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California Zero Net Energy State Buildings Decision Maker Study

California Public Utilities Commission

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Legal Notice

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Glossary

Term	Definition
Building	A structure with roof and walls built for permanent use (for occupation by people and/or equipment). For the purposes of this report, we use building to refer to the unique structure contained within a property tracked by Energy Star Portfolio Manager (ESPM).
Department	Throughout this report we use "department" to refer to the 35 state government offices that occupy or manage state-owned buildings. These represent offices at different levels of state government--that is, some are standalone agencies, while other may be departments, boards, or commissions that operate within other larger agencies.
ESCO	Within the energy efficiency industry, Energy Service Companies (ESCOs) provide a range of services needed to implement energy efficiency projects. Typical ESCO service offerings include: 1) building audits; 2) engineering services; 3) provision and/or arrangement of financing; 4) procurement and installation of equipment; 5) monitoring and verification of energy efficiency system/equipment performance; and 6) ongoing maintenance and related contracts.
ESPM	Energy Star Portfolio Manager (ESPM) is an online tool developed by the US Environmental Protection Agency (EPA) to measure and track energy and water consumption as well as greenhouse gas emissions. It can be used to benchmark the performance of one building or a whole portfolio of buildings, all in a secure online environment.
EUI	An expression of a building's energy use as a function of its size. Energy Use Intensity (EUI) is expressed as energy use per square foot per year. A building's EUI is calculated by dividing all the energy sources (e.g., electricity, natural gas, propane, etc.) consumed by the building in one year (measured in kBtu) by the total gross floor area of the building.
Existing Building	For purposes of this research study, Existing Building refers to a building where construction is complete and, in nearly all cases, it is occupied and operational.
Five Year Infrastructure Plan	These are capital improvement plans that each department drafts and submits to the Department of Finance for review and approval.
kBtu	British thermal units (BTU) is a unit of measure that represents the heat energy required to raise one pound of water one degree Fahrenheit. The prefix "k" stands for "kilo-," which means that one kBtu equals 1,000 BTUs.

Term	Definition
Property	A property (also commonly referred to as a "building") within ESPM could include only one structure, or could include an entire campus of buildings and structures. We use property throughout this report to refer to the distinct site, or location that includes either a single building or multiple buildings.
Site Energy	The amount of heat and electricity consumed by a building as reflected in utility bills (e.g., kWh, therms) and expressed in kBtu. Site Energy includes renewable energy produced and consumed on site.
Site EUI	Site Energy use per square foot for a given building.
Solar Power Purchase Agreement (PPA)	For this study, an agreement between a producer of solar power and a state department. Typically the solar photovoltaic (PV) array is located on state-owned property and energy production from the system is purchased by the department through a long-term (often 20 year) contract.
Source Energy	The heat (typically natural gas) and electricity requirements of a building traced back to the raw fuel input. Source Energy incorporates all production (e.g., generation), transmission, and delivery losses—allowing for an equitable assessment of building-level energy efficiency, expressed in kBtu.
Source EUI	Source Energy (typically electricity and natural gas) use per square foot for a given building.
Sustainability Road Map	Reports tilted *Road Map to Achieving Order B-18-12, B-16-12, and Other Polices* that each department subject to EO-B-8-12 submits biannually to report on the status, goals, stakeholders, and other information relevant to meeting the goals outlined by the gubernatorial administration's sustainability policies.

State Department Names and Abbreviations

Department Name	Acronym
Air Resources Board	ARB
California African American Museum	CAAM
California Conservation Corps	CCC
California Department of Corrections and Rehabilitation	CDCR
California Department of Education	CDE
California Department of Fish and Wildlife	CDFW
California Department of Food and Agriculture	CDFA
California Department of Forestry and Fire Protection	CAL FIRE
California Department of Public Health	CDPH
California Department of Technology	CDT
California Department of Transportation	Caltrans
California Department of Veterans Affairs	CalVet
California Exposition & State Fair	Cal Expo
California Highway Patrol	CHP
California Lottery Commission	CA Lottery
California Military Department	CMD
California Office of Emergency Services	Cal OES
California Prison Industry Authority	CALPIA
California Public Employees Retirement System	CalPERS
California Science Center	CSC
California Teachers Retirement System	CalSTRS
Department of Conservation	DOC
Department of Consumer Affairs	DCA
Department of Developmental Services	DDS
Department of General Services	DGS
Department of Justice	DOJ
Department of Motor Vehicles	DMV
Department of Parks and Recreation	DPR
Department of Rehabilitation	DOR
Department of State Hospitals	DSH
Department of Water Resources	DWR
Employment Development Department	EDD
Housing and Community Development	HCD
Santa Monica Mountains Conservancy	SMMC
State Lands Commission	SLC

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1. Executive Summary

The state of California is a large real estate holder and a major consumer of energy. State-owned building square footage totals approximately 112 million square feet, with grid purchases of energy for state buildings of approximately 9.9 billion kBtu in 2015; and on-site renewable energy generation of approximately 78.41 million kWh (267.4 million kBtu) in 2015.[1] In 2012, Governor Brown issued Executive Order B-18-12[2] directing all state departments to undertake sweeping energy-conserving initiatives including these state building Zero-net-Energy (ZNE) goals. We provide definitions of ZNE concepts on page 2 of this executive summary, and the specific goals outlined in Executive Order B-18-12 are that:

- 50% of all new state buildings beginning design after 2020 be ZNE;
- 100% of all new state buildings and major renovations beginning design after 2025 be ZNE; and,
- By 2025, state departments should take measures toward achieving ZNE for 50% of all existing state-owned building square footage.

The California Public Utilities Commission (CPUC) commissioned this study to examine state buildings and state building decision makers with respect to ZNE readiness, with the following two umbrella objectives guiding the research:

- **Objective 1:** Characterize state departments' pathways toward implementing ZNE at their properties through the identification of barriers they face when contemplating ZNE projects.
- **Objective 2:** Profile the energy use characteristics and performance of state buildings, with particular focus on energy intensity and the presence of onsite electric generation.

An important foundation for reading this report is a firm understanding of the definition of ZNE adopted by the State of California. The California Department of General Services (DGS)—in consultation with 20 energy professionals representing state departments, utilities, federal and private sectors—determined that "ZNE Source" will be the primary definition used by state departments in achieving and reporting on ZNE status for new and existing state buildings. This definition, outlined immediately below, was accepted by the governor's office.

> ***ZNE Source*** *– Produces as much energy as it consumes over the course of a year, when accounted for at the energy generation source.*

[1] DGS Whitepaper, dated May 19, 2016, entitled "Definition of Zero Net Energy (ZNE) for California State Department Compliance with Executive Order B-18-12," available at: https://www.calstate.edu/cpdc/ae/documents/ZNE-Definition-EO-B-18-12-20160519.pdf

[2] California Governor Jerry Brown. April 25, 2012. Executive Order B-18-12. Available at: https://www.gov.ca.gov/news.php?id=17508

Note: Source energy traces the heat and electricity requirements of a building back to the primary energy (raw fuel) input. Source Energy incorporates all production (e.g., generation), transmission, and delivery losses—allowing for an equitable assessment of building-level energy efficiency, expressed in kBtu. For a complete discussion and explanation of Source energy calculations, see Energy Star Portfolio Manager (ESPM) Technical Reference "Source Energy", dated July 2013, available through Energy Star®.

In addition to defining ZNE, it is important to understand the common characteristics of ZNE buildings, most importantly the fact that achieving ZNE is not dependent on experimental technologies or recent breakthroughs, but rather is a set of currently available best practices and technologies. Passive energy management strategies, better building envelope sealing, increased insulation, natural daylighting, heating and cooling controls, operable windows, and shading are often employed in ZNE designs as well as highly efficient appliances and systems. A common ZNE mantra is "reduce, reduce, reduce, then produce," reflecting the proper loading order is to design an ultra-low energy building, operate it efficiently, control plug loads, and, only then, install renewable energy generation.

To characterize state departments and state-owned building performance, the research process covered five primary activities, including:

1. A literature review and secondary data analysis, covering approximately 100 documents;
2. Interviews with 10 individuals who oversee the operation of existing ZNE buildings;
3. Interviews with 16 ZNE experts, spanning from utility personnel to regulatory staff from the CPUC;
4. Interviews with 60 decision makers, within 26 state departments; and
5. An analysis of building energy data collected by the US Department of Energy that contains key information about state-owned properties, buildings, and their associated energy use.

While each of the research activities had slightly different objectives, the over-riding objective of all research efforts is to understand pathways to ZNE and associated barriers and to characterize state-owned buildings.

1.1 Key Findings & Lessons Learned

The study covered a wide-range of topics and provided several key findings related to the readiness of departments and state-owned buildings to undertake ZNE retrofits and new construction projects. We outline the major report findings and follow this with a set of recommendations that state departments should consider as they continue to pursue the collective goal of reaching ZNE status for state-owned buildings.

- **Eight[3] of thirty-five departments have achieved ZNE status for a given building or have a ZNE building in progress.** While many departments are working toward increasing energy efficiency levels and installing on-site renewable generation, we use the term "progress" to indicate that a department has concrete plans, or has already achieved ZNE status for a newly constructed or existing building. Two of the departments with concrete plans—the Department of Motor Vehicles and the California Lottery Commission—are only pursuing ZNE through new construction or major gut rehabilitation projects. Combined, these two departments have eight buildings in some stage of planning, design, or construction and two completed buildings—the DMV's Fresno and the California Lottery's Santa Fe Springs buildings. In addition to these two completed buildings, the California Department of Public Health has one completed ZNE building. The remaining five departments have a ZNE building in progress. Collectively, these buildings--that have either achieved ZNE status or are in progress of achieving ZNE--account for less than 2% of state-owned building square footage.[4]

- **Departments that have either achieved ZNE status for a given building or have ZNE buildings in progress share a number of common elements of success, leading to important "lessons learned" that can be shared with other departments.** Common elements, that have led to success, include the following: 1) executive sponsorship, 2) careful planning (both before and during building design), including pre-construction energy-use analysis and post-construction commissioning; 3) identifying good candidate buildings, working to make them more efficient and continuing to iterate; 4) planning for future operations and maintenance challenges; and 5) consistently and clearly communicating with all stakeholders from initial planning through occupancy.

- **ZNE is a newer concept and the "rules" aren't always clear.** While department decision makers are aware of the Governor's Executive Order, the associated ZNE goals, and what ZNE means generally, they are less aware of several more technical, foundational concepts. Additionally, many departments are not clear on exactly what they need to do to achieve ZNE status or when milestones need to be met. The Executive Order states that departments should "take measures toward achieving ZNE" by 2025, but it is not clear to decision makers what that means.

- **With some notable exceptions, most departments face persistent barriers to achieving ZNE within existing buildings. While funding, procurement, and competing priorities can also complicate the ZNE new construction process, there are few real impediments to new construction once funding is secured.** These barriers include:

  - **Funding:** Funding has been, and likely will continue to be, a major barrier to ZNE achievement within state-owned buildings. Department decision makers consistently spoke of the lack of funding, the long and complicated path to securing funding, and their expectation that these challenges will persist into the future. While DGS has taken important steps to address funding issues—ranging from a more streamlined process for securing the project services to financing and installing solar electricity generation--important impediments persist in obtaining the level of funding needed to move toward ZNE.

[3] The eight departments are: Air Resources Board, California Conservation Corps, California Department of Corrections and Rehabilitation, California Department of Transportation, California Lottery Commission, Department of Motor Vehicles, Department of Public Health, and California Office of Emergency Services.

[4] The actual size of some of these buildings was not available to the research team. In these cases, we estimated the size based on known building characteristics and the average size of existing buildings within the given department.

- **Procurement:** The procurement process is a particularly challenging aspect of improving the energy efficiency of state-owned buildings (on the path to ZNE) and can result in significant extensions to project timelines. While some departments have procurement authority (and most have procurement authority up to set limits), many rely upon DGS and state-prescribed procurement practices that can be both time intensive and costly.

- **Competing Priorities:** State departments have a myriad of statewide energy initiatives to manage, including Executive Orders that address ZNE in addition to water efficiency and conservation, zero emission vehicle purchases, and other environmental goals. Departmental staff assigned to the pursuit of ZNE report that ZNE efforts are often competing with these other priorities, as well as their need to focus on activities pertaining to mission delivery and keeping buildings operational. Our interviews suggest that prioritizing and integrating these various needs and goals into an integrated and cohesive "plan" can be extremely challenging.

- **Building issues:** Decision makers report that many state-owned buildings have physical, locational, and technological barriers to achieving ZNE status. The most common among these were that buildings are:

  - ***In Poor condition:*** Many state-owned buildings are in need of a significant amount of repair and rehabilitation—ranging from addressing health and safety issues to deferred maintenance. As such, multiple departments stated that they are not going to pursue ZNE retrofits in all (in some cases) or most (in other cases) buildings they occupy and operate.

  - ***Unsuitable for site located solar generation:*** Many state-owned buildings have building footprints (e.g., insufficient roof characteristics) and site footprints (e.g., insufficient owned areas around a building) that will not accommodate solar PV. Although the DGS guidelines for ZNE achievement include scenarios that allow for PV placement outside the physical building site boundary, there are a myriad of issues—in many circumstances—in pursuing these options.

  - ***Located in challenging, densely populated areas:*** Many of the largest state-owned buildings—particularly office buildings—are located in densely populated urban settings. Their location along with their overall dimensions (i.e., height and width) reportedly present barriers to installing the type of retrofit measures (e.g., upgraded heating and cooling systems, natural lighting, natural ventilation, etc.) common to many ZNE buildings.

- **External issues**: Departments pursuing ZNE for specific buildings have encountered significant issues associated with connecting a building to the electrical grid (i.e., interconnection issues). Interconnection agreements can be difficult to execute and take a significant amount of time to get in place. In addition to an often-contentious legal agreement, the utility distribution system (e.g., distribution lines, substations, transformers, etc.) may not be able to accommodate without significant upgrades. Such upgrades--paid for by the department--can be extremely costly and take a substantial amount of time to plan, contract for, and execute, often resulting in delays in reaching ZNE goals.

- **Identifying buildings for energy efficiency retrofits, toward the goal of reaching ZNE, is not an easily replicable process, as each building's condition and circumstances are unique.** While that mantra is "reduce, reduce, reduce (through energy efficiency) and then produce (through renewables)," ZNE publications and practitioners tend to oversimplify the actual process of selecting and preparing buildings that can ultimately achieve ZNE. However, the process of selecting existing state-owned buildings that can achieve ZNE is more complicated than these sources suggest. Rather, each building has a unique set of characteristics (e.g., energy uses, orientation, size, height, condition, site footprint)

that are difficult to objectively compare to other buildings. Knowledge of ZNE concepts combined with informed judgement would seem to take precedent when prioritizing buildings, in many cases, over more objective measures of ZNE readiness such as current energy efficiency levels.

- **Department decision makers agree that achieving ZNE through new construction is considerably easier (i.e., has fewer barriers) than retrofitting existing buildings.** Upon securing funding—which can take a considerable amount of time—new construction projects proceed relatively quickly. Alternatively, retrofits of existing buildings tend to take a piece meal approach to energy efficiency improvements—implemented over multiple years—before renewables are even considered. Furthermore, many energy efficiency efforts are reportedly completed without an eye toward the eventual achievement of ZNE.

- **State-owned building energy use (expressed in kBtus) and building square footage is highly concentrated within a relatively small number of departments.** For example, the California Department of Corrections and Rehabilitation (CDCR) accounts for 75% of the number of state-owned buildings and 43% of overall state-owned building square footage. CDCR along with four other departments—Department of General Services, California Department of Transportation, Department of State Hospitals, and Department of Parks and Recreation—account for 77% of the overall building square footage within state-owned buildings. These same five departments account for 81% of overall energy consumption within state-owned buildings. While other departments have a substantial number of properties and buildings, they do not individually or collectively represent as significant an amount of overall square footage or energy consumption.

- **Among properties that can be mapped to energy efficiency targets set by DGS, 27% have energy use at or below the DGS established targets**. In total, these properties account for about 22.5 million square feet of building space, or about 20% of all square footage within state-owned buildings. Given that these properties are at or below the EUI target, it would appear[5] that the next step to ZNE is to pursue the installation of renewables.

- **The data available to assess (or rank) a given state-owned building's suitability or readiness for ZNE is very limited.** While many important building energy use characteristics are available through software provided through the US Department of Energy, a good deal of additional information would be useful when deciding on which specific properties and buildings to focus on. In particular, very little information exists regarding building footprints, site footprints, and suitability for solar electric generation installations.[6] Even with improved data sources, there is likely no supplement for key decision makers prioritizing buildings for ZNE retrofits based on known and detailed characteristics of a building—such as the buildings that surround it, historical designation, condition, and deferred maintenance needs.

[5] We use the words "it would appear" because we are not entirely sure how the EUI targets were established. We believe that they essentially represent the EUI threshold currently being met by 25% of state-owned buildings within a given property use type. If so, it is unclear — and we were unable to confirm through DGS — if these targets represent aggressive enough EUIs such that the buildings meeting them should stop pursuing energy efficiency and look to add renewables in order to get to ZNE.

[6] SolView is a tool that could possibly be used to provide satellite images to calculate solar potential for state-owned buildings (http://solview.com).

1.2 Recommendations

To enhance various state department's ability to pursue ZNE, our study findings suggest the following recommendations:

- **State decision makers should continue to pursue new ZNE funding sources.** Funding is clearly the most substantial and consistently mentioned barrier to achieving ZNE within state-owned buildings. And, through the research process, we were unable to identify a clear path forward to overcoming this key barrier. The capital outlay process is the typical way significant levels of funding is secured by state departments and that is subject to the state budgeting and the legislative process. Without a more significant source of funding, progress toward ZNE will be slow for nearly all departments. In absence of such funding, state departments should continue to utilize funding through Energy Service Companies toward the goal of increased energy efficiency and PPAs to pursue renewables. Alone, these two funding sources will help but more substantial funding will be needed to address the substantial investment needed to renovate existing buildings to ZNE and/or allow for their replacement through newly constructed ZNE buildings.

- **The Department of General Services (DGS) should develop a ZNE manual for use by other state departments.** While we note that DGS and other stakeholders have produced resources for departments working towards ZNE goals, we recommend that DGS develop a manual that specifically addresses topics such as 1) the necessity of identifying key stakeholders early in the process; 2) various sources of potential funding and how to secure it, 3) how the procurement process works and what vehicles (e.g., Energy Service Company and purchase power agreements) are available to facilitate the contracting process, and 4) how to assess and prioritize buildings given their condition, location, and site characteristics. A manual should also prescribe, as much as possible, how to develop building specific roadmaps to achieving ZNE. This would include, but not be limited to, establishing energy use targets and identifying the steps along the pathway to ZNE (e.g., building consensus, planning, executing and constructing, and verifying ZNE status upon occupancy). Building specific roadmaps will also help ensure that energy efficiency projects—which tend to be piece meal—will not be executed at the expense of a strategic focus on ZNE. Such a manual should include ZNE and related concepts. Ideally, such a manual would also help departments understand 1) the interrelationships among various green initiatives and how to approach them holistically, and 2) the need for grid harmonization which equates, in many instances, to the need for energy storage (either battery or thermal) to ensure that ZNE buildings do not exacerbate the duck curve, but contribute to a more temporally-balance grid[7].

- **The State of California should focus ZNE, at least initially, on those departments that represent the most significant portion of state-owned building square footage.** With respect to reaching the Governor's stated goal of taking measures toward achieving ZNE for 50% of all existing state-owned buildings square footage by 2025, we recommend focusing on a limited number of departments to formulate specific plans, select specific properties, and select buildings within those properties.

[7] The need for grid harmonization is, at this time, an important state policy issue at both the California Public Utilities Commission (CPUC) and California Energy Commission (CEC). At the time of this publication, the CPUC is in the middle of at least two proceedings primarily driven by it and the CEC's plans for the next iteration of the Building Energy Efficiency Standards (Title 24 Part 6) will require developers to address it.

Reducing the number of departments should bring focus to addressing the various barriers involved in reaching ZNE specific to each department's circumstances. Along this path, CDCR would appear to be the highest priority department given they are a dominant force with respect to the number of buildings, overall building square footage, and overall energy use. Additionally, and perhaps most importantly, many CDCR sites appear to have ample room (e.g., surface parking lots, green space) for solar electric generation installation and, given the number of buildings, significant levels of PV can be added without over production. Working with CDCR has the additional benefit of achieving ZNE within the physical site boundaries (a DGS priority).

  - **California Department of Corrections and Rehabilitation should consider installing individual electric and/or gas meters on at least some buildings, since currently all prisons are master metered.** CDCR far exceeds all other departments in solar PV production. Thus, CDCR properties with solar electric generation are most certainly producing more energy (over the course of a year) than a subset of the buildings located on the property consume. Installing electric and/or gas meters on individual buildings will allow for a direct comparison between consumption and solar energy production, allowing CDCR to claim ZNE status for a subset of buildings within a given campus/prison.

  - **Focus on campus settings** if possible as it will allow for solar electric generation within the campus boundaries—as opposed to having to secure renewables at the portfolio- or community-level. Producing renewable power at the campus-level to energize a subset of campus buildings should help mitigate over production issues. A campus approach could allow over-production from one building to be used by another, thus reducing the probability that over-production will be pushed back into the electrical grid.

- **Across all departments, identify high potential buildings and prioritize them.** For example, while CDCR is a key department, it is important to achieve some balance between targeting the largest department(s) and prioritizing the most promising buildings across the entire portfolio of state-owned buildings. While these "promising" buildings may be individually small (particularly in comparison to the overall 50% of state-owned square footage goal) they can still make an important contribution to goal attainment—particularly if they are below (or close to) established energy use targets and have good conditions for solar electric generation.

- **State departments should select buildings for energy efficiency retrofits, toward the goal of reaching ZNE, on a case-by-case basis as each building's condition and circumstances are unique.** Ranking existing state-owned buildings for energy efficiency and ZNE readiness is a worthy goal and, given the broad range of factors that influence "readiness," such an approach must take individual building conditions and department circumstances into account. The unique characteristics of each building—that are not easily relegated to a set of objective criteria—need to be considered and scrutinized. Knowledge of ZNE concepts combined with informed judgement would seem to take precedent when prioritizing buildings, in many cases, over more objective measures of ZNE readiness such as current energy usage. State department decision makers indicate that they cannot substantially reduce the energy use of many state buildings due to building conditions and/or install renewables given site limitations. Both of these factors need to continue to be considered as decisions are made regarding which existing buildings can realistically reach ZNE status.

- **DGS should supplement the data collection process for US Department of Energy's software tool.** DGS should work with departments to collect additional data, highly pertinent to the prospects of eventual achievement of ZNE status, for all state buildings.

- **Review and carefully consider data elements that could be collected as part of the data collection process**. Additional characteristics of each property would be useful. This includes, but is not limited to, the site's suitability to accommodate solar electric generation (e.g., building footprint, site footprint, existence of surface parking lot, existence of surrounding green space) as this information is a key ingredient to determining if ZNE can be achieved with the physical building boundary.

- **Identify buildings, leveraging institutional knowledge, that make little practical sense to address in terms of taking aggressive steps to reduce energy use and remove them from consideration.** Key departmental decision makers are aware of key building attributes (e.g., building condition, historical designation, presence of asbestos, deferred maintenance) that are crucial to prioritizing buildings for energy efficiency improvements and ZNE. It is our understanding that each department's Sustainability Roadmap's Energy Chapter, due in December 2017, asks each department to identify buildings—using institutional knowledge—that are good ZNE candidates. In short, there is likely no good supplement for "local knowledge" when it comes to selecting and prioritizing buildings. Decision makers within state departments are keenly aware of complications or issues associated with a given building that are hard to measure objectively or be relegated to a 3rd party.

- **The CPUC, utility companies, and DGS should work collectively to develop a legal template to cover interconnection issues in situations where a state department owns solar electric generation capacity.** As a general rule, key issues have been worked out when renewable generation is purchased through a third party who then owns the renewable generation equipment and signs the interconnection agreement with the utility company. However, when the state owns the solar equipment, and therefore must sign the interconnection agreement, there are inconsistencies and issues that arise when trying to satisfy both utility and state legal requirements. Generally, when budgets permit, some departments view owning the renewable energy generation installation as preferable to a PPA. Other departments, due to either budget limitations or concerns about long-term maintenance, prefer the third party approach. Nevertheless, solving complicated legal issues is important to departments preferring to own onsite renewable energy generation.

- **Utility companies should consider providing ZNE technical assistance to state departments.** Utilities are uniquely positioned, given their long-standing role in promoting energy efficiency, to provide advice and expertise around energy efficiency improvements. Some of the utilities also have staff that are intimately familiar with ZNE challenges in both new construction and retrofit. Finally, utility staff are often aware of the resources that can be leveraged (e.g., consulting firms, contractors, distributors, etc.) toward the goal of improving energy efficiency and reaching ZNE. Many state department decision makers are less familiar with ZNE and how to achieve it. Key IOU personnel could provide needed levels of expertise, training, and guidance.

2. Introduction

The state of California is committed to "the development of a robust and self-sustaining ZNE market."[8] ZNE was introduced into state policies as a strategy to reduce greenhouse gas emissions, conserve energy at state properties, and lead the state by example. As California Governor Edmund G. Brown Jr. stated "Doing something real about the growing threat of global warming requires more than just new laws. We must lead by example."[9] The state of California is a large real estate holder and a major consumer of energy within the state. State building square footage totals approximately 112 million square feet[10] with 2015 grid purchases of energy for state buildings of approximately 9.9 billion kBtu; and 2015 on-site renewable energy generation of approximately 78.41 million KWh (267.4 million kBtu).[11] In 2012, Governor Brown issued Executive Order B-18-12[12] directing all state departments to undertake sweeping green initiatives including these state building ZNE goals:

- 50% of all new state buildings beginning design after 2020 be ZNE;
- 100% of all new state buildings and major renovations beginning design after 2025 be ZNE; and,
- By 2025, state departments should take measures toward achieving ZNE for 50% of all existing state-owned building square footage.

As of May 2017, eight of the 35 California State departments—that own and operate buildings[13]—have made tangible progress towards ZNE status for at least one of their buildings. These departments include the California Department of Motor Vehicles (DMV), California Lottery, California Department of Transportation (Caltrans), California Conservation Corps (CCC), Air Resources Board (ARB), California Department of Corrections and Rehabilitation (CDCR), California Office of Emergency Services (OES), and the California Department of Public Health (CDPH). The California Public Utilities Commission (CPUC) commissioned a study in 2016 to study state buildings and state building decision makers with respect to ZNE readiness. This report presents findings from this study.

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[8] CEC (California Energy Commission) and CPUC (California Public Utilities Commission). June 2015. New Residential Zero Net Energy Action Plan 2015-2020. Available at: *www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5307*

[9] California Governor Edward G Brown, Retrieved from http://www.greenbuildings.ca.gov/ June 5, 2017.

[10] DGS Whitepaper, dated May 19, 2016, entitled "Definition of Zero Net Energy (ZNE) for California State Department Compliance with Executive Order B-18-12."

[11] Ibid.

[12] California Governor Jerry Brown. April 25, 2012. Executive Order B-18-12. Available at: https://www.gov.ca.gov/news.php?id=17508

[13] The other departments either lease buildings from DGS or lease buildings from private entities.

