomes Barriers, and a low rating for the category of Difficulty Level.

The lowest parameter score for this segment/building type is in the category of Payback Period for the energy efficiency features, which is expected to be more than 8 years, excluding any applicable energy efficiency subsidies, rebates, or tax credits.

An underlying obstacle that must be overcome in order to achieve widespread ZNE success in this segment/building type is the significant

role of plug loads in driving energy use and contributing to a higher-than-average EUI, particularly for consumer electronics retailers. If the retail entertainment, information, and telecommunication products are energy efficient and marketed in ways that do not require running them at maximum power settings, building ZNE performance will be easier to achieve. A related obstacle for this segment/building type is overcoming owner/tenant resistance to unconventional designs and employee resistance to behavior changes needed to market products successfully in a low-energy setting.

Big box retail stores represent another potential target for ZNE new construction and retrofit projects, particularly given the interest shown by major market players such as WalMart and Home Depot. However, examples of completed building projects or simulations for this business segment/building type could not be located. This same deficiency exists with mixed retail occupancies, as well as with most types of commercial building retrofit projects.

For both retrofit and new construction, it is recommended that data from the Medium Box Retail be extrapolated to address Big Box Retail as an initial effort to determine their ZNE potential. This should be followed by the development of simulations tailored to Big Box Retail in order to enable comparisons like those presented in this report.

The preceding recommendation also applies to mixed retail occupancies where the data can be extrapolated from other building types that are similar to mixed retail occupancies.

SCE D/S Relevance and Commentary

Although SCE does not currently have any D/S projects planned for this business segment/building type, because of the high ZNE potential score for this segment/building type, it is recommended that a concerted D/S effort be made to assess and validate the opportunity for new construction of ZNE medium box retail stores. Because of the rapid construction nature of these project types, coordinating and timing the projects to the 2012 or 2013 SCE ETP cycle should not be a problem. One obstacle may be finding suitable retail business and builder partners to participate in a D/S project.

Low-Rise Office Building - One to three stories – New Construction

Definition and Scope

This segment encompasses the construction of any low-rise (one- to three-story) small office building (average of 20,000 ft²) that is under the jurisdiction of the California Building Standard Code (Title 24). For the purpose of this report, the term 'new construction' represents a building that is new from the ground up, or that involves at least 75% by square footage of new construction, for major renovation projects.

Building Characteristics

The prototype low-rise small office building is based on EnergyPlus modeling of a 20,000-ft^2 two-story building[13]. The building has a square shape with dimensions of 100 ft by 100 ft. Building construction includes mass walls, a flat roof with insulation above the deck and slab-on-grade floors. Fenestration is manufactured windows in punch style openings.

Internal loads include heat generated by occupants, lights, and miscellaneous equipment (plug loads such as computers, printers, and vending machines). HVAC is provided by constant air volume packaged rooftop units with gas furnaces. Domestic hot water is provided by a small commercial water heater with 75-gallon storage and rated input of 75,100 British thermal unit (Btu)/hour (hr).

The low-energy version of the low-rise small office building includes the following energy efficiency features not present in the baseline version (minimally compliant with ASHRAE 90.1-2004) of the building:

- **Building envelope measures:** Enhanced exterior wall and roof insulation and high-performance fenestration, exterior shading for south windows, and cool roofing
- **Lighting measures:** These include advanced lighting fixtures and lamps to reduce connected lighting load, automatic lighting controls such as perimeter daylight harvesting sensors and controls and occupancy-based sensors and controls, as well as high-efficiency exterior lighting fixtures, lamps, sensors and controls.
- **Plug load measures:** These include ENERGY STAR labeled office equipment and adaptive power management software and controls for plug loads.
- **HVAC measures:** These include efficiently packaged rooftop or split system heat pumps and a dedicated outside air system (DOAS) with energy recovery and well-insulated, low pressure-drop ductwork design. A variable air volume (VAV) system is also considered as an alternative.

Demand controlled ventilation (DCV) is not included as an option in the simulation, but is estimated to produce an additional energy savings of 2%.

- **Service water heating measures:** These include high-efficiency condensing gas water heaters.
- **EUI measures:** Ensure that the baseline building (minimally compliant with ASHRAE 90.1-2004) has an EUI of 36.9 to 63.5, and the low-energy building has an EUI of 17.8 to 26.9, with the first value corresponding to climate zone 3B-CA (covering most of SCE's service territory) and the second to climate zone 6B (Mono County).

The low-energy version of the low-rise small office building saves 52% of the annual energy use relative to the baseline version in all climate zones except climate zone 6B, where the annual savings is 49%. This generates a simple payback of 8.6 years in climate zone 3B-CA, with longer payback of 9.6 years in climate zone 3C (Ventura County) and shorter paybacks of 5.3 years and 6.0 years respectively in climate zones 4B (Inyo County) and 6B (Mono County).

