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Jobs and Investments to Achieve Zero Net Energy in MUSH Sector Buildings in the SoCalREN Territory

A Labor Market Study for the Southern California Regional Energy Network (SoCalREN) and Emerald Cities Collaborative

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Donald Vial Center on Employment in the Green Economy
Institute for Research on Labor and Employment
University of California, Berkeley

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All errors, omissions, and conclusions are the sole responsibility of the authors.

About the Donald Vial Center on Employment in the Green Economy

The Donald Vial Center carries out research on the emerging green economy and climate change policy in California, as these relate to the labor market, to workforce development, and to workforce policy.

The Donald Vial Center is a project of the University of California, Berkeley, Institute for Research on Labor and Employment and is affiliated with the Center for Labor Research and Education (Labor Center).

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I. Executive Summary

This brief estimates the investment needed, and the jobs this investment would generate, to achieve zero net energy (ZNE) in all Municipal, University, School, and Hospital (MUSH) sector buildings in the Southern California Regional Energy Network (SoCalREN) territory. SoCalREN is a ratepayer-funded program regulated by the California Public Utilities Commission (CPUC) and serving public agencies and their constituents in the Southern California Edison (SCE) and Southern California Gas Company (SCG) service territories. This report was carried out at the request of the SoCalREN and its workforce development partner, Emerald Cities Collaborative, whose mission is to both reduce the region's energy consumption and create quality jobs and job opportunities for residents in the region.

ZNE for existing buildings is achieved by first making deep reductions in energy use and then generating the remaining energy needs from on-site renewable generation. While the exact level of energy reductions needed to make a building ZNE-ready depends on a variety of factors, including building size, energy use, space constraints, and operational patterns, we assume, based on available information on completed ZNE retrofits, that at least a 45 to 60 percent energy reduction is necessary to feasibly prepare MUSH buildings in the SoCalREN territory to achieve ZNE. We present two ZNE scenarios using two combinations of energy efficiency retrofits and on-site solar photovoltaic (PV) system installations for the remaining energy needs. We find that deeper levels of energy efficiency lead to lower total costs, since at least within this range, energy efficiency is more cost-effective than PV.

- Scenario 1 assumes a 60 percent reduction in energy use in all MUSH sector buildings, requiring an investment of $14.1 billion, and energy generation by on-site solar PV systems for the remaining 40 percent of energy demand, requiring an investment of $21.4 billion, at a total cost of $35.5 billion.
- Scenario 2 assumes a 45 percent reduction in energy use in all MUSH sector buildings, requiring an investment of $10.6 billion, and energy generation by on-site solar PV systems for the remaining 55 percent of energy demand, requiring an investment of $29.4 billion, at a total cost of $40 billion.

These numbers show that there is an enormous gap between the investment needed to achieve ZNE and the current levels of incentives and public investments for energy upgrades in all MUSH sector buildings. While the goal that the CPUC has adopted is less ambitious, requiring that 50 percent of existing commercial buildings should be ZNE by 2030, this study shows that the investment deficit needed to achieve this goal is huge. In the SoCalREN territory, SCE and SCG allocated $256 million for commercial and public sector energy efficiency programs during the 2013-14 program cycle and SCE currently spends about $100 million each year on two distributed generation programs. Only a portion of these program funds are available for MUSH sector buildings. Proposition 39 funds are available for school retrofits in this region, and there are a number of other potential funding sources. In total, however, achieving ZNE for all (or half of) MUSH buildings in the SoCalREN region would require substantially more public and private investment.

More investment will produce more jobs. We estimate that achieving ZNE on all MUSH sector buildings in the SoCalREN territory would create between 177,300 and 189,200 direct job-years. One job-year is equal to one full-time job that lasts for one year.

- In Scenario 1, energy efficiency retrofits would create 87,420 direct job-years and on-site solar PV installation would create 89,880 direct job-years, for a total of 177,300 job-years.
- In Scenario 2, energy efficiency retrofits would create 65,720 direct job-years and on-site solar PV installation would create 123,480 direct job-years, for a total of 189,200 job-years.
- If investments to achieve ZNE were spent over a five-year period, this would create between 35,460 (Scenario 1) and 37,840 (Scenario 2) direct full-time jobs annually.
- If the same investments were spread across 10 years this would create between 17,730 (Scenario 1) and 18,920 (Scenario 2) direct full-time jobs annually for 10 years.
- Investments spread across 15 years would create between 11,820 (Scenario 1) and 12,613 (Scenario 2) direct full-time jobs annually. This investment period aligns with California's goal for 50 percent of existing commercial buildings to achieve ZNE by 2030.

ZNE investments will also create indirect jobs in the supply chain for ZNE projects and induced jobs by increasing regional demand for goods and services. We forecast that between 461,718 (Scenario 1) and 509,248 (Scenario 2) total job-years—including direct, indirect, and induced job-years—would be created in the SoCalREN region if all MUSH sector buildings were retrofitted to ZNE based on 60 percent and 45 percent energy reduction, respectively.[i]

Annual construction apprentice openings, which provide unskilled, entry level workers with career-track job opportunities, will also vary based on the time period for investment.

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[i] These are gross job projections, i.e. they do not subtract out jobs that would otherwise be created from power sold by the utilities. Estimating net jobs is difficult for a variety of reasons, including because jobs in the traditional power sector may or may not be located in the SoCalREN region. Studies show that energy efficiency and distributed solar generation are more labor-intensive than power plant generation, so we believe there is positive net job creation but since we cannot quantify it, we only report gross job creation here.

- If investments to achieve ZNE were spent over a five-year period, we estimate that this would produce between 4,019 and 4,289 annual apprentice openings for five years.
- If investments were instead spent over 10 years, the number of annual apprentice openings would be between 2,009 and 2,144 openings annually for 10 years.
- Investments spread across 15 years would create between 1,340 and 1,430 annual apprentice openings for 15 years.

Investments to achieve ZNE in SoCalREN MUSH sector buildings will create a significant number of job and training opportunities for Southern California workers while helping the state meet its energy efficiency and clean distributed generation goals.

II. Introduction

The California Public Utilities Commission (CPUC) 2008 California Long-Term Energy Efficiency Strategic Plan sets a goal that one half of existing commercial buildings statewide will be zero net energy (ZNE) by 2030 through achievement of deep levels of energy efficiency and clean distributed generation. Meeting the state goal would require deep, whole building energy efficiency improvements along with distributed generation for 250 million square feet of commercial space per year for 20 years.[1] The state is woefully behind in meeting these goals.[2]

Municipal, University, School, and Hospital (MUSH) sector buildings in the Southern California Regional Energy Network (SoCalREN) region represent about 12 percent of California's commercial building floor area.[ii] This brief, carried out at the request of the SoCalREN and its workforce partner, Emerald Cities Collaborative, estimates the investment needed, and the jobs this investment would generate, to achieve ZNE in **all** MUSH sector buildings in the SoCalREN territory. We compare this potential investment to current program budgets and estimate the number of jobs generated by current investments. We then estimate the number of job openings for entry level workers in career-track construction trades jobs by estimating the number of new apprentices that would be hired because of the investments in ZNE projects.

In the California Long-Term Energy Efficiency Strategic Plan, a ZNE building is defined as one in which "the amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building."[3] For policy purposes, the California Energy Commission and CPUC have proposed a nuanced definition of ZNE buildings that incorporates the societal value of energy saved and produced and clarifies that energy efficiency should remain the foundation of ZNE buildings.[4] For the purposes of this brief, however, we rely on the simpler definition in the strategic plan, calculating the investment needed to achieve deep levels of energy efficiency (for both gas and electric) and converting the remaining gas usage (measured in therms) to kilowatt hours (kWh) to calculate the on-site renewable generation needs.

III. Background

Starting in 2013, the CPUC created two Regional Energy Networks (RENs) to complement the investor-owned utility (IOU) energy efficiency programs – the Bay Area Regional Energy

[ii] The California Energy Commission (http://www.energy.ca.gov/2009publications/CEC-200-2009-012/CEC-200-2009-012-CMF.PDF p. 27, Figure 16) estimates approximately 7.3 billion square feet of commercial floor area in California in 2014. The Southern California Edison planning area accounts for 2.7 billion square feet. We calculate about 31 percent of commercial floor area is in the MUSH sector. We estimate that SoCalREN buildings account for 837 million square feet, which is 11.5 percent of California's total commercial floor space.

