State of California **ITEM 1a.ii** California Natural Resources Agency

M e m o r a n d u m

To: Drew Bohan
Executive Director

Date : August 5, 2019

Telephone: (916) 654-5013

From: **Kristen Driskell**
Deputy Director, Efficiency Division
California Energy Commission -
1516 Ninth Street
Sacramento CA 95814-5512

Subject: **POSSIBLE APPROVAL OF THE CITY OF DAVIS'S LOCAL BUILDING ENERGY STANDARDS: ORDINANCE NO. 2554**

<u>Summary of Item</u>

The California Public Resources Code establishes a process that allows local governmental agencies, such as cities or counties, to adopt and enforce local energy standards that are more stringent than, or equivalent to but different from, the statewide standards. This process, described in Public Resources Code Section 25402.1, Subdivision (h)(2), and the *2019 Energy Code* (Standards) provided in California Code of Regulations, Title 24, Part 1, Chapter 10, Section 10-106, requires local governmental agencies to apply to the California Energy Commission for approval of these local energy standards.

City of Davis Ordinance 2554 specifies three energy related building measures:

- Compliance with CALGreen Tier 1 efficiency levels (10 percent improvement over basic code compliance) as a mandatory requirement for newly constructed nonresidential and high-rise residential buildings;
- Installation of solar photovoltaic systems as a mandatory requirement for newly constructed nonresidential and high-rise residential buildings; and
- Installation of 120-volt electrical sockets under specified sinks in single-family residences "to accommodate the future installation of an on-demand hot water recirculation pump."

The ordinance also specifies two requirements relating to electric vehicles that affect energy used for transportation rather than for the use of the building. These two measures are not before the Energy Commission Commission for approval, however for completeness, these are:

- Installation of electric vehicle charging stations in new nonresidential and highrise residential buildings; and
- Installation of 8-gauge wiring in single-family residences "to support Level 2 electric vehicle charging."

The local governmental agency must submit an application to the Executive Director of the Energy Commission, which must be approved before the local energy standards may be enforced. This application must contain:

1) the proposed energy standards;
2) the local governmental agency's energy-savings and cost-effectiveness findings and supporting analyses;
3) a statement or finding by the local governmental agency that the local energy standards will require buildings to be designed to consume no more energy than permitted by Title 24, Part 6; and
4) a finding or determination required under the California Environmental Quality Act. (Standards, § 10-106.)

In reviewing this application, the Energy Commission must find that the standards will require the reduction of energy consumption levels permitted by the current Standards and that the local governmental agency's governing body, at a public meeting, adopted its determination that the standards are cost effective. (Pub. Resources Code, § 25402.1, subd. (h)(2); Standards, § 10-106.)

Summary of Staff's Application Review

The complete application, including the local ordinance and cost effectiveness analysis, will be made available on the Energy Commission website as part of the back-up materials for the proposed agenda item when presented to the Energy Commission for action. The application will also be posted on the webpage for Local Ordinances Exceeding the *2019 Energy Code* upon Energy Commission approval of the local ordinance. Currently, the submitted application is docketed on the Energy Commission's website under 15-BSTD-03 for a 60-day public comment period, which concluded on August 2, 2019.

Staff reviewed the city of Davis's application for approval of its local energy standards enumerated in Ordinance No. 2554. Staff found that the application contains all of the application components required by Section 10-106, Subdivision (b) of the Standards. Specifically, the city's application contains:

- Proposed energy standards;
- Findings and supported analysis on the energy savings and cost effectiveness of the proposed energy standards;
- Finding that the local energy standards will require buildings to be designed to consume no more energy than permitted by Title 24, Part 6; and
- CEQA determination.

In addition, staff reviewed the application to determine whether the standards will require the reduction of energy consumption levels permitted by the current Standards.

Project Manager

Gabe Taylor, Building Standards Office.

Staff Position

Staff has found that the application meets all requirements under Public Resources Code Section 25402.1, Subd. (h)(2), and Section 10-106 of the Standards. Staff believes that the city should be commended for seeking to achieve the energy savings that result from this local energy ordinance.

The city has been informed that the approved ordinance will be enforceable during the time that the *2019 Energy Code* are effective. If the statewide Standards are subsequently revised or amended (as they are regularly on a three-year cycle), the Ordinances will no longer be enforceable if the revisions create “a substantial change in the factual circumstances affecting the determination”. In such a case, if the city wishes to enforce either these local energy standards or other local energy standards revised in response to the updated statewide Standards, under Public Resources Code Section 25402.1, Subdivision (h)(2), and Section 10-106 of the Standards the city must submit a new application.

Oral Presentation Outline

Staff will be available at the August 14, 2019, business meeting to provide a brief summary if requested and to answer questions.

Business Meeting Participants

Peter Strait and Gabe Taylor, Building Standards Office.

Commission Action Requested

Approval of the City of Davis’s locally adopted energy standards that are more stringent than, or equivalent to, but different from, the *2019 Energy Code.*

DEPARTMENT OF COMMUNITY DEVELOPMENT & SUSTAINABILITY

23 Russell Boulevard, Suite 2 – Davis, California 95616
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Davis California

May 14, 2019

Mr. Drew Bohan
Executive Director
California Energy Commission
1516 Ninth Street, MS-37
Sacramento CA 95817-5512

RE: Application for Locally Adopted Energy Efficiency Standards by the City of Davis in Accordance with Section 10-106 of the California Code of Regulations, Title 24, Part 1.