2.1 What is ZNE?

An important foundation for reading this report is a firm understanding of the definition of ZNE adopted by the State of California. Through a May 19, 2016 whitepaper,[14] the California Department of General Services (DGS)—in consultation with 20 energy professionals representing state and federal departments, utilities, federal and the private sector—determined that "ZNE Source" will be the primary definition used by state departments in achieving and reporting on ZNE status for new and existing state buildings. This definition, outlined immediately below, was accepted by the governor's office.

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>
> *Note: Source energy traces the heat and electricity requirements of a building back to the primary energy (raw fuel) input. Source Energy incorporates all production (e.g., generation), transmission, and delivery losses—allowing for an equitable assessment of building-level energy efficiency, expressed in kBtu.*[15]

DGS considered two alternative definitions, "ZNE Site" and "ZNE TDV." A ZNE Site definition dictates that, within its site boundary, a building must produce (through renewables) as much energy as it consumes over the course of a year, as reflected in its utility bills. A ZNE TDV (Time Dependent Valuation) definition reflects the utility cost value of energy whereby the energy consumed by a building over the course of a year needs to be less than or equal to the utility cost value of the on-site renewable energy generated. While there are important nuances and relative strengths and weaknesses of each of these definitions, the most important takeaway is that the purpose of all three definitions is to determine what the renewable offset needs to be (i.e., how much renewable energy needs to be produced over the course of a year) for a given building to be considered ZNE. Each definition provides a different renewable offset. As a general rule—and as applied to California state-owned buildings overall—a ZNE Source definition results in the lowest renewable production goal.[16] In fact, using the ZNE Source definition to achieve ZNE for 50% of state-owned building square footage will require approximately 377 MW (approximately 39%) less renewable energy production when compared to the renewable generation required to satisfy a ZNE Site definition.[17]

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[14] DGS Whitepaper, dated May 19, 2016, entitled "Definition of Zero Net Energy (ZNE) for California State Department Compliance with Executive Order B-18-12."

[15] For a complete discussion and explanation of Source energy calculations, see Energy Star Portfolio Manager (ESPM) Technical Reference "Source Energy", dated July 2013, available through Energy Star®

[16] With the exception of all electric buildings, for which a Source ZNE and Site ZNE definition call for the same renewable offset, the Source ZNE definition calls for a lower renewable offset (e.g., less PV) than a Site ZNE definition. Similarly, with the exception of all electric buildings, a TDV ZNE definition also results in a lower renewable offset than a Site ZNE definition, but it is considerably more complicated to determine and can change, over time, given changes in utility avoided costs at various time of the day (this is a particularly acute issue in jurisdictions where peak demand periods are shifting over time, often from mid-afternoon to late-afternoon and evening).

[17] DGS Whitepaper, dated May 19, 2016, entitled "Definition of Zero Net Energy (ZNE) for California State Department Compliance with Executive Order B-18-12."

Another equally foundational issue is the question of where the renewable production (e.g., PV, wind, biomass) is located in relation to the building for it to achieve ZNE status. This question is completely unrelated to the *amount* of renewable production required to achieve ZNE (the discussion in the previous paragraph). Our assessment is that the original intent, or "spirit of ZNE,"[18] is that designers should first strive to improve a building's energy efficiency as much as economically feasible and then place the required renewable offset within the physical building site boundary.[19] This "spirit of ZNE" is an important backdrop and guiding principle to the remainder of this study.

As stated in the 2016 Whitepaper, DGS's preference is to place the renewable energy (e.g., PV) within the physical building site boundary.[20] However, for many state buildings—especially those located in densely populated urban areas (e.g., city centers)—this is not an achievable goal. As a result, DGS has determined that variations in definitions are needed to accommodate the variety of state buildings, campuses, and portfolios that exist. As such, DGS has allowed for the following adaptations, but notes that state buildings should strive to obtain ZNE in the order listed below.[21] In other words, a *ZNE Building* approach is preferred (aligning most closely with the "spirit of ZNE"), the next most preferable approach would be *ZNE Campus*, followed by *ZNE Portfolio*, and then *ZNE Community*.

- ***ZNE building*** – An energy-efficient building where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy. Under this definition, the building footprint (i.e., rooftop), or the building site (i.e., parking lot, adjacent land) must be utilized for on-site renewable generation.
- ***ZNE campus*** – An energy-efficient campus where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy. Under this definition, a multiple building campus can be utilized as a boundary for on-site renewable generation to offset energy use of all or a portion of the campus buildings. This approach allows ZNE to be achieved for energy-efficient buildings within the campus where the individual building capacity for on-site renewable energy is very restricted.
- ***ZNE portfolio*** – An energy-efficient portfolio in which, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy. Under this definition, multiple building sites by the same owner (i.e., the State of California) could be used and aggregated so that the combined on-site renewable energy generated could offset the combined building energy use from the aggregated set of buildings. This could apply to the entire portfolio, or portions of the portfolio, and allow ZNE to be achieved for energy-efficient buildings within the portfolio where the capacity for on-site renewable energy for a given building site is very restricted.

[18] The term "spirit of ZNE" was coined by the research team (though it is possible that, unknown to us, it has been used elsewhere or used previously by others).
[19] For example, the 11 case study buildings highlighted in the building level barriers section of this report either have—or intend to have—the renewable energy production (e.g., PV) located within the building site boundary.
[20] DGS Whitepaper, dated May 19, 2016, entitled "Definition of Zero Net Energy (ZNE) for California State Department Compliance with Executive Order B-18-12."
[21] Ibid.

- ***ZNE community*** – An energy-efficient community where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy. This could be applied to allow long-term purchase agreements of locally generated, renewable energy, dedicated to providing energy for the building(s). Agreements should extend a minimum of 20 years.

As mentioned above, it is our opinion that some of these definitions (particularly ZNE Portfolio and, to a lesser extent, ZNE Community) may go well beyond what many practitioners would consider true ZNE. This is due to the fact that they allow an individual building to qualify as ZNE despite the fact that their energy needs are being met by a renewable energy source that may be located well beyond the *physical* building site boundary.

2.1.1 Common ZNE Building Characteristics

In addition to defining ZNE, it is important to understand the common characteristics of ZNE buildings. In particular, as outlined in the most recent status report for State buildings[22], it is important to understand that ZNE is not dependent on experimental technologies or recent breakthroughs, but rather is an integration of commonly available best practices and "state-of-the-shelf" technologies. Passive energy strategies, efficient building envelope, increased insulation, natural daylighting, controls, operable windows, and shading are often employed in ZNE designs as well as highly efficient components. Non-conventional HVAC design of radiant heating and cooling, ground source heat pumps, heat recovery, and natural ventilation are commonly installed as well. Careful architectural techniques of structure placement and orientation, use of natural light, building envelope design, and thermal bridging detailing generally result in the downsizing of lighting and HVAC and allow for additional energy efficient architectural strategies.

As further articulated in the most recent status report, a common ZNE mantra is "reduce, reduce, reduce, then produce". The proper loading order is to design an ultra-low energy building, operate it efficiently, control plug loads, and, only then, to install the renewable energy components. A particular challenge with ZNE is the inclusion of non-regulated elements in the annual performance of the building. Designing a highly efficient building and renewables alone are not sufficient to achieve the overall goal. Occupant behavior, plug loads, building operations, maintenance, scheduling, and weather patterns all have an impact on energy consumption. Occupant engagement needs special attention for informing the building's users of the ZNE strategies, expectations on energy usage, equipment procurement, and best practices. An on-site advocate is instrumental to assure persistence of the measures, monitor energy usage continuously and make the necessary modifications.

[22] Zero Net Energy Status Report. Department of General Services—Real Estate Services Division, Energy & Environmental Section (May, 2015).

In addition to these characteristics, our review of 11 case study buildings[23]—five of which were major renovations of existing buildings (i.e., gut rehabs)—revealed a few additional attributes that appear to be common to ZNE buildings:

- **Unoccupied during the renovation/construction process.** All buildings retrofitted to achieve ZNE status were unoccupied throughout the construction process. Related to this, most involved significant structural changes to the building—particularly to accommodate natural ventilation, natural lighting (e.g., skylights), and support roof mounted PV.
- **Limited Building Square Footage.** Eight of the 11 buildings are relatively small, ranging in size from 6,300 to 49,000 square feet.
- **Relatively Narrow Building Width.** While the width of each building (i.e., the shortest distance between two parallel exterior walls) was rarely provided, individual building pictures and floor plans indicate that most of the buildings are relatively narrow—a feature that allows for natural ventilation and more opportunity for daylighting.
- **One or Two Stories/Floors.** With the exception of two three-story buildings, all the buildings are single- or two-story. The main advantages of these structures are: 1) ease of adding structural support to the roof in order to accommodate the weight of solar PV panels; 2) increased ability to use natural lighting (e.g., skylights) to illuminate multiple floors; and, 3) increased ability to include natural ventilation given a smaller building footprint.
- **Site Footprints extending beyond the Building Itself.** With a few exceptions, the buildings had a relatively large site footprint—parking lot and/or green space immediately around the building. Associated with this, most included solar PV mounted on the building's roof or ground mounted solar PV at the building's site.[24]
- **Mild Climate Zone.** A number of the case study buildings were located in mild climate zones (e.g., climate zones 3 & 4) making the use of outside air to pre-cool the building at night (i.e., night purging) possible.[25]

2.2 Policy Landscape

State departments have many other green initiatives to manage, including Executive Orders that address ZNE (referenced above) as well as water efficiency and conservation, zero emission vehicle purchases, and environmental impacts. These Executive Orders are summarized below.

- **Water Efficiency and Conservation.** Executive Order B-29-15, issued April 1, 2015, directs the state to reduce potable water use by 25% by February 28, 2016, as compared with 2013. On November 13,

[23] Zero Net Energy Case Study Buildings *Volume 1* (September 2014) and *Volume 2* (April 2106). Written by Edward Dean, FAIA – Bernheim & Dean, Inc. Forward by Peter Turnbull, Principal, Commercial Buildings, Pacific Gas and Electric Company.
[24] While none of the case studies reviewed for this study had PV mounted on the roof of a parking structure, it is another possible approach.
[25] Opinion Dynamics mapped state buildings to climate zones according to California Energy Commission guidelines. http://www.energy.ca.gov/maps/renewable/building_climate_zones.html

2015, Executive Order B-36-15 was issued, directing the Water Board to extend until October 31, 2016, restrictions to achieve a statewide reduction in urban potable water usage.[26] In Executive Order B-37-16[27] "Making Water Conservation a California Way of Life", issued on May 9, 2016, the State Water Resources Control Board was directed to develop by January 2017, a proposal to achieve a mandatory reduction in potable water usage that builds off the mandatory 25% reduction called for in Executive Order B-29-15 and lessons learned through 2016. On April 7, 2017, Governor Brown issues Executive Order B-40-17, ending the drought state of emergency in most of California and rescinding B-29-15 and B-36-15 but continuing the provisions in Executive Order B-37-16 Permanent restrictions prohibit the use of potable water for:

- Hosing off sidewalks, driveways and other hardscapes;
- Washing automobiles with hoses not equipped with a shut-off nozzle;
- Using non-recirculated water in a fountain or other decorative water feature;
- Watering lawns in a manner that causes runoff, or within 48 hours after measurable precipitations; and,
- Irrigating ornamental turf on public street medians.

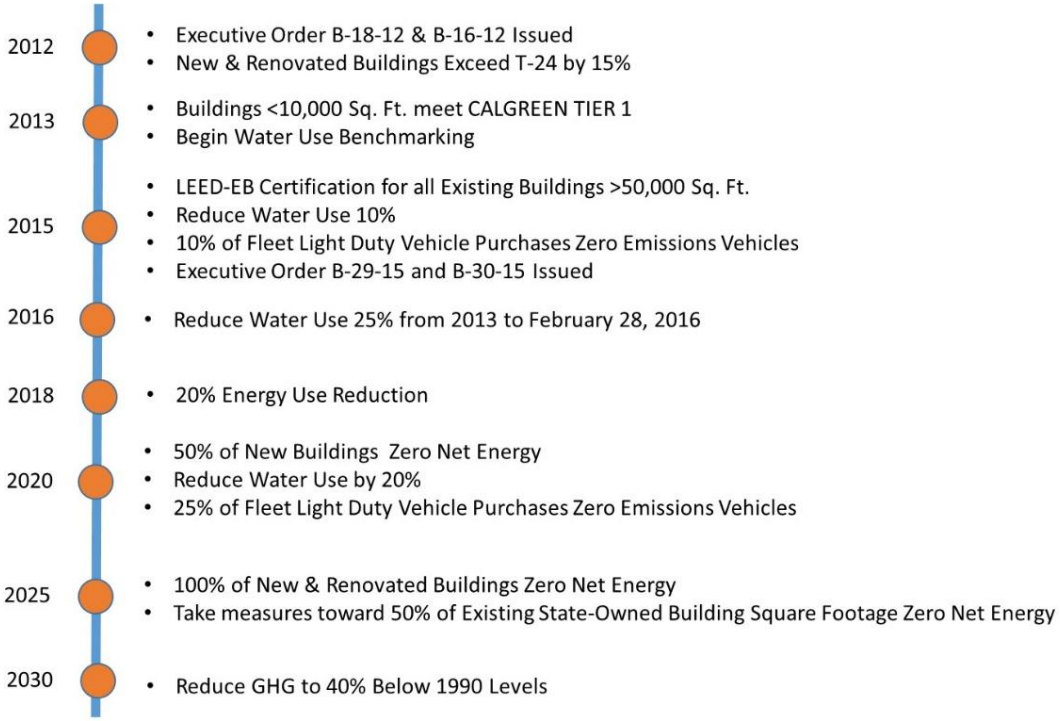
With the decision to lift drought restrictions, Governor Brown cautions "This drought emergency is over, but the next drought could be around the corner. Conservation must remain a way of life."[28]

- **Environmental Impacts.** Executive Order B-18-12 (reference above) and the Green Building Action Plan, both issued on April 25, 2012, outline requirements for state departments related to reducing environmental impacts of state operations including greenhouse gas emissions, energy, and water use, as well as improving indoor air quality, onsite renewable energy, environmentally preferable purchasing, and developing the infrastructure for electrical vehicle charging stations at state buildings. The Green Building Action Plan also established two oversight groups to ensure these measures are met. On April 29, 2015, Executive Order B-30-15 was issued to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030. Regarding this aggressive benchmark, Governor Brown states "With this order, California sets a very high bar for itself and other states and nations, but it's one that must be reached – for this generation and generations to come."[29]
- **Zero Emission Vehicles.** Executive Order B-16-12 directs state entities to support and facilitate the rapid commercialization of zero-emission vehicles. It directs the state toward establishing an infrastructure to support increased public and private sector zero emission vehicles. Additionally, it directs state departments replacing fleet vehicles by 2015 to replace at least ten percent with zero emission vehicles, and by 2020 to purchase at least 25% replacement fleet vehicles as zero emission vehicles.

[26] https://www.gov.ca.gov/docs/11.13.15_EO_B-36-15.pdf
[27] https://www.gov.ca.gov/docs/5.9.16_Executive_Order.pdf
[28] http://www.reuters.com/article/us-california-drought-idUSKBN179384
[29] https://www.gov.ca.gov/news.php?id=18938

Every two years state departments are required to complete and submit a *Roadmap to Achieving Executive Orders B-18-12, B-16-12, B-29-15, & B-30-15*. Figure 2-1, adapted from the template the Department of General Services (DGS) developed for these road maps, outlines the many green Executive Order milestones and their associated timelines. When available, these road maps were used to inform this study.

Figure 2-1: Green Executive Order Milestones and Timeline



2.3 Research Objectives and Questions

The overall goal of this study was to examine state buildings and state building decision makers with respect to ZNE readiness with the following two umbrella objectives guiding the research:

- **Objective 1:** Characterize state departments pathways on their "road to ZNE" through the identification of barriers they face when contemplating ZNE.
- **Objective 2:** Profile energy use characteristics and performance of state buildings, with particular focus on energy intensity and the presence of onsite renewables or other types of distributed generation.

Table 2-1 below shows the researchable questions associated with each of the overarching objectives.

Table 2-1. Research Questions and Study Objectives

Research Objectives and Questions
Objective 1: Characterize pathways of CA state departments on the "road to ZNE"
1) What are barriers to ZNE?
2) What are useful interventions to help move state buildings toward ZNE?
3) What are the project approval pathways for the state departments? How does this structure facilitate or impede moving toward ZNE?
4) What level of financing is required for state buildings to perform ZNE-type retrofits? What are the financing options? Which of these options are accessible to state buildings?
Objective 2: Profile energy use characteristics and building performance for state buildings
5) What data is available to profile the energy use characteristics of state departments? What additional data, if any, should be collected to contribute to the ultimate ranking of state department buildings in terms of ZNE readiness?
6) Which buildings include distributed generation and how much does it offset building energy use?
7) How do the buildings rank in terms of performance (which are the best candidate, from a performance perspective, for ZNE)?

3. Research Methods

This chapter summarizes the primary data collection activities and secondary data review conducted as part of this study. Figure 3-1 illustrates the overall tasks Opinion Dynamics undertook to complete this study. In the remainder of this section, we discuss each method employed in detail.

Figure 3-1: Research Design

3.1 Literature and Secondary Data Analysis

The literature review and secondary data analysis covered a host of documents created and provided by state departments as well as other relevant documents identified by members of the advisory team, known ZNE experts, other interested parties, academic literature searches, and website searches. The research process began with an extensive literature review, which shed light on what was (at the time) currently known about California state buildings, their energy use, and associated organizational structures. In addition, the literature review identified gaps that this ZNE State Buildings Study could help fill through additional, more targeted, research. Overall, the literature review covered approximately 35 documents and a number of informational inquiries (i.e., brief emails or phone conversations).

In addition to the formal literature review, a significant number of documents were carefully reviewed and analyzed as this study unfolded. These documents included legislation, executive orders, and guiding principles pertaining the efforts to move toward ZNE in state-owned buildings as well as presentations from ZNE-related webinars. The Department of General Services (DGS) was instrumental in assisting the research team in both identifying and then supplying a good deal of documents that outline the guidelines, mandates, and principles to be followed as departments move toward ZNE. Of particular relevance is a whitepaper issued

by DGS[30] that defines ZNE for California State Department Compliance with Executive Order B-18-12 and the State Administrative Manual (SAM), "a reference resource for statewide policies, procedures, requirements and information".[31]

The research team also reviewed sustainability roadmaps for 27 state departments. The reviews provided important information on a given department's efforts to reach multiple sustainability goals (e.g., water, energy efficiency, ZNE) and important context to interviews that were completed with individuals (or groups of individuals) within specific departments who are largely responsible for carrying out and reporting on department accomplishments. The California Department of Transportation's (Caltrans) 2015 Road Map (Road Map) is indicative of the type of information contained in a Road Map document. Caltrans states, for example, that their "2015 Road Map describes the status of steps to achieve the objectives, targets, and requirement of various Governor's Executive Orders (EOs) designed to protect and enhance California's sustainability, economy, and livability."[32]

3.2 Existing ZNE Building Staff

To better explore and understand how buildings achieved ZNE and Ultra Low Energy status, in-depth interviews were completed with 10 designers/architects, owners, and/or managers of current ZNE buildings in California. The primary purpose of these interviews was to: (1) characterize the pathway of successful ZNE buildings; (2) document any best practices and lessons learned in the process; and, (3) enhance the design of subsequent interview instruments. In particular, the 10 interviews were instrumental in identifying topics of relevance for our interviews with ZNE Experts (including utilities and regulators) and state department decision makers, both of which are described in the subsections that follow.

The ZNE building staff interviews explored design, contractual, financial, occupancy, and operational issues associated with ZNE building efforts. Of particular relevance was understanding how challenges and barriers to ZNE differed (if at all) between newly constructed and retrofit buildings. Because they were highly relevant to this study, the interviews included members of four state departments (CA Lottery, CDCR, DMV and CDPH) who have ZNE buildings within their portfolio. Though the number of ZNE buildings among these state departments is limited, the research team was able to specifically ask about the entire process from conceptualization to completion for these specific buildings. In the end, the 10 interviews not only greatly enhanced the subsequent research process but also provided a great deal of information regarding whether or not (and how) the steps taken and lessons learned—on the pathway to ZNE—are transferrable to other state departments. Specifically, interview results were used to inform interview guides, provide context and background on the ZNE Landscape in California, and to identify barriers and best practices that can be shared with other departments about pathways to achieve ZNE.

[30] Definition of Zero Net Energy (ZNE) for California State Department Compliance with Executive Order B-18-12, issued May 19, 2016.
[31] http://sam.dgs.ca.gov/
[32] Road Map to Achieving Executive Orders B-18-12 & B-16-12, December 2015. Issued by the State of California Department of Transportation.

3.3 Interviews: ZNE Experts, Utilities, and Regulatory

Over the course of the project, multiple ZNE experts within state departments, regulatory commissions, utilities, research think tanks, and private sector organizations were interviewed. These interviews provided important background and context to ZNE in California. The interviews also allowed the research team to understand current activity levels and future plans associated with ZNE in both the private and public sector. Our approach to interviewing these ZNE experts was through a snowball sample, identifying knowledgeable individuals (and obtaining their associated contact information) as we progressed from one interviewee to the next. Similar to our interviews with existing ZNE buildings staff, the group of experts provided important background information on the pathway to ZNE, including insights regarding challenges that occur during each step in the process. Specifically, interview results were used to inform subsequent interview guides, provide context and background on the ZNE landscape in California, and to identify barriers and best practices.

In addition, the research team formed an Advisory Group (Table 3-1) below, to engage stakeholders at state departments and utilities that are actively involved in ZNE within their respective organizations. The Advisory Group's primary role was to advise the Study Team on the context of ZNE in the state of California, provide information about specific state processes and utility efforts that support ZNE, to identify contacts within state departments for interviews, and to provide overall guidance on the study.

Table 3-1. ZNE Study Advisory Group Members

Organization	Advisor
DGS	Dan Burgoyne
OPR	Sandy Goldberg
DOJ	Laura Sainz
GOVOPS	Matt Henigan
PG&E	Peter Turnbull
SCE	Randall Higa
SoCalGas	Adam Manke
SDG&E	Chip Fox
Advisor to the CPUC	Ralph Prahl
Advisor to the CPUC	Nikhil Gandhi
CPUC Study Manager	Robert Hansen

While select members of the advisory team—due to their specific ZNE expertise—were individually interviewed as part of the study, all advisory group members engaged with the study in the following ways:

- Participated in guided discussions with all members of the Advisory Group to discuss research scope, provide context on state department efforts, provide context on IOU programs and initiatives related to ZNE, and provide an initial set of barriers to ZNE;
- Reviewed and provided input on all survey instruments and interim memos;

- Reviewed and provided input on sections of the report for accuracy and completeness;
- Supported efforts to secure data on state departments buildings (Energy Star Portfolio Manager); and,
- Provided an initial set of contact information for each of the state departments to support interviews with decision makers.

3.4 Interviews: State Department Decision Makers

The most time intensive and significant single research step involved completing in-depth interviews with 60 state department decision makers. In some cases, interviews may have included multiple interviewees with decision makers within the same department—often interviewed together in a group setting and sometimes conducted through separate interviews. These interviews covered a wide range of topics, spanning from the department's understanding of current ZNE and related energy efficiency mandates and directives (e.g., the Governor' order, DGS white paper that largely interpreted that order, etc.) to specific barriers that departments either anticipate encountering (for those who have yet to take action) to those encountered as specific steps have been taken to move toward ZNE for specific buildings or sets of buildings.

The interview process was particularly illuminating given the fact that our research team reviewed, prior to each interview, each department's sustainability road map, along with information presented on each department's page on California's Green Buildings website[33]. This allowed the research team to tailor each interview to what the department had currently accomplished, what they have formally stated as their "plan" moving forward, and what obstacles they may have encountered along the way. The majority of departments spoke to the challenges they were having in "getting going" on the retrofit process, rather than giving direct experience of the challenges encountered as part of completing a retrofit. To date, 8 departments have experience either designing or completing ZNE buildings, and were able to speak to the entire process. It is important to note, however, that only three departments have experience retrofitting existing state-owned buildings to ZNE status.[34] The majority of the current ZNE buildings were new construction as opposed to retrofits.

3.5 Energy Star Portfolio Manager (ESPM) Data Analysis

Executive Order B-18-12 established the baseline years, energy reduction goals, and reporting requirements for California state department reporting of progress toward key sustainability outcomes. Prior to 2013, water

[33] http://green.ca.gov/Buildings/ provides information gathered through Energy Star Portfolio Manager, and other sources, and shows each department's status with regard to the various sustainability goals set by the Brown Administration
[34] Projects include Cal OES's headquarters building, CDPH's Richmond campus building P, and CCC's Camarillo Center Pilot Project.

and energy data was reported to DGS annually, with each reporting department providing their own energy baseline numbers[35] for comparability purposes.

ESPM is an online tool developed by the Environmental Protection Department (EPA) to measure and track energy and water consumption as well as greenhouse gas emissions. It can be used to benchmark the performance of one building or a whole portfolio of buildings, all in a secure online environment. As of 2013, California state departments have been directed to use ESPM to document energy and water use data to track progress toward achieving targets of Governor Brown's Executive Order B-18-12 and Green Building Action Plan.

A key output of ESPM, based on the underlying monthly energy usage data, is the energy use intensity (EUI) of a given building. EUI is an expression of a building's energy use as a function of its size. For most property types in ESPM, EUI is expressed as energy use per square foot per year. A building's EUI is calculated by dividing all the energy sources (e.g., electricity, natural gas, propane, etc.) consumed by the building in one year (measured in kBtu) by the total gross floor area of the building. Expressing a building's energy use in kBtu per square foot per year (kBtu-sq.ft.-yr) allows for the comparison—in terms of energy use—of two buildings that might use different primary fuel inputs (e.g., all electric building vs. a combination gas-electric building) and be of different sizes (based on square footage).

The research team received the entire ESPM database from DGS, including monthly energy usage information (e.g., water, electricity, natural gas, fuel oil, etc.) and renewable generation[36] dating back to 2003 for some properties. Based on 2015 detailed monthly usage data, the research team computed EUIs for all properties[37] within ESPM and compared this information to that provided by DGS[38]. Ultimately, as described later in this report, we used the DGS provided EUI's and related property information to characterize state properties in terms of overall square footage, EUI's, and other relevant statistics. Finally, combined with information obtained from state departments regarding barriers to ZNE, we use the ESPM data to rank state buildings in terms of readiness for ZNE.

3.6 Study Limitations

When interpreting this report, the reader should take into account the following methodological limitations.

[35] The baseline year is the starting year of energy or water use, or greenhouse gas emission reporting, that a building or department uses for comparison to later years. For example, most state facilities use 2003 as a baseline year for measurement of energy use, and 2010 as a baseline for measurement of water use and greenhouse gas emissions.
[36] In 2015, state departments—usually in the form of solar photovoltaics (PV)—generated 78,400 megawatt hours of electricity, representing about 3% of the electricity used in state buildings. Installed PV capacity in 2015 was approximately 40 megawatts.
[37] A property (also commonly referred to as a "building") within ESPM could include only one structure, or could include an entire campus of buildings and structures.
[38] DGS used the ESPM front end (i.e., interface) to run these calculations on an automated basis. Because the discrepancies between the research team's calculations and those provided by DGS were both few and minor, we use the values provided by DGS in order to maintain consistency with other reporting processes.