Network (BayREN) and the Southern California Regional Energy Network (SoCalREN). RENs are ratepayer-funded energy efficiency programs directed by networks of local governments in a region, and were approved by the CPUC in 2013 as part of the state's energy efficiency program portfolio. As an addition to programs run by the IOUs, RENs support deeper involvement of local governments in energy upgrades and are meant to serve as an incubator for new ideas. The CPUC also instructed the RENs to address workforce training and to leverage other state and federal resources to lower the costs of energy efficiency for ratepayers.[5]

The SoCalREN serves public agencies and their constituents in the Southern California Edison (SCE) and Southern California Gas Company (SCG) service territories. As an initiative based in local government and accountable to local communities, the SoCalREN can provide tools and resources to support energy upgrades while also investing in workforce development efforts and creating real, long-term career pathways for local workers.

IV. Methodology

We approached this analysis by calculating the total investment required to achieve ZNE for all MUSH sector buildings in the SoCalREN region, and multiplying the investments for both energy efficiency and distributed generation by the average number of jobs per million dollars of investment to arrive at the jobs estimates. We calculated distributed generation costs using available cost data for on-site solar PV.

We used a jobs per million dollars calculation rather than a jobs per MW approach because we had better data for employment effects based on cost. However, since the costs of solar PV continue to decline and the labor costs remain relatively steady, future analyses should use caution in relying on static jobs per million dollars figures from our research or other studies. A jobs per MW calculation may prove more stable over time.

We relied on raw data provided by state and federal sources, extensive literature review, utilization of our prior research, and interviews with subject matter experts as inputs for this analysis.

We vetted our findings with subject matter experts and compared our findings to other studies and collections of case studies related to deep energy efficiency, commercial solar PV, and ZNE buildings.

Given the uncertainties regarding key assumptions, we present low and high scenarios for achieving ZNE through a combination of energy efficiency retrofits and the installation of on-site solar PV systems. Specific data sources and methodologies are described in the following sections. Appendix 1 documents our investment calculation.

V. Sources for Estimates of Key Assumptions

In order to generate our estimates of the investment and jobs needed to reach ZNE for the MUSH market in the SoCalREN territory, we came up with a set of assumptions for key inputs from the best available sources.

A. MUSH Energy Consumption Percentage

We can estimate the investment required for ZNE by using cost per kWh data or cost per square foot data. In this analysis, both methods yielded similar figures, so we used cost per kWh in our calculations.

The SoCalREN territory includes nearly 200 cities, plus unincorporated areas, spread across all or parts of 16 counties.[6] Given the large size of the SoCalREN territory and the scope and timeline of this research project, we could not directly sample local governments and other MUSH entities to collect building energy consumption data. Instead, we approximate the SoCalREN MUSH building landscape using national and state figures on building ownership, building types, and energy consumption.

We estimate that MUSH buildings (including state and federally-owned buildings) account for roughly 35 percent of the state's electricity use and 40 percent of the state's gas use in the commercial sector. We assume that MUSH buildings in the SoCalREN region account for the same proportion of the region's energy use.

This estimate is based on the following data and assumptions:

- Government-owned (federal, state, and local) buildings consume 28 percent of energy in the U.S. commercial sector.[7] We assume the same for California. Since not all universities, schools, and hospitals are publicly owned however, we add to this figure private/non-profit education and health care facilities.
- Eleven percent of California commercial energy is consumed by the education sector (universities and schools).[8] Eight to 10 percent of California students are enrolled in private schools;[9] so we will assume that private/non-profit schools account for about one percent of California commercial energy consumption (0.11 x 0.09 = 0.01)

- The health sector (including outpatient facilities) in California accounts for seven percent of commercial electricity use and 14 percent of commercial gas use.[iii] Eighty-one percent of hospitals in California are owned by private or non-profit entities;[10] so we will assume that these health care facilities account for about six percent of the state's electricity consumption (0.07 x 0.81 = 0.06) and 11 percent of the gas (0.14 x 0.81 = 0.11).

B. SoCalREN MUSH Energy Consumption

In 2012, commercial buildings in the SoCalREN territory consumed 37.1 billion kWh of electricity and 946 million therms of gas.[11] If SoCalREN MUSH buildings represent approximately 35 percent of the commercial electricity and 40 percent of the commercial gas use, these buildings consumed about 13 billion kWh of electricity and 380 million therms of gas.

C. Energy Efficiency: Cost per kWh and Therm

ZNE can be achieved by varying combinations of energy efficiency retrofits and distributed renewable generation, but since energy efficiency is first in the loading order and, up to a point, cheaper than generation, analysts concur that significant energy efficiency retrofits should be done before investing in generation. We estimate that a 45 to 60 percent energy reduction is necessary to feasibly prepare all MUSH buildings in the SoCalREN territory to achieve ZNE. This equals 5.8 to 7.8 billion kWh and 170 to 227 million therms. Assuming a cost of $1.40 per kWh and $14 per therm for deep whole building energy retrofits, the investment required to achieve these savings ranges from $10.6 billion to $14.1 billion.

We base these assumptions on the following literature. A 2007 study conducted for the U.S. Department of Energy found that, on average, a commercial building must reduce its energy use by 59 percent to feasibly achieve ZNE goals (assuming that an on-site solar PV system is installed within the footprint of the building).[12] A 2012 study on the technical feasibility of new zero net energy buildings in California[13] found energy reductions around 45 percent (above baseline)[14] were necessary depending on the climate zone and building type.

The exact level of energy reductions needed to make a building ZNE-ready depends on a variety of factors such as patterns of energy use and building characteristics. Schools are prime candidates for ZNE because they operate for short hours and limited days and they are typically low-rise buildings with large roof and parking areas for solar PV. Hospitals and high rise office

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[iii] For government-owned buildings in general and education facilities, we assume the same proportion of electric and gas usage.

buildings, on the other hand, are more challenging, due to high energy use intensity and space constraints for on-site solar. These building types face technological and cost barriers preventing them from getting all the way to ZNE. Finally, while it is possible to achieve very deep (up to 75 percent) energy reductions (according to some case studies) in a cost-effective way, there is a point at which the cost of solar is less than the cost of some energy efficiency measures. Saving additional energy is less cost-effective than installing additional solar capacity. Since the price of solar continues to decline, the exact percent of energy efficiency reductions necessary on any particular building is a moving target.

Given these uncertainties, we use a range of 45 to 60 percent reduction in energy use in our calculations of the energy reduction component of ZNE. This level of savings can only be achieved through whole building deep energy efficiency retrofits or renovations that take advantage of multiple savings opportunities. These often include installing high-efficiency heating, ventilating, and air conditioning (HVAC) measures, the use of passive ventilation and daylighting, high efficiency water heating and lighting equipment, and optimizing the efficiency of the building itself through envelope improvements. Improving the operations of buildings through control systems, retro-commissioning, energy monitoring, regular maintenance of mechanical and electrical systems, and occupant behavior also contribute to energy reductions. These improvements are generally undertaken in order of lowest to higher life-cycle cost, which can vary somewhat from building to building.

To estimate the investment required to achieve this level of energy savings, we used statewide data from a 2011 study produced for the CPUC. This study estimated that the cost to save energy is $0.70 per annual kWh and $7 per annual therm.[15] According to the firm that authored the study, Harcourt Brown & Carey, these cost estimates are based on “industry rules of thumb, experience and demand-side management data, taking the number of units of energy saved in the first year[iv] and dividing by the total installed cost”.[16]

The current level of savings produced by energy efficiency measures is typically in the range of 20 to 30 percent. The costs to achieve deeper (45 to 60 percent) reductions will be higher than current average efficiency costs. Some cost increases may be offset due to improvements in technology, “learning curve” and economy of scale benefits, and synergistic effects, i.e. more efficient lighting can reduce the required size of an HVAC system; however, even with steady cost reductions, deeper energy retrofits will still cost significantly more than simpler, more superficial energy efficiency measures. Therefore, we assume that costs will double from the

[iv] The energy savings multiply year after year, but the cost estimate is based on the annual kWh savings, rather than the total accumulated savings over the life of the measure installed.