Dear Mr. Bohan

At the Davis City Council regular meeting on April 9, 2019 the Council conducted a public hearing and approved an ordinance mandating the following:

1. New Nonresidential Buildings. New nonresidential buildings shall comply with the Tier 1 (10% compliance margin) requirement for energy efficiency by employing energy efficiency measures. In addition, a PV system sized to offset a portion of the total building energy use based on TDV energy is required. The PV sizing shall be consistent with the methodology included in the cost effectiveness study provided by TRC. The PV sizing calculations were developed such that PV size would be the lessor of approximately 80% offset of the building's modelled annual electric load or 15 DC watts per sq. ft. of solar zone[1].
2. New High-rise Multifamily Dwellings. New high-rise multifamily dwellings shall comply with the Tier 1 (10% compliance margin) requirement for energy efficiency by employing energy efficiency measures. In addition, a PV system sized to offset a portion of the total building energy use based on TDV energy is required. The PV sizing calculations were developed such that PV size would be the lessor of approximately 80% offset of the building's modelled annual electric load or 15 DC watts per sq. ft. of solar zone[1].

The City has obtained a cost effectiveness study prepared by TRC demonstrating that nonresidential buildings in all California climate zones have a market-ready and cost effective set of measures to achieve at least 10% energy performance higher than the California Energy Code requirements. Thus, the City has the required justification for adopting a 10% nonresidential reach code meeting the requirements of section 10-106 of the California Code of Regulations Title 24, Part 1.

The Ordinance also requires a PV system sized to be consistent with the methodology included in the cost effectiveness study also prepared by TRC. The PV sizing calculations were developed such that the PV size would be the lessor of approximately 80% offset of the electricity used on site or 15 DC watts per sq. ft. of solar zone.

I am currently serving on the CALBO Energy Commission Advisory Committee. As Chief Building Official for the City of Davis I am committed to enforcement of Title 24, Part 6 with the City of Davis. Any exemptions or exceptions are applicable to only to the proposed ordinance and do not apply to Title 24, Part 6.

Additionally, the City of Davis found that, under the California environmental Quality Act pursuant to Section 15061(b)(3) of the CEQA Guidelines, there is no possibility that the implementation of the ordinance will have a significant negative impact on the environment and is thus exempt from the requirements of CEQA.

Enclosed with this application are the following:

1. Signed ordinance adopting the reach code as stated above and associated staff reports.
2. Cost effectiveness study dated July 2017, demonstrating cost effectiveness of 10% compliance margin.
3. Cost effectiveness study dated December 2018, demonstrating cost effectiveness of PV systems.

The proposed energy standards found in the City of Davis ordinance will require buildings to be designed to consume no more energy that permitted by Title 24, Part 6. Please approve the enclosed ordinance pursuant to Public Resources Code, Subsection 25402.1(h)(2).

Sincerely,

Gregory Mahoney, CBO
Assistant Director
Community Development & Sustainability
City of Davis
23 Russell Blvd
Davis CA 95616
530 757-5655
gmahoney@cityofdavis.org

ORDINANCE NO. 2554

AN ORDINANCE AMENDING SECTIONS 8.01.060 RELATED TO ELECTRICAL REQUIREMENTS AND 8.01.090 RELATED TO GREEN BUILDING AND ADDING SECTION 8.01.094 RELATED TO ENERGY EFFICIENCY STANDARDS FOR NONRESIDENTIAL AND HIGH-RISE MULTIFAMILY BUILDINGS UNDER THE GREEN BUILDING CODE

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF DAVIS DOES HEREBY ORDAIN AS FOLLOWS:

SECTION 1. Subsection (c) of Section 8.01.060 of the Davis Municipal Code is hereby amended to read in full as follows:

1. In new single family residential construction a 120-volt receptacle shall be installed under the sink of the most remote sink, measured from the water heater, to accommodate the future installation of an on-demand hot water recirculation pump.

   Exception: Where compact hot water design credit is achieved, the receptacle for a future recirculation pump is not required.

2. In bathroom or kitchen remodels and additions that include the most remote sink, measured from the water heater, a 120-volt receptacle shall be installed under the sink to accommodate the future installation of an on-demand hot water recirculation pump.

   Exception: If it is determined that the installation of the 120 volt receptacle is not practical because the existing wiring is not easily accessible the receptacle is not required.

SECTION 2. Subsection (e) of Section 8.01.090 of the Davis Municipal Code is hereby amended to read in full as follows:

1. Chapter 4 Section 4.106.4.1 of the California Green Building Standards Code is hereby amended to add a sentence to the end of the paragraph to read as follows :

   Single Family Residential developments are required to pre-install 8 Gauge wiring to support Level 2 electric vehicle charging.

SECTION 3. Section 8.01.090 of the Davis Municipal Code is hereby added to read in full as follows:

8.01.094 Energy Efficiency "Reach" Green Building Code Requirements for Nonresidential and High-Rise Residential Buildings

In addition to all requirements of the Green Building Code applicable to new nonresidential and high-rise multifamily dwellings, the following shall apply:

1. New Nonresidential Buildings. New nonresidential buildings shall comply with the Tier 1 (10% compliance margin) requirement for energy efficiency by employing energy efficiency measures. In addition, a PV system sized to offset a portion of the total building energy use based on TDV energy is required. The PV sizing shall be consistent with the methodology included in the cost effectiveness study provided by TRC. The PV sizing calculations were developed such that PV size would be the lessor of approximately 80% offset of the building's modelled annual electric load or 15 DC watts per sq. ft. of solar zone[1].
2. New High-rise Multifamily Dwellings. New high-rise multifamily dwellings shall comply with the Tier 1 (10% compliance margin) requirement for energy efficiency by employing energy efficiency measures. In addition, a PV system sized to offset a portion of the total building energy use based on TDV energy is required. The PV sizing calculations were developed such that PV size would be the lessor of approximately 80% offset of the building's modelled annual electric load or 15 DC watts per sq. ft. of solar zone[1].
3. New nonresidential and high-rise multifamily buildings shall incorporate EV charging stations as determined by tables 1 and 2. Each EV charging station installed shall be credited toward the California Green Building Standards Code requirement for charging spaces.