ZNE Potential Evaluation

Table 5. ZNE Potential Evaluation For Low-Rise Office Building - One to three stories – New Construction

Parameters	Scoring
Percent of energy savings over baseline towards ZNE	16
On-site generation potential	12
Payback Period for Owner	3
CLTEESP Alignment	12
Overcomes Barriers	16
Future Growth Potential	9
Market Acceptability	9
Difficulty Level	8
TOTAL	**85**

ZNE Opportunities and Obstacles

Low-Rise Office Building – New Construction is the lowest of the relatively high-scoring business segments/building types examined in this report. It is rated "good" for On-site Generation Potential. Since many buildings of this type are two- or three-story, available surface area might be an obstacle in achieving ZNE. However, it is rated 'high' for Percent Energy Savings Over Baseline, CLTEESP Alignment, and Overcomes Barriers parameters. In addition, it is rated 'low' for the Difficulty Level parameter.

The lowest parameter score for this segment/building type is for Payback Period for the energy efficiency features, which is expected to be

considerably higher than the 50% savings prototype described in the Building Characteristics section for Low-Rise Office Buildings.

Unlike Medium Box Retail, plug load is generally easier to manage in this segment/building type with monitoring and control systems. One obstacle that must be overcome in order to minimize plug load energy impacts is employee resistance to behavior changes.

SCE D/S Relevance and Commentary

Although SCE does not currently have any D/S projects planned for this business segment/building type, because of the significant ZNE Potential score for this segment/building type, it is recommended that a D/S effort be made to assess and validate the opportunity for new construction of ZNE Low-Rise Office Buildings. Unlike Medium Box Retail, these projects may not be driven by aggressive developer schedules, so timing the project relative to the 2012 or 2013 SCE ETP cycle can be a problem.

Sports and Recreation Center - Retrofit

Definition and Scope

This segment encompasses the retrofit of a large-scale recreation center (25,000 to 150,000 ft²) that is under the jurisdiction of the California Building Standard Code (Title 24). A recreation center typically includes one or more swimming pools, one or more gymnasia, one or more weight rooms, multiple squash and/or racquetball courts, locker rooms, showers, and offices.

Building Characteristics

Although several recreational facility new construction projects meeting some of these criteria have already been built or are in progress, a suitable source for characterizing a ZNE or near-ZNE sports and recreation center retrofit has not been identified.

The Challengers Tennis Club for Boys and Girls, Los Angeles, CA[14] yielded relevant information for this project. The facility occupies approximately 53,600 ft² and consists of a 3,500- ft² clubhouse with observer stands, four tennis courts, a small outdoor meeting and eating area, a parking area, pedestrian walkways, and planted space. Challengers Tennis Club meets all of its net electricity needs through a PV system that is within the building's footprint. A small amount of natural gas used for heating is also offset by on-site PV generation.

The facility, constructed in 2002, uses 60% less energy than a similar building constructed according to California's Title 24 requirements then in effect.

The building has no mechanical cooling, and is kept comfortable through natural ventilation, ceiling fans, internal thermal mass, high R-value insulation, spectrally selective low U-value glazing, and appropriate shading. Daylighting minimizes requirements for artificial lighting, and all lighting is fluorescent with either photocell or motion-sensor controls. Kitchen appliances and office equipment are ENERGY STAR-rated. The

building has a 2,000-ft² PV array on the roof that provides 100% of the facility's annual electricity.

The total project cost, excluding land, was $1.8M. The calculated energy savings is approximately $4,000 per year, and the calculated payback of the net total investment for efficiency and solar generation is 12 years.

More recent examples of low-energy recreational facilities include the 15,000 ft^2 Leadership in Energy & Environmental Design (LEED) platinum Carbondale Recreation & Community Center[15] completed in 2008 in Carbondale, CO and the 118,000 ft^2 California State University Northridge Student Recreation Center[16], scheduled for completion in 2012 and expected to receive a LEED gold certification.

ZNE Potential Evaluation

Table 6. ZNE Potential Evaluation For Sports And RECREATION - RETROFIT

Parameter	Scoring
Percent of energy savings over baseline towards ZNE	12
On-site generation potential	16
Payback Period for Owner	3
CLTEESP Alignment	12
Overcomes Barriers	8
Replicability	6
Market Acceptability	12
Difficulty Level	6
TOTAL	**75**

ZNE Opportunities and Obstacles

Sports and Recreation Center - Retrofit is the lowest scoring of the six business segments/building types examined in this report. As mentioned previously, the variation among scores for the six segments/building types is moderate, ranging from 72 to 90 out of a possible 130 points.

Although Sports and Recreation Center - Retrofit scored lower than the other two commercial building new construction prototypes on most parameters, it generally scored only one level lower. The notable exception is that it scored two levels lower for Overcomes Barriers, receiving a rating of low-to-medium due to the expectation that sport and recreation center retrofits will not have a strong influence on the commercial building sector as a whole.