Harcourt Brown & Carey estimates, yielding our assumption of a $1.40 per annual kWh and $14 per annual therm average cost for deep whole building retrofits.[17]

D. Estimated Required Investment in SoCalREN MUSH Energy Efficiency

The SoCalREN MUSH buildings annually consume approximately 13 billion kWh and about 380 million therms. Using a $1.40 per annual kWh and $14 per annual therm cost estimate, achieving 45 to 60 percent energy savings would require a $10.6 to 14.1 billion investment.

An Alternate Estimate: Cost per Square Foot for Deep Energy Savings

Cost data for deep whole building commercial retrofits is often collected and calculated per square foot rather than per kWh or therm, so we checked the above assumptions using data from case studies of actual deep building retrofits. A series of case studies produced by the Rocky Mountain Institute[18] and the New Buildings Institute[19] collected cost data for a number of commercial buildings in the U.S. that have undergone deep energy retrofits or more comprehensive renovations. They collected actual data on cost per square foot of energy retrofits and comprehensive renovations and reported the total energy reductions as percent savings relative to a baseline. We aggregated data from these case studies to determine average costs for retrofits and renovations per square foot. The average cost for retrofits was $13.41 per square foot with average energy savings of 58 percent (see Table 1), while the average cost for comprehensive renovations was $148.30 per square foot yielding average energy savings of 60 percent above baseline (see Table 2).

Table 1. Average Cost per Square Foot for Commercial Energy Efficiency Retrofits

Case Study	Cost per Square Foot	Percent Energy Savings
The Aventine, California	$3.20	75%
1525 Wilson, Virginia	$3.50	43%
Alliance Center, Colorado	$4.42	55%
Retail Franchise (Pilot Retrofit #2), USA	$5.00	44%
Retail Franchise (Pilot Retrofit #1), USA	$7.00	72%
Indianapolis City-County, Indiana	$11.17	46%
Johnson Braund, Washington	$31.00	69%
Empire State Building, New York	$42.00	58%
	AVERAGE: $13.41	**AVERAGE: 58%**

Table 2. Average Cost per Square Foot for Commercial Major Renovations

Case Study	Cost per Square Foot (including Deep Energy Efficiency)	Percent Energy Savings
Beardmore, Idaho	$105.50	66%
Lovejoy, Oregon	$115.00	67%
Home On The Range, Montana	$169.00	72%
Empire State Building, New York	$203.70	38%
	AVERAGE: $148.30	**AVERAGE: 60%**

MUSH Building Floor Area (Square Footage)

Absent regional or California-specific data on the distribution of commercial floor space by building type,[20] we used national data. Government-owned buildings occupy 24 percent of commercial floor area in the U.S. So as not to double count public schools and hospitals, we add private/non-profit schools and hospitals to this figure, as we did for the energy consumption calculation above. Education facilities (including universities) represent 14 percent of commercial floor area, and hospitals (including outpatient facilities) seven percent.[21] Again assuming that eight to 10 percent of schools are private/non-profit (0.14 x 0.09 = 0.01) and 81 percent of health care facilities are private/non-profit (0.07 x 0.81 = 0.06), we add those buildings to the government-owned and estimate that MUSH buildings represent 31 percent of the total commercial floor area in the U.S. We assume that MUSH buildings in the SoCalREN region account for the same proportion of the region's commercial floor area. Commercial buildings in the SoCalREN territory represent 2700 million square feet,[22] so MUSH buildings occupy roughly 837 million square feet.

Estimated Required Investment in SoCalREN MUSH Energy Efficiency (using building floor area)

Based on cost data from the above-mentioned case studies, the energy efficiency costs would range between $11.2 billion (retrofit only of all 837 million square feet of SoCalREN MUSH buildings) and $124.1 billion (comprehensive, state-of-the-art renovations of all 837 million square feet). Since, for many aging buildings a renovation will result in more value for the building owner than an energy retrofit, we assume that some of the SoCalREN buildings will invest in a comprehensive renovation. This would require substantially higher levels of investment and generate more jobs. The energy efficiency retrofit estimated cost of $11.2 billion is within the range of our estimate of $10.6 to $14.1 billion calculated using a cost per kWh figure.

E. On-Site Solar PV

Although there are several options for distributed generation for commercial buildings, we assume the remaining 40 to 55 percent of energy consumed by MUSH sector buildings in the SoCalREN territory will be generated by on-site solar PV systems.[v] Solar PV is the lowest cost and most common way for most buildings to get to ZNE after all cost-effective energy improvements are made.[23] We also assume that all SoCalREN MUSH buildings can get to ZNE.[vi]

In order to achieve ZNE, we estimate that the SoCalREN MUSH sector would need to offset its remaining 7.15 billion kWh and 209 million therms with renewable generation. To calculate energy generation requirements, we convert therms for gas use to kWh, so that solar production will offset remaining gas use. The total annual kWh required by distributed generation to offset both electric and gas use is 9.6 to 13.2 billion kWh. For the Los Angeles area with an average of 5.62 sun hours per day, between 4,695 and 6,456 MW (AC) of on-site solar PV will be needed, depending on the level of energy reductions achieved. Based on the assumptions described below, we estimate this will cost between $21.4 billion and $29.4 billion. (See Appendix 1 for a more detailed documentation of the investment calculation).

Solar PV systems installed on-site can range in size from a few kW for small buildings to hundreds of kW or a few MW for large buildings, depending on the energy needs and footprint of the building or site. MUSH buildings will require a range of different-sized systems since the building stock includes both small buildings, such as offices and libraries, and large buildings, such as high rise office buildings and hospitals. Costs will vary by project, and larger projects cost less per watt, on average, than smaller projects. For example, in the SoCalREN territory, since 2007 the average cost of commercial solar PV systems greater than one MW were almost 40 percent less per watt than systems less than 20 kW.[24]

To estimate investment costs, we use the average cost of installed commercial (government and non-profit) solar PV systems for the SoCalREN/SCE territory since 2013. This average cost is $4.56 per watt (connected AC) for systems of all sizes.[25]

[v] Even though hospitals cannot get to ZNE, we do not exclude them here.

[vi] We know this assumption is not true based on the feasibility studies cited in this brief. Hospitals, even with rooftop and parking lot PV, are unlikely to get to ZNE, and limited parking in urban areas may pose challenges for large office buildings trying to get to ZNE as well. However, since the purpose of this brief is to estimate the investment required and jobs that investment might generate, we assume that all buildings can get to ZNE equivalency, even if some of their generation capacity is met through community distributed generation.

The average cost to install solar PV has fallen consistently over time. For example, the average installed costs for the same types of commercial projects in the SoCalREN/SCE territory have fallen by an average of 13.6 percent per year every year since 2007.[26] Historical data indicates that installed price declines in recent years are primarily due to falling prices for solar PV modules, which have declined at a faster rate than non-module costs such as labor, permits, and overhead.[27] The California ZNE technical feasibility report[28] cites data from the U.S. Department of Energy, showing that the price of PV module manufacturing was reduced by 20 percent for every doubling of total installed PV volume since the 1970s. The report also points out that construction sector productivity has remained largely flat over the past 40 years.[29] We conclude that even as the costs of solar continue to decline, the related construction jobs will hold relatively steady.[30] In this analysis, we used a jobs per million dollar investment calculation based on data from the last several years, but as the price of solar continues to decline, a jobs per MW calculation may be more accurate and stable over time.

Solar PV costs tend to be higher for tax-exempt customers, i.e. government and non-profit buildings, potentially due to factors such as prevailing wage requirements, preferences for domestically manufactured components, and more complex government procurement processes.[31] Since 2007, in the SoCalREN territory, commercial-scale solar installed costs averaged about $0.80 per watt higher for government customers and $0.35 per watt higher for non-profit customers compared to similar-sized commercial (for-profit) systems, roughly equivalent to six and 13 percent price premiums.[32] Furthermore, these tax-exempt entities do not qualify for the 30 percent federal business energy investment tax credit, making the out-of-pocket costs higher for governments and non-profits. Even so, 44 percent of the 168 MW of commercial solar PV installed in the SoCalREN territory since 2007 has been on government and non-profit buildings.[33]

Although the scale of solar PV generation required to get to ZNE on existing MUSH sector buildings is dramatic, it is also feasible. Local governments and researchers have already begun to evaluate solar potential within the SoCalREN territory. Los Angeles County developed a solar map detailing solar potential for every roof throughout the county and used the map to calculate the solar rooftop and solar “parking lot” potential across the entire County and for County-owned facilities.[34] The solar map was used by the UCLA Luskin Center for Innovation to identify solar rooftop potential by sub region throughout Los Angeles County, and found 19,000 MW of potential.[35] The solar map uses Los Angeles County Assessor parcel information so MUSH buildings can be screened and individually evaluated for solar potential.