[1]2016 Nonresidential Compliance Manual section 9.3.1: solar zone must have a total area of no less than 15% of the total roof area.

TABLE 1 - Non-Residential EV Charging Station Standards

Non-Residential Land Use Category	**Required Parking Spaces**	**EV Chargers**	**Land use (From City Parking Code; City Code Section** 40.25.090**)**
Retail	0-10	0	1. Automobile or machinery sales and service garages 2. Banks, post offices, business and professional offices 3. Furniture and appliance stores, household equipment or furniture repair shop 4. Launderettes 5. Restaurants, beer parlors, nightclubs, and cardrooms 6. Retail stores, shops, etc. 7. Rooming and lodging houses 8. Shopping center, neighborhood 9. Shopping center, community 10. Land uses where up to 50% of spaces serving employees.
	11-51	1	
	52-102	2	
	Every additional 50	+1	
Non-Retail	0-10	0	1. Group care homes

	11-26	1	2. Hospitals 3. Hotels and motor hotels, motels 4. Manufacturing plants, research or testing laboratories and bottling plants 5. Medical or dental clinics 6. Rest home, sanatorium, convalescent home or hospital 7. Wholesale establishments, warehouses 8. Land uses where more than 50% of spaces serving employees.
	27-42	2	
	Every additional 15	+1	
Destination	0-10	0	1. Bowling alleys 2. Churches, schools, day care centers and nursery schools 3. Dance halls and assembly halls without fixed seats, exhibition halls except assembly rooms in conjunction with auditorium 4. Funeral home, mortuaries 5. Sports arenas auditoriums, theaters, assembly halls
	11-36	1	
	37-62	2	
	Every additional 25	+1	

Notes:

1) All other non-modified Tier 1 standards for non-residential EV charging apply.
2) All required charging is Level 2 with the exception of non-retail (Workplace) charging which can be satisfied by 50% level 1 chargers with 50% payment-ready level 2 chargers due to longer dwell times. Note: calculations for total number of chargers shall be rounded up and rounding shall favor Level 2 chargers.
3) The first two chargers placed at non-retail (Workplace) locations must be payment ready Level 2 with subsequent chargers optionally Level 1.
4) 50% of required non-retail (Workplace) chargers to be installed prior to issuance of Certificate of Occupancy if approved prior to January 1, 2020. Remaining required chargers do not have to be installed at time of construction but must be pre-wired and have adequate electrical panel capacity for each future charger. After January 1, 2020, all required chargers must be fully installed.
5) Chargers should be placed to serve multiple parking spaces – see design recommendations in Section 5 of the City of Davis EV Charging Plan.
6) EV charging parking spaces shall be included in the required number of parking spaces per Article 40.25 of the City of Davis Zoning Ordinance. If space is available in a parking lot, additional EV charging spaces may be installed beyond the minimum number required subject to review and approval by the Department of Community Development and Sustainability.
7) Conversion of existing parking spaces for EV charging purposes shall be reviewed and approved by the Director of Community Development & Sustainability to assure a balance between full-size parking spaces, compact parking spaces and parking spaces for persons with disabilities.

TABLE - 2 Residential Standards

Development Type	Tier 1 Modifications	Notes
Single Family (1-3 units)	1. Single Family Residential development required to pre-install 8 Gauge wiring plus reserve room in electrical panel necessary to support Level 2 electric vehicle charging.	1. Addresses key barrier for adding Level 2 Home EV charger.
Multi-family (4 or more units)	1. Multi-family Residential development projects are required to provide: (1) Level 1 charging at 5% of all required parking spaces with a minimum of 2 parking spaces served, (2) Level 2 charging at 1% of all required parking spaces where more than 20 parking spaces are required with a minimum of 1 parking space served, (3) conduit adequate for Level 2 charging to serve or reasonably be extended in the future to 25% of all parking spaces, and (3) room in panel(s) and capacity to serve 20% of all parking spaces with Level 1 charging and 5% of all parking spaces with Level 2 charging. Notes: (1) properly located, a single charger can serve multiple parking spaces; (2) Reasonable future extension of conduit would not include the removal or trenching of hardscaped surfaces or areas where mature trees would be expected to establish (e.g. pavement, tree wells, etc.)	1. Addresses key barrier for EV use in residential rental settings.

Notes:

1) All other non-modified Tier 1 standards for residential EV charging apply.
2) Chargers in Multi-family residential settings should be placed to serve multiple parking spaces – see design recommendations in Section 5 of the City of Davis EV Charging Plan.
3) Level 1 in the context above is defined as a 20A 120V circuit and Level 2 is defined a 40A 208V/240V circuit
4) Level 1 is defined as a 120V hardwired EVSE not a household outlet.
5) Monitoring equipment to properly charge tenants is encouraged at multi-family locations

4. The most current version of the International Code Council (ICC) G4 Commissioning Process Application (Cx Guidelines) shall be adopted by reference. Compliance with the guidelines shall be required for nonresidential and high-rise residential projects. The application shall be consistent with the application specified in the current

version of the California Green Building Standards Code and the California Energy Code.