3.6.1 Literature Review, Secondary Data Analysis, and Interviews

This study involved gathering a large amount of qualitative data. Our research faced a few important limitations consistent with qualitative research:

- **Generalizability:** A common limitation often cited in relationship to qualitative research is the lack of generalizability–the extent to which findings from a study apply to a wider population. Given that this study was focused on a narrow population, our inherent goal was not to necessarily develop findings that are transferrable beyond this group. However, while we attempted a census of state department decision-makers involved in decisions pertaining to ZNE, we were unable to schedule interviews with 9 departments as well as some key DGS Staff. As such, these limitations impact our ability to draw universal conclusions about state department decision makers.

- **Volume of Data:** The volume of data generated through our numerous interviews and secondary data review was significant. In order to ensure all data were tracked, coded, and synthesized we utilized NVIVO, a powerful software for qualitative data analysis.

- **Social Desirability Bias:** Given the nature of interviews, participants may respond more favorably to questions thus not representing their true feelings.

3.6.2 ESPM Data Analysis

This study also included a thorough analysis of California State Department property data. Through this analysis, we compiled a list of limitations that need to be considered when interpreting this data, including:

- **2015 ESPM Data:** The ESPM data provided includes data from only calendar year 2015, and therefore contains some buildings that have been sold, or closed, since the end of 2015. Additionally, the ESPM data may not contain information on buildings that have been purchased or constructed, or on-site renewable generation that has been installed after 2015. For example, the database includes a building of one department which has recently been sold and was their last state-owned property, meaning that the executive order no longer applies to that department.

- **Data Matching:** Not all of the 1,540 department state-owned properties could be matched with the portfolio-level data provided. We were not able to match 50 buildings. Most of these buildings were listed as being "sub-buildings", which could indicate that the building is not tracked independently of other adjacent buildings. Additionally, most of the properties that were not able to be matched were listed as having zero energy use at the property level.

- **Single Building vs Campus:** There are instances where a large square footage property is listed as having only a single building. Upon further investigation, it becomes clear that some of these properties are actually composed of multiple buildings that appear to be distinct and non-connected. It is not clear under what circumstances multiple buildings are aggregated to one building for any one property. It is also not clear how certain buildings are grouped; there is no indication of why what appears to be a "campus" is classified as a single building.

- **Square Footage = Zero**: Some buildings are listed as having a small square footage value, including buildings with zero square feet. A small square footage value appears to be accurate in some situations, such as properties that are currently being constructed and are not yet completed. However, in other cases, it appears to have been incorrectly designated. A more specific entry for the amount of square footage that is represented by a building would be ideal to reduce the impact that

these erroneously, or temporarily, small footprint buildings have on any analysis, and can be better understood. There are also properties in ESPM that appear to include land surrounding a building in the square footage listed for the actual buildings.

- **ESPM Building Use Field**: The building use type field in the ESPM database is listed as "Other" for 490 of the 1,490 matched properties. The lack of specificity in this field can introduce issues with being able to analyze these buildings, most significantly, identifying which of these match with DGS's expanded property use types, and thus being able to measure against the DGS established Source EUI targets for each associated property use type and climate zone. With additional descriptive data for these buildings, it would be possible to more effectively apply a Source EUI target and understand the current state of these properties.

- **Missing or Inaccurate Usage Data**: There are multiple properties that are missing energy usage information, resulting in blank EUI data. Further, there are several properties that have a EUI of zero, some of which appear to be accurate while others do not. The properties accounted for approximately 5.2 million square feet. However, approximately 2.7 million square feet appear to be associated with properties that have been closed, as indicated in the "Property Name" field of the ESPM data. In order to be able to better analyze the current state of buildings in California, it would be ideal if a field in the ESPM data would be added to indicate the current status of a building, such as open, closed, sold, under construction, or otherwise unused. Additionally, it is unclear why buildings that have been sold are still included in the ESPM database. If the EUI cannot be calculated for some properties because of missing underlying data necessary to calculate EUI, then that should be recorded; additionally, an EUI that is truly zero should be listed as such.

4. Characterization of State-owned Properties

Within this section, we characterize state-owned properties that are occupied/managed by 35 departments. To provide this characterization, we draw on information collected and entered, since 2013, by these 35 departments into Energy Star Portfolio Manager (ESPM). As outlined in the Section 3, ESPM is an online tool developed by EPA to measure and track energy and water consumption as well as greenhouse gas emissions.

4.1 Description of ESPM Database

As part of the characterization process, Opinion Dynamics acquired the entire ESPM database for state-owned buildings from DGS. In addition to basic property information (e.g., property address, building square footage, property use type, etc.), the ESPM database includes detailed monthly metered energy use data for a given property. This information includes grid purchased electricity, on-site renewable generation, natural gas use, propane use and water consumption. While this energy usage information is extremely valuable, there is additional property information specific to ZNE efforts that state departments may want to collect along with ESPM (discussed in detail in Section 6). However, the vast majority of information collected within ESPM (for any given variable) appears to be of high quality and—through our analysis—we were able to match key outputs for each property (e.g., Site EUI, Source EUI) to summary data provided by DGS.

A key statistic available through ESPM is the energy use intensity (EUI) of a given property. EUI is an expression of a building's energy use as a function of its size; and is calculated by dividing the total energy that a building consumes in one year (measured in kBtu) by the total gross floor area of the building. The result, expressed as kBtu-sq.ft.-yr, allows decision makers to compare the energy use of buildings of various sizes to one another. There are two methods of calculating EUI using either a *Site Energy* or *Source Energy* definition[39], each of which is described below:

- Site Energy—The amount of heat and electricity consumed by a building as reflected in utility bills (e.g., kWh, therms) and expressed in kBtu.
- Source Energy—Traces the heat and electricity requirements of a building back to the raw fuel input. *Source Energy*[40] incorporates all production (e.g., generation), transmission, and delivery losses—allowing for an equitable assessment of building-level energy efficiency, expressed in kBtu.

ESPM has the capacity to produce EUIs for a given property on either a site energy or source energy basis. Because DGS has set EUI targets for state-owned properties using source energy, we use this metric within this section for analyzing and describing state properties, and throughout the remainder of this study (as described in Section 3). For a complete explanation and discussion on the benefits of looking at a property from a Source Energy (Source EUI) perspective, we refer the reader to the ESPM Technical Reference Manual.[41] Additionally, as outlined in Section 6, it is important to note that California elected to use a Source

[39] Source: ESPM Technical Reference Manual (Source Energy), July, 2013.
[40] ESPM uses national average ratios for the conversion to source energy. To convert grid purchased electricity to Source Energy, each metered kWh (Site Energy)—expressed in kBtu—is multiplied by 3.14 while each metered therm of natural gas (Site Energy)—expressed in kBtu—is multiplied by 1.05.
[41] ESPM Technical Reference Manual (Source Energy), July 2013.

Energy definitions, versus site, for a variety of reasons; one of which was the need for less on-site renewable generation across the portfolio of state buildings. [42]

Prior to characterizing state properties, it is important to note a few additional issues associated with the interpretation of ESPM data. These issues are important to keep in mind when reviewing the outputs presented in this section. They include, in rough order of importance, the following:

- ESPM includes 1,540 California state department properties. A property (also commonly referred to by state departments as a "facility") could include only one structure, or could include an entire campus of buildings and structures. For example, a single prison property (and the associated Source EUI, building square footage, etc.) may pertain to over 100 buildings.[43]
- Source EUI's are based on calendar year 2015 energy use.
- Our analysis covers 1,490 of the 1,540 properties within ESPM because 50 Caltran buildings are listed as single properties when, in fact, they are part of another property.
- There is, to a limited degree, some missing data within ESPM for some properties. However, given the number of properties tracked and the associated detailed metering data, the overall dataset appears to be very sound.

4.2 Profile of State-Owned Properties

According to data tracked through ESPM, the 35 state departments that occupy state-owned buildings occupy 1,490 properties, which represent 8,612 buildings. In the remainder of this section, we characterize these properties, where they are located, the share of square footage and buildings associated with each department. Additionally, Appendix A contains a detailed summary of ESPM data that Opinion Dynamics received as part of this study. For each department, we provide the number of properties, buildings, building square footage, and overall energy (e.g., electricity and natural gas) usage.

As shown in Table 4-1, the vast majority of state-owned properties tracked through ESPM contain a single building. Of the 1,490 properties included in our analysis, 1,246 contain only a single building. While these properties represent only 14% of the total number of buildings owned by the state, they also account for roughly 47% of the total square footage. According to ESPM, there appears to be several properties with a single building listed, though there appear to be multiple buildings at that location. Also, there are 63 properties that have no buildings associated with them. For some properties, this appears to be accurate,[44] while others seem to be missing building count information.

[42] DGS Whitepaper, dated May 19, 2016, entitled "Definition of Zero Net Energy (ZNE) for California State Department Compliance with Executive Order B-18-12."
[43] Our understanding, from discussions with DGS, is that this is primarily due to the fact that such properties are mastered metered. In other words, the individual buildings within the property are not separately metered and, because of this, all building information is aggregated to effectively match the level of aggregation represented by the metered energy use.
[44] These properties represent things like pumps in a field, a very small building (less than 10' X 10') located in a remote area, etc.

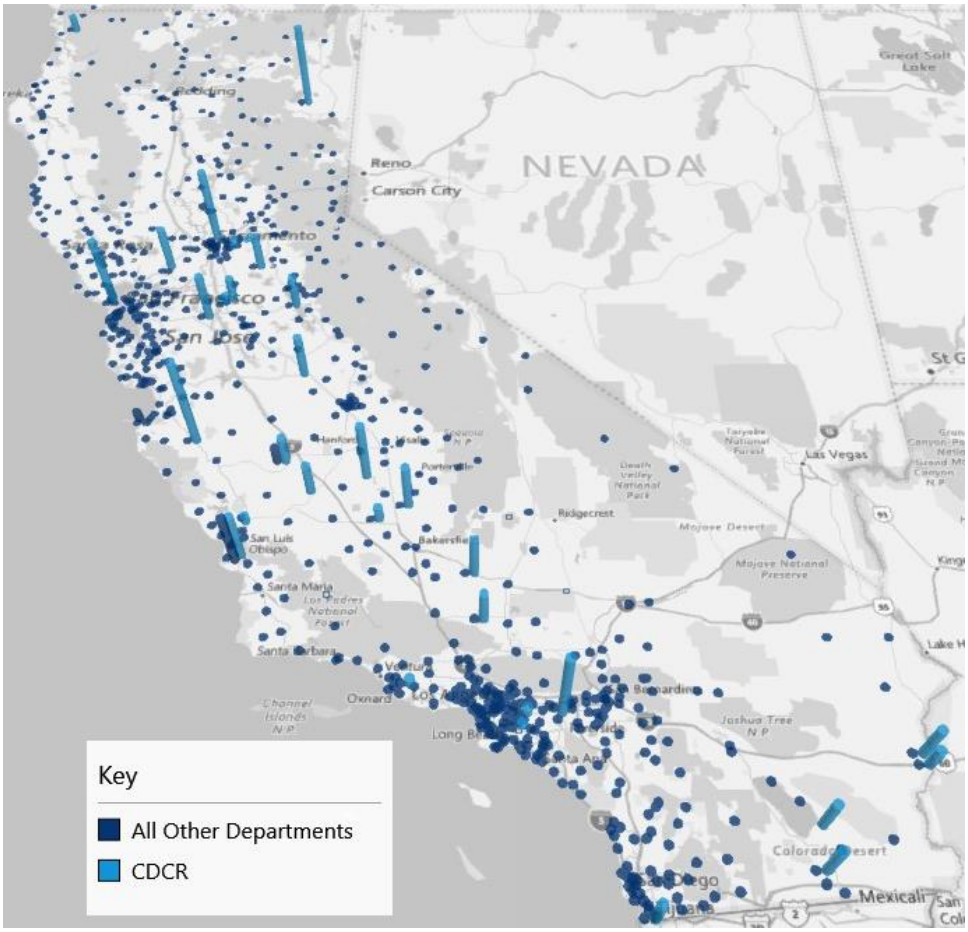
Table 4-1. Summary of Property and Building Counts, Square Footage, Energy Use, and Renewable Generation

	Properties	Buildings	Square Footage (Millions)	Total Energy Use (Billion Btu per Year)	On-Site Renewable Generation (Million kWh)
All Properties	1,490	8,612	107.1	9,276.6	79.0
Properties With a Single Building	1,246	1,246	50.1	3,041.0	5.9
Properties with Multiple Buildings	181	7,366	54.2	5,861.4	72.4

Note: There are 63 properties listed in ESPM with 0 buildings—these account for 2.9 million square feet, 374.3 billion Btu of energy use per year, and 748,382 kWh of on-site renewable generation. As such, statistics for properties with single and multiple buildings do not add up to totals for all properties.

Figure 4-1 shows the location and density of state-owned buildings, with the height of each bar representing the number of buildings per zip code. While the highest concentration of buildings are often in large metropolitan areas, CDCR properties (highlighted separately below) are dispersed throughout the state and a single property may account for over 300 buildings. Other than CDCR properties, most state-owned buildings are clustered around Sacramento, Los Angeles, the Bay area, and the San Luis Obispo military base, which includes 293 buildings occupied by CMD.

Figure 4-1. State-owned Building Concentration by Zip Code



As shown in Figure 4-2, approximately 28% of the total square footage owned by the state is located in climate zone 12. Roughly 12% is located in climate zones 3 and 4, generally regarded as the most hospitable for ZNE buildings (see Section 6). Climate zone 12 encompasses part of the Northern California Central Valley, which tends to experience more variation in seasonal temperatures than the Bay Area (climate zones 3 and 4)—that is, colder winters and hotter summers. Additionally, in the summer months, night time temperatures in climate zone 12 tend to remain higher, reducing the effectiveness of passive cooling during the evening ours (i.e., night purging), which is a key design component of a number of existing ZNE buildings.

Figure 4-2. Total Building Square Footage by CA Climate Zone

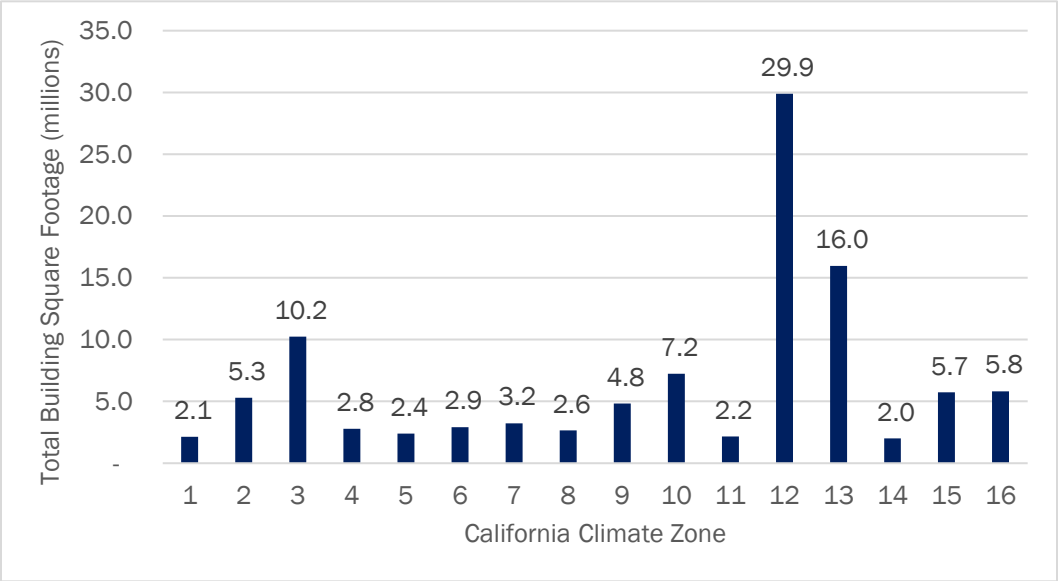


Figure 4-3 below shows a comparison between state-owned properties and buildings reported through ESPM. As discussed previously, properties are the distinct site or location that a department reports on through ESPM. A single property may include one, or multiple buildings. In terms of the number of unique properties, the top departments in terms of the total number of unique properties are Caltrans, CAL FIRE, DPR, CHP, CMD, DMV, and CDFW. However, the vast majority of state-owned buildings (75%) are occupied by CDCR. This points to high concentrations of buildings at a few distinct CDCR properties (also highlighted in Figure 4-1). While there is some overlap between the departments with the highest count of properties and buildings—that is, Caltrans, DPR, CAL FIRE, and CMD—many of these are smaller buildings with inconsistent or lower energy usage dispersed throughout the state.

Figure 4-3. Number of Properties and Buildings by Department

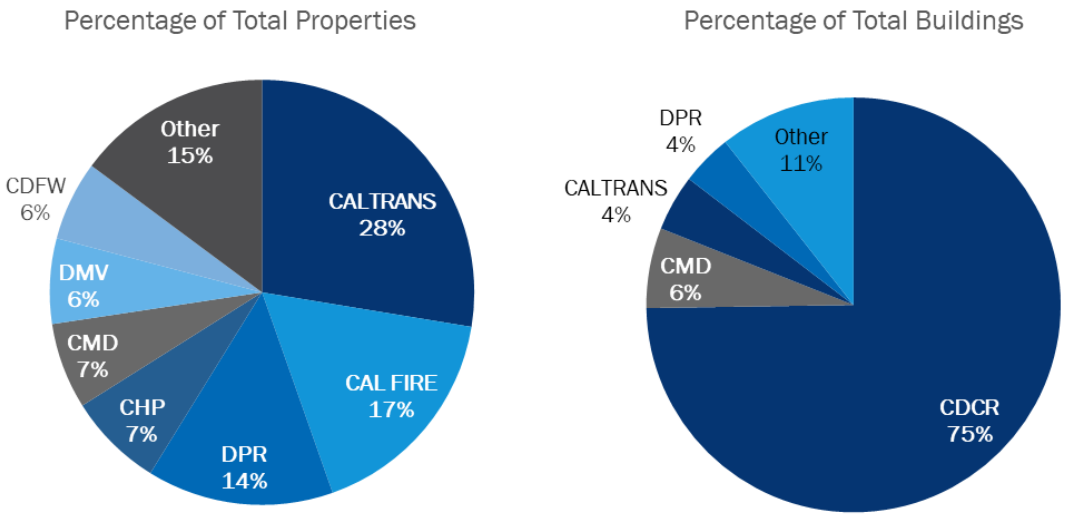
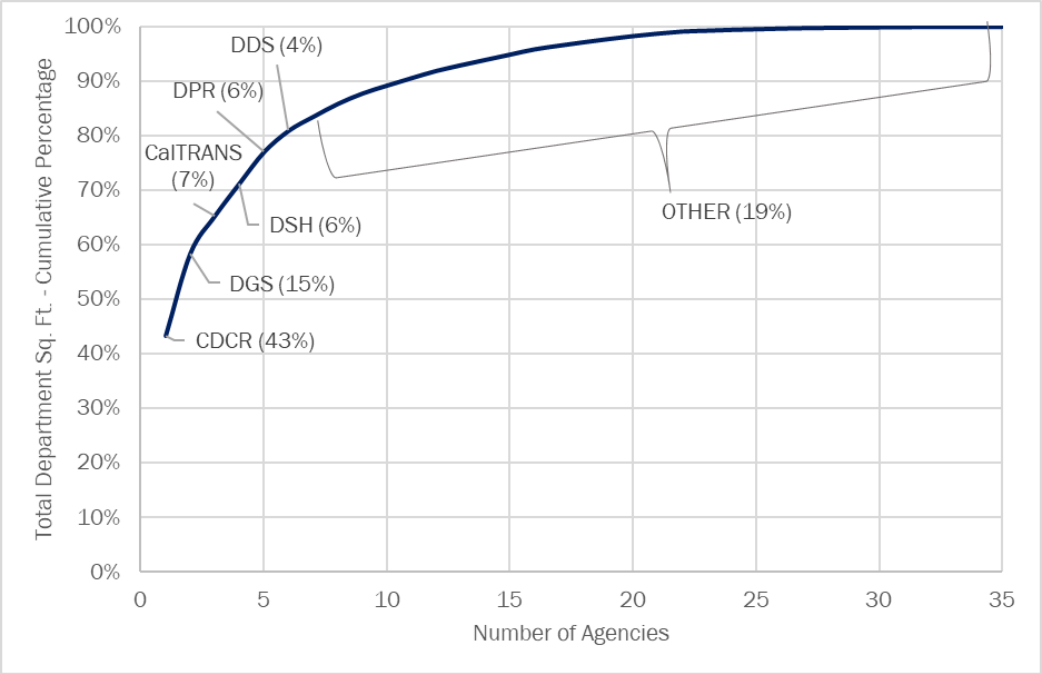


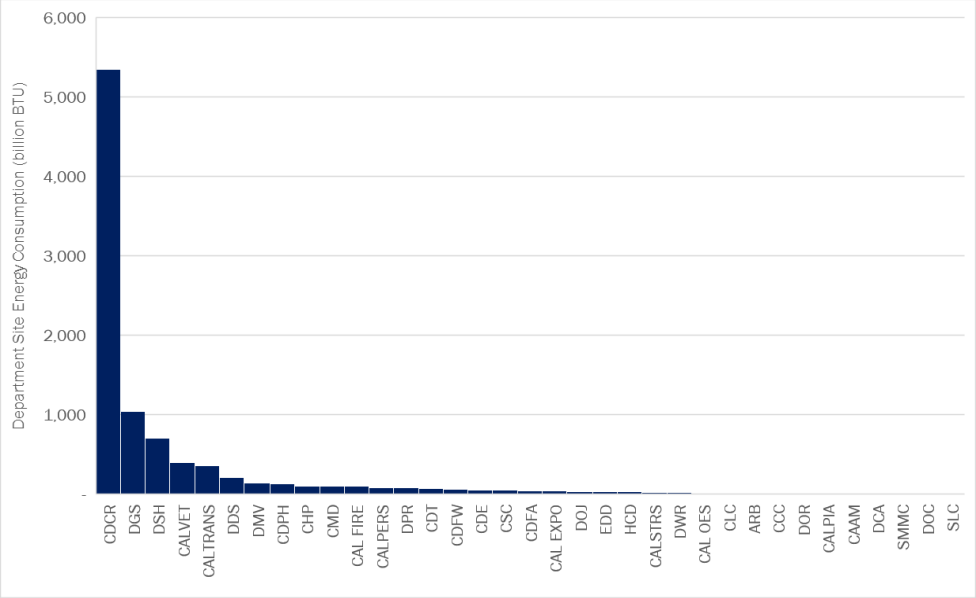
Figure 4-4 shows the cumulative percentage of state-owned square footage by department, along with the total percentage of state-owned square footage that each occupies. When considering property and building counts, those occupied by CDCR, DGS, Caltrans, DSH, DPR, and DDS (six departments) account for 81% of the total state-owned square footage. CDCR alone accounts for roughly 43% of the total square footage owned by the state.

Figure 4-4. Department Buildings Square Footage—Cumulative Percentage



The top 5 state departments in terms of total energy usage, as shown in Figure 4-5, are CDCR, DGS, DSH, CalVET, and Caltrans—accounting for 85% of the total energy consumption in all state-owned buildings tracked through ESPM. While departments such as DPR, CAL FIRE, and CMD may occupy a larger share of state-owned buildings, they do not account for substantial energy usage as they may have non-standard usage patterns (e.g., they may only be occupied for part of the year). Alternatively, departments such as DSH and CalVet (6% and 2% of state-owned square footage respectively) do not occupy substantial space, but account for a larger share of the state's energy consumption (8% and 4% respectively). This makes sense given these buildings are hospitals and outpatient facilities which have very specific (and often intensive) energy needs.

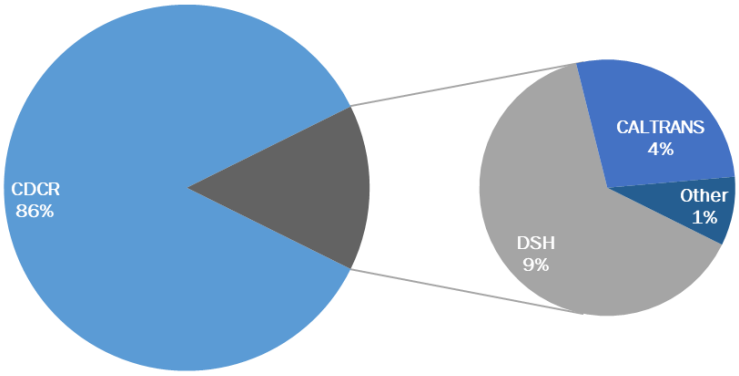
Figure 4-5. Total Energy Consumption by Department



Finally, Figure 4-6 shows the breakdown of renewable generation at state-owned building sites. The vast majority (86%) of existing on-site renewable generation comes from CDCR alone, while DSH and Caltrans account for 14% of on-site generation. Other departments that have on-site generation, account for just over 1% of the total; these include DMV, CHP, DPR, CA Lottery, CalVet, and CalPERS.[45]

[45] These generation totals are self-reported by departments via ESPM through the end of the 2015 calendar year. While other departments have reportedly installed on-site PV since (such as CDT and Cal OES), these are not included in the data for this study.

Figure 4-6. On-Site Renewable Generation by Department



When we review the number of buildings within each of these properties, their square footage, and overall energy consumption (site kBtu), the concentration within specific departments becomes apparent. Table 4-2 below summarizes the major departments, in terms of state-owned square footage occupied, energy use, on-site renewable generation, the number of buildings, and the number of properties. For reporting purposes, we define "highest" or "most" in each category in Table 4-2 as a minimum of 3% of the total for all state-owned buildings for each of the statistics. While some departments have quite a few properties and buildings (see Figure 4-3), this does not necessarily contribute to a substantial amount of square footage, the key metric to address when considering the governor's goal of achieving ZNE status for 50% of the existing state-owned square footage. The five departments highlighted below (Caltrans, CDCR, DGS, DSH, and CDPR) account for roughly 75%[46] of building square footage owned by the state. Further, existing renewable generation is also concentrated within a few departments, pointing to some ability to circumvent several of the barriers to installing on-site renewable generation discussed in the remainder of this report. For these reasons, it is clear that, to reach the state's aggressive ZNE goals, it is likely useful to focus resources on the major players outlined in the table below.

[46] Caltrans, CDCR, DGS, DSH, and CDPR account for 77% of the total square footage owned by the state; however, 2% of that square footage has no usage information, the majority of which appears to be properties that have since closed or are otherwise unoccupied.