F. Total Estimated Investment

Using the inputs described above, we estimate that the combined cost for energy efficiency and on-site solar PV to achieve ZNE in SoCalREN MUSH buildings will range between $35.5 billion to $40 billion. (See Table 3 for a summary of investment estimates and Appendix 1 for more detailed documentation of the investment calculation). The lower scenario ($35.5 billion) assumes that energy efficiency measures reduce energy use by 60 percent and the remaining 40 percent of energy demand is supplied by on-site solar PV systems. The higher scenario ($40 billion) assumes that energy efficiency measures reduce energy use by 45 percent and on-site solar PV installed generates the remaining 55 percent of energy demand.

Table 3. Summary of ZNE Investment Estimates

ENERGY EFFICIENCY	
Scenario 1	
Investment required to achieve 60% energy reduction @$1.40/kWh OR @$14/therm (2x cost estimates from Harcourt Brown & Carey)	**$14,094,892,025**
Scenario 2	
Investment required to achieve 45% energy reduction @$1.40/kWh OR @$14/therm (2x cost estimates from Harcourt Brown & Carey)	**$10,571,169,019**
ON-SITE SOLAR PV	
Scenario 1	
Investment required to generate remaining 40% of MUSH building energy needs @$4.56/W (source: California Solar Statistics; averaged from 2013-2014 data current as of Nov. 12, 2014)	**$21,410,967,640**
Scenario 2	
Investment required to generate remaining 55% of MUSH building energy needs @$4.56/W (source: California Solar Statistics; averaged from 2013-2014 data current as of Nov. 12, 2014)	**$29,440,080,505**
TOTAL INVESTMENT	
Scenario 1: ZNE achieved through 60% energy efficiency and 40% on-site solar PV	**$35,505,859,665**
Scenario 2: ZNE achieved through 45% energy efficiency and 55% on-site solar PV	**$40,011,249,524**

To assess the validity of our assumptions and calculations, we checked our cost figures with those used in the California ZNE technical feasibility study.[36] This study developed preliminary estimates of the incremental cost of getting new construction from code compliance to ZNE. The study estimated the costs of different efficiency features to bring a new building from baseline to exemplar (ZNE-ready) status for a number of different building types and climate zones, drawing on data from a variety of sources. Although the purpose of this study evaluated the technical feasibility of ZNE in new construction rather than retrofits, their cost figures provide a useful comparison. The authors average cost figure per square foot for MUSH-related buildings (offices, hospitals, schools, universities, etc.) in California Climate Zone 10 was roughly $34. Assuming the retrofit costs for existing MUSH buildings are similar, achieving ZNE for SoCalREN MUSH sector would cost $32.5 billion through a combination of efficiency and on-site solar PV. This number is within 10 percent of our estimate.

G. Funding and Financing for ZNE

1. Current Funding for ZNE

Our estimates of the investment needed to fund deep energy efficiency retrofits of $10.6 to $14.1 billion in the SoCalREN MUSH sector indicate the need for substantially higher investments for ZNE than are available from the variety of current ratepayer and other programs.

Table 4 provides examples of current utility, ratepayer-funded energy efficiency investment projections. The majority of these program funds are spent on direct implementation and incentives, with the remaining funds going to administration and marketing. We also include the larger commercial sector and government partnership programs, but only some of this funding is spent directly on MUSH sector buildings.[vii]

Table 4. Examples of SCE and SCG Energy Efficiency (EE) Programs Relevant to MUSH Sector

IOU	Program	2013-14 Total Program Budget (Millions)
SCE	Statewide Commercial EE Program	$171.4
	Institutional & Government Core EE Partnership Program	$21.2
	Energy Leadership Partnership Program	$29.1
	Healthcare EE Program (third-party program)	$3.3
	Cool Schools (third-party program)	$2.2
	School EE Program (third-party program)	$10.7
SCG	Statewide Commercial EE Program	$18.3
	TOTAL	**$256.2**

Source: Southern California Edison. 2013-14 Energy Efficiency Program Implementation Plan. See Exhibit 4A, 4C, and 4D. Southern California Gas Company. 2013-14 Energy Efficiency Program Implementation Plan.

[vii] It is not possible to parse out the percent or actual value of utility programs serving MUSH building owners.

In addition, in recent years, SCE spent $74 million per year to provide California Solar Initiative upfront and performance-based incentives for solar systems installed within SCE service territory.[37] SCE also spent $28 million per year (2007-2014) to help fund the CPUC Self-Generation Incentive Program to support new and emerging distributed energy resources, including both renewable and non-renewable sources, installed on the customer's side of the utility meter.[38] These were total investments for all customer types, not only MUSH. While these are just two examples of SCE programs to help incentivize distributed generation projects, these investments totaling $102 million indicate the small scale of current funding. Our estimates that a range of $21.4 to $29.4 billion is needed to fund the installation of on-site solar PV systems for MUSH sector buildings in the SoCalREN region suggests that the gap between current investments and anticipated costs is even larger for distributed generation than the already large gap in funding for energy efficiency.

In addition to ratepayer funds, Proposition 39 provides up to $2.5 billion for all of California over five years with specified funding allocated annually to public K-12 school districts and community colleges. We estimate that schools in the SoCalREN territory received roughly $150 million during the first two years of program allocations.[viii] Another potential funding source for MUSH sector projects is the auction revenues from the state's cap and trade program, expected to generate billions of dollars over time for investments to reduce greenhouse gas emissions. Thus far, very few of these funds have been allocated to the MUSH sector.[ix]

Although these are important current or potential sources of funding, they are insufficient to meet or exceed state goals. There are a variety of ways the state can encourage more MUSH sector investments, including redirecting current ratepayer, cap and trade, or other funding sources, and/or making new public investments, or financing programs, as discussed below.

2. Financing for Energy Efficiency

Financing has been identified as a way to meet California's long-standing commitment to energy efficiency as the primary resource in the utilities' energy procurement loading order. Harcourt Brown & Carey was hired by the CPUC to evaluate the role of energy efficiency financing to help achieve levels of energy efficiency implementation consistent with California's goals. Harcourt Brown & Carey calculated that this would require a capital investment of approximately $4 billion per year but that current levels of energy efficiency investment in

[viii] To date, statewide allocations for public K-12 schools total $381 million for FY 13-14 and $279 million for FY 14-15. Community colleges received $47 million for FY 13-14 and $37.5 million for FY 14-15.

[ix] The state allocated $20 million from the Greenhouse Gas Reduction Fund (i.e. cap and trade auction proceeds) in the FY 14-15 for energy efficiency retrofits of public buildings.

California are approximately one-half that amount.[39] They concluded that "the rate of adoption of energy efficiency technologies and the capital to finance that up-take, must increase for California to achieve its goals. Along with other market solution mechanisms, appropriate cost-effective financing for energy efficiency can play a significant role in achieving these investment goals."[40]

Even if ZNE was achieved on all SoCalREN MUSH buildings, this would only represent 20 percent of the state's 2030 goal for 50 percent of commercial buildings to be retrofitted to ZNE. If it will take $35 billion to $40 billion, as we estimate, to meet 20 percent of the state's ZNE retrofit goal, achieving this goal across the entire commercial sector in California will cost $175 billion to $200 billion by 2030, or $11.6 billion to $13.3 billion per year between 2015 and 2030.

It is therefore essential that public agencies adopt energy efficiency financing on a widespread basis. Currently available financing products include: Utility On Bill Financing, Municipal Lease Financing, Energy Service Company (ESCO) financing programs, California Energy Commission Local Government Loans, and the SoCalREN Public Agency Master Lease Financing Program.[41]

VI. Job Creation Potential

This section estimates the number of jobs that would be created if the estimated investments needed to achieve ZNE for all SoCalREN MUSH buildings were made. We first project the direct jobs that would be created in entities that directly implement ZNE investments. We also estimate the number of new construction apprentices that could be hired due to these investments. We then forecast total jobs, including the indirect and induced jobs from the "multiplier effect." Indirect jobs are generated in the supply chain due to the demand for inputs from the direct investment in ZNE projects. Induced jobs are created from the demand for goods and services generated by increases in income from businesses and workers carrying out the ZNE projects. For comparison, we also estimate the number of direct jobs supported by current levels of investment as described in Table 4.