SECTION 3. Express Findings

As required by Health and Safety Code sections 17958.7, 18941.5(c) and 18942, the City Council of the City of Davis hereby expressly finds that the above amendment to the California Building Standards Code is necessary for the protection of the public health, safety and welfare, due to the local climatic, geological or topographical conditions. The amendment is justified by all of the following conditions.

Express Finding #1: Climatic

The effects of climate change are increasingly self-evident, and costly. Hurricanes wildfires and other natural disasters take many lives and cost billions of dollars. Across the globe, higher temperatures are contributing to record heat waves and droughts, rising sea levels, more intense storms, wildfires, and floods. Even if humanity were to immediately stop releasing CO_2, the climate would continue to change because the greenhouse gases that we have already released into the atmosphere could take years to dissipate. Climate change is the fundamental design problem of our time. The threat climate change poses is existential, and buildings are large contributors.

In Davis climate is one of the greatest impacts to fire behavior and other major emergency events because it cannot be controlled. The drying out of wood shakes and wild land fuels in the summer months allows for easy ignition. The combustible weeds on vacant urban lots coupled with windy conditions are a recipe for disaster. The Sacramento region has extreme variations in weather patterns. Summers are arid and warm; winters are cool to freezing, but void of significant snowfall. Fall and spring can bring any combination of weather pattern together. The doubling of average rainfall called an "El Nino" event has occurred from time to time and does cause the grass to mature and grow in excess of six feet high before it dries out. Ten (10) square feet of this type of fuel is equivalent to the explosive force of one gallon of gasoline. Average yearly rainfall for the City is approximately 17.87 inches. This rainfall normally occurs from October to April. Low-level fog (tulle-fog) is present throughout the winter months, which brings visibility to almost zero feet. The fog delays emergency responders. The fog can also cause freezing and slick roadways. During the summer months there is generally no measurable precipitation. Temperatures for this dry period range from 70 to 112 degrees F and are frequently accompanied by light to gusty Delta winds. The relative humidity during the summer month's range from 2 to 30 mm HG, which is classified as arid. The severe hot climate for several summer months makes it essential to provide for future solar power, paddle fans, electric vehicles and drip irrigation.

Express Finding #2: Geological

The City of Davis is subject to ground tremors from seismic events as the City is located in Design Category C, which relates to a high risk of earthquakes. Gas appliance located in attics or garages must be adequately braced and protected from damage from moving objects. Large portions of the City of Davis have very poor soil conditions. The soil is often expansive in nature and very acidic which leads to pre-mature deterioration of plumbing piping installed in the ground. Potable water is predominately pumped from City wells and has a higher than usual content of minerals contributing to extremely hard water. Additionally, the very low elevations are subject to a very high water table. Prior experience with lightly-loaded footing and foundations and concrete slabs on grade revealed structural cracks resulting in differential settlement in addition to moisture migrating from the soil to occupied, habitable areas of buildings.

Express Finding #3: Topographical

The City features include open space, drainage canals, freeways and railroad tracks. Traffic has to be channeled around several of these topographical features and limitations which creates traffic congestion and delays in emergency response. These features are located between the Fire Stations located within the City of Davis. Heavy traffic congestion on the City streets already acts as a barrier to timely response for fire and emergency vehicles. In the event of an accident or other emergency at one of the key points of intersection between a road and freeway, sections of the City could be isolated or response times could be sufficiently slowed so as to increase the risk of injury or damage. The topography of the downtown area together with traffic congestion makes it necessary reduce or eliminate overhead power lines to allow large fire trucks easy access to this area.

SECTION 4. The City Clerk is hereby directed to file a copy of this ordinance with the California Building Standards Commission of the State of California.

SECTION 5. This ordinance shall take effect and be in full force thirty (30) days from and after the date of its final passage and adoption.

SECTION 6. The City Clerk shall certify to the adoption of this ordinance and shall cause a summary thereof to be published at least five (5) days prior to the meeting at which the proposed ordinance is to be adopted and shall post a certified copy of the proposed ordinance, and within fifteen (15) days of its adoption, shall cause a summary of it to be published, including the vote for and against the same, and shall post a certified copy of the adopted ordinance, in accordance with California Government Code Section 36933.

INTRODUCED on the 9th day of April, 2019, and PASSED AND ADOPTED by the City Council of the City of Davis on this 23rd day of April, 2019, by the following vote:

AYES: Arnold, Carson, Frerichs, Partida, Lee

NOES: None

Brett Lee
Mayor

ATTEST:

Zoe S. Mirabile, CMC
City Clerk

STAFF REPORT

DATE: April 9, 2019

TO: City Council

FROM: Ashley Feeney, Assistant City Manager
Gregory Mahoney, Assistant Director, Community Development and Sustainability

SUBJECT: Ordinance to adopt a Nonresidential and High-rise Residential Energy and Green Reach Code (Nonresidential Reach Code).

Recommendation

Introduce an Ordinance:

> Enacting an energy efficiency and green "reach code" for nonresidential and high-rise residential projects that would require a 10% compliance margin per cost effectiveness study prepared by TRC, dated July 2017.
>
> Codification of Davis Electric Vehicle (EV) Charging Plan previously adopted by Council resolution.
>
> Requirement for installation of photovoltaics (PV) to achieve the lessor of approximately 80% offset of the building's modelled annual electric load or 15 DC watts per sq. ft. of solar zone[1], as supported by cost effectiveness study prepared by TRC.
>
> Adoption of the latest draft or publication of the International Code Council (ICC) Commissioning (Cx) Guideline to clarify and define the required commissioning process.
>
> Requirement for a 120 volt receptacle at the most remote sink, measured from the water heater, for a new single family dwellings, additions and remodels to accommodate the future installation of an on-demand hot water recirculation pump.