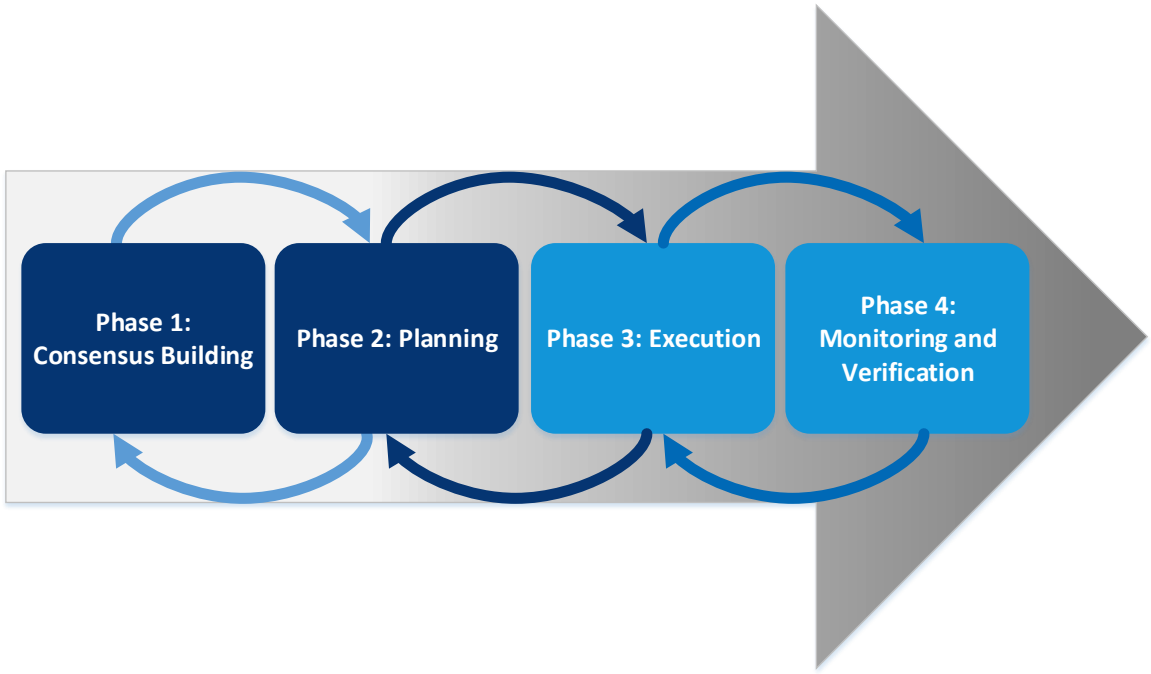
Table 4-2. Dominant Departments by Building Statistic

	Most Square Footage	Highest Energy Use	Most On-Site Renewables	Highest Building Count	Highest Property Count
Caltrans	✓	✓	✓	✓	✓
CDCR	✓	✓	✓	✓	
DGS	✓	✓			
DSH	✓	✓	✓		
CDPR	✓			✓	✓
CalVet		✓			
CAL FIRE					✓
CHP					✓
CMD				✓	✓
DMV					✓
CDFW					✓

5. State Department Road to ZNE

Based on interviews with 26 different state departments, Opinion Dynamics developed a high-level pathway illustrating the road to ZNE. This road to ZNE, illustrated in Figure 5-1, shows four phases that departments move through as they work towards achieving the ZNE goals outlined in EO-B-18-12, and how each relates to one another. The figure presents the path as linear; however, the first three phases are iterative as there are countless issues that may arise during the Consensus Building, Planning, and Execution phases. Additionally, for existing buildings, decision makers may execute different energy efficiency retrofit projects for a given building — on the road to ZNE — over multiple years because of funding limitations and/or to keep the building operational. As such, state departments may go through each phase multiple times for a given building.

Figure 5-1. Road to ZNE for California State Departments



Our departmental interviews indicate that the first two phases (i.e., Consensus Building and Planning) are the most critical and tend to include the most significant barriers. As with any major project, the first step is to identify, and then gather, internal and external stakeholders and agree on a set of goals and a general strategy to meet them. Particularly when dealing with state-owned properties, decision making authority may be distributed among several different stakeholders and it is necessary to have an agreed upon path forward. For example, while internally a single department may agree on one of their buildings to retrofit and a set of goals for that building, they may need endorsements from DGS and the DOF before moving forward with a project. And, once they move forward, they may need the expertise of one or more departments to navigate the process with external entities, such as the local utility company or a renewable power producer.

The planning phase (Phase 2 in Figure 5-1) is the most critical and tends to take the longest amount of time, especially when retrofitting an existing building to ZNE. This phase includes both technical planning (e.g.,

assessing the different points that an energy management system can control) and non-technical planning (e.g., considering leasing or owning a solar PV array to be installed on-site). Given the range of challenges that any department may face at this phase, the outcomes of the early planning process may result in the need to reevaluate the originally agreed upon goals. As such, ZNE champions may need to re-engage with stakeholders and repeat Phase 1 (and perhaps Phase 2) before moving into the execution phase.

During the execution phase, departments have begun construction/renovation. As is often the case, issues are uncovered during construction that require re-working some initial plans; this is particularly true for retrofit projects. Additionally, as discussed above, departments may work toward achieving energy efficiency upgrades over multiple years. Thus, they may go through elements of Consensus Building and Planning for each and every energy efficiency upgrade, which could span 5+ years.

The final step in reaching ZNE status is to measure energy usage and renewable generation to verify that the generation is offsetting usage (on a Source Energy basis) for an entire calendar year. As with the other phases presented in Figure 5-1, departments may go through a number of different monitoring and verification cycles before a building may truly be classified as zero-net-energy.

Table 5-1. Road to ZNE — Phases and Descriptions

Phase	Stage Description
Phase 1: Consensus Building	Internal department stakeholders are working towards an understanding of their desired goals/outcomes, building consensus and commitment to achieving those goals/outcomes, and working internally to identify ZNE champion(s) that will coordinate internally and externally to drive the department towards the agreed upon goals. Additionally, ZNE champion(s) begin to engage external stakeholders (e.g., DGS, utility companies, local/federal departments, etc.) to coordinate the project(s).
Phase 2: Planning	In Phase 2, ZNE champion(s) are working with technical professionals in-house (e.g., buildings managers and engineers) to determine the combination of energy reduction and renewable energy generation required to meet the agreed upon goals. Additionally, ZNE champion(s) coordinate with building staff to weigh the potential and feasibility of specific system-upgrades and renewable site selection. Simultaneously, ZNE champion(s) are working with decision-makers and contracting/finance stakeholders internally to determine what the desired upgrades will cost, which upgrades are feasible based on the available resources and preferred contracting mechanisms, and how to navigate any potential hurdles while weighing tradeoffs.
Phase 3: Execution	Energy efficiency and renewable energy projects are in the process of being implemented, along with any required metering infrastructure required to monitor energy usage and generation.

Phase	Stage Description
Phase 4: Monitoring &Verification	ZNE champion(s), in coordination with buildings staff, monitor energy usage and renewable energy output to ensure buildings are meeting ZNE guidelines. Additionally, ZNE champion(s) marshal resources and work with Operations and Maintenance staff to ensure that building systems continue to operate as scoped and identify any potential hurdles (e.g., occupant behavior) that may unintentionally increase energy usage.

In Appendix D, we provide snapshots for the 26 departments we interviewed. Each profile includes: a description of the department's mission, characteristics of the departments' buildings, a status of where the department is on the Road to ZNE, and a characterization of agency-specific barriers.

In the remainder of the section, we discuss each of these phases in detail and the various barriers that state departments face during each phase. The majority of the information presented is based on the in-depth interviews with department decision makers, conversations with ZNE experts, and document consultation to provide context as necessary.

For a variety of reasons, discussed in the forthcoming section, many departments are currently in the early phases of planning ZNE-related projects and, as such, were not able to speak to all the barriers they may face over a project's life-cycle. For example, many departments face difficulty in justifying the expense of initiating deep retrofit projects that would eventually allow a property to reach ZNE status. As such, they are—at this point—unfamiliar with some of the issues that will arise as they pursue more aggressive energy efficiency technologies or on-site renewable generation. Finally, only 3 departments have retrofitted existing buildings to ZNE status, or are in the process of doing so — these are CDPH's Richmond campus building P (complete), Cal OES's headquarter building in Mather (in progress), and CCC's Camarillo Center pilot project. The remaining 5 departments that have made progress towards achieving ZNE in one of their buildings have done so through new construction, or major gut rehabilitation projects, both of which circumvent occupancy challenges and the added cost of re-deigning existing systems to meet ZNE design goals. Thus, even those departments with ZNE experience tend to have knowledge of newly constructed buildings, as opposed to retrofits.

5.1 Phase 1: Consensus Building

As shown in Figure 5-1, the first phase in moving state properties towards ZNE is Consensus Building. There are a number of key steps in the Consensus Building process, including identify and onboarding key stakeholders, reviewing the department's portfolio of buildings, setting portfolio level goals, and, where plausible, selecting buildings to target for ZNE-related improvements. Additionally, after agreeing on which buildings to target, department stakeholders must agree on building specific ZNE road maps — that is, which specific steps to take to reach ZNE status. In the remainder of this subsection, we discuss these steps in detail, along with the various pitfalls associated with each.

5.1.1 Identifying Stakeholders

The first step in the Consensus Building phase is identifying all the stakeholders that need to be involved in the decision making process. As reported by some departments, this is a task that is often easier said than

done. Many state departments rely on other departments (such as DGS and the DOF) for key services related to building upgrades and improvements, such as securing funding, procuring services, and project design. Additionally, many of the issues that we highlight throughout this report are either specific to or made even more difficult when attempting to retrofit existing buildings to ZNE status. As we highlight throughout this report, these issues range from building conditions to building locations and whether a site is suitable for on-site renewable generation. On top of these, the effort will need funding—which has its own set of complications and constraints. Having the right people "at the table" early in the process is key to avoiding setbacks and delays, largely due to issues known by key stakeholders but, perhaps, unknown to department staff just becoming familiar with ZNE-related challenges.

As part of this process, departments who have completed ZNE projects indicate that having a "champion" is key to the process. This champion is the one who pushes others through the planning process, engages other departments and external stakeholders as necessary, works through the often challenging issues associated with financing and—in the end — sees the project through to fruition. For larger departments with the appropriate resources, this may mean establishing a position dedicated to sustainable building design — for example, an Assistant Director of Sustainability — that has purview and expertise in facilities management, building science, and the capacity to develop actionable sustainability policies for the department. For smaller departments, this may mean a high-level program manager or coordinator position that has visibility into the highest levels of the department where policies are developed, and the ability to implement sustainability policies as agreed upon by department decision makers. Regardless, this champion needs to be empowered to represent the department, and its sustainability-related goals externally. We note that establishing these sorts of positions are challenging for departments that already face budget constraints. However, adding these types of responsibilities to existing building management staff that already have full-time responsibilities is equally problematic in terms of meeting goals in the target timeframe.

> *The new Executive Order and the new sustainability rules and regulations -- it's just it's coming down so hard and fast on us that it's difficult to find staff time to acquire all this information… You know trying to get our team, get really involved with it. It's just our shortsightedness as a department not seeing how this was going to expand has caused a problem with staffing and getting things done you know. But overall I think it's good, but just sometimes we move a little slow.*

5.1.2 Portfolio Goals

For any department, establishing and agreeing on a set of specific goals is a crucial step in moving towards ZNE. Stakeholders should agree on high-level targets — that is, their plan for reaching the broad goals outlined in EO B-18-12 within the portfolio of state-owned properties they manage. Departments which have completed ZNE buildings, many of which were newly constructed, often highlight the importance of setting goals as a way of grounding future conversations, leading to a clear plan of attack. Without a set of tangible goals, they report that there is little hope that departments will make concrete progress towards ZNE. When discussing the West Berkeley Branch Library at the Zero Net Energy Workshop for State of California Agencies on February 16, 2017, one experienced attendee stated "Goal setting is essential. You need to set a goal or you won't get there."

> *One of the goals—not a goal—when we started the facilities masterplan we realized for an organization that's been around for 30 years that was leasing all these facilities, it just really didn't make a lot of sense financially. Then what I realized is, well, there's this nice gap between what we're paying in lease payments versus what we can build and own our own buildings for as far as how that all hits us in administrative expenses. So the idea was to use that extra savings, if you will, to make them ZNE.*

Each of the 35 departments that manage state-owned properties submits an annual Sustainability Road Map. As part of the Road Map, departments must include information on their targeted approach and the steps they plan to take to reach the Administration's stated ZNE goals. While California has outlined a number of aggressive energy-related goals for the state, this doesn't always translate into an actionable plan that any given department can replicate. While all of the departments we interviewed are aware of the broad goals outlined by the Governor's executive order, very few have translated that into a concrete plan for their existing properties. As we will outline in this report, this is due to both perceived and real barriers to ZNE as well as various competing priorities.

Competing priorities are wide and varied. While agencies generally want to achieve both energy efficiency (EE) and ZNE goals, the respondents have all stated that their agency's primary purpose is to fulfill the agency's mission. As such, achieving EE and ZNE mandates happens in the context of facility management for mission delivery, and mandates alone (especially unfunded ones) are often insufficient to trigger building upgrades. Agencies are focused on activities pertaining to keeping them operational, such as roof leaks, HVAC repairs, or other agency-specific activities. ZNE upgrades are not urgent and do not affect them doing business, so they are typically relegated to lower priority. In addition, many departments don't necessarily have the staff resources—given that the goals specified by their "mission" generally come first—to dedicate to ZNE. Additionally, ZNE projects may often compete for resources with deferred maintenance projects. Often related to employee or constituent health and safety, these types of projects are nearly always completed before energy efficiency or ZNE-related projects. Some departments have used deferred maintenance projects as opportunities to improve upon building efficiency; however, depending on the type of project, this isn't always feasible. Further, appropriations for deferred maintenance are typically earmarked for specific projects, which further limits flexibility.

> *It's not that we're not fans of the administration's energy policies, but faced with building closures due to water penetration, potential for mold and those kind of things, those projects always command the limited dollars. I won't say always, but 90% of the time we have to address those first, and energy efficiency projects fall below health and safety and building occupancy.*

Roughly one third of departments interviewed mentioned that energy-reduction goals contend with other competing priorities that vie for their limited staffing and financial resources. Even departments that have had some moderate success moving towards the state's energy efficiency and ZNE goals mention this as a continuous issue.

5.1.3 Building Specific Guidance

While this may change during the planning phase for a variety of reasons, it is important for stakeholders to agree on specific buildings to focus their efforts. Where possible[47], some departments are building all newly constructed buildings to ZNE and hope—due to their overall growth—to be able to meet the ZNE mandate through new construction only. Unfortunately, for all but very few departments, reaching ZNE through new construction is not feasible given that there are about 8,600 state-owned buildings (as profiled in ESPM) and it appears that less than 50 new state-owned buildings are constructed per year[48]. At that pace, it could take 80 years before half of all buildings could be replaced. During the existing building selection process, there are a range of criteria that stakeholders may consider. A few worth mentioning here are building occupancy, condition, use, age, and size.

- **Occupancy.** The challenge associated with the need to keep buildings occupied comes into play during the Execution Phase. Most departments indicate that their buildings need to be occupied during the process and, as such, this issue must be considered when selecting buildings to target. If relocating building occupants is an option, this can result in massive inconvenience and affect other department goals, and, if this is not an option, completing major renovations outside of normal working hours can add considerably to a project's cost.
- **Building Structure and Use.** The structure and organization of a building can introduce issues, and may limit how it can be modified. For example, a tall building that houses several data centers may have extremely high usage, but limited space for renewable generation, making it an ill-suited candidate for ZNE. Additionally, the primary use of the building, which is directly related to the mission of the department, may dictate its occupancy needs.
- **Building Vintage.** Several department decision makers noted that their portfolios contain older buildings that may make ZNE retrofits extremely complicated or, at the very least, add considerably to the project's cost.
- **Building Size.** The size of the building and the density of building occupants can affect how the improvements can be made, including the project timeframe. Multiple departments mentioned that they will focus on retrofitting smaller buildings.

[47] In some instances facilities with very specific usage requirements (e.g., laboratories) may be unable to achieve ZNE, especially in the event that renewable generation on site is not possible given a building's location.

[48] We were unable to secure the exact number of new state-owned buildings that are being constructed per year. However, from our interviews, it was very infrequent for a department to state that they were either building or had plans to build a new building. In many cases, departments were silent on this specific issue because they already made it clear (early in the interview process) that they lacked the funding needed to address existing building issues (many went on to say or strongly imply that given the lack of funding for critical building improvements, there was little chance of securing—and little reason to pursue—funding for replacing an existing building with a new building).

Once departments have set their goals at the portfolio level and decide what buildings to focus on, they don't seem to know how to take the next step. A common ZNE strategy is to first address a building's efficiency needs and then install renewable energy to offset the remaining usage. Unlike new construction, where energy efficiency and renewable installations happen simultaneously, retrofits tend to be performed as funds become available and old equipment needs to be replaced.

A number of department decision makers noted the difficulty of setting goals given that the majority of their properties are non-standard building types, or those with specific usage and occupancy needs. These include armories, fish hatcheries, and other buildings with very specific uses.

> *One major issue…is [that we have] primarily weekend usage. And so a lot of our facilities are smaller…and so they don't have enough usage to make the major energy projects work. Like we tried working with DGS with their state energy retrofit program but they*

For both portfolio and building-specific goals, departments with non-standard buildings (e.g., rural, small, warehouses, low usage, etc.) need additional guidance on developing achievable goals and creating plans to achieve those. These non-standard buildings can be a substantial portion of a department's total square footage, yet, for a number of reasons, it may be difficult, if not altogether impossible, to achieve ZNE in these buildings.

In most cases, departments reported not having building specific road maps to ZNE. That is, currently, retrofit projects are not necessarily thought of in the context of a larger plan to achieve ZNE.

5.2 Phase 2: Planning

During the Planning phase, department stakeholders are finding out how to operationalize ZNE and developing strategies to achieve their goals. In this phase, decision makers confer with building science professionals to determine a projects' technical feasibility, while also considering a projects' financial and administrative needs—most notably, project funding, procuring construction-related services, interconnection agreements, and any other external factors that may arise.

In the subsections that follow, we discuss each of these issues in detail, beginning with funding considerations, which encompass arguably the most intractable barriers to improved energy efficiency and ZNE for all but a few departments. Assuming that departments are able to secure funding and are able to move through the procurement process successfully, departments are then faced with a whole new set of challenges with respect to buildings' physical condition, location, and systems. Most departments are highly aware of the condition of their existing building stock and this knowledge is often enough to prevent decision makers from taking aggressive steps toward energy efficiency improvements and ZNE. There are also a set of largely external issues — in particular, connecting to the electric utility grid—that pose a final set of planning challenges to department stakeholders.

5.2.1 Funding

Having access to funding is one of the most critical barriers that departments face when developing plans to achieve ZNE in state-owned buildings, particularly when retrofitting existing buildings to ZNE. Nearly 60% of department decision makers interviewed cited insufficient funding as the largest barrier preventing them from making progress towards the state's ZNE goals. These issues have been well documented in the ZNE Status

Report, released by DGS in 2015. In this section we breakdown the various sources of funding, financing mechanisms, and the processes that departments go through to make use of each.

Funding Sources

There are a few different funding sources that departments may use to implement capital improvement projects. Each year, in coordination with the State legislature, the Governor issues a budget which includes any major construction or renovation projects for that fiscal year included in the State's General Fund. Aside from projects that are funded in this way, departments must find alternative financing mechanisms (e.g., energy savings performance contracts or utility on-bill financing). Additionally, departments will search for other external funding sources such as rebates from utility companies and different grant opportunities; however, these generally make up a small portion of a project's total cost and are not typically the impetus (i.e., are not sufficient on their own) for choosing to move ahead with a ZNE project.

While there are five different departments that have their own revenues and thus control expenditures, the vast majority of departments are reliant on major projects being approved through the State's annual budget cycle. Below, we outline the different funding sources that most departments have used to either complete a ZNE project or energy efficiency projects that will eventually lead to ZNE. In addition to describing the funding source, we describe the corresponding process involved in securing it.

Capital Outlay

Most departments rely on budget appropriations through the General Fund; approved by the governor and state legislature as part of the state's annual budget. Within the General Fund, Capital Outlay is a character of expenditure that covers land acquisition, planning, construction, and major renovation projects.

> *If you think about being 18 months in advance with submitting a request for [capital outlay] funding, then going through a budget cycle to see if we get the funding. If you have to have an acquisition component, sometimes that's taking us a year to three years to find a site, a year for preliminary plans, a year for working drawings, and two years for construction, and that's if we don't hit any delays. So it can be an eight-year process or so to get even one of these, by other standards, small…offices authorized and constructed.*

When using funding through Capital Outlay, departments are required to go through a lengthy process of review and approval, as outlined in California's State Administrative Manual. The 10 step process, shown in Table 5-2, is based on the design-bid-build approach and begins with a concept and documentation phase and ends with a claims and close-out phase. The budget approval phase, which is the third step, typically takes seventeen months, making it the longest step. Altogether, the capital outlay process can take up to 63 months (>5 years), not including the construction phase, which is an addition three to 36 months. It is important to note that projects funded through bonds and financing leases complete additional steps, which are discussed below. Additionally, most of the steps apply to both major renovations and new construction.

Table 5-2. Capital Outlay Process

Phase Number	Capital Outlay Phase	Description	Length of Time to Complete Phase
1	Concept and Documentation	The department defines a problem, drafts a conceptual solution, and collects supporting data and documentation to support the plan	2-5 months
2	Historical Resources	If the project will impact a state-owned structure over 50 years of age, the proposal, along with a Historic Resources Inventory, must be reviewed by the State Historic Preservation Officer.	Coincides with phases 1 and 3
3	Budget Approval	Budget approval includes review of the department's five-year plan, technical feasibility review, budget development and related hearings, and approval or adjustments to the proposed project. Each stage in the process has sub-stages.	17 months
4	Site Selection and Acquisitions *(new construction only)*	A site is selected, approved and acquired through settlement or eminent domain (only applicable for new construction).	Up to 12 months
5	Environmental Review	The department meets California Environmental Quality Act (CEQA) requirements	Coincides with phases 1-4
6	Preliminary Plan	Architects/engineers design the project and estimate project costs, environmental regulations must be met, and the preliminary project plans are approved.	3-12 months
7	Working Drawing	Architects/engineers prepare detailed plans, specifications for bidding, and refined budget	3-11months

Phase Number	Capital Outlay Phase	Description	Length of Time to Complete Phase
		estimates. The plan undergoes mandatory review and approvals, and the Department of Finance (DOF) certifies the plan before proceeding to the bidding phase.	
8	Bidding	DGS advertises the project, bidders prepare proposals, and the DOF authorizes eligible (within budget) awards. DGS awards the contract to the contractor.	3-6 months
9	Construction	Contractor completes project as designed and budgeted.	3-36 months
10	Claims and Closeout	Where applicable, contractor files a claim against the State of California seeking compensation, which are resolved with the DGS through arbitration, mediation and/or court. The project is closed out.	

Source: California State Administrative Manual Rev. 364 May, 1998.

While this is the most common method of funding projects, the process is lengthy and requires additional planning and foresight when justifying project budgets to the DOF. First, decision makers should include new construction and ZNE-related major renovation projects in their departments' five-year infrastructure plans. The infrastructure plan is a key reference document for subsequent budgetary planning and requests. While inclusion within the five-year infrastructure plan is not mandatory, it illustrates the importance of ZNE and ensures that funding will at least be considered during the budgeting process. Additionally, project budgets need to be set well ahead of time, typically at least one budget cycle prior to the year the department intends to commence project implementation. According to the timelines laid out in Table 5-2, at minimum, projects take roughly 2 and half years and, at most, they can take over 5 years before reaching the Execution (i.e., construction) phase. Using capital outlay funding may be more realistic for new construction projects as these typically coincide with department growth or another major long-term need, and do not have the timing challenges inherent in retrofit projects—for example, the need to keep buildings occupied during construction may require a project to span multiple fiscal years and, therefore, be justified over the course of multiple budget cycles.

Related to these issues, and discussed in the preceding section, almost a third of department decision makers mentioned having a lack of internal staff resources to manage this process. Departments that have made progress towards the state's ZNE goals have dedicated sustainability staff to these mandates, given the

complexity and the time needed to work through the process. One department that has had success working through the Capital Outlay process is the CDCR, which occupies roughly 43% of the state-owned square footage and represents 58% of the energy consumption in state-owned buildings. Along with CDCR's commitment to sustainability and efficient building design, they have a dedicated sustainability group that is tasked with both facilitating ZNE projects and ensuring that the department has the associated funding to execute.

> *But we facilitate all of the funding that they need for the day to day maintenance, preventative maintenance, facilitate all the funds for any of the major repairs and do all that work for them. So we have a role, but it's not the day to day hiring and management of the staff.*

DGS Statewide Energy Retrofit Program

While some departments elect to use the Capital Outlay process to fund ZNE projects outright, there are other means of financing these projects over time. DGS, and other stakeholders, have worked to create other funding options for departments to use for energy-related projects. The most common of these is the DGS Statewide Energy Retrofit Program, commonly referred to as the ESCO program. For state departments, going through DGS's ESCO program alleviates the need to go through the lengthy Capital Outlay process because, through one of the mechanisms described below, DGS facilitates a loan that the department re-pays through their operating budget. Additionally, it avoids potential cash-flow issues associated with paying the cost of the project up-front, and instead through monthly payments connected to the building's energy savings. For example, a department may classify the monthly payment as an operational expense, similar to how they would classify paying their utility bills, as opposed to a capital expense which would require going through the process outlined in Table 5-2.

The DGS ESCO program uses two different financing mechanisms:

- *DGS Energy Efficiency State Property Revolving Fund*—The California Energy Commission (CEC) was awarded $226 million in funds through the American Recovery and Reinvestment Act (ARRA) of 2009. As part of this award, the CEC disseminated the bulk of these funds to DGS to establish a revolving loan fund for energy efficiency upgrades to state-owned and operated buildings. As with similar revolving loan programs, this fund allowed departments to re-pay the cost of the project exclusively based on energy savings, allowing for approved projects to remain cash-flow neutral. And, as "re-payments are made," the funds can be loaned out again for other energy efficiency projects.

- *Golden State Financial Marketplace (GS $Mart) loans*--GS $Mart provides financing for energy efficiency and sustainability projects. Importantly, a cost-benefit analysis must show that energy savings from the project will cover all project costs, including financing, and a DGS-provided life cycle cost (LCC) model *must* be used to complete the analysis. Projects cannot be financed unless they show completion of the LCC model and prove energy savings high enough to offset the cost of the project. Projects requiring $10 million or over in financing must seek pre-approval by the DOF. The most substantial drawback of the GA $Mart loans is that they cannot be used for bond-encumbered buildings and many state-owned buildings have bond debt and bondholders who will not accept another lien on the property. While the revolving fund can be used, there is not enough revolving fund

cash to address all the bond encumbered buildings[49]. Another drawback it that the maximum loan is 15 years. When DGS overhead is included in the project cost, the blend of energy efficiency measures that can be included need to have a maximum payback of about 10 years. And, importantly, a 10 year payback in not deep enough to include low payback measures—such as windows and boilers—that are important to ZNE attainment.

Recently, DGS has taken steps to streamline this program in an effort to cut down on the administrative time required to review and approve individual contracts with ESCOs. Passage of SB 840 in 2016 ("The Trailer Bill") authorizes departments to assign projects to a pre-qualified ESCO. After establishing a most-qualified pool of ESCOs through a competitive Request for Qualifications (RFQ) process, the department then assigns projects on a rotational basis. In 2017 DGS simplified this process further through the most recent iteration of its ESCO program. DGS eliminated the need for legal review of individual contracts for each project by pre-approving a single master contract, thus speeding up the contracting process.

> *So a lot of agencies are doing smaller projects directly with the utility companies, but I think they shy away from coming to [DGS] because our process was slow before, so hopefully they will [now] because it…helps them, they don't have to come up with the capital funding, it is just through their utility line item and we've already got the ESCO's*

Though DGS's ESCO program (both the revolving fund and GS $Mart) have been in operation for some time and has had some success spurring energy efficiency projects; to date, it has not been leveraged for ZNE projects. This may be, in part, related to the complexity and added challenges associated with retrofitting an existing building to ZNE standards.