A. Jobs from ZNE Investments: Assumptions Derived from the Research Literature

Job forecasting is not an exact science. We provide a detailed explanation below of our assumptions, data sources, and definitions of terms.

Estimates for direct jobs are considered more reliable than estimates for indirect and induced jobs because they are generally derived from actual data on average jobs per million dollars of investment from federal government data or other large surveys of firms. Moreover, their accuracy can be checked if jobs are tracked during program implementation. Estimates of direct jobs are critical for determining training needs. Forecasts of total jobs including the multiplier effect are less reliable as they model interaction effects in the economy.

For this analysis, we use estimates of direct jobs generated from previous studies as shown in Table 5. The studies estimate the jobs created per one million dollars of investment in energy efficiency or solar PV. These studies use a variety of methodologies and data sources and include investments in a number of different building types. A few of these studies have specific information on the jobs created by investments in large commercial building retrofits.

Job creation is expressed in job-years, defined as one full-time job that lasts for one year – not one permanent job that continues year after year. For funds spent on energy efficiency retrofits, the studies listed in Table 5 suggest a range between 2.5 and 9.9 direct job-years created per one million dollars invested. The estimates for projects carried out by ESCOs indicate the smallest number of jobs.[x] Including the indirect and induced jobs, these studies suggest a total of 11.0 to 21.3 job-years per million.

Table 5 also provides job estimates for funds spent on solar energy installations, showing 3.0 to 5.4 direct job-years per million dollars invested and 9.9 to 13.7 total job-years, including indirect and induced, created per million.

Many of the studies listed in Table 5 include employment effects averaged across different types of energy efficiency measures and projects. However, employment effects can vary significantly depending on the type, size, age, and maintenance history of a building as well as the type of retrofit or solar installation carried out. A 2011 study from the Political Economy Research Institute identified a range of direct employment effects for different energy efficiency measures in commercial buildings.[42] The study found, for example, that building envelope improvements create 7.7 direct job-years per one million, HVAC retrofits create 5.3 direct job-years per one million, and lighting retrofits create 5.1 direct job years per one million.[43]

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[x] It is not clear whether this is due to the very small sample of interviews from which this data is derived, or because ESCOs obtain greater revenues per worker by capturing revenues from energy savings.

Table 5. Range of Estimated Job-Years Based On Literature Review

Data Source	Sector of Investment	Job-Years (Direct) Per $1 Million	Job-Years (Direct, Indirect & Induced) Per $1 Million
ENERGY EFFICIENCY			
Lawrence Berkeley National Lab (2010)[44]	ESCOs and Associated Building and Construction Industry	2.5	-
Powell Center for Construction and Environment (2007) / Center on Wisconsin Strategy (2009)[45]	Large Commercial Building Retrofit	4.3	-
UC Berkeley Donald Vial Center WE&T Needs Assessment and IMPLAN analysis (2011)[46]	All Investor-Owned Utility (CA) Energy Efficiency Programs	5.1	11.0
Political Economy Research Institute (2011)[47]	Commercial Building Retrofit	5.7	13.6
UC Berkeley Center for Labor Research and Education IMPLAN analysis (2013)[48]	Maintenance and Repair, Non-Residential Construction	6.2	14.3
Lawrence Berkeley National Lab (2010)[49]	Ratepayer-Funded Energy Efficiency Programs	6.2	-
Lawrence Berkeley National Lab (2010)[50]	Public Sector (Federal and State) Energy Efficiency Programs	6.5	-
UCLA Luskin Center for Innovation (2014)[51]	Los Angeles Department of Water and Power Energy Efficiency Programs	-	16.0
Political Economy Research Institute / Center for American Progress (2009)[52]	Energy Efficiency Building Retrofit	7.0	16.7
Booz Allen Hamilton / U.S. Green Building Council (2012)[53]	New Nonresidential Commercial and Health Care Structures	7.9	19.2
Booz Allen Hamilton / U.S. Green Building Council (2012)[54]	Maintenance and Repair Construction of Nonresidential Structures	9.9	21.3
American Council for an Energy-Efficient Economy (2011)[55]	Energy Efficiency Building Retrofit	-	20.3
SOLAR ENERGY			
UC Berkeley Donald Vial Center WE&T Needs Assessment and IMPLAN analysis (2011)[56]	California Solar Initiative[57]	3.0	9.9
Political Economy Research Institute / Center for American Progress (2009)[58]	Solar Energy	5.4	13.7

B. Job Projections for Estimated ZNE Investments in SoCalREN MUSH Sector

This section documents our range of jobs projections for energy efficiency and on-site solar PV to achieve ZNE in MUSH sector buildings in the SoCalREN territory. We analyzed two scenarios for achieving ZNE in SoCalREN MUSH sector buildings through a combination of energy efficiency retrofits and the installation of on-site solar PV systems.

Scenario 1 includes deep levels of energy efficiency to reduce energy use in MUSH sector buildings by 60 percent (requiring an investment of $14.1 billion) and on-site solar PV systems installed to generate the remaining 40 percent of energy demand (requiring an investment of $21.4 billion) at a total cost of $35.5 billion.

Scenario 2 is comprised of energy efficiency measures to reduce energy use in MUSH sector buildings by 45 percent ($10.6 billion) and on-site solar PV systems installed to generate the remaining 55 percent of energy demand ($29.4 billion) at a total cost of $40 billion.

We derive the job projections in Table 6 using a rule of thumb, based on our review of the existing literature summarized in Table 5. We estimate that 6.2 job-years are created per one million spent on energy efficiency retrofit work and 4.2 direct job-years are created per one million spent to install on-site solar PV systems. We then use a multiplier of 2.3 for energy efficiency projects and 2.9 for on-site solar to estimate the total jobs impact, including indirect and induced jobs, based on our review of studies that use IMPLAN and/or JEDI economic multiplier models[xi].[59]

[xi] These are gross job projections, i.e. they do not subtract out jobs that would otherwise be created from power sold by the utilities. Estimating net jobs is difficult for a variety of reasons, including because jobs in the traditional power sector may or may not be located in the SoCalREN region. Studies show that energy efficiency and distributed solar generation are more labor-intensive than power plant generation, so we believe there is positive net job creation but since we cannot quantify it, we only report gross job creation here.

Table 6. Job-Years Created by Potential ZNE Investments

Investment Type	Total Investment (Billions)	Total Job-Years (Direct, Indirect & Induced)	Direct Job-Years	Construction Job-Years	Apprentice Job-Years	First-Year Apprentice Job-Years
Energy Efficiency (6.2 direct job-years per million; multiplier = 2.3)						
Scenario 1	$14.1	201,066	87,420	58,280	9,908	2,477
Scenario 2	$10.6	151,156	65,720	43,813	7,448	1,862
On-Site Solar PV (4.2 direct job-years per million; multiplier = 2.9)						
Scenario 1	$21.4	260,652	89,880	59,920	10,186	2,547
Scenario 2	$29.4	358,092	123,480	82,320	13,994	3,499
Combined Total Investment						
Scenario 1	**$35.5**	**461,718**	**177,300**	**118,200**	**20,094**	**5,024**
Scenario 2	**$40.0**	**509,248**	**189,200**	**126,133**	**21,443**	**5,361**

The jobs estimates summarized in Table 6 vary based on the level of energy efficiency reductions to achieve ZNE in SoCalREN MUSH sector buildings. We estimate that energy efficiency retrofits combined with the installation of on-site solar PV systems will create between 177,300 and 189,200 direct job-years based on 60 percent and 45 percent energy reduction, respectively. Both types of investments will produce jobs located within the SoCalREN territory that will be geographically accessible to Southern California workers.

In Scenario 1, energy efficiency measures to reduce energy use in MUSH sector buildings by 60 percent would create 87,420 direct job-years. The installation of on-site solar PV systems to generate the remaining 40 percent of energy demand would create 89,880 direct job-years.

In Scenario 2, energy efficiency measures to reduce energy use in MUSH sector buildings by 45 percent would create 65,720 direct job-years. The installation of on-site solar PV systems to generate the remaining 55 percent of energy demand would create 123,480 direct job-years.