As in the residential sector, the single greatest obstacle to achieving ZNE in the commercial retrofit market is cost. The Challengers Tennis Club project described in the Building Characteristics section of this section has a long payback period but does not incorporate many energy-using features encountered in a larger-scale sports and recreation center. This, together with the complexity of retrofitting an existing facility, is likely to increase the payback period. Conversely, because many large sports and recreation centers are located at colleges and universities that are slightly less sensitive to the payback period, the market acceptability for this

segment/building type is medium-to-high, with builders and administrators open to ZNE retrofits in principle.

SCE D/S Relevance and Commentary

SCE has a committed ETP D/S project at the University of California at Santa Barbara recreation center. The energy efficiency charrette completed by SCE and its consultants for this project in 2009 provides a solid foundation for a single or multiple-building ZNE retrofit project. It is recommended that SCE commission a facility model for energy and cost modeling of the various options developed in the charrette.

CONCLUSIONS

It is recommended that SCE adopt the ZNE Potential Evaluation system developed for this Technical and Market Potential Review, or modify the system described in this report to meet SCE needs optimally. This type of project screening system, based on clear definitions and applied consistently, will provide support for SCE decisions on proposed or potential ZNE projects in the preliminary stages of development.

Although ZNE new construction and retrofit projects are still uncommon, especially in the U.S., this Technical and Market Potential Review demonstrates the ZNE potential for a number of market segments and building types.

RESULTS FOR SELECTED BUSINESS SEGMENTS AND BUILDING TYPES

TABLE 7. RESULTS FOR SELECTED BUSINESS SEGMENTS AND BUILDING TYPES

Business Segment / Building Type	ZNE Potential Score	D/S Recommendation
Residential New Construction (NC)	90	Pursue D/S projects in this segment/building type, using Sacrament Municipal Utility District (SMUD) and LivingHomes Projects as potential resources
Residential Retrofit	79	Pursue D/S ZNE Home Retrofit projects, using Building America Retrofit projects as sources and exploring alternatives to address retrofit cost issues.
Residential Multi-Unit Retrofit	88	Pursue D/S ZNE Tract Home Retrofit project, using Building America Retrofit projects as sources and exploring ways to optimize economies-of-scale in multi-home retrofits.
Medium Box Retail – NC	89	Perform further analysis and explore potential projects in this promising commercial new construction segment / building type for ZNE. For potential consumer electronics retail store projects, examine plug load issues and undertake innovative approaches to address them.
Low-Rise Office – NC	85	Perform further analysis and explore potential projects in this promising commercial new construction segment / building type for ZNE.
Sports & Recreation Retrofit	72	Continue with D/S ZNE Recreation Center Retrofit project, using the existing SCE energy efficiency charrette as a reference point, commissioning a building simulation model to gain a deeper understanding of energy and cost options and trade-offs, and seeking other examples of low-energy Sports and Recreation Center Retrofit and new construction projects for additional insights.
Big Box Retail – NC & Retrofit	N/A	
Mixed-Use – NC & Retrofit	N/A	

RECOMMENDATIONS FOR FURTHER STUDY

It is recommended that SCE pursue all D/S projects already planned, with particular emphasis on the Single Family Home – New Construction category due to its strong potential.

It is also recommended that SCE consider additional projects for Medium Box Commercial - New Construction and Low-Rise Office Building – New Construction as the opportunities and ETP budget allows. Although it scored lower than others in ZNE potential, the Sports and Recreation Center – Retrofit project has considerable promise for ZNE, but should be approached with an awareness of its unique and challenging characteristics as a ZNE project.

The following recommended actions will resolve issues that emerged during the preparation of this report, but have not been addressed definitively as of this writing:

1. Develop a universal ZNE energy savings metric as recommended[1] by Charles Eley of Architectural Energy Corporation. This metric is valuable for the SCE D/S ETP element and will potentially make a durable contribution toward the ZNE goals of the CLTEESP, and to ZNE activities elsewhere.

   Development and advocacy of a universal ZNE metric will be a significant contribution by SCE to the design community body of knowledge, and will reinforce SCE's leadership role in the Emerging Technology (ET) domain.

2. Update energy models of available prototype baseline and ZNE buildings by replacing DOE/ International Energy Conservation Code (IECC)/ASHRAE climate zones with California Energy Commission (CEC) climate zones to obtain better resolution.

3. Update available prototype baseline building models to reflect ASHRAE 90.1-2010, 2008 Title 24 and pending 2011 requirements.

4. Perform thoughtful extrapolations from data on completed low-energy buildings and simulations to address related segments/building types for which no examples or data are available. This should be followed by the development of prototype building simulations for these additional segments/building types.

5. Perform energy modeling of proposed ZNE D/S projects as early as possible during the project initiation to determine how effectively EE measures will bring the building(s) to ZNE and how much on-site generation is necessary to achieve ZNE. This will clarify project energy impacts and cost-effectiveness for management, regulatory, and customer/builder/partner buy-in.

6. Investigate using owner return on investment (ROI) as an alternative to payback period when detailed project analysis and decision-making is performed.

7. Address the five ZNE potential evaluation parameters not used in this report for detailed project decision-making, and consider the challenges and advantages of adding the sixth parameter – SCE Systemwide Savings Potential - for in-depth analysis of project impacts.

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