DGS Renewable Energy Program

The DGS Solar Program, sometimes referred to as DGS's "PPA program", provides a streamlined mechanism for state departments to install cost-effective on-site renewable energy generation. DGS facilitated the first PPA through the program in 2005, and since has helped to initiate 25 projects (amounting to 40 MW) throughout the state. DGS is in the process of releasing 20 additional projects (amounting to 30 MW) during 2017, with a goal of reaching 100 MW of solar generation facilitated through the program by 2020. Through the program, DGS established a pool of qualified solar vendors that offer canopy- or roof-mounted systems. Additionally, the program established standard site license agreements that allow vendors to install solar systems on state-owned properties. The program requires no up-front cost to departments and DGS facilitates the entire process (i.e., RFP and contracting, evaluates bid packages, and awards the PPA).

Utility On-Bill Financing

Government and institutional utility customers may acquire on bill financing (OBF) from several California utilities, including PG&E, SCE, SoCalGas, and SDG&E. OBF loans typically have zero interest or fees, and the loan is repaid to the utility through energy bill savings. To qualify, potential recipients must also obtain pre-

[49] This is a problem that has yet to be solved by state departments. I-Bank, or refinancing bonds to take out equity for use on energy efficiency project are reportedly two possible methods of addressing this issue.

approval for equipment rebates through another PA energy efficiency program. Project financing amounts range from a minimum of $5,000 to a maximum of $1,000,000 for each loan[50] (specifically for government buildings) with a loan term of up to ten years. Utilities generally cap loan amounts based on the service account. That is, one service account may initiate multiple different OBF loans over the course of a ZNE project up to the pre-determined maximum loan amount. Additionally, with the exception of emerging technologies, OBF is not generally granted for single end use projects, or those where 1 end use makes up more than 20% of the entire project's cost. Similar to GS $Mart loans, a 10-year payback period may not be enough to get to the deep retrofits needed to reach ZNE.

Similarly, PG&E proposed an OBF "Alternative Pathway" Program in 2016, which focused on guaranteed energy savings from the efficiency projects and removed the incentive of rebates. Though the OBF alternative path was approved in 2016, it is not advertised on PG&E's website and may not be available to state departments seeking to finance retrofits.

While, some departments have also taken advantage of utility OBF programs, these tend to be for smaller energy efficiency projects. Similar to the DGS ESCO program, OBF can be an attractive option for departments looking to avoid the complexity of the Capital Outlay process. However, OBF does not alleviate the issues related to retrofitting an existing building to ZNE — that is, OBF can help facilitate the piecemeal process of improving the efficiency of a building, but is not applicable for renewable generation nor is it enough money (in most cases) to drive significant changes in a buildings overall energy use. In addition, utility OBF programs typically have 10 year max payback periods.

Other Financing Mechanisms

There are a number of other, less common, mechanisms available to state departments to finance infrastructure projects and could, in theory, be used by departments to finance ZNE-related building upgrades or new construction projects. While departments have taken advantage of the mechanisms described below for specific energy efficiency projects, departments had limited experience with each of the following.

Long-Term Bond Financing

Some departments opt to fund new construction projects using long-term bond financing, though this may limit their ability to enter into another long term agreement with a 3rd party (e.g., solar PPAs). Departments have several options for long-term financing of infrastructure, which is considered a capitalized asset. The most common of these finance strategies are general obligation bonds and lease-revenue bonds. We describe each below in detail:

- **General Obligation bonds** offer long-term borrowing where the state pledges repayment and issues municipal securities to back the bond. Importantly, the California Constitution prohibits the creation of debt in excess of $300,000 without a majority vote by the people, except in case of war.[51] For projects

[50] All four California investor owned utilities cap loans for most taxpayer funded institutions at $250,000; however, specify that at their discretion for certain government agencies—in some cases specifically for state government—loan amounts may be offered up $1 Million.

[51] California State Constitution. Article XVI, Public Finance. Section 1.3 (2004)

not exceeding $300,000, the use of these types of bonds may be a reasonable option for some EE or ZNE retrofit projects.

- **Revenue and lease-revenue bonds** are secured by revenues generated from issuing bonds related to the specific project, as opposed to general obligation bonds where the department may re-pay the loan with any revenues available to them. The occupying department makes lease payments to repay the financing entity that paid the construction costs. In these types of agreements, a third party finances the construction project, issues the bonds, and then retains the title to the building until the debt is repaid by the occupying department.

Less common financing strategies are lease-revenue bonds issued through the public works board (PWB) and a joint powers authority (JPA)[52] between different state and local government entities. Both the PWB and a JPA typically finance the construction project, issue the bonds, and retain the title to the building until the debt is repaid. Leases may have terms up to 35 years but leases cannot exceed the useful life of the capital asset. The SAM defines PWB and JPA-backed bonds separately but for the purpose of funding ZNE projects, their utility is the same.

Architecture Revolving Fund

The Architecture Revolving Fund (ARF) receives funds for the construction, improvement, and repair of state buildings. Transfer of funds to the ARF requires DOF approval, and for major projects, the amount transferred to the ARF must not exceed the amount agreed upon via competitive bidding. The ARF does not necessarily provide an additional funding source for projects but acts as a reserve for projects that have completed the Capital Outlay process.

California Infrastructure and Economic Development Bank

The California Infrastructure and Economic Development Bank (IBank) finances public infrastructure and private developments that promotes jobs, a strong economy, and quality of life in California. Within IBank, the California Lending for Energy and Environmental Needs (CLEEN) Center provides financing for projects related to greenhouse gas reduction, water conservation, and environmental preservation. Financing can be obtained through IBank or through public tax-exempt bonds, as previously discussed, for projects ranging from $500 thousand to $30 million in cost. The CLEEN Center offers a valuable opportunity for ZNE project funding as it offers two programs that explicitly support energy conservation projects.

IBank also manages the Infrastructure State Revolving Fund (ISRF) Program, which finances a wide variety of infrastructure and economic development projects for public departments and non-profit corporations sponsored by public departments. ISRF Program offers between $50,000 and $25 million in financing for projects, with loan terms for the useful life of the project up to a maximum of 30 years. The ISFR does not explicitly finance EE projects but may finance broader projects that have an energy conservation component.

[52] A JPA, enabled by the Joint Powers Agreement Section 6500, is an agreement between two or more state or local government entities in California that establishes joint decision making authority over, in this context, the management of a state-owned building or portfolio of buildings.

5.2.2 Procurement Process

The vast majority of state departments that own or occupy state-owned buildings must go through DGS Construction Services to procure construction and other related services. A number of decision makers interviewed for this study mentioned that this process can be challenging, most notably as it adds considerably to projects' total cost and timeline. Recognizing this, DGS has taken steps (i.e., through DGS's ESCO and Renewable Energy programs described above) to come up with workable solutions that streamline the process.

Procurement Authority

DGS is the primary contracting channel for most departments and, as such, there is a dollar limit on the services that those departments can obtain without DGS authorization. This dollar limit is typically much lower than ZNE-related project costs and therefore forces departments to go through DGS. While this does provide some benefits in that DGS is able to maintain a centralized position on sustainability, building design, and quality construction, it also exacerbates other barriers, such as the lack of funding for energy efficiency and renewable energy projects (discussed below). Working with DGS on procurement comes into play for a range of ZNE-related issues—that is, construction services, project financing, solar PPAs, and interconnection agreements.

> *For the state of California, the Department of General Services is the authorizing body in charge of all procurement—both contracts, goods, services, etc. They delegate that authority to different departments based on a number of things…So when we're trying to deal with these interconnection agreements, PG&E was reticent to sign any additional agreement that was required on our part, and we do not normally, as the State of California, have the authority to bind the state under someone else's agreement. So we had to go to the head of the legal department at the Department of General Services and ask for them to please allow us to sign their agreement.*

Additionally, working with DGS can add substantial time to a project's lifecycle. This was partially a symptom of the need for the state to thoroughly vet each project's contract. As described above, DGS has recently launched an updated ESCO program that alleviates this issues through a single master contact and a pre-approved list of vendors.

There are some departments that do not face this hurdle. Of the eight departments mentioned that have made some progress towards achieving ZNE source status in at least one building, four have special procurement authority and therefore are not required to go through DGS to obtain construction services—the CA Lottery, the CDPH, Caltrans, and the CDCR. Though the absences of these issues is not the sole reason for these four departments' relative success, it does provide far greater flexibility. For other departments dealing with centralized procurement, legal considerations and RFP award disputes lead to delays and sometimes the cancellation of projects altogether. Nevertheless, it is important to point out that at least some decision makers suggest that many department do, indeed, have procurement authority at a level (as high as $300,000 in some cases) that—combined with the use of ESCOs and PPAs—may allow buildings to achieve ZNE (or get close to it) without going through DGS.

> *We have our own plant ops department with our own engineering staff. So DGS is only coming into our building when we have a project that exceeds our delegated authority. And the folks at, say, [other departments], who have their own delegated authority and don't go through DGS, don't have that obstacle or issue.*

In particular, buildings under 50,000 square feet were mentioned as buildings where departmental procurement authority may be enough to get a building to ZNE. These same decision makers note that DGS is busy working on multimillion dollar retrofits and solar projects and, therefore, it is important for departments to do more on their own.

Added Cost of Procurement

As funding is already a major issue for most departments, the added cost of working through DGS Construction Services can make some already costly projects unpalatable for department decision makers. Through this process, DGS assigns a project management team to help facilitate the construction process. While this is beneficial in that it helps maintain consistent standards for ZNE-related projects, billing DGS staff time adds considerably to the overall cost of the project and, in some cases, diminishes its cost-effectiveness.

> *I think it's a major drain to the department's operating budget. If we're looking at a large capital project that we maybe can set aside $1.5 million for, were we to run the project ourselves, then we go through DGS, and that $1.5 million quickly becomes $2.25 million. If we don't have a way to close that gap, then that is a barrier to the smaller agencies.*

Further, as alluded to above, the added cost of working with DGS Construction Services is on top of engineering and buildings management staff that most departments already have in-house, essentially having to bear these costs twice. This is specifically an issue for departments that own their own buildings, as they have staff that manage day-to-day building operations and oversee basic maintenance projects. This is less of an issue for departments that lease space from DGS.

5.2.3 Building Specific Barriers

Assuming that funding can be secured and the procurement process completed, departments are then faced with a whole new set of challenges with respect to state-owned buildings themselves. All the departments interviewed are highly aware of the condition of their existing building stock and this knowledge is often enough to prevent them from taking aggressive steps toward energy efficiency improvements and ZNE.

We characterize these issues as building level barriers, which include the physical, locational, and technological issues incurred when trying to achieve and maintain ZNE-status within a given building. To inform the discussion, we draw on several key sources of information including, but not limited to, interviews with 26 of the state departments that are subject to the Governor's Executive Order, key findings from a review of 11 ZNE case study buildings in California as documented in two publications[53], interviews with owners or occupants of another 7 ZNE buildings in California that were not included in the case studies, and a review of available literature. Each of our information sources (i.e., interviews, case studies, literature review, etc.)

[53] Zero Net Energy Case Study Buildings *Volume 1* (September 2014) and *Volume 2* (April 2106). Written by Edward Dean, FAIA – Bernheim & Dean, Inc. Forward by Peter Turnbull, Principal, Commercial Buildings, Pacific Gas and Electric Company.

provide unique insights into building level barriers, yet all have limitations[54]. Because of this, we integrate information drawn from all these sources.

It is important to note — at the outset — that our interviews with state departments provided a limited amount of information with respect to certain barriers (e.g., technological) for two interrelated reasons. First, only a handful of state departments have ZNE buildings within their respective building portfolio and, among those that do, most are newly constructed buildings or gut rehabilitation projects (5), not retrofits of existing buildings (3). This is important because reaching the goal of 50% of state-owned building square footage to ZNE is — as expressed by multiple state department — highly dependent upon significant levels of retrofit activity. Second, given the lack of building retrofits, many departments have limited experience[55] to draw upon when asked to identify and discuss building level barriers. Despite this, many individuals we interviewed within state departments — given their deep knowledge of the characteristics of the state buildings they manage and oversee — appear to have formed reasoned expectations regarding what those barriers will be.

> *All of these projects are New Construction… It is really challenging to do ZNE for an existing building. These are really old buildings. Most field offices are 35 years old, have bad windows, they are not seismically sound, insulation is substandard, not ADA compliant. Huge challenges. Not cost effective to force it to work. You want to reduce energy use but bolting enough solar panels on them [if even possible] is the only way to get there.*

One thing that became clear in the research process is that ZNE buildings — particularly the 11 cases studies — share similar characteristics that are key to achieving ZNE status. And, when we consider the implications of these characteristics on state buildings, the challenges and barriers to achieving ZNE within them become quite clear.

In the remainder of this subsection, we provide a more detailed — and state department specific — analysis around the key building level barriers to ZNE. We organize the barriers into the aforementioned categories — physical, locational, and technological — and then discuss the implications on state buildings. It is noteworthy that the common characteristics of ZNE buildings essentially become barriers (or challenges) when it comes to retrofitting state buildings, as a high proportion of the state buildings stock would appear to lack many of these key characteristics.

[54] A limitation of the state department interviews, for example, is that many interviewees do not have direct experience building a new or renovating an existing building to ZNE. A limitation of the case studies is that they are, with a couple exceptions, privately owned buildings.

[55] A lack of direct experience, however, does not mean that these agencies cannot correctly identify what the barriers are, or will be, at the building level.

Physical Building Attributes

Several different attributes of some state-owned buildings present challenges to completing ZNE retrofit projects, such as the buildings' age, size, shape, height, and site footprint. A frequently mentioned concern of state departments is the fact that a significant amount of the total square footage of state buildings is within very large multi-storied buildings in densely populated areas. And, highly related to this, is the fact that few existing ZNE buildings have these attributes. In addition to the size of the building, many are older and have other issues that may inhibit obtaining ZNE status — such as inadequate structural elements, asbestos, and overall poor condition. Below, we outline specific physical barriers — many of which are highly related to and overlap with each other.

Of the various physical challenges associated with the state-owned buildings, their vintage was amongst the most frequently mentioned by department decision makers. Thirteen of the 26 departments interviewed for this study mentioned the age and condition of their state-owned buildings as a major barrier to reaching the state's ZNE goals. Many state buildings were reported to be old, in very poor condition, and in need of major upgrades and maintenance. As a result, departments focus on keeping the building operational and question the usefulness of further investing in a debilitated structure.

> *So I would say first of all I really tried to identify facilities [for ZNE] that were on the smaller side so Marina, for instance, I believe it's about 15,000 gross square feet. Now having said that, our largest one, the Sacramento Juvenile is 100,000. So most of these kind of varied. I think the average is maybe 30,000 square feet. So these aren't huge facilities.*

The size and shape of some state-owned buildings also present a challenge to retrofitting to ZNE. Unlike most existing ZNE buildings, there are a good number of very large state buildings, exceeding 100,000 square feet. Lowering the EUI of large buildings with high heating/cooling loads — particularly through the use of common ZNE building design elements, such as natural ventilation, natural lighting, etc. — is very challenging if not impossible.

Natural ventilation is a key element of many ZNE design strategies and is difficult to achieve in wider buildings. The ability to passively distribute outside air throughout the interior of a building to heat or cool spaces offsets the need to do so using mechanical systems. As HVAC usage can account for a substantial portion of a building's energy needs, eliminating this demand at different points throughout a typical day can be an essential strategy to increasing a buildings efficiency, and thereby lower its EUI.

> *Even if we put solar in every square inch of our campus, we wouldn't be able to…become a ZNE successful building. It just wouldn't work. We have…a small little 40,000 square foot data center [that] requires a ton of energy, so anyway it's a little bit of a challenge.*

Throughout all 26 interviews with state department decision makers, while all were aware and understood the importance of the ZNE goals set forth by EO B-18-12, it was clear that the department's mission supersede any such goals. While this means that departments are continuously searching for additional cost-effective energy reduction strategies, it is also clear that — particularly for laboratories or other buildings that require substantial energy use throughout the day and year — there are limits to how much departments can reduce their energy consumptions. As such, regardless of other issues associated with interconnection discussed below, some departments simply cannot generate enough renewable energy on-site to achieve ZNE.

Additionally, the height of certain buildings may present a challenge when implementing ZNE-related retrofits. The majority of existing ZNE buildings in California have a limited number of floors, typically 1-2. Tall buildings tend to present problems with respect to the ability to install rooftop solar PV. In addition, the taller the building the more likely it is to be very large (e.g., multiple stories, large footprint) and the less likely that ample roof space exists (even if no structural impediments exist) to support a sufficient number of solar PV panels to reach ZNE.

> *Our buildings are the easiest type, I think. Our district offices, typically a single story, 10,000 to 15,000 square feet. Typically about 20% of that is warehouse, unconditioned. So almost just by that formula, we're almost always going to have enough canvas on the roof to handle our [PV] array. Certainly other folks, multi-story, urban setting, it's certainly a whole different challenge than we've had.*

Finally, the size of certain building sites, may present a challenge for ZNE. Many state buildings — particularly some of the largest offices — have a relatively small site footprint. Comparatively, with a few exceptions, all the case study buildings had a relatively large site footprint with sufficient parking lot and/or green space immediately around the building. Site footprints that are nearly identical to the building footprint, have implications on the ability to install ample amounts of non-roof mounted solar PV.

Building Location

The location of some state-owned buildings also present a challenge. Issues such as the climate zone within which an existing state building is located, the density (number and size) of buildings around it, and how the building is positioned with respect to surrounding buildings and exposure to the sun. Below, we outline specific locational barriers that, to some degree, overlap with each other.

A common characteristic of ZNE buildings is to use outside air temperature to regulate the interior temperature of the building. With the exception of the two buildings at UC-Merced, all of the 11 case study buildings are in climate zones 3 or 4. While higher daytime temperatures can be reached in these climate zones, they tend to have fairly cool nighttime temperatures — allowing for night purging. For example, the Bacon Street office project in San Diego[56], one of the case studies reviewed for this study, located such that it "takes advantage of prevailing coastal breezes to draw cool air across the building's thermal mass and exhaust warm air through skylights to naturally ventilate the building," thereby reducing the building's HVAC load.[57] Certainly, ZNE buildings outside of climate zones 3 or 4 exist, but it is likely that achieving ZNE status may be more difficult (e.g., require more PV), especially in climate zones with high cooling requirements.

Regardless of whether a building is located in an urban center, a remote location, or somewhere in between, there are a range of issues that must be considered when considering a ZNE retrofit. Several departments' mission (e.g., CAL FIRE, the CMD, Caltrans, and DPR) require buildings in rural, sometimes even remote locations. This introduces a range of challenges, such as added construction costs for implementing projects in remote

> *The other minor thing is in some of the really remote areas you just throw solar on everything, within three months, especially if you are not manning the site, all that would be gone because it would be stolen because… you're an easy target because you're the state.*

[56] Not a state-owned building and located in climate zone 7 but was studied from a technical perspective.
[57] Zero Net Energy Project Profile: Small Office Retrofit. NBI. 2013

areas or risk of theft or vandalism to solar PV systems if remote buildings are only occupied for part of the year. Conversely, many state buildings — particularly the larger ones — are located in dense urban areas, which introduce another set of challenges. These include less ability to install solar PV and limitations on natural lighting and natural ventilation given the density/height and characteristics of surrounding buildings.

Irrespective of climate zone or its rural or urban location, buildings may simply be positioned (on the existing site) in a manner that does not allow it to benefit from (or block) exposure to the sun. The majority of renewable energy generation on site for ZNE buildings, particularly those located in California, is solar PV. As such, unobstructed space oriented towards the sun is significantly important when planning for ZNE. Four out of the 26 departments interviewed for this study mentioned that none of their state-owned building sites are suitable locations for solar installations. For those departments, reaching the State's ZNE goals will pose ever greater challenges.

> *For many buildings the major barrier is there is no room for onsite renewables [given the urban setting]. That is probably the biggest barrier.*

Technological Considerations

Planning to achieve ZNE requires designing either a new construction or retrofit project with very particular building technology specifications. For retrofit projects, existing building systems may present implacable barriers or limitations — given building size, orientation, age, and other characteristics — to the type of technological features or equipment that can be deployed toward reaching ZNE status. Technological barriers often result from the impact of other barriers — particularly physical and locational — that effectively limit the use or performance of a given technology. It is important to note here that the "spirit" of ZNE would appear to suggest that achieving the lowest possible (e.g., economically feasible) EUI within a building is the first order of business. Then, after achieving this, installing enough solar PV to get a building to ZNE. However, there may be technological limits to the EUI that can be achieved within a given building — especially large, multi-stored, urban buildings — along with a limitation on the installation of solar PV. Combined, these issues can make it nearly impossible to achieve ZNE for some buildings (at least at a site level).

Newly constructed and renovated ZNE buildings include significant passive design elements. For the most part, the major renovation projects highlighted in the 11 case studies took aggressive steps to incorporate elements of passive design — to the extent feasible and physically possible — into the renovation process. It is doubtful that such features can be incorporated into many existing state buildings given the physical barriers discussed previously. Specifically, night purging is a central design element included in some ZNE buildings. Highly associated with climate zone, this is the use of outside air at night to pre-cool the building and computer server rooms for the next day. Again, depending on climate zone and building density, this might not be a realistic feature to pursue in many state buildings.

> *You know you've got two [buildings] that are over 125 years old …it's just I think going to be really challenging to modify the way in which those [buildings] are designed and operated to achieve ZNE you know on a building basis. They might benefit from solar outside, but to actually go into the energy systems and make them ZNE. One of our biggest problems is we don't have a lot of building automation systems. We have a lot of old energy, you know old boilers, bulbs, plants and no building automation system to actually you know optimize operations.*

Nearly all of the case study buildings undertook significant efforts to reduce the use of centralized HVAC systems that

push air through duct work to various parts of a building. Most focused on more localized distribution of cooling with low velocity (VSD) fans. The use of localized cooling may be difficult, if not impossible, in state buildings that currently have large, centralized systems or physical barriers (e.g., HVAC and/or electrical conduits encased in asbestos, space constraints, occupancy issues, etc.) that stand in the way of major changes.

All the case study buildings attempt, in some fashion, to use automated control systems[58] that communicate with one another. Many state buildings are antiquated and lack building control systems. Furthermore, installing such systems in the wake of other physical obstacles — such as antiquated wiring and asbestos — can be cost prohibitive.

Overall, due to lack of direct experience, state departments had a very limited amount to say about technological barriers to ZNE although some suggests the wireless controls, mini-split or chilled beams to replace failed ducts, and other solutions exist that help address at least some of these issues.

> *Even with the most energy-efficient design features, there are a number of reasons why some individual buildings will be unable to reach ZNE performance levels…. These primarily involve a lack of access to renewable energy sources in one way or another. For example, practical restrictions such as the size and footprint of the building, the inability to provide enough physical space for on-site renewable energy systems, the lack of solar access at the site, or some combination of these — such as might happen in an urban environment — are all potential barriers to ZNE performance.*

Characteristics of Existing State-owned Buildings

Existing state-owned buildings do not often share many of the common ZNE building characteristics. As such, making wholesale changes to a building's design to reach the efficiency required may be cost prohibitive, or simply not technically feasible. Further, if reaching a target EUI is not feasible, given the buildings location or site footprint, generating enough renewable energy to off-set the building's usage may also not be feasible. At some larger properties, such as those occupied by CDCR or Cal Expo, there may be opportunity for substantial on-site renewable generation that would be able to offset some buildings' usage after addressing all cost-effective energy efficiency opportunities. However, this is not the case for the vast majority of state-owned properties. While most state departments expressed concerns — given age, condition, occupancy, etc. — around significantly increasing the energy efficiency of many buildings, there was strong agreement that reaching ZNE is not realistic given the characteristics of a good share of the existing building stock. The quote above, from the case studies and pertinent to primarily privately owned buildings, captures a good deal of the over-riding sentiments expressed by state department decision makers around the prospects of reaching the 50% of existing square footage within state-owned building to ZNE by 2025.[59] However, it is important to note that the amount of detailed information available pertaining to individual state-owned buildings is extremely limited—making it difficult to assess whether or not an optimistic or pessimistic view of ZNE goal attainment is appropriate. There is a great deal of information that would be needed on individual state-owned buildings

[58] This includes, but is not limited to, HVAC, operable windows, ceiling fans, etc.
[59] Zero Net Energy Case Study Buildings *Volume 1*, page xii (September 2014). Written by Edward Dean, FAIA – Bernheim & Dean, Inc. Forward by Peter Turnbull, Principal, Commercial Buildings, Pacific Gas and Electric Company.

to objectively assess a building's overall condition, suitability for energy efficiency improvements, suitability for solar PV, and prospects for ZNE attainment. At this point, the most accurate information on a given building is the EUI. However, existing EUI does not provide any real information as to the prospects of cost-effectively lowering it further nor does it provide any information on whether or not solar PV can provide a suitable offset.

5.2.4 External Issues

Finally, in the few instances where departments have installed all the elements needed to achieve ZNE for a given building (either through retrofit, which has been rare, or new construction), there are a set of largely external issues — in particular, connecting to the electric utility grid — that pose a final set of challenges.

> *And we [the utility] have other restraints that are very specific. So each customer's electrical interconnection is reviewed and approved by our engineering staff and they are looking for the probability of back feeding and the safety around back feeding during over generation periods [when the building is producing more electricity than it needs]. That can be quite a costly endeavor if customers have to pay for infrastructure upgrades as a result of that design review.*

Under the jurisdiction of the CPUC, interconnection rules (or standards) are the requirements a customer must meet when connecting solar and other forms of electrical generation to the utility electrical grid. Interconnection to the utility grid presents significant barriers to ZNE efforts within state buildings for a multitude of reasons.

In 1999, the CPUC issued Rule 21 which outlined the screening process to be followed toward the goal of making the interconnection review process more efficient for small, low-impact generation. As part of Rule 21, a 15% threshold was established to identify situations where the amount of distributed generation (e.g., PV) on a line section exceeds 15% of the line section annual peak load. Distributed generation (DG) levels higher than 15% of peak load trigger the need for supplemental studies[60] to determine if additional PV can be added or if utility distribution system enhancements are needed.

> *The paces that they're being put through by the PUC and the utilities themselves it's a time problem and it's a cost problem. Some of them are in the hundreds and hundreds of thousands of dollars to make changes on the utility side of the meter that they say are necessary in order to receive our power.*

The cost of first studying and then upgrading a utility's distribution system can be substantial. Depending on the size of the renewable generation system and the local utility infrastructure, costs can range from several thousand dollars to hundreds of thousands of dollars. Improvements to the utility distribution system are primarily paid for by the entity (i.e., the state department) requesting permission to connect to the grid.

[60] The 15% threshold is based on a rationale that unintentional islanding, voltage deviations, back feeding and other potentially negative impacts are negligible if the combined DG generation on a line section is always less than the minimum load.

Interconnection agreements can be difficult to execute and take a significant amount of time to get in place. In addition to the legal agreement itself, the utility distribution system (e.g., distribution lines, substations, transformers, etc.) may not be able to accommodate — due to age, size, configuration — customer owned renewables without significant upgrades. Such upgrades can take a significant amount of time to plan, contract for, and execute — resulting in significant delays in reaching ZNE. Additional delays are incurred because of the utility review, approval, and inspection process.