Our analysis shows that getting to ZNE through deeper energy efficiency retrofits is more cost effective and creates more jobs per one million invested. Scenario 2 will create more direct job-years (189,200) but costs nearly $5 billion more compared to Scenario 1 (177,300 direct job-years). Energy efficiency retrofits create more direct job-years per million (6.2) compared to the installation of on-site solar PV (4.2 direct job-years per million) so Scenario 1 (60 percent energy reduction) is more cost effective because it includes deeper levels of energy efficiency compared to Scenario 2 (45 percent energy reduction).

We forecast that between 461,718 (Scenario 1) and 509,248 (Scenario 2) total job-years would be created in the SoCalREN region if all MUSH sector buildings were retrofitted to ZNE, including the indirect and induced jobs, based on 60 percent and 45 percent energy reduction, respectively.

It is useful to consider a range of years over which projects will be completed to further understand the real-world job impacts of these investments, since one job-year equals one full-time job that lasts for one year. Tables 7 through 9 present annual job projections for ZNE investments spread out over five, 10, and 15 years, respectively. If the 177,300 to 189,200 direct job-years created by energy efficiency retrofits combined with the installation of on-site solar PV were completed over a five-year period, this would equal between 35,460 (Scenario 1) and 37,840 (Scenario 2) direct full-time jobs annually for five years. If total direct job-years were instead spread across 10 years, ZNE investments would create between 17,730 (Scenario 1) and 18,920 (Scenario 2) direct full-time jobs. If total direct job-years were spread across 15 years, ZNE investments would create between 11,820 (Scenario 1) and 12,613 (Scenario 2) direct full-time jobs in the SoCalREN region.

The 15-year investment period aligns with California's goal for 50 percent of existing commercial buildings to achieve ZNE by 2030. Achieving ZNE on all SoCalREN MUSH buildings would represent roughly 23 percent of the state's goal.[xii] If we extrapolated these figures to estimate the jobs generated from the investment necessary to achieve the state's ZNE goal for half of existing commercial buildings, we would see over 55,000 people directly employed for 15 years in full-time clean energy jobs.

[xii] We estimate that half of the commercial floor area in California covers 3.65 billion square feet. SoCalREN MUSH covers about 837 million square feet, which is 22.9 percent of the state's ZNE goal for existing buildings.

Table 7. Annual Job Projections for ZNE Investments (5-Year Time Period)

Investment Type	Annual Investment (Billions)	Total Jobs (Direct, Indirect & Induced)	Direct Jobs	Construction Jobs	Apprentice Jobs	First-Year Apprentice Jobs
Energy Efficiency (6.2 direct job-years per million; multiplier = 2.3)						
Scenario 1	$2.8	40,213	17,484	11,656	1,982	495
Scenario 2	$2.1	30,231	13,144	8,763	1,490	372
On-Site Solar PV (4.2 direct job-years per million; multiplier = 2.9)						
Scenario 1	$4.3	52,130	17,976	11,984	2,037	509
Scenario 2	$5.9	71,618	24,696	16,464	2,799	700
Combined Total Investment						
Scenario 1	**$7.1**	**92,344**	**35,460**	**23,640**	**4,019**	**1,005**
Scenario 2	**$8.0**	**101,850**	**37,840**	**25,227**	**4,289**	**1,072**

Table 8. Annual Job Projections for ZNE Investments (10-Year Time Period)

Investment Type	Annual Investment (Billions)	Total Jobs (Direct, Indirect & Induced)	Direct Jobs	Construction Jobs	Apprentice Jobs	First-Year Apprentice Jobs
Energy Efficiency (6.2 direct job-years per million; multiplier = 2.3)						
Scenario 1	$1.4	20,107	8,742	5,828	991	248
Scenario 2	$1.1	15,116	6,572	4,381	745	186
On-Site Solar PV (4.2 direct job-years per million; multiplier = 2.9)						
Scenario 1	$2.1	26,065	8,988	5,992	1,019	255
Scenario 2	$2.9	35,809	12,348	8,232	1,399	350
Combined Total Investment						
Scenario 1	**$3.6**	**46,172**	**17,730**	**11,820**	**2,009**	**502**
Scenario 2	**$4.0**	**50,925**	**18,920**	**12,613**	**2,144**	**536**

Table 9. Annual Job Projections for ZNE Investments (15-Year Time Period)

Investment Type	Annual Investment (Billions)	Total Jobs (Direct, Indirect & Induced)	Direct Jobs	Construction Jobs	Apprentice Jobs	First-Year Apprentice Jobs
Energy Efficiency (6.2 direct job-years per million; multiplier = 2.3)						
Scenario 1	$0.9	13,404	5,828	3,885	661	165
Scenario 2	$0.7	10,077	4,381	2,921	497	124
On-Site Solar PV (4.2 direct job-years per million; multiplier = 2.9)						
Scenario 1	$1.4	17,377	5,992	3,995	679	170
Scenario 2	$2.0	23,873	8,232	5,488	933	233
Combined Total Investment						
Scenario 1	**$2.4**	**30,781**	**11,820**	**7,880**	**1,340**	**335**
Scenario 2	**$2.7**	**33,950**	**12,613**	**8,409**	**1,430**	**357**

C. Opportunities for Unskilled and Disadvantaged Job Seekers: Apprentice Openings

Not all of the new jobs created by ZNE investments are accessible to unskilled job seekers, including disadvantaged workers, since many of the jobs require specific skills and experience. To assess where entry points for trainees and disadvantaged workers will be available, it is critical to understand the occupational distribution of jobs from these investments. Using our occupational analysis from the 2011 *California Workforce Education and Training (WE&T) Needs Assessment for Energy Efficiency, Distributed Generation, and Demand Response*, we estimate that about two-thirds of the direct jobs on SoCalREN MUSH energy efficiency and on-site solar projects will be in traditional construction trades occupations, one-sixth will be in professional and managerial occupations associated with the building and construction industries (such as architects, engineers, project managers and contractors), and one-sixth will be in a variety of supportive occupations such as administrative personnel.[60] Only two percent of the jobs will be in specialized energy efficiency occupations, such as energy auditor.[61]

Construction trades jobs are perceived as accessible entry points for disadvantaged workers because they do not require a college degree but can provide, at least in the unionized sector, a career-track, middle-class job, and paid training through the earn-while-you learn apprenticeship training model. Entry into public works and most career-track construction jobs occurs through acceptance into an apprenticeship program.

We estimate that ZNE projects in SoCalREN MUSH buildings will create roughly 5,000 construction job-years for first-year apprentices, as shown in Table 6. This is based on our estimate that between 177,300 to 189,200 direct job-years will be created in businesses hired to complete energy efficiency projects and install on-site solar PV systems, and that two-thirds of the direct jobs will be in the construction trades. In any occupation, new hires of workers at the beginning of their career are always a small percentage of the total number of workers working in the occupation at any point in time. In public works construction, the percentage of new hires is largely determined by the California Labor Code which requires at least one hour of apprentice work for every five hours of journey-level work on any project with public funding where the contract totals $30,000 or more.[62] Therefore, we estimate that the construction workforce for SoCalREN MUSH projects will be comprised of at least 17 percent apprentice hours, translating into roughly 20,094 to 21,443 apprentice job-years. Between roughly 5,024 and 5,361 apprentice job-years would be completed by first-year apprentices, assuming that apprenticeship programs average four years and that there is an even distribution of first-year through fourth-year apprentices for these projects.

However, as Tables 7 through 9 illustrate, the number of annual apprentice openings created by new investments depends on the time period over which projects are completed. If ZNE investments were spent over a five-year period, this would produce between 4,019 and 4,289 annual apprentice openings in the SoCalREN region. If investments were instead spent over 10 years, the number of annual apprentice openings would decrease to between 2,009 and 2,144 openings. Investments spread across 15 years would create between 1,340 and 1,430 annual apprentice openings in the SoCalREN region. While the overall number of one-year apprentice slots remains the same, the time period for investment impacts the distribution of annual apprentice openings in a given year.

D. Jobs Generated from Current SCE and SCG Investments

In order to compare jobs generated by current levels of investment and the levels of investment needed to reach ZNE in the MUSH sector, we estimate that current SCE and SCG commercial sector energy efficiency investments create roughly 1,580 direct job-years, which are equivalent to 790 direct jobs per year for two years. We derive this estimate by applying the average of 6.2 job-years created per one million spent on energy efficiency retrofits to the combined $256 million allocated by SCE and SCG for commercial sector energy efficiency programs over the 2013-14 two-year program cycle (see Table 4).[xiii] Since the commercial

[xiii] Current investments fund different types of energy efficiency measures. Findings from a 2011 Political Economy Research Institute study suggest that deeper retrofits that include HVAC and building envelope improvements will

programs encompass more than just the MUSH sector, current job creation for MUSH investments is smaller.