Executive Summary

Davis has a history of leadership in energy efficiency and sustainability. In the 1970s, Davis adopted an energy code before the State of California had developed a statewide energy code. The City was also the first jurisdiction to adopt a green building ordinance in the region. The State has a goal of Zero Net Energy by 2030 for all new nonresidential buildings. On March 5, 2019, City Council approved a Resolution declaring a climate emergency and proposed mobilization efforts to restore a safe climate that included an acceleration of the carbon neutrality goal for the Davis community from 2050 to 2040. Approval of the proposed Ordinance would further these efforts.

In recent years, there has been uncertainty around green building requirements for projects seeking discretionary entitlements. This has resulted in project specific requirements being negotiated through the City commission process and ultimately at the dais. Approval of the proposed Ordinance would provide clarity and certainty of green building expectations for architects, developers, builders, staff, and the community. An understanding of these expectations at the beginning of a project planning process will have greater benefit for all rather than learning what the requirements are at the end of project processing. Adoption of the proposed Ordinance would also save time for the applicant, staff, and the Natural Resources Commission as project specific energy efficiency requirements will no longer need to be reviewed on an individual project basis.

In the absence of an approved "reach code" for nonresidential and high-rise residential, several project approvals have been conditioned to achieve Leadership in Energy and Environmental Design (LEED) Silver or more commonly, Gold equivalency. The LEED rating system is a proprietary system for rating buildings where LEED certification requires some pre-requisites, but the majority of the measures are selected from a self-chosen menu of sustainability choices. LEED Gold equivalency is not necessarily an efficient path for developers and applicants as compliance with two separate sustainability approaches (LEED and Code) can be challenging, confusing, and costly. The equivalency standard requires third party verification and because of the menu approach, there is a lack of certainty regarding what will ultimately be required to comply. The LEED menu approach results in some projects benefiting on the point scale by way of the project location and other means that do not have anything to do with energy efficiency. The City also has limited ability to verify compliance because the LEED process is not consistent with the State and local sustainability nor the energy code compliance process.

The proposed Ordinance is based on a comparison of the LEED rating system with CALGreen, the Energy Code and the Davis Municipal Code. In comparing the existing City requirements, including CALGreen Tier 1 and the Davis Municipal Code, a compliant design would result in approximately a LEED Silver level of sustainability. Rather than allow an arbitrary path from effectively a LEED Sliver level equivalency to LEED Gold equivalency, in the proposed Ordinance, staff have included requirements for photovoltaics (PV) and enhanced energy efficiency (approximately 10% more efficient than code) beyond what is required by the Energy Code. The proposed Ordinance also codifies the EV charging requirements already approved by Council resolution. Finally, the proposed Ordinance recognizes the importance of energy systems to perform "as designed" by utilizing a defined commissioning process which is essential to optimize the efficiency of energy systems. CALGreen and the California Energy Code require commissioning but the process is not clearly defined. The International Code Council (ICC) has developed a Commissioning Guideline to be used by code officials and designers to clarify and provide consistency in the commissioning process. The proposed Ordinance requires projects to be consistent with the ICC G4 Guideline to Commissioning.

In an effort to get community feedback on the proposed reach code, the proposed Ordinance in both conceptual and final form was presented to the Natural Resources Commission three time over the last 16 months. The NRC unanimously supports the proposed Ordinance. Cool Davis is also a supportive of the proposed Ordinance. The proposed Ordinance has been presented to the Chamber of Commerce on two occasions to solicit feedback and address concerns. The Chamber has voiced appreciation for the engagement on the matter and has taken a neutral position on the proposed Ordinance (Attachment 7).

The proposed Ordinance provides a meaningful and clear path to LEED Gold equivalency through using code requirements that City staff can review and verify without the costs of a third party. Approval of the proposed Ordinance would also relieve architects, builders, developers, and the community of drawn-out negotiations and related to uncertain green building requirements.

Fiscal Impact

The minor increase in staff time associated with reviewing plans, issuing building permits and conducting inspections will be recovered through plan check and permit fees.

City Council Goals

The proposed Ordinance is consistent with adopted City Council goal:

- Pursue environmental sustainability

Background and Analysis

There have been several projects in Davis approved with a condition to achieve Leadership in Energy and Environmental Design (LEED) Silver or Gold equivalency. The LEED rating system is a proprietary system for rating green buildings. LEED enjoys wide market recognition but there are several important considerations with this strategy for incorporating sustainable measures into new projects. First, Davis City plan review and inspection staff are not trained in the LEED rating system. Consequently, LEED equivalency requires third party verification which comes at an additional cost to the applicant and project. However, City staff are well trained in the California Green Building Standards Code (CALGreen) and California Energy Code compliance. Second, LEED is a rating system that does not have specific requirements other than the prerequisites included in the program. The design team is allowed to choose which measures are most easily achievable rather than which measures are most meaningful for the City. There is the potential for projects to earn significant credit based solely on the location rather than sustainable measures included in the project design. In many cases, it may be more beneficial to the City to require measures such as PV systems and EV charging systems rather than allow the project design team to select other less beneficial measures. Finally, since the LEED rating system and the other sustainable codes enforced in Davis (CALGreen and the California Energy Code) are not necessarily consistent with one another there are questions concerning how reasonable and fiscally appropriate it is to require compliance with two separate "green" approaches. Staff recommends adoption of sustainable measures selected by staff, in concurrence with the NRC that would be most beneficial to the City and would be essentially equivalent to LEED Gold.