> *They [the utility] didn't want us over-producing. The good news, I guess, what's worked out is we are also putting electric vehicle charging stations at all of our buildings, and that provides a cushion, because the way the state decided to measure ZNE was the building proper without the charging stations. So that sort of gives us a contingency… we don't have charging stations included in the measurement of ZNE.*

For IOUs, current Net Energy Metering (NEM) tariffs limit renewable generated power to 1 MW per meter for nonresidential premises[61]. This limits the size of the renewable system (e.g., size of PV system) which, in turn, may compromise the building's ability to generate enough electricity to achieve ZNE. For example, part of CDT's mission requires the operations and maintenance of energy intensive data centers at their 154,250 sq. ft. building located on the out-skirts of Sacramento. CDT has installed a 1 MW capacity PV system on-site, which only off-sets up to 12% of their energy usage. Due to renewable generation limits, along with limited space on-site, CDT is now working with DGS and SMUD to find alternative options to renewable generation which may include purchasing "green power" directly from SMUD. While some larger departments have worked with utilities to circumvent this issues, such limits on the size of on-site renewable generation present substantial barriers to meeting the traditional definition of ZNE — that is, generating renewable energy on-site — and force certain departments to find alternative options to make progress towards ZNE goals.

> *Some of the things that we typically end up having problems with are the legalese in the interconnection agreements for like indemnification and such language. DGS's attorneys have said that they will not allow that kind of verbiage in contracts with the state, so that could be a big hurdle that so far we have been solving on a project by project basis.*

[61] SMUD staff indicated that 3 MW is their interconnection maximum.

Interconnection agreements contain indemnification language. The State of California (through DGS) has a conflict with the typical IOU language in this regard as departments are not able to indemnify and hold harmless (as state institutions) an IOU — or any other entity for that matter. In addition, state departments (often through DGS) are nearly always stipulating contract language and have little experience with and are often barred from signing legal agreements that are principally created by another entity (e.g., an IOU). Due to these legal challenges, departments typically pursue solar through PPAs because the PPA (as a private entity) can instead sign such agreements. While there have been instances of a state department owning the PV system, the legal wrangling and ultimate agreements have been characterized by state departments as largely an appeasement to utility requirements. Those familiar with these situations, often state that the resulting agreement is "no template" for other state buildings.

> *The challenge of dealing with the PUC and the utility providers. This is not their business model… It seems like they don't really want to help facilitate departments and other entities you know doing this solar on their own. They certainly don't seem to be supportive of any ZNE stuff. The fact that we've struggled so mightily even with expertise that we hired suggests to me that smaller departments are never going to get to the point that we've gotten to [installing PV] and it's unfortunate.*

Highly associated with indemnification, interconnection agreements typically stipulate that only a single entity — in addition to the IOU — can be party to an interconnection agreement. The one entity restriction is for liability purposes as it establishes one clear party to hold the liability associated with the solar installation. This can be an issue when one entity (e.g., a solar energy provider under a PPA) may not be able to, or want to, take on the entire liability or where more than one PPA is desirable.

Some state department staff that have worked on ZNE projects don't perceive the IOUs to be particularly interested in making the interconnection process easy. One utility representative also indicated that his/her company was struggling with how to approach ZNE (and interconnection) and to what degree they want to invest in programs and efforts to help promote it.

5.3 Phase 3: Execution

The Execution phase addresses the actual implementation of energy efficiency and renewable energy projects within specific buildings. In the case of retrofit efforts, the implementation of energy efficiency improvements may occur over the course of many years. Additionally, ZNE retrofit projects take longer to execute because the construction required is generally extensive and may require disrupting normal building operations or displacing department staff. Further, given the age and condition of some state-owned buildings, issues may arise during a retrofit project that could add cost and delays to the project's timeline. Regardless of the type of ZNE project (retrofit vs. new construction), it is critical to consider final Measurement and Verification (M&V) needs at this phase and add the metering or other M&V infrastructure required to monitor system performance upon occupancy.

> *And a lot of our facilities too when we start doing these type of changes with wiring, plumbing, replacing old galvanized piping, putting in insulation, a lot of our facilities have lead paint and asbestos, so any time we start opening the walls up… now we have to have a hazardous contractor do the work, because it's all lead paint and asbestos.*

Key to the Execution Phase is understanding occupancy patterns (and needs) and the departments mission and to take both into consideration during the scheduling process.

5.3.1 Occupancy

A clear theme from the interviews with state department decision makers is that state buildings — with few exceptions — will need to be occupied during the ZNE renovation process. A careful analysis of existing ZNE buildings suggest that this is a major barrier to lowering building energy use and, in the process, minimizing the amount of installed solar PV. Our review of ZNE retrofitted buildings indicates that nearly all were unoccupied throughout the retrofit process and all measures were installed during that process. Related to this, most involved significant structural changes to the building that could not be achieved within an occupied building — particularly to accommodate natural ventilation, natural lighting (e.g., skylights), and support roof mounted PV.

It is noteworthy that the majority of departments interviewed did not comment on building occupancy as a potential barrier to ZNE retrofits. This may be due to the fact that many of the departments have yet to seriously contemplate and then complete a ZNE retrofit, nor are they far enough along in the planning phase to consider execution-phase barriers.

5.3.2 Department Mission

When completing building retrofits, departments will have to consider how to prevent the retrofit process from interfering with the department's mission and current operations. A respondent from one department states that their previous retrofit projects were constrained because they were required to keep the buildings occupied in order to serve the public. For some departments, projects may need to be executed exclusively at night, which may add to the overall cost. For most departments, it may be cost prohibitive to even considering moving staff, vital operations, and associated equipment to a temporary location (even if that temporary location is in the same building).

Multiple state departments are focused on sustainability, and have staff that are dedicated to sustainability initiatives, so the ZNE initiative closely matches the mission of the department. One respondent at a sustainability-focused department described that they have utilized and experienced a top-down approach to sustainability and that the ZNE goals are helpful for them to achieve their department mission, stating that "We really believe in conservation and protection of the natural environment. So, we're philosophically very bound to that, as well as mission-related to it. So, sure, anything that helps give us additional impetus, additional nudges to do the right things in that arena are useful, I think."

Most departments that have had successful experiences with building retrofits stated that the retrofit improvements were incremental and, in some cases, the interior spaces of the building were only slightly modified. Another strategy mentioned by respondents is that they plan to complete the retrofit over a longer period of time and move the building occupants around the building as one section is completed at a time. One respondent said that retrofit activities at their department's building took place over a long period of time and that "our buildings are occupied and they will need to remain occupied while we convert them to ZNE." Some departments have completed interior lighting retrofit projects without affecting employees — working around occupants where possible and when retrofits are unobtrusive.

> *The staff that work here never knew that we were probably even doing this [ZNE retrofit] with exception of changing all of the lamps, the lighting. We put out a note and we notified staff that we were going to be retrofitting all of the lighting in the interior of the building to LED lamps. And so we went through their space you know one space at a time and we changed over 6,000 lamps and that was a matter of three months . . . with exception to the lighting there has been zero disruption to the campus occupants.*

The types of measures used in the retrofit process also influence the retrofit timeframe. According to most respondents, they have had to—during the bidding process—require that all retrofit projects be worked on during off-hours or weekends, which resulted in higher retrofit costs.

5.4 Phase 4: Monitoring & Verification

The final phase (on the road to ZNE) is to monitor and ultimately verify that the building does, in fact, achieve zero-net-energy. Actual performance of building and renewable systems can differ substantially from modeled performance, so M&V is critical to ensure that building systems are operating as intended and controls are calibrated accordingly. Additionally, M&V is required to measure renewable generation capacity and identify underperformance. Given the range of factors that may affect building performance — occupancy behavior, weather, number of occupants, type of building usage to name a few — models cannot predict load with full accuracy. Therefore, building managers must constantly measure and monitor building performance and renewable energy production, toward the goal of proving net zero energy over one full year. ZNE building managers have said the post-construction commissioning period can last from one to three years to fully optimize building performance.

> *I've talked to some [ZNE building modelers] over the last couple of years. Amazingly, very few of them have ever in their life gone back and looked at how did their model compare with reality, and that's what we're doing. We're actually looking at the exact — I'm making them give us the model that we should anticipate, and that way we can look at are we deviating, are we tracking with the model or what.*

As only eight departments have either completed, or have plans to complete a ZNE building, the majority of departments that manage state-owned buildings have not yet made it to this phase. Key to the M&V process is training and educating the workforce (i.e., building occupants), managing plug loads, and constantly evaluating and harmonizing various controls and subsystems. It should, however, be noted that monitoring and ensuring maximum solar PV output is vastly simplified through PPAs because the 3rd party (i.e., the PPA)

has an economic interest in ensuring maximum uptime and power production. This is much harder to achieve when state departments own the equipment and monitory the output themselves.

5.4.1 Workforce Education & Training

A potential barrier to achieving ZNE status is the fact that all buildings have occupants, particularly building operators that need to be highly aware of the building's ZNE objective and are motivated to achieve, maintain, and perhaps enhance that status. Many ZNE buildings incorporate natural ventilation and elements of natural lighting and it is important for occupants to understand how the natural ventilation system works and how it complements mechanical ventilation systems. In particular, occupants need to be motivated to ensure that natural ventilation is used properly, whenever possible, and that mechanical ventilation is used as a last resort.

Buildings designed to meet ZNE specifications can only do so if they maintain energy usage patterns that are consistent with those modeled during the planning phase. As such, building control systems, passive cooling strategies, and other design features that are key to achieving ZNE status must be closely monitored and maintained throughout the buildings' useful life. Additionally, renewable systems must be monitored to ensure they are producing capacity that consistently off sets the buildings energy usage. Particularly as ZNE is a relatively nascent concept, building owners and operators need to be knowledgeable on these topics — such as, monitoring building energy usage; renewable systems operation and maintenance; natural ventilation strategies; occupant behavior, including plug load management; among other areas. It would appear that a sizeable investment in training will be needed to ensure that staff have the skills need to use building controls and monitor performance.

> *In January of 2016 one of our three inverters was down at Santa Fe Springs, and we didn't realize it for a few weeks…We finally said, "Okay. Something's got to be wrong. Our production numbers are way too low." Went down and found out we had not been getting energy. One of the inverters was having a problem, and it wasn't producing at all. That's probably a gap between the design folks and the building operator. The design folks aren't always thinking about the reality of operating it and measuring it.*

5.4.2 Managing Plug Loads

The impact of plug loads is very difficult to model during the ZNE retrofit planning phase. As such, managing plug loads is an important aspect of achieving and maintaining ZNE status. Again, occupant education is key to the process in order to ensure that equipment is not left turned on during periods of non-use or non-occupancy and that the ancillary equipment (such as printers, fax machines, etc.) are minimized. Given the proliferation of plug load devices (e.g., cell phones, ipads, etc.) it is important to understand how changes in technology and their related-use are impacting building energy consumption as such changes can threaten a given building's ZNE status.

5.4.3 Modeled vs. Actual Energy Use

As discussed during the Planning Phase, building energy management systems are an extremely important design feature in ZNE buildings. Many state buildings reportedly do not have automated controls or have antiquated control systems.

> *The biggest challenge other agencies, I think, will have, they'll be able to build it [to ZNE], but if they don't keep an eye [on energy use of various systems and PV production], it could be for naught.*

Additionally, predictive models are commonly used to estimate, prior to construction or renovation, newly constructed or retrofit ZNE building energy use. The accuracy of predictive modeling is vitally important because it is central to sizing the solar PV system — typically the most expensive aspect of getting to ZNE. In many ZNE buildings, predicted or targeted energy use (through modeling) and actual post-construction or post-retrofit energy usage do not match. Thus, given the challenges that arise, building operational (and occupant) training and commissioning may need to play a role—possibly extending the verification phase well beyond the initial 12 months following a retrofit. While occupant and owner staff will likely fulfill many of these post occupancy functions, the architectural and engineering design team will likely need to be consulted as the actual energy usage is brought into alignment with the modeled energy use and target. Commissioning agent services may also be required to periodically ascertain performance and adjust various systems.

6. Progress toward Source EUI Targets and ZNE Readiness Ranking

We characterized state-owned properties, and the buildings within them, in Section 1. This section takes the characterization further by presenting the results of an analysis to determine the status of various property use types and departments with respect to energy efficiency (i.e., a key aspect of the road to ZNE). Specifically, we illustrate the extent to which state-owned properties are meeting the Source EUI targets established by DGS. We then turn our attention to ranking state-owned properties in terms of ZNE readiness — that is, which properties to pursue first, second, third, etc. Finally, we conclude the section with a discussion of additional data that, if collected by state departments, could contribute to a more effective future ranking exercise.

6.1 Progress toward DGS Target EUI

The information presented in this section is largely based on an extensive review of Energy Star Portfolio Manager (ESPM) data collected by state departments and overseen by DGS. In February of this year (2017), DGS issued a set of energy efficiency targets for existing state buildings to pursue on their path to ZNE. The efficiency targets (expressed as Source EUI) represent the top quartile of energy efficiency.[62] Table 6-1 provides the DGS Source EUI targets by property use type. We present the average California EUI targets for each property use type, although specific Source EUI targets have been set by property use type and climate zone. We provide these additional (by climate zone) Source EUI targets in Appendix B. The executive order's specific wording states that "By 2025, state departments ***should take measures toward achieving*** ZNE for

[62] DGS indicates that the targets are based on three primary sources: 1) historic 2015 state building energy use as recorded in Energy Star Portfolio Manager (ESPM); 2) the California Commercial End-Use Survey (CEUS); and 3) ASHRAE Standard 100 Data. DGS provides, for a given property use type, the statewide (or California average) target EUI as well as target EUI's for each climate zone. Based on its property use type and climate zone, each property with ESPM was compared to its corresponding DGS established EUI Target.

50% of all existing state-owned building square footage." Given this wording, it is unclear as to when 50% of state-owned building square footage should reach these EUI targets and, presumably subsequent to that, when they will then need to reach ZNE. It is also unclear if these targets are simply advisory or binding in some way. We tried to clarify these issues with DGS but were unsuccessful in our attempts to gain their insight into these issues.

The property use types presented in Table 6-1 (and Appendix B) and in this section correspond to ESPM property use types as reconfigured by DGS as part of establishing source EUI targets. For example, DGS separated Offices into various subcategories based on their size and department. In some cases, we were unable to definitively match state-owned properties tracked in ESPM to the DGS established property use types. For the purposes of this analysis, we have grouped these into the "Other"[63] category in the tables and figures included in this section. Additionally, there are a number of properties (amounting to roughly 5.2 million square feet) tracked through ESPM that either have no usage information, or information appears to be inaccurate, resulting in either no source EUI or a source EUI of zero. As such, we did not measure either properties included in the "Other" category or those with no source EUI information against the source EUI targets provided as Appendix B.

Table 6-1. California Average Source EUI Targets—Established by DGS

State Building Type	Average Source EUI Target
Adult Education - CCC	54
College/University	142
Data Center	100
Fire Station - CALFIRE	65
K-12 School	85
Laboratory	261
Library	114
Mixed Use Property (CALFIRE)	49
Multi-family Housing	133
Non-Refrig. Warehouse	37
Office - Average All Types	81
Office - Large >50K sq. ft.	106
Office - Small <50K sq. ft. - CHP	201
Office - Small <50K sq. ft. - CMD	30
Office - Small <50K sq. ft. - DMV	162

[63] These properties include: *Other-Maintenance DOT/DWR, Other-Caltrans TMC, Other-CDFA, Other CDFW ecolog. Reserve, Other-CDFW fish hatchery, Other-CDFW wildlife area, Other-DPR park structures, and Other-HCD migrant centers*.

State Building Type	Average Source EUI Target
Office - Small <50K sq. ft. - EDD	132
Office - Small <50K sq. ft. - Others	114
Other - Maintenance DOT/DWR	71
Other - Caltrans TMC	567
Other - CDFA	249
Other - CDFW ecolog. reserve	22
Other - CDFW fish hatchery	118
Other - CDFW wildlife area	55
Other - DPR park structures	27
Other - HCD migrant centers	30
Other - Education	54
Other - Entertainment public	17
Other - Lodging/Residential	189
Other - Specialty Hospital (DSH)	426
Outpatient Rehab/Phys - (DSH)	113
Prison/Incarceration - CDCR	187
Residence Hall/dorm - CALFIRE	112
Senior Care Facility – CalVet	161

We compare various state properties to these targets in the series of tables and figures that follow. It is important to note that our determination of whether or not a property was at or below the Source EUI target was based on the property specific climate zone (since EUI targets vary by climate zone). Table 6-2 lists the various property use types by total square footage[64], with prison/incarceration and large offices as the dominant property use types from an overall square footage perspective. For each property use type, we provide the percentage of square footage that is at or below the EUI target and above the EUI target. We see, for example, that 36% of prison/incarceration square footage (just under 16 million square feet) is below the DGS established Source EUI target for that property use type. This percentage drops to just 16% for Large Offices (>50K sq.ft.), the next largest property use type in terms of square footage. Overall, across all the property use types included in Table 6-2, 27% of the 78,451,780 square feet represented (about 21.5 million square feet) is currently below the EUI Target set by DGS.

[64] We list by square footage as the Governor's Executive Order focuses on an aspirational goal of 50% of building square footage moving toward ZNE.

Table 6-2. Property Use Type Square Footage Over and Under DGS Source EUI Target

Property Use Type	Total Square Footage	Source EUI Target*	Under Source EUI Target		Over Source EUI Target	
			Square Footage	Percent of Square Footage	Square Footage	Percent of Square Footage
Prison/Incarceration	43,400,497	187	15,694,580	36%	27,705,917	64%
Office - Large >50K sq. ft.	20,662,823	106	3,329,251	16%	17,333,572	84%
Outpatient Rehabilitation/Physical Therapy	2,676,044	113	0	0%	2,676,044	100%
Senior Care Community	2,404,386	161	0	0%	2,404,386	100%
Office - Small <50K sq. ft. - CMD	1,505,083	30	298,101	20%	1,206,982	80%
Mixed Use Property	1,413,265	49	192,832	14%	1,220,433	86%
Fire Station	1,390,577	65	461,813	33%	928,764	67%
Office - Small <50K sq. ft. - DMV	961,126	162	270,019	28%	691,107	72%
Office - Small <50K sq. ft. - CHP	861,084	201	369,431	43%	491,653	57%
Office - Small <50K sq. ft. - Others	658,470	114	359,498	55%	298,972	45%
Office - Small <50K sq. ft. - EDD	449,045	132	92,717	21%	356,328	79%
Other - Entertainment/Public Assembly	444,132	17	14,852	3%	429,280	97%
Non-Refrigerated Warehouse	384,684	37	121,212	32%	263,472	68%
Laboratory	340,729	261	33,447	10%	307,282	90%
Library	303,569	114	188,569	62%	115,000	38%
College/University	262,756	142	0	0%	262,756	100%
Other - Education	139,253	54	0	0%	139,253	100%
Adult Education	47,013	54	0	0%	47,013	100%
K-12 School	61,631	85	0	0%	61,631	100%
Data Center	43,800	100	0	0%	43,800	100%
Residence Hall/Dormitory	27,308	112	27,308	100%	0	0%
Other - Lodging/Residential	14,505	189	14,505	100%	0	0%
Sub-Total	***78,451,780***		***21,468,135***	***27%***	***56,983,645***	***73%***
Other	***23,464,961***			—		—
Grand Total	***101,916,741***			—		—

Note: Square footage totals do not include properties with no usage information (roughly 5.2 million square feet) from all property use types.

* Source EUI targets are the California average for each property use type. Individual buildings were measured against the source EUI target for each property use type and the climate zone where it is located.

Figure 6-1 is a graphical representation of Table 6-2 and provides the number and percentage of square footage for a given property use type that is above the source EUI targets established by DGS. Perhaps most notable in Figure 6-1 is the fact that nearly all of the light blue dots (representing the percentage of square footage for a given property use type that is above the EUI target) are around 70% or higher. The table also illustrates, for example, that Prisons/Incarceration has almost 28 million square feet of buildings that do not

meet the established source EUI targets (representing about 64% of the square footage within that property use type). At the same time, it highlights the importance of Prisons/Incarceration and Large Offices (>50K square feet) in meeting the Governor's mandate to make progress toward ZNE for 50% of state-owned property square footage. Making progress without these two property use types will be impossible as together they represent 63% of the total square footage owned by the state. However, it is important to note that these two property use types should not be focused on to the point of excluding others. For example, warehouses, small offices, fire stations, and other property use types can make an important contribution to overall goal attainment.

Figure 6-1. Square Footage above DGS Source EUI Target by Property Use Type

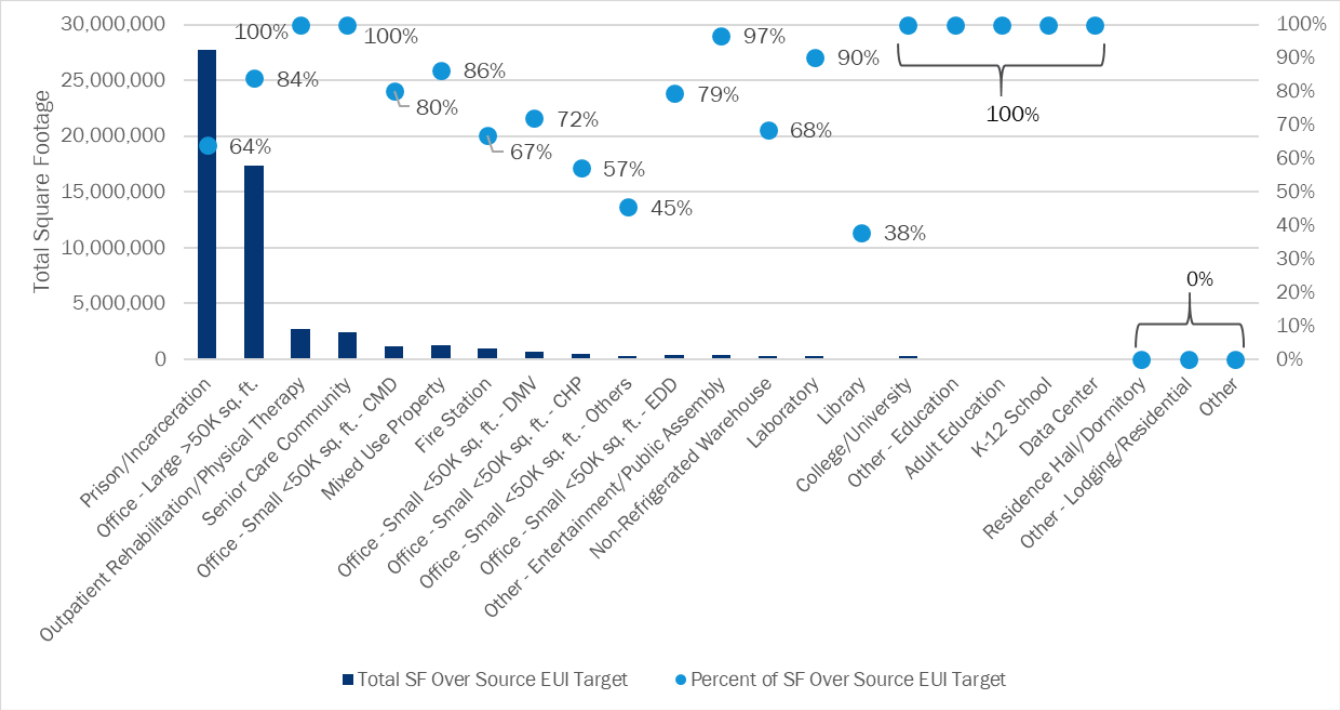


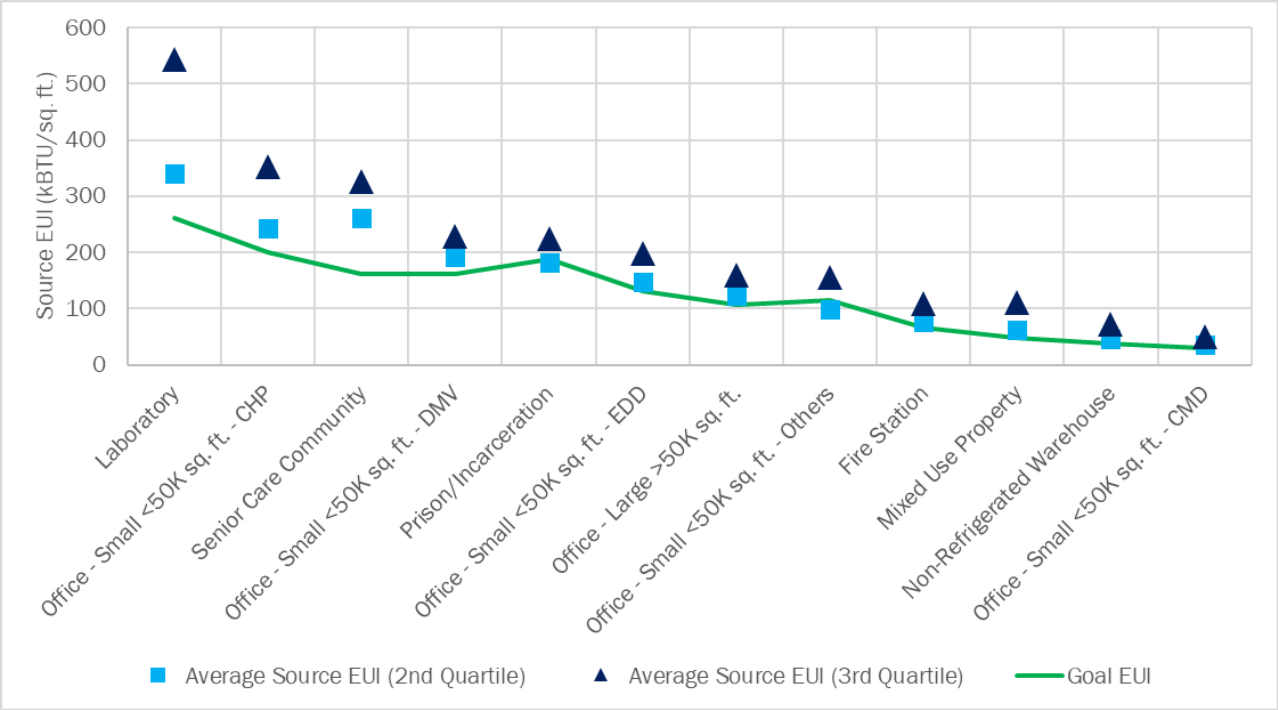
Table 6-3 provides more detailed information on where buildings that do not currently meet the EUI target for their respective property use type sit in relation to that target. As detailed in Table 6-2, about 57 million of existing state-owned building square footage does not meet the EUI target for its corresponding property use type. However, Table 6-3 illustrates that about 34% of this square footage (19,532,548 square feet) is within 25% of the target and another 24% (13,457,554 square feet) is within 50% of the target. Combined with the 21,468,135 square feet already at or below the target, the prospects for getting 50% of state-owned building square footage to the EUI target and then to ZNE would appear to be achievable if funding and other barriers could be addressed. That said, we state this with one very important caveat: It is in unclear to us—and we were unable to confirm with key DGS staff—whether or not the EUI targets were set at a level whereby their achievement (by a given building) would translate to the ability to meet the remaining energy needs of a given building through renewables. In other words, we can't state with any confidence whether or not the targets represent aggressive enough EUI thresholds to consider a building ready for renewables (on the road to ZNE). It may be, for example, that further energy efficiency improvements should be (could be) made to these buildings before renewables become the most cost-effective option.