Investments to achieve ZNE in SoCalREN MUSH sector buildings will create significantly more direct job-years compared to current SCE and SCG investments. The estimated 1,580 direct job-years created by current energy efficiency investments pales in comparison to our estimate that energy efficiency and on-site solar PV investments to achieve ZNE will create between 177,300 and 189,200 direct job-years in the SoCalREN region, including between 65,720 and 87,420 direct job-years for energy efficiency alone.

Table 10. Annual Job Projections for Current SCE and SCG Investments

Investment Type	Average Annual Allocation for FY 13-14 (Millions)	Direct Job-Years	Construction Job-Years	Apprentice Job-Years	First-Year Apprentice Job-Years
SCE & SCG Commercial & MUSH Sector Energy Efficiency Programs	$128	794	529	90	22

We calculate the job estimates in Table 10 by applying the average of 6.2 job-years created per one million spent on energy efficiency retrofits and other assumptions previously described. We estimate that current SCE and SCG energy efficiency investments will create roughly 22 annual openings for first-year apprentices over the two-year period. Investments to achieve ZNE in SoCalREN MUSH sector buildings will create many more opportunities for first-year apprentices, between roughly 300 and 1,000 annual openings depending on the time period for investment (see Tables 7 through 9).

VII. Conclusion

Our analysis of ZNE potential for SoCalREN MUSH sector buildings identifies a large gap between investment needs and current funding streams for energy retrofits to MUSH sector buildings. Significantly higher levels of investment are needed to help achieve ZNE in MUSH buildings in the SoCalREN territory. This is also reflected in the job creation numbers: the jobs generated by current investments pale in comparison with the job creation potential of making the investments needed to achieve ZNE in the SoCalREN MUSH sector.

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create more job-years per million compared to projects that consist of mostly lighting measures. See Garrett-Peltier, H. (2011).

This brief presented two scenarios for achieving ZNE in all SoCalREN MUSH sector buildings through a combination of energy efficiency retrofits and on-site solar PV systems. We estimate that energy efficiency measures to reduce energy use in MUSH sector buildings by 60 percent combined with on-site solar PV systems installed to generate the remaining 40 percent of energy demand (Scenario 1) would cost $35.5 billion. Energy efficiency measures to reduce MUSH building energy use by 45 percent and on-site solar PV installed to generate the remaining 55 percent of energy demand (Scenario 2) would cost an estimated $40 billion.

Our analysis shows that getting to ZNE through deeper energy efficiency retrofits (Scenario 1) is more cost-effective and creates more jobs per million dollar investment. Getting to ZNE through a greater reliance on solar generation (Scenario 2) will create more direct job-years (189,200) but costs nearly $5 billion more than Scenario 1 (177,300 direct job-years). Energy efficiency retrofits create more direct job-years per million (6.2) compared to the installation of on-site solar PV (4.2 direct job-years per million) so Scenario 1 (60 percent energy reduction) is more cost effective because it includes deeper levels of energy efficiency compared to Scenario 2 (45 percent energy reduction).

Construction trades jobs will account for two-thirds of the direct job-years created by ZNE investments and offer entry points for new workers through acceptance into an apprenticeship program. The number of annual construction apprentice openings created by new investments will depend on the time period over which projects are completed, ranging from roughly 1,000 annual apprentice openings for a 15-year investment period to around 4,000 annual apprentice openings in the SoCalREN region for a five-year investment period.

Investments to achieve ZNE in SoCalREN MUSH sector buildings will create significant job and training opportunities for Southern California workers while helping the state meet its energy efficiency and clean distributed generation goals.

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[17] This dollar per kWh figure is in line with recent data provided to Los Angeles County by the Energy Coalition which calculated an average construction cost factor of $1.35 per kWh of savings for potential public agency energy efficiency projects in the combined SCE and SCG territory. The Energy Coalition cost estimates pertained only to the electric sector as they did not yet have sufficient data to estimate gas project costs.

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[20] This type of data can be determined from information collected by a real estate data company such as CoStar.

[21] D&R International, Ltd. p. 113.

[22] California Energy Commission. (2009, December). *California Energy Demand 2010-2020 Adopted Forecast* http://www.energy.ca.gov/2009publications/CEC-200-2009-012/CEC-200-2009-012-CMF.PDF. See p. 99, Figure 60.

[23] Heschong Mahone Group, Inc. (2012, December 20). *The Road to ZNE: Mapping Pathways to ZNE Buildings in California*. Prepared for Pacific Gas & Electric Company. http://www.cpuc.ca.gov/NR/rdonlyres/0474B6C9-2288-4EA0-B3B1-83ECBD4C70A4/0/TheRoadtoZNEReport.pdf. p. 13.

[24] California Energy Commission and California Public Utilities Commission. *California Solar Statistics*. Calculated from data current as of November 12, 2014. http://www.californiasolarstatistics.ca.gov/reports/quarterly_cost_per_watt/.

[25] Same as previous endnote.

[26] Same as previous endnote.

[27] Barbose, G. et al. (2013, July). *Tracking the Sun VI: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012*. Lawrence Berkeley National Laboratory and U.S. Department of Energy. http://emp.lbl.gov/publications/tracking-sun-vi-historical-summary-installed-price-photovoltaics-united-states-1998-201. For more information about the California Solar Initiative, see http://www.gosolarcalifornia.ca.gov/about/csi.php. p. 14-15.

[28] Arup. p. 34.

[29] Arup. p. 35.

[30] Barbose et al. p. 16.

[31] Barbose et al. p. 33-34.

[32] California Energy Commission and California Public Utilities Commission. *California Solar Statistics*. Calculated from data current as of November 12, 2014. http://www.californiasolarstatistics.ca.gov/reports/quarterly_cost_per_watt/.

[33] Same as previous endnote.

[34] LA County Solar Map and Green Planning Tool available at: http://solarmap.lacounty.gov/.

[35] DeShazo, J.R. et al. (2014, July). *Los Angeles Solar and Efficiency Report (LASER): An Atlas of Investment Potential for LA County Version 2.0*. UCLA Luskin Center for Innovation. Commissioned by Environmental Defense Fund. http://innovation.luskin.ucla.edu/content/profile-clean-energy-investment-potential. p. 8.

[36] Arup. p. 97, 102, 146, 159.

[37] California Public Utilities Commission (2014, February). *Report to the Legislature in Compliance with Public Utilities Code Section 910.* Retrieved from: http://www.cpuc.ca.gov/NR/rdonlyres/428F0F2F-1275-4441-9FAE-EC690AAF57AC/0/Section910Report_2014_FINAL.pdf. p. 21-23.

[38] Same as previous endnote. For more information about the Self-Generation Incentive Program, see http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/.

[39] Harcourt Brown & Carey, Inc. p. 4 and Appendix C.

[40] Harcourt Brown & Carey, Inc. p. 4.