The 2016 California Green Building Standards Code (CALGreen) contains checklists for residential and nonresidential projects. The checklists specify mandatory measures for all new construction. CALGreen also provides a list of additional "Tier 1" and "Tier 2" voluntary measures for designers and property owners who seek to design a more sustainable building and environment. CALGreen includes requirements for residential and commercial alterations, remodels, or additions. While most cities do not require it, the City of Davis has required Tier 1 compliance as mandatory, not optional. Adoption of Tier 1 energy efficiency measures requires California Energy Commission approval prior to implementation.

LEED certification equivalency would require a design that would achieve a minimum number of points to meet the Gold threshold. There are 110 possible points with a score of 60 to 79 points required for LEED Gold certification. There are seven (7) different categories from which an applicant could earn points. There is no defined energy efficiency required other than the prerequisite which is to conduct a building simulation demonstrating an improvement of 5% for new construction compared to the baseline performance rating; or Prescriptive compliance (ASHRAE 50% Advanced Energy Design Guide); or Prescriptive compliance (Advance Buildings™ Core Performance ™ Guide). These standards fall well short of the California Energy Code requirements. There are only three (3) possible points for incorporating renewables into a project. PV is not a prerequisite for LEED Gold. Nor are EV Charging stations. Although LEED certification enjoys market recognition it does not necessarily achieve the level of sustainability desired. LEED and CALGreen are similar in some ways and inconsistent in others. It is staff's opinion that it is unnecessary to require both CALGreen Tier 1 and LEED Gold compliance. CALGreen compliance is not optional; it is required by the State of California. The City has chosen to increase the level of compliance to Tier 1 for all measures and to require additional measures that are meaningful to the City.

The concept of developing LEED Gold equivalent building standards by utilizing existing Davis Municipal Code, California Energy Code in addition to the required and voluntary measures found in the CALGreen was first proposed to the NRC in November of 2017. Staff requested feedback from the NRC regarding sustainability measures that should be incorporated into projects under review. In a subsequent meeting, staff provided a comparison of LEED and the codes currently being enforced as well as other voluntary measures that could be incorporated into projects under review. The purpose of the comparison was to identify sustainable measures that are important to the City's plan to be zero carbon by 2050. A LEED comparison (Attachment 2) lists all of the possible LEED measures that can be incorporated in to a project. A comparison is made between LEED and the measures included in CALGreen, California Energy Code and the Davis Municipal Code. The current codes in effect including the CALGreen Tier 1 compliance get projects very close to the LEED Silver threshold of 50 points. Some specific measures such as PV, EV Charging, Enhanced Commissioning and increased energy compliance allow projects to be equivalent to LEED Gold without consideration of location.

The cost effectiveness study prepared by TRC (Attachment 3) shows that nonresidential buildings in all California climate zones have a market-ready and cost effective set of measures to achieve at least 10% energy performance higher than the California Energy Code requirements. Thus, the City has the required justification for adopting a 10% nonresidential reach code meeting the requirements of section 10-106 of the California Code of Regulations Title 24, Part 1.

The Zero Net Energy option was not shown to be cost effective in Davis (Climate Zone 12) at this time. Staff will continue to monitor the cost effectiveness of ZNE and additional energy efficiency measures as the market and technology allow. Table 1 below shows the cost effective compliance margins for all climate zones in California. The City of Davis is in Climate Zone 12.

TABLE 1 – Recommended Compliance Margins

Climate Zone	Cost Effective Compliance Margin	B/C Ratio		Recommended Reach Code Compliance Margin
		TDV Methodology	On-Bill Methodology	
1	15.7%	3.0	5.3	15%
2	12.8%	1.4	2.3	10%
3	15.5%	1.2	2.0	15%
4	13.1%	1.4	2.3	10%
5	15.9%	1.2	2.0	15%
6	14.7%	1.4	1.5	10%
7	15.6%	1.4	2.3	15%
8	13.7%	1.4	1.5	10%
9	12.6%	1.4	1.5	10%
10	11.6%	1.5	2.5	10%
11	11.0%	1.6	2.5	10%
12	11.8%	1.4	2.2	10%
13	10.8%	1.6	2.5	10%
14	11.0%	1.6	1.8	10%
15	10.4%	1.9	2.1	10%
16	12.8%	1.5	2.3	10%

Staff recommends continued compliance with the previously adopted California Green Buildings Standards Code. The previously adopted provisions include the following:

- All new construction, both residential and non-residential, would be required to comply with both the mandatory measures and the measures contained in Tier 1.
- All residential and non-residential remodels and additions would also be required to comply with both the mandatory measures and the measures contained in Tier 1, as applicable.

Photovoltaic Requirements

The proposed Ordinance would require PV sizing consistent with the methodology included in the cost effectiveness study also prepared by TRC (Attachment 4). The PV sizing calculations were developed such that the PV size would be the lessor of approximately 80% offset of the electricity used on site or 15 DC watts per sq. ft. of solar zone.

Codification of EV Ready

The proposed Ordinance would reinforce compliance with the EV Ready plan adopted by council resolution (Attachment 5). The tables below specify the number and type of charging stations required for new nonresidential and multifamily buildings. The proposed Ordinance will also augment the current CALGreen requirement regarding single family dwelling EV readiness by requiring #8 gauge conductors to be installed in the required conduit for a future EV charging station.