Table 6-3. Property Use Type Square Footage Over Source EUI Target—Proximity to Target

Property Use Type	Total Square Footage Over Source EUI Target	Within 25% of Target		Within 25 - 50% of Target		Within 50 - 75% of Target		Within 75 - 100% of Target		Over 100% of Target	
		Square Footage	Percent of Square Footage	Square Footage	Percent of Square Footage	Square Footage	Percent of Square Footage	Square Footage	Percent of Square Footage	Square Footage	Percent of Square Footage
Prison/Incarceration	27,705,917	14,035,962	51%	6,604,427	24%	794,994	3%	2,574,868	9%	3,695,666	13%
Office - Large >50K sq. ft.	17,333,572	3,842,856	22%	5,504,818	32%	4,923,670	28%	1,394,259	8%	1,667,969	10%
Outpatient Rehabilitation/Physical Therapy	2,676,044	0	0%	0	0%	1,150,512	43%	1,525,532	57%	0	0%
Senior Care Community	2,404,386	291,484	12%	207,548	9%	376,808	16%	1,063,107	44%	465,439	19%
Mixed Use Property	1,220,433	28,769	2%	38,655	3%	17,132	1%	25,786	2%	1,110,091	91%
Office - Small <50K sq. ft. - CMD	1,206,982	240,449	20%	293,654	24%	127,010	11%	229,609	19%	316,260	26%
Fire Station	928,764	193,099	21%	122,004	13%	156,707	17%	128,853	14%	328,101	35%
Office - Small <50K sq. ft. - DMV	691,107	149,719	22%	194,250	28%	136,482	20%	99,896	14%	110,760	16%
Office - Small <50K sq. ft. - CHP	491,653	139,442	28%	114,216	23%	72,289	15%	27,297	6%	138,409	28%
Other - Entertainment/Public Assembly	429,280	0	0%	0	0%	0	0%	0	0%	429,280	100%
Office - Small <50K sq. ft. - EDD	356,328	121,485	34%	27,734	8%	82,320	23%	72,463	20%	52,326	15%
Laboratory	307,282	0	0%	38,477	13%	89,804	29%	0	0%	179,001	58%
Office - Small <50K sq. ft. - Others	298,972	8,969	3%	115,110	39%	44,552	15%	32,300	11%	98,041	33%
Non-Refrigerated Warehouse	263,472	102,558	39%	57,408	22%	30,893	12%	21,200	8%	51,413	20%
College/University	262,756	262,756	100%	0	0%	0	0%	0	0%	0	0%
Other - Education	139,253	0	0%	139,253	100%	0	0%	0	0%	0	0%
Library	115,000	115,000	100%	0	0%	0	0%	0	0%	0	0%
K-12 School	61,631	0	0%	0	0%	0	0%	61,631	100%	0	0%
Adult Education	47,013	0	0%	0	0%	0	0%	0	0%	47,013	100%
Data Center	43,800	0	0%	0	0%	0	0%	0	0%	43,800	100%
Sub Total Over Source EUI Target	**56,983,645**	**19,532,548**	**34%**	**13,457,554**	**24%**	**8,003,173**	**14%**	**7,256,801**	**13%**	**8,733,569**	**15%**

Figure 6-2 provides another perspective on the challenge of meeting the source EUI targets set by DGS. Within the figure, we list the average source EUI for properties that fall within the second quartile (average 2nd quartile EUI) and third quartile (average 3rd quartile EUI) for various property use types. For several property use types, there were not enough individual properties associated to break into quartiles for this analysis. Several properties falling into the 1st and 4th quartile have abnormally low or high source EUIs. As such, we use the average source EUIs for the 2nd and 3rd quartiles below to illustrate, at a high level, how different property use types fare with respect to the source EUI targets set by DGS (the green line below). As illustrated in the figure, on average, many properties within the 2nd and 3rd quartiles are probably not all that far from the source EUI targets, while reaching those targets for other specific property types — that is, laboratories and some large office buildings with particularly high usage — may be more challenging

Figure 6-2. Average Source EUI by Property Use Type—Comparison to DGS Source EUI Targets



Note: Property use types not included in this figure did not have enough individual properties to break into quartiles.

Finally, Table 6-4 illustrates the current status of the square footage occupied by the 5 key departments identified in Section 1, with regard to the DGS established source EUI targets. Additionally, the table shows the square footage within the different property use types associated with each department that is over or under the source EUI targets. We conducted this analysis at the property level, by assigning the source EUI target corresponding with each's property use type and climate zone. As with the other tables and figures in this section, these totals do not include properties with no usage information, and properties that we were unable to definitively match to a specific property use type created by DGS are included in the "Other" rows and are not measured against a source EUI target.

As outlined in Section 1, the five departments included in Table 6-4 below account for roughly 75% of all of the square footage owned by the state. Additionally, within these 5 departments, over 17% of the total state-owned square footage already meets or exceeds the source EUI targets set by DGS. It is important to note that several different property use types appear to have more difficulty meeting the source EUI targets, such as large office buildings. However, concentrated efforts to address the largest properties within these 5

departments, while continuing to aggressively pursue on-site renewable generation where possible will make substantial progress towards the aggressive ZNE goals set forth in EO B-18-12.

Table 6-4. Key Departments and Property Use Types Under and Over Source UI Targets

Department and Property Use Type	Total Square Footage	Under Source EUI Target		Over Source EUI Target	
		Square Footage	Percent of Square Footage	Square Footage	Percent of Square Footage
CDCR	**43,400,497**	**15,694,580**	**36%**	**27,705,917**	**64%**
Prison/Incarceration	*44,409,137*	*16,703,220*		*27,705,917*	
DGS	**16,200,686**	**2,889,120**	**18%**	**11,957,791**	**74%**
Office - Large >50K sq. ft.	*14,242,382*	*2,506,300*		*11,736,082*	
Library	*303,569*	*188,569*		*115,000*	
Office - Small <50K sq. ft. - Others	*170,148*	*73,039*		*97,109*	
Non-Refrigerated Warehouse	*121,212*	*121,212*			
Data Center	*9,600*			*9,600*	
Other	*1,353,775*	---		---	
Caltrans	**6,537,170**	**17,581**	**0%**	**2,781,751**	**43%**
Office - Large >50K sq. ft.	*2,642,017*			*2,642,017*	
Non-Refrigerated Warehouse	*102,558*			*102,558*	
Data Center	*34,200*			*34,200*	
Office - Small <50K sq. ft. - Others	*11,307*	*8,831*		*2,476*	
Laboratory	*9,250*	*8,750*		*500*	
Other	*3,737,838*	---		---	
DSH	**6,414,664**	**0**	**0%**	**2,676,044**	**42%**
Outpatient Rehabilitation/Physical Therapy	*2,676,044*			*2,676,044*	
Other	*3,738,620*	---		---	
DPR	**5,625,100**	**66,118**	**1%**	**4,452**	**0.079%**
Mixed Use Property	*53,111*	*53,111*			
Office - Small <50K sq. ft. - Others	*17,459*	*13,007*		*4,452*	
Other	*5,554,530*	---		---	

Note: Square footage totals for each department and property use type do not include properties with no usage information.

6.2 Property Ranking Exercise

In this subsection, we provide an initial ranking of what we consider to be strong ZNE candidate properties (and associated buildings), based on what we presently know about them. We base this ranking exercise primarily on high level energy usage information, DGS's expanded property use types, and property size

(square footage). As we have described in Section 1, and elsewhere in this report, we used these data (tracked through ESPM) to identify departments that occupy the majority of state-owned square footage (described as "key departments"). Additionally, we have compared source EUIs[65], where possible, against DGS's source EUI targets, which vary based on the associated properties climate zone (see Appendix B). It is important to note, as described in Section 5, that there are a variety of other factors that are crucial when considering a property's "readiness" for ZNE. As such, in this section we outline several other pieces of data that we recommend are captured for each property for similar property ranking exercises in the future. Further, as each property and building are unique and face different circumstances, we stress the importance of deferring to department decision makers when truly assessing if specific properties are good candidates for ZNE. We intend this ranking to be a guide for decision makers looking for direction on which properties to consider first, which might have the largest impact when considering the goal of reaching ZNE status for 50% of the states existing building square footage.

It is important to note at the outset that the identification of properties that may be good candidates for ZNE retrofits is unlikely to ever be a completely objective exercise. There will always be known attributes of a given building (e.g., known to facility management staff, agency decision makers, etc.) that either positively or negatively impact ZNE suitability. In the process of completing our interviews, for example, it became clear that many state agency decision makers have a clear understanding of the various buildings they manage and the potential obstacles to ZNE (e.g., poor building condition, historical designation, presence of asbestos, occupancy challenges, no opportunity to install PV on site, etc.). While the additional technical information outlined below will certainly improve the accuracy of future ranking exercises, it is unlikely to supplant key decision makers applying their own judgement to the process. In fact, through the interviewing process, it became clear that the judgement of agency decision makers is a very important component of the effort to reach current energy efficiency targets by 2018. We found, for example, that department decision makers balance the need to achieve energy efficiency with other building-related needs, such as health and safety or differed maintenance issues. Ultimately, decision makers select buildings for energy efficiency improvements based on a combination of objective data, including the retrofit's return on investment, and judgement as to which building issues should be addressed first. We expect decision makers to follow this same process when identifying buildings for ZNE retrofits — aided through improvements in ESPM data and the collection of additional property and building information.

Finally, we also note that EUI is undoubtedly a very important metric for establishing energy efficiency and ZNE goals. However, it is but one factor in the ZNE decision making process and likely of lesser importance when compared to the need to understand key department, property, and building level barriers (some of which can effectively prevent movement from low EUI buildings to ZNE buildings).

Our approach to ranking state-owned buildings for suitability and readiness to ZNE is principally driven by the Governors Executive Order that stated, as outlined in Section 2, that "by 2025, state departments should take

[65] Source EUI is defined in the Glossary of this report.

measures toward achieving ZNE for 50% of all existing state-owned building square footage." Taken one step further, this mandate would appear to imply that the ultimate goal (at some point beyond 2025) would be to actually reach ZNE verified status for 50% of state-owned square footage. Given this backdrop, we outline our ranking steps and criteria in Table 6-5 below.

The benefit of working within one department before moving to the next is many. First, overcoming the barriers to energy efficiency and ZNE within a given department should be less challenging than trying to overcome obstacles across 30+ departments simultaneously. Additionally, we address departments that are the largest (e.g., control/mange the most square footage) and, as discussed throughout this report, as they would appear to be key — given their size — to meeting the 50% of square footage target. Finally, a benefit of CDCR being ranked first is that adding solar PV to these properties (given the makeup and size of most prison/incarceration facilities) may be the easiest to meet (Note: this also meets a DGS priority of achieving ZNE within the building/property boundary).

Table 6-5. ZNE Readiness Ranking Steps and Criteria

Ranking Step	Ranking Criteria Description
1	Removed properties known to be ZNE, or in the process of becoming ZNE and those that have no usage information.
2	Selected those state-owned properties that meet, or are under, the source EUI target established by DGS (see Appendix B). For these properties, we then followed steps 3 -5.
3	Grouped properties by the department they fall within and then summed the square footage of all properties within each department.
4	Ranked departments from highest square footage to lowest. Thus, all properties within the departments with the higher overall square footage will be ranked before all properties within subsequent departments.
5	Within each department, we ranked properties from lowest EUI to highest EUI.
6	Selected those state-owned properties that have Source EUIs above the DGS targets and repeated steps 3 – 5. All of these properties are then ranked below all the properties that were selected in Step 2.
7	Took all properties that were not previously selected in step 2 or 6 (i.e., properties which could not be mapped to the DGS provided target EUIs) and repeated steps 3-5 again. All of these properties are then ranked below all the properties that were selected in Step 6. We are unable to determine if the properties in this grouping fall into it due to the fact that we could not create the DGS cross-walk from ESPM property use types to the modified property use types used by DGS to set targets or because DGS did not create a cross-walk for many property use types.

Note: There are 64 properties with ranked below all other properties with no usage information, or that have already achieve ZNE status.

The high level results of the ranking exercise are illustrated in Table 6-6. While we have ranked every single property (and provide this information in Appendix C), Table 6-6 illustrates which departments rose to the top given the underlying characteristics of their properties. At the very top of the ranking is CDCR properties (totaling 15,694,580 square feet) that are at or below the DGS established Source EUI target. While we just list the department (e.g., CDCR) in the table, the detailed appendices then list each of the specific CDCR properties — further ranked from lowest to highest EUI — that make up this 15,694,580 square feet. Next on the list, are DGS properties (totaling 2,889,120 square feet) that are at or below the DGS established Source EUI target, etc. In the end, every single property, across all departments, that are at or below the Source EUI target (i.e., are in the "At or Below Source EUI Target" Ranking Category) are ranked prior to moving to the second major "Ranking Category", which consists of properties that are "Over the Source EUI Target". Then, we follow the same process, outlined above for all properties falling into this second Ranking Category. We then followed the same process for all properties falling into the final Ranking Category (i.e., "Other-No Source EUI Target Available).

Table 6-6. Ranked Square Footage By Ranking Category and Department

Ranking Category	Department (Top Five listed)	Total Square Footage	Ranked Square Footage	Percent of Square Footage
	CDCR	46,351,263	15,694,580	34%
	DGS	16,200,686	2,889,120	18%
	CMD	2,745,053	915,899	33%
	CAL FIRE	2,038,062	678,607	33%
At or Below	CHP	1,123,840	369,431	33%
Source EUI Target	*All Other Departments*	*19,637,220*	*715,345*	
Total			*21,262,982*	
	CDCR	46,351,263	27,705,917	60%
	DGS	16,200,686	11,957,791	74%
	Caltrans	7,374,367	2,781,751	38%
	DSH	6,414,664	2,676,044	42%
Over Source EUI	CalVet	2,542,263	2,532,036	100%
Target	*All Other Departments*	*21,261,585*	*9,212,402*	
Total			*56,865,941*	
	DPR	6,169,271	5,554,530	90%
	DDS	4,181,548	4,088,749	98%
	DSH	6,414,664	3,738,620	58%
Other-No Source	Caltrans	7,374,367	3,737,838	51%
EUI Target	HCD	1,556,500	1,556,500	100%
Available	*All Other Departments*	*25,926,878*	*4,788,724*	
Total			*23,464,961*	
	*Total Square Footage Not Ranked **		*5,535,730*	
	Total State-owned Square Footage		***107,129,615***	

** The 5.5 million square feet un-ranked, represents 256 properties with no source EUI information. Additionally, 3 of the 26 properties have already reached ZNE status.*

6.2.1 Additional ZNE Raking Data Needs

There is a considerable amount of information that is needed to thoughtfully identify and rank good candidate state buildings for ZNE retrofit. ESPM, which includes over 100 variables ranging from a buildings' physical location (i.e., street address, city, zipcode) to its' historical energy consumption (e.g., electricity, natural gas, propane, etc.) is undoubtedly a key informational source. Given this, our objective in this subsection is not to rehash or highlight every variable currently available within ESPM. Rather, our objective is to suggest opportunities to both strengthen and expand the available data and we do this by 1) identifying a set of additional variables (not currently collected through ESPM) that would be helpful to a future ZNE ranking exercise; and 2) highlighting variables within ESPM that would appear to need attention in terms of the data collection process and data quality.

Additional Data Needs: A significant amount of very useful and important information is collected through ESPM at, whenever possible, an individual property level. This includes, but is not limited to, the overall square footage and EUI[66]. While EUI is an important metric in determining a buildings energy efficiency level (e.g., energy use per square foot) it does not, in and of itself, indicate the extent to which that EUI could be lowered nor does it provide any indication of whether or not the building can reach ZNE. As previously discussed, a property may have significant barriers (e.g., overall condition, asbestos, etc.) that effectively prevent any further cost-effective reduction of energy use (a lower EUI). Further, a low EUI does not provide information needed to judge whether or not site specific ZNE can be reached (e.g., adding enough PV to the building or property around it might not be possible).

Below, we identify several additional variables that we think would greatly enhance future ZNE ranking exercises. The variables represent the type of building and building site characteristics, based on our review of existing ZNE buildings that are important inputs to the level of energy efficiency that can be reached within a given building as well as the prospects for meeting ZNE through the placement of on-site solar PV. For example, natural ventilation and extensive use of daylighting are key characteristics of most ZNE buildings. Given this, it is important to know whether or not a given building can accommodate these measures. Similarly, understanding parking footprints and the greenspace around a building provides insight into the potential for adding solar PV. While we recognize that ESPM property data does not always represent a single building (it may represent multiple buildings), the ultimate goal would be to list each building in ESPM separately. This would appear to be possible for properties that are current mastered metered, such as CDCR[67]. This taken into consideration, we list variables that will provide more information about a given building (whenever possible), the area around it, and the prospects for on-site renewables.

Building Ownership: An indication if a given building is state- or privately-owned.

Department Ownership: The name of the department that owns a given building. We suggest this variable because, as we understand it, there are instances where DGS owns a building that they lease to another state agency.

Bond Financing Status: A "yes/no" indicating if a given building is bond financed.

Roof Warranty Status: A "yes/no" indicating if a given building has an existing roof warranty.

Roof Warranty Expiration Date: The date the roof warranting for a given building expires.

[66] A core function of ESPM is to collect detailed monthly building energy use data (e.g., kWh, therms, etc.) at a meter level and then aggregate that information to a building level. Annual energy use data is the central input to EUI, which is typically expressed in terms of btus per square foot, per year. ESPM has multiple functions, including—among other capabilities—the ability to compute EUI using a site or source definition.

[67] We state this because it is likely that there is a single energy feed to each building. Thus, over time, it should be possible—through either the installation of utility-style meters or an adaptation to circuits that record usage—to individually meter buildings within a campus or prison setting.

Historical Designation: A "yes/no" indicating if a given building is on the California Register of Historical Resources.

Building Orientation: A somewhat subjective measure (that could, perhaps, be expressed on a scale of 1 to 10) of how suitable a given building orientation is to taking advantage of (during the heating season) and mitigating the impacts of (during the cooling season) solar heat gain.

Natural Ventilation: A somewhat subjective measure (that could, perhaps, be expressed on a scale of 1 to 10) of how suitable a given building might be to the inclusion/retrofitting of natural ventilation.

Daylighting. A somewhat subjective measure (that could, perhaps, be expressed on a scale of 1 to 10) of how suitable a given building might be to the inclusion of natural daylighting.

Number of Floors: The number of floors for a given building.

Building Footprint: The area (expressed in square feet) of ground covered by a building.

Site Footprint: The square footage of the entire site (i.e., square footage of the building footprint + greenspace footprint + parking structure footprint)

Green Space Footprint: The area (expressed in square feet) of green space around a building.

Green Space support of PV: A "yes/no" indicating if the Green Space can support solar PV and, if so, the percentage of the green space footprint that could accommodate (without obstruction) PV production.

Parking Structure Footprint: The area (expressed in square feet) of ground covered by the parking structure.[68]

Parking Structure support of PV: A "yes/no" indicating if the parking structure can support solar PV (a canopy) and, if so, the percentage of the parking structure footprint that could accommodate (without obstruction) PV production.

Surface Parking Lot Footprint: The area (expressed in square feet) of the surface parking lot.

Surface Parking Lot support of PV: A "yes/no" indicating if the surface parking can accommodate solar PV (a canopy) and, if so, the percentage of the surface parking lot footprint that could accommodate (without obstruction) PV production.

[68] It is notable that ESPM does contain a variable that is intended to indicate if a parking structure is present on a given site and, if so, the associated square footage. However, the actual parking lot footprint (i.e., a footprint separate from the building) is more pertinent to ZNE. Additionally, information on the presence of a parking structure and/or is associated square footage is often not recorded correctly in ESPM.

ZNE Status: An indicator of current ZNE status (e.g., planned, in progress, complete but not verified, verified).

Above, we began this discussion by outlining the types of information that, based on our research, we believe would be a valuable addition to data currently collected through ESPM. As part of this process, we also highlight information (i.e., key variables) currently tracked within ESPM that need attention with respect to completeness and overall data quality.

<u>Variables currently available through ESPM (in need of quality improvements):</u> ESPM contains a wealth of information about state properties, their primary use type, and their associated energy use. Our review of ESPM[69], however, suggests that a thorough re-examination of the currently recorded key property characteristics is warranted. We found, for example, data quality issues with important variables for some properties, such as missing or questionable building square footage information[70]. Overall, these issues do not rise to the level of serious concern. However, they suggest that each department could/should review each of the buildings under their purview and ensure that all variables are filled out as accurately as possible.

State departments are routinely entering monthly energy use information (at a meter level) into ESPM. However, it is unclear how long it has been since key property characteristic data (e.g., square footage, connected meters, presence of a parking structure, etc.) has been systematically updated. Additionally, there are a number of property records within ESPM that contain information for multiple buildings. In instances where energy use information is not available at an individual building level, such as a prison or campus setting that is master metered, this is entirely reasonable. However, agencies should ensure — as part of a systematic review process — that the information housed in ESPM is at an individual building level whenever possible (i.e., whenever the gas/electric metering isolates the use of a single building that single building should be listed in ESPM).

The following variables were the most problematic, in terms of missing information or lack of detail. We believe this information could prove useful when determining a buildings suitability for ZNE and/or understanding EUIs and the prospects for lowering them.

Percent that Can Be Heated: Sparsely populated but an important source of insight into a buildings' EUI and the prospects for reducing it.

Percent that Can Be Cooled: Sparsely populated but an important source of insight into a buildings' EUI and the prospects for reducing it.

[69] Our review of ESPM data included a detailed analysis of all the associated inputs, including information provided in the following components of the relational database: Properties, Property IDs, Uses, Use Details, Meter, Meter Consumption Data.
[70] Across 1,500+ buildings we saw missing data (39 buildings) as well as other potential errors such as a value of "1" square foot (41 buildings), a value of "100" square feet (22 buildings), and a mix other questionable values (57 buildings).

Number of Workers on Main Shift: Sparsely populated but an important consideration when determining the prospects for reducing/eliminating occupancy to achieve deeper retrofits. The number of employees might also provide insight into a buildings' EUI (e.g., a high concentration of employees per square foot may translate into a higher EUI).

Number of Computers: Sparsely populated but an important source of insight into a buildings' overall EUI (e.g., a high concentration of computers per square foot may translate into a higher EUI).

Weekly Operating Hours: Sparsely populated but an important source of insight into a buildings' EUI (e.g., longer operating hours may translate into a higher EUI). High operating hours may also indicate whether or not energy efficiency upgrades and ZNE retrofits can take place during off hours.

7. Findings and Recommendations

The study covered a wide-range of topics and provided several key findings related to ZNE readiness within state-owned buildings. We outline the major report findings, including lessons learned, and follow this with a set of recommendations that state departments should consider as they continue to pursue the collective goal of reaching ZNE status for state-owned buildings.

7.1 Findings

- **Eight[71] of 35 departments have achieved ZNE status for a given building or have a ZNE building in progress.** While many departments are working toward increasing energy efficiency levels and installing on-site renewable generation, we use the term "progress" to indicate that a department has concrete plans, or has already achieved, ZNE status for a newly constructed or existing building. Two of the departments with concrete plans — the Department of Motor Vehicles and the California Lottery Commission — are only pursuing ZNE through new construction or major gut rehabilitation projects. Combined, these two departments have eight buildings in some stage of planning, design, or construction and two completed buildings.[72] In addition to these two completed buildings, the California Department of Public Health has one completed ZNE building. The remaining 5 departments have a ZNE building in progress. Collectively, these buildings that have either achieved ZNE status or are in progress account for less than 2% of state-owned building square footage.[73]

- **ZNE is a nascent concept and the "rules" aren't always clear.** While department decision makers are aware of the Governor's Executive Order, the associated ZNE goals, and generally what ZNE means, they are less aware of foundational concepts like "Source EUI" and "ZNE Source". Additionally, many departments are not clear on exactly what they need to do to achieve ZNE status (e.g., achieve a certain level of energy efficiency first, compute the solar PV offset using a Source energy definition, monitor energy use for an entire year, etc.) or when EUI and ZNE milestones need to be met. The Executive Order states that departments should "take measures toward achieving ZNE" by 2025 but it is not clear to decision makers what that means.

- **With some notable exceptions, most departments face a persistent set of barriers that are substantial impediments to achieving ZNE within existing buildings. While funding, procurement, and competing priorities can also complicate the ZNE new construction process, there are few real impediments to new construction once funding is secured.** These barriers include:

  - **Funding:** Funding has been, and likely will continue to be, a major barrier to ZNE achievement within state-owned buildings. Department decision makers consistently spoke of the lack of funding, the long and complicated path to securing funding, and their expectation that these challenges will persist into the future. While DGS has taken important steps to address funding

[71] The departments are: Air Resources Board, California Conservation Corps, California Department of Corrections and Rehabilitation, California Department of Transportation, California Lottery Commission, Department of Motor Vehicles, Department of Public Health, and California Office of Emergency Services.
[72] Completed ZNE buildings are: 1) DMV Fresno building; and 2) California Lottery Santa Fe Springs building.
[73] The actual size of some of these buildings was not available to the research team. In these cases, we estimated the size based on known building characteristics and the average size of existing buildings within the given department.

issues—ranging from a more streamlined process for securing the services of Energy Service Companies (ESCOs) to financing and installing solar PV through Power Purchase Agreements—important impediments persist in obtaining the level of funding needed to move toward ZNE.

- **Procurement:** The procurement process is a particularly challenging aspect of improving the energy efficiency of state-owned buildings (on the path to ZNE) and can result in significant extensions to project timelines. While some departments have procurement authority (and most have procurement authority up to set limits), many rely upon DGS and state-prescribed procurement practices that can be both time intensive and costly.

- **Competing Priorities:** State departments have a myriad of green initiatives to manage, including Executive Orders that address ZNE in addition to water efficiency and conservation, zero emission vehicle purchases, and other environmental goals. Departmental staff assigned to the pursuit of ZNE report that ZNE efforts are often competing with these other priorities, as well as their need to focus on activities pertaining to mission delivery and keeping buildings operational. Our interviews suggest that prioritizing and integrating these various needs and goals into an integrated and cohesive "plan" can be extremely challenging.

- **Building issues:** Decision makers report that many state-owned buildings have physical, locational, and technological barriers to achieving ZNE status. The most common among these were that buildings are:

  - *In Poor condition:* Many state-owned buildings need a significant amount of repair and rehabilitation—ranging from addressing health and safety issues to the presence of asbestos to deferred maintenance. As such, multiple departments stated that they are not going to pursue ZNE retrofits in all (in some cases) or most (in other cases) buildings they occupy and operate.

  - *Unsuitable for site located solar PV:* Many state-owned buildings have building footprints (e.g., insufficient roof characteristics) and site footprints (e.g., insufficient owned areas around a building) that will not accommodate solar PV. Although the DGS guidelines for ZNE achievement include scenarios that allow for PV placement outside the physical building site boundary, there are a myriad of issues—in many circumstances—in pursuing these options.

  - *Located in challenging, densely populated areas:* Many of the largest state-owned buildings—particularly office buildings—are located in densely populated urban settings. Their location along with their overall dimensions (i.e., height and width) reportedly present barriers to installing the type of retrofit measures (e.g., decentralized HVAC, natural lighting, natural ventilation, etc.) common to many ZNE buildings.