[41] Email communication with Howard Choy, General Manager, Office of Sustainability, County of Los Angeles (2014, October 17).
[42] Garrett-Peltier, H. (2011, June). *Employment Estimates for Energy Efficiency Retrofits of Commercial Buildings*. Political Economy Research Institute, University of Massachusetts, Amherst. http://www.peri.umass.edu/236/hash/294809398e497bee9c8abe6ac7df2bdc/publication/466/. p. 2.
[43] Same as previous endnote.
[44] Goldman, C. et al. (2010, September). *Energy Efficiency Services Sector: Workforce Size and Expectations for Growth.* Ernesto Orlando Lawrence Berkeley National Laboratory. http://emp.lbl.gov/sites/all/files/REPORT%20bnl-3987e.pdf. p. 55- 58. ESCO workforce information is based on interviews with nine ESCOs. It reports only direct employment effects, and does not include a multiplier for indirect or induced jobs.
[45] Kibert, C. & Fobair, R. (2007, August). *Assessing the Job Creation Potential of Energy Conservation Investments: A Research Study for the Center on Wisconsin Strategy*. Powell Center for Construction and Environment, University of Florida. Cited in: Sundquist, E. (2009, April). *Estimating Jobs From Building Energy Efficiency.* Madison, WI: Center on Wisconsin Strategy, University of Wisconsin-Madison. http://www.cows.org/estimating-jobs-from-building-energy-efficiency. This study developed a model to predict the number of jobs created by an investment in energy conservation. It uses an investment of $1 million as the base model and deconstructs this investment into the number of jobs likely to be created in the installation phase and the manufacturing phase. Detailed methodology is explained on p. 11 and p. 20-27.
[46] Zabin, C. et al. (2011). *California Workforce Education and Training Needs Assessment for Energy Efficiency, Demand Response, and Distributed Generation*. University of California, Berkeley. Job estimates reported here are derived from estimates of jobs per million of the industry mix from IOU energy efficiency investments reported in Appendix D. http://www.irle.berkeley.edu/vial/publications/WET_Part1.pdf. See Chapter 3 and Appendix D. Calculations were performed by Bill Lester, University of North Carolina and used IMPLAN 3.0 (2010 California data).
[47] Garrett-Peltier, H. (2011, June). *Employment Estimates for Energy Efficiency Retrofits of Commercial Buildings*. Political Economy Research Institute, University of Massachusetts, Amherst. http://www.peri.umass.edu/236/hash/294809398e497bee9c8abe6ac7df2bdc/publication/466/. This study uses an input-output model (IMPLAN version 3 with 2009 U.S. Department of Commerce, Bureau of Economic Analysis data and other sources) to estimate job creation. Detailed methodology is described on p. 1.
[48] UC Berkeley Center for Labor Research and Education analysis of IMPLAN 3.0 (2010 California data) conducted by Laurel Lucia.
[49] Goldman et al. (2010), p. 24, 51-55, 58. Workforce data for ratepayer-funded energy efficiency programs is based on interviews with program administrators and implementers, program evaluations, and other sources.
[50] Goldman et al. (2010), p. 25, 51, 58. Workforce data for government energy efficiency programs is based on FY 2010 federal budget appropriations and employment (FTE) for federal and state energy efficiency programs (excluding ARRA investments and the Weatherization Assistance Program) funded through the Department of Energy, Energy Efficiency and Renewable Energy division, along with workforce data for state energy offices from a 2009 study by the National Association of State Energy Officials.
[51] DeShazo, J.R., Turek, A. & Samulon, M. (2014). *Efficiently Energizing Job Creation in Los Angeles*. UCLA Luskin Center for Innovation. Sponsored by the Los Angeles Department of Water and Power. http://innovation.luskin.ucla.edu/content/efficiently-energizing-job-creation-los-angeles. This study uses an input-output model (IMPLAN 3.0 and Los Angeles County data) to estimate job creation for the 18 largest energy efficiency programs administered by the Los Angeles Department of Water and Power. Methodology is described on p. 16-18.

[52] Pollin, R., Heintz, J. & Garrett-Peltier, H. (2009). *The Economic Benefits of Investing in Clean Energy*. Political Economy Research Institute and Center for American Progress. http://www.americanprogress.org/wp-content/uploads/issues/2009/06/pdf/peri_report.pdf. p. 28-29. This study uses an input-output model (IMPLAN 2.0 software and IMPLAN 2007 data set) to estimate job creation. Detailed methodology is described in Appendix 1, p. 50-56.

[53] Booz Allen Hamilton. (2012, January). *Green Jobs Study*. Prepared for the U.S. Green Building Council. http://www.usgbc.org/resources/green-jobs-study. See Exhibit D-1 on p. D-2. This study uses an input-output model (IMPLAN) to estimate job creation. Methodology is described on p. D-1.

[54] Same as previous endnote.

[55] American Council for an Energy-Efficiency Economy. (2011). *Fact Sheet: How Does Energy Efficiency Create Jobs?* http://aceee.org/files/pdf/fact-sheet/ee-job-creation.pdf. ACEEE job estimates are derived from IMPLAN and their in-house Dynamic Energy Efficiency Policy Evaluation Routine (DEEPER) model, explained here: http://aceee.org/fact-sheet/deeper-methodology.

[56] Zabin et al., same as endnote #46 except data is for IOU investments in California Solar Initiative.

[57] The California Solar Initiative is a solar rebate program for customers of California's investor-owned utilities: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E). See http://www.gosolarcalifornia.ca.gov/about/csi.php.

[58] Pollin et al. (2009). p. 28-29.

[59] We use 6.2 direct job-years per million for energy efficiency projects and a 2.3 multiplier to calculate total job-years from our 2013 UC Berkeley Center for Labor Research and Education IMPLAN analysis. We estimate 4.2 direct job-years per million spent on on-site solar energy projects and a 2.9 multiplier to calculate total job-years based on the median average of the two studies listed in the Solar Energy section of Table 2: UC Berkeley Donald Vial Center WE&T Needs Assessment and IMPLAN analysis (2011) and the Political Economy Research Institute / Center for American Progress (2009).

[60] Zabin et al. p. xi-xiii, 71-75. We mapped the distribution of occupations from our analysis of the industries engaged in energy efficiency and distributed generation using the U.S. Bureau of Labor Statistics O NETs database.

[61] Zabin et al. p. xi-xiii, 71-75.

[62] California Labor Code. Division 2, Part 7, Chapter 1, Article 2, Section 1777.5(g).

Appendix: Estimated Investment Required to Achieve ZNE for MUSH Buildings in SoCalREN Territory

	Electric (kWh, unless noted)	Gas (therms, unless noted)	Total
ENERGY CONSUMPTION			
Annual energy consumption for commercial buildings in SCE/SCG territory (source: California Energy Consumpton Database, 2012 data for SCE & SCG)	37,135,757,346	945,529,573	-
Estimated annual energy consumption by SoCalREN MUSH buildings (35% of commercial electric consumption and 40% of commercial gas consumption)	12,997,515,071	378,211,829	-
ENERGY EFFICIENCY			
Scenario 1			
Investment required to achieve 60% energy reduction @$1.40/kWh OR @$14/therm (2x cost estimates from Harcourt Brown & Carey)	$10,917,912,660	$3,176,979,365	**$14,094,892,025**
Scenario 2			
Investment required to achieve 45% energy reduction @$1.40/kWh OR @$14/therm (2x cost estimates from Harcourt Brown & Carey)	$8,188,434,495	$2,382,734,524	**$10,571,169,019**
ON-SITE SOLAR PV			
kWh equivalent for estimated annual energy consumption by SoCalREN MUSH buildings. We assume overproduction of solar energy to offset gas use so we convert therms to kWh (1 therm = 29.3 kWh)	-	11,081,606,596	-
Scenario 1			
MW production required to generate 40% of SoCalREN MUSH annual energy consumption	2,534	2,161	**4,695**
Investment required to generate remaining 40% of MUSH building energy needs @$4.56/W (source: California Solar Statistics; averaged from 2013-2014 data current as of Nov. 12, 2014)	$11,557,289,275	$9,853,678,365	**$21,410,967,640**
Scenario 2			
MW production required to generate 55% SoCalREN MUSH annual energy consumption	3,485	2,971	**6,456**
Investment required to generate remaining 55% of MUSH building energy needs @$4.56/W (source: California Solar Statistics; averaged from 2013-2014 data current as of Nov. 12, 2014)	$15,891,272,753	$13,548,807,752	**$29,440,080,505**
TOTAL INVESTMENT			
Scenario 1: ZNE achieved through 60% energy efficiency and 40% on-site solar PV	$22,475,201,935	$13,030,657,730	**$35,505,859,665**
Scenario 2: ZNE achieved through 45% energy efficiency and 55% on-site solar PV	$24,079,707,248	$15,931,542,276	**$40,011,249,524**

Solar PV array size (MW for connected AC) = (annual kWh usage) / (365 days/year) / (5.62 average solar hours/day in Los Angeles) / 1000 kW

SOURCES:

California Energy Commission. *California Energy Consumption Database.* http://www.ecdms.energy.ca.gov/

California Energy Commission and California Public Utilities Commission. *California Solar Statistics* . http://www.californiasolarstatistics.ca.gov/reports/quarterly_cost_per_watt/

Harcourt Brown & Carey, Inc. (2011, July 8). *Energy Efficiency Financing in California: Needs and Gaps* . Presented to the California Public Utilities Commission, Energy Division. www.caleefinance.com/wp-content/uploads/2014/04/CPUC_FinancingReport_HBC_Jul8v2.pdf