TABLE 2 - Non-Residential EV Charging Station Standards

Non-Residential Land Use Category	**Required Parking Spaces**	**EV Chargers**	**Land use (From City Parking Code; City Code Section** 40.25.090**)**
Retail	0-10	0	1. Automobile or machinery sales and service garages 2. Banks, post offices, business and professional offices 3. Furniture and appliance stores, household equipment or furniture repair shop 4. Launderettes 5. Restaurants, beer parlors, nightclubs, and cardrooms 6. Retail stores, shops, etc. 7. Rooming and lodging houses 8. Shopping center, neighborhood 9. Shopping center, community 10. Land uses where up to 50% of spaces serving employees.
	11-51	1	
	52-102	2	
	Every additional 50	+1	
Non-Retail	0-10	0	1. Group care homes 2. Hospitals 3. Hotels and motor hotels, motels 4. Manufacturing plants, research or testing laboratories and bottling plants 5. Medical or dental clinics 6. Rest home, sanatorium, convalescent home
	11-26	1	
	27-42	2	
	Every additional 15	+1	

			or hospital 7. Wholesale establishments, warehouses 8. Land uses where more than 50% of spaces serving employees.
Destination	0-10	0	1. Bowling alleys 2. Churches, schools, day care centers and nursery schools 3. Dance halls and assembly halls without fixed seats, exhibition halls except assembly rooms in conjunction with auditorium 4. Funeral home, mortuaries 5. Sports arenas auditoriums, theaters, assembly halls
	11-36	1	
	37-62	2	
	Every additional 25	+1	

Notes:

1. All other non-modified Tier 1 standards for non-residential EV charging apply.
2. All required charging is Level 2 with the exception of non-retail (Workplace) charging, which can be satisfied by 50% level 1 chargers with 50% payment-ready level 2 chargers due to longer dwell times. Note: calculations for total number of chargers shall be rounded up and rounding shall favor Level 2 chargers.
3. The first two chargers placed at non-retail (Workplace) locations must be payment ready Level 2 with subsequent chargers optionally Level 1.
4. 50% of required non-retail (Workplace) chargers to be installed prior to issuance of Certificate of Occupancy if approved prior to January 1, 2020. Remaining required chargers do not have to be installed at time of construction but must be pre-wired and have adequate electrical panel capacity for each future charger. After January 1, 2020, all required chargers must be fully installed.
5. Chargers should be placed to serve multiple parking spaces – see design recommendations in Section 5 of Davis EV Charging Plan.
6. EV charging parking spaces shall be included in the required number of parking spaces per Article 40.25 of the City of Davis Zoning Ordinance. If space is available in a parking lot, additional EV charging spaces may be installed beyond the minimum number required subject to review and approval by the Department of Community Development and Sustainability.
7. Conversion of existing parking spaces for EV charging purposes shall be reviewed and approved by the Director of Community Development & Sustainability to assure a balance between full-size parking spaces, compact parking spaces and parking spaces for persons with disabilities.

TABLE - 3 Residential Standards

Development Type	Tier 1 Modifications	Notes
Single Family (1-3 units)	1. Single Family Residential development required to pre-install 8 Gauge wiring plus reserve room in electrical panel necessary to support Level 2 electric vehicle charging.	1. Addresses key barrier for adding Level 2 Home EV charger.
Multi-family (4 or more units)	1. Multi-family Residential development projects are required to provide: (1) Level 1 charging at 5% of all required parking spaces with a minimum of 2 parking spaces served, (2) Level 2 charging at 1% of all	1. Addresses key barrier for EV use in residential rental settings.

	required parking spaces where more than 20 parking spaces are required with a minimum of 1 parking space served, (3) conduit adequate for Level 2 charging to serve or reasonably be extended in the future to 25% of all parking spaces, and (3) room in panel(s) and capacity to serve 20% of all parking spaces with Level 1 charging and 5% of all parking spaces with Level 2 charging. Notes: (1) properly located, a single charger can serve multiple parking spaces; (2) Reasonable future extension of conduit would not include the removal or trenching of hardscaped surfaces or areas where mature trees would be expected to establish (e.g. pavement, tree wells, etc.)	

Notes:

1. All other non-modified Tier 1 standards for residential EV charging apply.
2. Chargers in Multi-family residential settings should be placed to serve multiple parking spaces – see design recommendations in Section 5 of the Davis EV Charging Plan.
3. Level 1 in the context above is defined as a 20A 120V circuit and Level 2 is defined a 40A 208V/240V circuit
4. Level 1 is defined as a 120V hardwired EVSE not a household outlet.
5. Monitoring equipment to properly charge tenants is encouraged at multi-family locations

The two referenced studies provided by TRC show that the proposed energy reach code (10% compliance margin) and the proposed PV portion of the proposed Ordinance are cost effective in compliance with the Warren/ Alquist Act of 1974.

Commissioning Guideline

CALGreen includes basic commissioning[2] for nonresidential and high-rise residential projects over 10,000 sq. ft. The proposed Ordinance will include a requirement to adopt the International Code Council (ICC) G4 Commissioning Process Application. The ICC G4 is a set of commissioning guidelines to define and clarify the commissioning process (Attachment 6). Exceptions to the application of the commissioning requirement will be consistent with CALGreen. Exceptions include unconditioned warehouses and open parking garages.