- **External issues**: Departments pursuing ZNE for specific buildings have encountered significant issues associated with connecting a building's onsite renewable generation to the electrical grid (i.e., interconnection issues). Interconnection agreements can be difficult to execute and take a significant amount of time to get in place. In addition to an often-contentious legal agreement, the utility distribution system (e.g., distribution lines, substations, transformers, etc.) may not be able to accommodate, due to age, size, and configuration, customer owned renewables without significant upgrades. Such upgrades -- paid for by the department -- can be extremely costly and take a substantial amount of time to plan, contract for, and execute, often resulting in delays in reaching ZNE goals.

- **Identifying buildings for energy efficiency retrofits, toward the goal of reaching ZNE, is not an objective "one size fits all" process, as each building's condition and circumstances are unique.** While that mantra is "reduce, reduce, reduce (through energy efficiency) and then produce (through renewables)", ZNE publications and practitioners tend to oversimplify the actual process of selecting and preparing buildings that can ultimately achieve ZNE. If anything, with respect to existing state-owned buildings, the process of selecting building that can achieve ZNE is complicated and does not involve a "one size fits all" approach. Rather, each building has a unique set of characteristics (e.g., energy uses, orientation, size, height, condition, site footprint, etc.) that are difficult to objectively compare to other buildings that are equally unique. In fact, knowledge of ZNE concepts combined with informed judgement would seem to take precedent when prioritizing buildings, in many cases, over more objective measures of ZNE readiness such as current energy efficiency levels.

- **Department decision makers agree that achieving ZNE through new construction is considerably easier (i.e., has fewer barriers) than retrofitting existing buildings.** Upon securing funding — which can take a considerable amount of time—new construction projects proceed relatively quickly. Alternatively, retrofits of existing buildings tend to take a piece meal approach to energy efficiency improvements—implemented over multiple years—before renewables are even considered. Furthermore, many energy efficiency efforts are reportedly completed without an eye toward the eventual achievement of ZNE.

- **State-owned building energy use (expressed in kBtus) and building square footage is highly concentrated within a relatively small number of departments.** For example, the California Department of Corrections and Rehabilitation (CDCR) accounts for 75% of state-owned buildings and 43% of overall building square footage. CDCR along with four other departments—Department of General Services, California Department of Transportation, Department of State Hospitals, and Department of Parks and Recreation—account for 77% of the overall building square footage within state-owned buildings. These same five departments account for 81% of overall energy consumption within state-owned buildings. While other departments have a substantial number of properties and buildings, they do not individually or collectively represent a significant amount of overall square footage or energy consumption.

- **Among properties that can be mapped to energy efficiency targets set by DGS, 27% have energy use intensity (Source EUI) values at or below the DGS established targets**. In total, these properties account for about 22.5 million square feet of building space, or about 20% of all square footage within state-owned buildings. Given that these properties are at or below the EUI target, it would appear[74] that the next step to ZNE is to pursue the installation of solar PV.

- **The data available to assess (or rank) a given state-owned building's suitability or readiness for ZNE is very limited.** While many important building energy use characteristics are available through Energy Star Portfolio Manager (ESPM), a good deal of additional information would be useful when deciding on which specific properties and buildings to focus on. In particular, very little information exists

[74] We use the words "it would appear" because we are not entirely sure how the EUI targets were established. We believe that they essentially represent the EUI threshold currently being met by 25% of state-owned buildings within a given property use type. If so, it is unclear—and we were unable to confirm through DGS—if these targets represent aggressive enough EUIs such that the buildings meeting them should stop pursuing energy efficiency and look to add renewables in order to get to ZNE.

regarding building footprints, site footprints, and suitability for solar PV installations[75]. Even with improved data sources, there is likely no supplement for key decision makers prioritizing buildings for ZNE retrofits based on known and detailed characteristics of a building—such as the buildings that surround it, historical designation, condition, and deferred maintenance needs.

7.2 Lessons Learned

A number of state-owned buildings have already achieved (or will soon achieve) ZNE status. Interviews completed with 10 existing ZNE building owners or managers (both in the public and private sectors), combined with information gleaned from interviews with various state departments, provide a number of important lesson learned. These lessons learned should aid state decision makers as they pursue ZNE status for additional state-owned buildings.

- **Careful planning (both before and during building design) is extremely important.** Considering the importance of both financing and buy-in from different state decision making bodies (i.e., state legislature in the case of capital outlay projects), it is important that departments begin the planning process early. In particular, ZNE-related planning should be included in departmental efficiency goals and long- and medium-term infrastructure planning.
  - As specific buildings are selected, decision makers should work with their design team to set aggressive EUI targets. ZNE building owners in the private sector note the importance of working with design teams to set aggressive building EUI targets. Additionally, it is important to share EUI targets with key stakeholders to help create consensus on the goals (i.e., what to build to) and what it will take to achieve them.
- **Analysis and commissioning are key aspects of the planning process.** Owners or operators of existing ZNE buildings stress the importance of conducting detailed analysis of building systems to identify where efficiency improvements may be worthwhile. Additionally, ZNE buildings owners stress the need to start this process with retro-commissioning so that the building is operating as efficiently as possible before making decisions on which systems may be worth retrofitting or replacing. There are reportedly "only a handful" of consulting firms that do this work well, so it is important to be deliberate in finding an experienced design team that can help stakeholders understand what will be necessary to achieve ZNE goals.
- **Once decision makers identify a building to target for ZNE, make it more efficient and then continue to iterate.** The DPH's Building P, one of the state buildings that has successfully achieved ZNE status, has been a target of decision makers for a number of years. The building continuously improved its efficiency, originally receiving an ENERGY STAR rating of 91 in 2005 and steadily improved that rating to 94 in 2008 and 98 by 2010. Given that efficiency projects may be costly and time consuming, planning effectively and breaking such projects into smaller efforts may be more practical.

[75] SolView is a tool that could possibly be used to provide satellite images to calculate solar potential for state-owned buildings (http://solview.com).

- This iterative strategy is also relevant in terms of the process that departments go through to make major efficiency, or other ZNE-related improvements to targeted buildings. As documented throughout this report, there are a range of very specific operational and process challenges that decision makers frequently face. Several departments that have had success reaching ZNE noted that documenting what went well, what did not, and the hurdles encountered along the way is extremely helpful. These lessons learned not only help decision makers when targeting/selecting the "next" ZNE project but also help other state departments working towards ZNE goals.

- **Future operations and maintenance is extremely important.** Making substantial investments in building systems to increase efficiency is only a part of the process. Building operators require training to ensure they are not circumventing newly installed automated energy management systems and that they have the know-how to ensure that other systems are operating properly. Similarly, decision makers need to make the same considerations for newly installed solar PV systems—that is, either training staff to monitor and maintain generating capacity, or allowing for this in the associated solar agreement (e.g., solar PPA). The California Lottery Commission noted this when one of the three inverters stopped working on the recently completed Santa Fe Springs ZNE site, it took several weeks to realize the system was not generating to design specifications.

  - Existing ZNE building owners and operators noted the need for decision makers to ensure that design teams factor in operations and maintenance at the earliest stages of design. This include using different operating conditions when modeling building performance to make sure the building can still meet ZNE goals under various scenarios. These operations and maintenance considerations also have implications in terms of monitoring and verifying both usage and generation to ensure that ZNE buildings are, in fact, offsetting their energy consumption with renewable generation.

- **Communication and collaboration with the different stakeholders throughout the road to ZNE is critical.** There are many players involved in ZNE projects (e.g., design firms, decision makers, constituents, utility companies, general contractors, etc.) and the most successful projects are those where there is consistent and clear communication between all parties. Given the need to be creative and flexible throughout the design and construction of ZNE buildings, it is critical to have constant communication between the design team and decision makers and common understanding of the project's goals. Further, the decision makers should seek to collaborate with other stakeholders to maximize external funding and find creative ways to address challenging issues.

  - One of the major themes we heard from decision makers across different state departments was a general lack of funding for ZNE-related building improvements. As such, any external funding (e.g., utility incentives) or other creative ways of managing costs have been extremely valuable to successful ZNE projects. For example, the Department of Public Health worked with Government Operations to leverage California Conservation Corps personnel to retrofit 756 LED lamps at a fraction of the cost of a conventional lighting retrofit project.

7.3 Recommendations

To enhance various state department's ability to pursue ZNE, our study findings suggest the following recommendations:

- **State decision makers should continue to pursue new ZNE funding sources.** Funding is clearly the most substantial and consistently mentioned barrier to achieving ZNE within state-owned buildings. And, through the research process, we were unable to identify a clear path forward to overcoming this key barrier. The capital outlay process is the typical way significant levels of funding is secured by state departments and that is subject to the state budgeting and the legislative process. Without a more significant source of funding, progress toward ZNE will be slow for nearly all departments. In absence of such funding, state departments should continue to utilize ESCO funding toward the goal of increased energy efficiency and PPAs to pursue renewables. Alone, these two funding sources will help but more substantial funding will be needed to address the substantial investment needed to renovate existing buildings to ZNE and/or allow for their replacement through newly constructed ZNE buildings.

- **DGS should develop a ZNE Manual for use by other state departments:** While we note that DGS, and other stakeholders, have produced resources for departments working towards ZNE goals, we recommend that DGS develop a manual that specifically addresses topics such as 1) the necessity of identifying key stakeholders early in the process; 2) various sources of potential funding and how to secure it, 3) how the procurement process works and what vehicles (e.g., Energy Service Company and purchase power agreements) are available to facilitate the contracting process, and 4) how to assess and prioritize buildings given their condition, location, and site characteristics. A manual should also prescribe, as much as possible, how to develop building specific roadmaps to achieving ZNE. This would include, but not be limited to, establishing EUI targets and identifying the steps along the pathway to ZNE (e.g., building consensus, planning, executing and constructing, and verifying ZNE status upon occupancy). Building specific roadmaps will also help ensure that energy efficiency projects — which tend to be piece meal — will not be executed at the expense of a strategic focus on ZNE. Such a manual should include ZNE and related concepts, such as how to compute Source energy use, how to determine the solar PV offset using a Source energy definition, and what this means in terms of goal attainment. Ideally, such a manual would also help departments understand 1) the interrelationships among various green initiatives and how to approach them holistically, and 2) the need for grid harmonization which equates, in many instances, to the need for energy storage (either battery or thermal) to ensure that ZNE buildings do not exacerbate the duck curve, but contribute to a more temporally-balance grid[76].

- **The State of California should focus ZNE, at least initially, on those departments that represent the most significant portion of state-owned building square footage.** With respect to reaching the Governor's stated goal of taking measures toward achieving ZNE for 50% of all existing state-owned buildings square footage by 2025, we recommend focusing on a limited number of departments to formulate specific plans, select specific properties, and select buildings within those properties. Reducing the number of departments should bring focus to addressing the various barriers involved in reaching ZNE specific to each departments' circumstances. Along this path, CDCR would appear to be the highest priority department given they are a dominant force with respect to the number of buildings, overall building square footage, and overall energy use. Additionally, and perhaps most importantly, many CDCR sites appear to have ample room (e.g., surface parking lots, green space) for solar PV installation and, given the number of buildings, significant levels of PV can be added without

[76] The need for grid harmonization is, at this time, an important state policy issue at both the California Public Utilities Commission (CPUC) and California Energy Commission (CEC). At the time of this publication, the CPUC is in the middle of at least two proceedings primarily driven by it and the CEC's plans for the next iteration of the Building Energy Efficiency Standards (Title 24 Part 6) will require developers to address it.

over production. Working with CDCR has the additional benefit of achieving ZNE within the physical site boundaries (a DGS priority).

- ***CDCR should consider installing individual electric and/or gas meters on at least some buildings.*** CDCR far outweighs all other departments in solar PV production. Thus, CDCR properties with solar PV production are most certainly producing more energy (over the course of a year) than a subset of the buildings located on the property consume. Installing electric and/or gas meters on individual buildings will allow for a direct comparison between consumption and solar PV energy production, allowing CDCR to claim ZNE status for a subset of buildings within a given campus/prison.

- ***In addition to CDCR, focus on campus settings*** if possible as it will allow for PV generation within the campus boundaries—as opposed to having to secure renewables at the portfolio or community level. Producing renewable power at the campus level to energize a subset of campus buildings should help mitigate the often contentious and complicated interconnection and over production issues. A campus approach could allow PV over production from one building to be used by another, thus eliminating or greatly reducing the probability that over-production will be pushed back into the electrical grid.

- ***Across all departments, identify high potential buildings and prioritize them.*** For example, while CDCR is a key department it is important to achieve some balance between targeting the largest department(s) and prioritizing the most promising buildings across the entire portfolio of state-owned buildings. While these "promising" buildings may be individually small (particularly in comparison to the overall 50% of state-owned square footage goal) they can still make an important contribution to goal attainment—particularly if they are below (or close to) established EUI targets and have ample room for PV.

- ***Continue to work toward energy efficiency goals with all departments*** but, perhaps, delay or postpone ZNE for all but the most promising buildings. However, it is important (perhaps as part of the ZNE manual) to provide guidance toward the goal of ensuring that energy efficiency project decisions are made in the context of a longer-term ZNE strategy.

- **State departments should select buildings for energy efficiency retrofits, toward the goal of reaching ZNE, on a case-by-case basis as each building's condition and circumstances are unique.** While ranking existing state-owned buildings for energy efficiency and ZNE readiness is a worthy goal, it cannot be relegated to a "one size fits all" process or approach. Rather, the unique characteristics of each building—that are not easily relegated to a set of objective criteria—need to be considered and scrutinized. Knowledge of ZNE concepts combined with informed judgement would seem to take precedent when prioritizing buildings, in many cases, over more objective measures of ZNE readiness such as current energy efficiency levels.

- **DGS should supplement the Energy Star Portfolio Manager (ESPM) data collection process.** DGS should work with departments to collect additional data, highly pertinent to the prospects of eventual achievement of ZNE status, for all state buildings.

  - ***Review and carefully consider data elements that could be collected as part of the ESPM data collection process***. Additional characteristics of each property would be useful. This includes, but is not limited to, the site's suitability to accommodate solar PV (e.g., building footprint, site footprint, existence of surface parking lot, existence of surrounding green space) as this information is a key ingredient to determining if ZNE can be achieved with the physical building boundary.

- **Identify buildings, leveraging institutional knowledge[77], that make little practical sense to address in terms of taking aggressive steps to reduce energy use.** Key departmental decision makers are aware of key building attributes (e.g., building condition, historical designation, presence of asbestos, deferred maintenance) that are crucial to prioritizing buildings for energy efficiency improvements and ZNE. In short, there is likely no good supplement for "local knowledge" when it comes to selecting and prioritizing buildings. Decision makers within state departments are keenly aware of complications or issues associated with a given building that are hard to measure objectively or be relegated to a 3rd party.

- **The CPUC, IOUs, and DGS should work collectively to develop a legal template to cover interconnection issues in situations where a state department owns the solar PV.** As a general rule, key issues have been worked out when renewables are purchased through a Power Purchase Agreement (PPA) as the PPA technically "owns" the solar PV and signs the interconnection agreement. However, when the state owns the solar PV, and therefore must sign the interconnection agreement, there are inconsistencies and issues that arise when trying to satisfy both IOU, DGS and state legal and indemnification requirements. Generally, when budgets permit, some departments view owning the solar PV installation as preferable to a PPA. Other department, due to either budget limitations or concerns about long-term PV maintenance, prefer PPAs. Nevertheless, solving complicated legal issues is important to departments preferring to own the solar PV.

- **IOUs should consider providing ZNE technical assistance to state departments.** IOUs are uniquely positioned, given their long-standing role in promoting energy efficiency, to provide advice and expertise around energy efficiency improvements. Some of the IOUs also have staff that are intimately familiar with ZNE challenges in both new construction and retrofit. Finally, utility staff are often aware of the resources that can be leveraged (e.g., consulting firms, contractors, distributors, etc.) toward the goal of improving energy efficiency and reaching ZNE. Many state department decision makers are less familiar with ZNE and how to achieve it. Thus, key IOU personnel could provide needed levels of expertise and guidance. Ultimately, it is up to the CPUC to determine whether or not—and to what extent—incentives are needed to encourage IOUs to promote ZNE within state government and include the service in their respective State Partnership Programs.

[77] It is our understanding that each department's Sustainability Roadmap's Energy Chapter, due in December 2017, ask each department to identify buildings—using institutional knowledge—that are good ZNE candidates.

Appendix A. Detailed Property Characteristics by Department

Table 7-1 below outlines provides a detailed breakdown of properties, buildings, square footage, and site energy use for each state department. The information contained below is based exclusively on what departments track in ESPM.

Table 7-1. Detailed Property Characteristics by State Department

	Number of Properties		Count of Buildings		Square Footage		Site Energy Use	
Department	Count	Percent of Total	Count	Percent of Total	Total (Sq. Ft.)	Percent of Total	Total kBtu	Percent of Total
ARB	1	0.067%	1	0.012%	53,797	0.050%	7,810,704	0.084%
CAAM	1	0.067%	1	0.012%	45,000	0.042%	2,772,972	0.030%
Cal Expo	1	0.067%	1	0.012%	1,058,336	0.99%	37,007,281	0.40%
CAL FIRE	244	16%	248	2.9%	2,038,062	1.9%	95,797,120	1.0%
Cal OES	1	0.067%	3	0.035%	117,704	0.11%	15,262,771	0.16%
CalPERS	4	0.27%	4	0.046%	1,473,231	1.4%	79,696,428	0.86%
CALPIA	2	0.13%	10	0.12%	60,000	0.056%	3,132,822	0.034%
CALSTRS	1	0.067%	1	0.012%	409,000	0.38%	22,233,635	0.24%
Caltrans	396	27%	377	4.4%	7,374,367	6.9%	353,949,439	3.8%
CalVet	10	0.67%	32	0.37%	2,542,263	2.4%	396,964,859	4.3%
CCC	3	0.20%	12	0.14%	91,513	0.085%	5,255,210	0.057%
CDCR	45	3.0%	6438	75%	46,351,263	43%	5,344,527,195	58%
CDE	4	0.27%	4	0.05%	1,034,288	0.97%	53,976,411	0.58%
CDFA	23	1.5%	23	0.27%	134,731	0.13%	43,584,248	0.47%
CDFW	87	5.8%	76	0.88%	1,036,340	0.97%	55,645,271	0.60%
CDPH	3	0.20%	2	0.023%	727,909	0.68%	132,577,186	1.4%
CDT	1	0.067%	1	0.012%	154,250	0.14%	74,543,072	0.80%
CHP	104	7.0%	92	1.1%	1,123,840	1.0%	100,984,736	1.1%
CLC	5	0.34%	3	0.035%	576,442	0.54%	11,916,079	0.13%
CMD	94	6.3%	539	6.3%	2,745,053	2.6%	96,502,739	1.0%
CSC	5	0.34%	6	0.070%	669,321	0.62%	50,945,762	0.55%
DCA	1	0.067%	1	0.012%	30,893	0.029%	897,806	0.010%
DDS	5	0.34%	5	0.058%	4,181,548	3.9%	208,061,268	2.2%
DGS	55	3.7%	55	0.64%	16,200,686	15%	1,039,740,499	11%
DMV	93	6.2%	91	1.1%	1,409,625	1.3%	137,668,441	1.5%
DOC	1	0.067%	1	0.012%	2,000	0.0019%	88,599	0.0010%
DOJ	8	0.54%	8	0.093%	172,604	0.16%	34,752,278	0.37%
DOR	1	0.067%	3	0.035%	42,152	0.039%	4,430,940	0.048%
DPR	204	14%	343	4.0%	6,169,271	5.8%	77,333,252	0.83%

Department	Number of Properties		Count of Buildings		Square Footage		Site Energy Use	
	Count	Percent of Total	Count	Percent of Total	Total (Sq. Ft.)	Percent of Total	Total kBtu	Percent of Total
DSH	5	0.34%	94	1.09%	6,414,664	6.0%	706,525,908	7.6%
DWR	26	1.7%	81	0.94%	489,663	0.46%	19,854,009	0.21%
EDD	31	2.1%	27	0.31%	619,600	0.58%	32,888,019	0.35%
HCD	23	1.5%	23	0.27%	1,556,500	1.5%	28,931,673	0.31%
SLC	1	0.067%	1	0.012%	3,270	0.0031%	38,647	0.00042%
SMMC	1	0.067%	5	0.058%	20,429	0.019%	346,011	0.0037%
Total	*1,490*		*8,612*		*107,129,615*		*9,276,643,287*	

Appendix B. DGS Established Source EUI Targets by Climate Zone

Table 7-2below provides the detailed list of Source EUI targets by climate zone as set by DGS for each property type. The property use types below are based on default property use types from ESPM, expanded by DGS to fit building types occupied by state departments.

Table 7-2. Detailed Source EUI Targets by Climate Zones—Established by DGS

Property Use Type	Average Source EUI	Source EUI Targets for State Climate Zones															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Conversion Factors for Zones	1.00	0.99	1.01	0.92	0.97	0.95	0.94	0.90	0.95	0.97	0.99	1.06	1.02	1.05	1.06	1.09	1.12
Adult Education - CCC	54	53	55	50	52	51	51	49	51	52	53	57	55	57	57	59	60
College/University	142	141	143	131	138	135	133	128	135	138	141	151	145	149	151	155	159
Data Center	100	99	101	92	97	95	94	90	95	97	99	106	102	105	106	109	112
Fire Station - CALFIRE	65	64	66	60	63	62	61	59	62	63	64	69	66	68	69	71	73
K-12 School	85	84	86	78	82	81	80	77	81	82	84	90	87	89	90	93	95
Laboratory	261	259	264	240	254	248	246	235	248	254	259	277	267	274	277	285	293
Library	114	113	115	105	111	108	107	103	108	111	113	121	116	120	121	124	128
Mixed Use Property (CALFIRE)	49	48	49	45	47	46	46	44	46	47	48	52	50	51	52	53	55
Multi-family Housing	133	132	134	122	129	126	125	120	126	129	132	141	136	140	141	145	149
Non-Refrig. Warehouse	37	37	37	34	36	35	35	33	35	36	37	39	38	39	39	40	41
Office - Average All Types	81	81	82	75	79	77	77	73	77	79	81	86	83	85	86	89	91
Office - Large >50K sq. ft.	106	105	107	98	103	101	100	95	101	103	105	112	108	111	112	116	119
Office - Small <50K sq. ft. - CHP	201	199	203	185	195	191	189	181	191	195	199	213	205	211	213	219	225
Office - Small <50K sq. ft. - CMD	30	30	30	28	29	29	28	27	29	29	30	32	31	32	32	33	34
Office - Small <50K sq. ft. - DMV	162	160	164	149	157	154	152	146	154	157	160	172	165	170	172	177	181
Office - Small <50K sq. ft. - EDD	132	131	133	121	128	125	124	119	125	128	131	140	135	139	140	144	148
Office - Small <50K sq. ft. - Others	114	113	115	105	111	108	107	103	108	111	113	121	116	120	121	124	128
Other - Maintenance DOT/DWR	71	70	72	65	69	67	67	64	67	69	70	75	72	75	75	77	80

Property Use Type	Average Source EUI	Source EUI Targets for State Climate Zones															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Other - Caltrans TMC	567	561	573	522	550	539	533	510	539	550	561	601	578	595	601	618	635
Other - CDFA	249	247	252	229	242	237	234	224	237	242	247	264	254	262	264	272	279
Other - CDFW ecolog. reserve	22	22	22	20	21	21	21	20	21	21	22	23	22	23	23	24	25
Other - CDFW fish hatchery	118	117	119	109	114	112	111	106	112	114	117	125	120	124	125	129	132
Other - CDFW wildlife area	55	54	56	51	53	52	52	50	52	53	54	58	56	58	58	60	62
Other - DPR park structures	27	27	27	25	26	26	25	24	26	26	27	29	28	28	29	29	30
Other - HCD migrant centers	30	30	30	28	29	29	28	27	29	29	30	32	31	32	32	33	34
Other - Education	54	53	55	50	52	51	51	49	51	52	53	57	55	57	57	59	60
Other - Entertainment public	17	17	17	16	16	16	16	15	16	16	17	18	17	18	18	19	19
Other - Lodging/Residential	189	187	191	174	183	180	178	170	180	183	187	200	193	198	200	206	212
Other - Specialty Hospital (DSH)	426	422	430	392	413	405	400	383	405	413	422	452	435	447	452	464	477
Outpatient Rehab/Phys - (DSH)	113	112	114	104	110	107	106	102	107	110	112	120	115	119	120	123	127
Prison/Incarceration - CDCR	187	185	189	172	181	178	176	168	178	181	185	198	191	196	198	204	209
Residence Hall/dorm - CALFIRE	112	111	113	103	109	106	105	101	106	109	111	119	114	118	119	122	125
Senior Care Facility – CalVet	161	159	163	148	156	153	151	145	153	156	159	171	164	169	171	175	180

Appendix C. California State-Owned Property Rankings

The document embedded below contains the ranked list of the 1,490 properties tracked in ESPM by state departments and discussed throughout the body of this report. We have outlined the criteria for this ranking exercise in detail in Section 6 above.

CA Properties
Ranked for ZNE Rea

Appendix D. Department Snapshots

As part of this study, Opinion Dynamics has combined information from ESPM, interviews with department decision makers, and secondary sources such as the sustainability road maps to create individual snapshots for each of the departments with whom we completed an interview. Of the 35 departments that manage state-owned buildings, we developed 20 department snapshots. Snapshots were created for departments which had department decision makers interviewed, and provided a sustainability road map. Some information in the snapshots may not be up-to-date due to the ESPM data and sustainability road maps being completed in 2015.

Department Acronyms

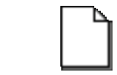
Table 7-3 below provides a list of each of the 35 departments that manage state-owned buildings, and are therefore subject to EO-B-18-12, and their associated acronym.

Table 7-3. Department Names and Acronyms

Department Name	Abbreviation
Air Resources Board	ARB
California African American Museum	CAAM
California Conservation Corps	CCC
California Department of Corrections and Rehabilitation	CDCR
California Department of Education	CDE
California Department of Fish and Wildlife	CDFW
California Department of Food and Agriculture	CDFA
California Department of Forestry and Fire Protection	CAL FIRE
California Department of Public Health	CDPH
California Department of Technology	CDT
California Department of Transportation	Caltrans
California Department of Veterans Affairs	CalVet
California Exposition & State Fair	Cal Expo
California Highway Patrol	CHP
California Lottery Commission	CA Lottery
California Military Department	CMD
California Office of Emergency Services	Cal OES
California Prison Industry Authority	CALPIA
California Public Employees Retirement System	CalPERS
California Science Center	CSC
California Teachers Retirement System	CalSTRS
Department of Conservation*	DOC
Department of Consumer Affairs	DCA
Department of Developmental Services	DDS

Department Name	Abbreviation
Department of General Services	DGS
Department of Justice	DOJ
Department of Motor Vehicles	DMV
Department of Parks and Recreation	DPR
Department of Rehabilitation	DOR
Department of State Hospitals	DSH
Department of Water Resources	DWR
Employment Development Department	EDD
Housing and Community Development	HCD
Santa Monica Mountains Conservancy	SMMC
State Lands Commission	SLC

The department snapshots are embedded in the document below.



Department Snapshots.pdf

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