120 Volt Receptacle Requirement

The most significant obstacle to the installation of a code compliant on-demand hot water recirculation pump is the installation of a 120-volt receptacle under the most remote sink. This is a simple and cost effective installation during construction but significantly more costly and time consuming as a retrofit. Installation of a 120-volt receptacle during construction or remodel will allow the occupant to install an on-demand pump without any plumbing or electrical modifications other than to install the necessary hoses to connect the pump. The purpose of the recirculation pump is to significantly reduce the amount of water wasted while waiting for hot water at a sink or shower. The recirculation pump fills the hot water system with hot water so that when the faucet is opened hot water is at the fixture with little or no water loss. The current energy code only allows on-demand pumps.

[1]2016 Nonresidential Compliance Manual section 9.3.1 solar zone must have a total area of no less than 15% of the total roof area.

[2] *Basic commissioning is the process of verifying and documenting that the building and its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the owner's project requirements.*

Commissions

On November 27, 2017 at a Natural Resources Commission meeting staff introduced the concept of utilizing existing codes and a reach code to replace LEED Gold equivalency as a standard for new construction. Staff presented a proposed reach code ordinance and sought feedback during two subsequent Natural Resources Commission meetings on June 26, 2018 and September 24, 2018. A final draft was presented to the Natural Resources Commission on November 26, 2018 for approval. The Commission recommended approval of the final version of the proposed reach code Ordinance with a 5-0 vote.

Outreach

Staff presented the proposed reach code Ordinance to the Davis Chamber of Commerce on two separate occasions. Local developers attended these meetings. The Chamber has submitted a letter expressing gratitude for staff outreach and stating a neutral position on the proposed Ordinance (Attachment 7). Cool Davis is supportive of the proposed Ordinance.

Attachment

1. Ordinance
2. LEED comparison
3. Nonresidential Cost Effectiveness Study (10% compliance margin)
4. PV System Cost Effectiveness Study
5. EV Readiness Plan adopted by council resolution
6. ICC Cx Guidelines (Draft)
7. Davis Chamber of Commerce Letter on Building Standards

TRC
Results you can rely on

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Statewide Nonresidential Reach Code Cost Effectiveness Analysis

July 2017

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company

Submitted To:

Southern California Edison
Mr. Chris Kuch
1515 Walnut Grove
Rosemead, CA 91770

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TABLE OF FIGURES

TRC would like to acknowledge and thank the following entities for their support during this study: sixteen5hundred, EFCO Corporation, Viracon, and SSG MEP, Inc.

EXECUTIVE SUMMARY

Southern California Edison (SCE) engaged TRC to provide a cost effectiveness study to support nonresidential new construction reach code requirements above 2016 Title 24, Part 6, Building Energy Efficiency Standards (T24) in all California climate zones (CZs). The T24 Standards are the minimum energy efficiency requirements for building construction in California, and a reach code would require energy performance beyond the minimum in jurisdictions that adopt it.

Based on the results of TRC's analysis, the cities in all California CZs may move forward with a reach code requiring that nonresidential buildings improve energy performance by at least 10% better than the state minimum requirements, and 15% better in CZs 1, 3, 5, and 7.

TRC conducted cost data collection and energy simulations of four lighting and two envelope energy efficiency measures to show that nonresidential new construction can comply with a 10% reach code cost effectively:

- Reduced lighting power density
- Open office occupancy sensors
- Daylight dimming-plus-off
- Institutional tuning
- Reduced window solar heat gain coefficient
- Cool roofs

Note that the measures are not intended to serve as prescriptive measures, but one possible package achieving 10%. The 10% compliance margin improvement is measured in terms of Time Dependent Valuation (TDV). Measures were simulated in 2016 CBECC-Com compliance software to inform energy impacts using a medium office prototype. TRC quantified the incremental costs for the construction, maintenance, and replacement of the proposed measures relative to T24 through industry expert interviews and online research.

TRC's analysis consisted of two methods to estimate and quantify the value of the energy savings over the 15-year life of the measures:

- **TDV:** The California Energy Commission Life Cycle Cost (LCC) methodology using 2016 Time Dependent Valuation (TDV) of energy, and
- **On-Bill:** Customer cost effectiveness using utility rate schedules to value On-Bill energy impacts.

Each cost effectiveness methodology (TDV and On-Bill) determines cost effectiveness by comparing the incremental cost of a measure to the energy cost savings, in a combined Benefit to Cost (B/C) Ratio metric. The B/C Ratio is the incremental energy costs savings divided by the total incremental costs. When the B/C ratio is greater than 1.0, the added cost of the measure is offset by the discounted energy cost savings, and the measure is cost effective.

TRC's analysis shows that nonresidential buildings in all California CZs have a market-ready and cost effective set of measures to achieve at least 10% energy performance higher than the T24, through both the TDV and On-Bill cost effectiveness methodologies. Thus, all California jurisdictions have justification for adopting a 10% nonresidential reach code meeting the requirements of Section 10-106 of the California Code of Regulations Title 24, Part 1. Furthermore, TRC found 15% compliance margins cost effective in CZs 1, 3, 5 and 7, and recommends the a 15% nonresidential reach code in these climate zones (Figure 1). Final measure packages represent one possible way to achieve higher compliance margins, and are not intended to represent a mandatory or prescriptive set of measures.

Figure 1. Compliance Margin and Cost Effectiveness Summary Results

Climate Zone	Cost Effective Compliance Margin	B/C Ratio		Recommended Reach Code Compliance Margin
		TDV Methodology	On Bill Methodology	
1	15.7%	3.0	5.3	15%
2	12.8%	1.4	2.3	10%
3	15.5%	1.2	2.0	15%
4	13.1%	1.4	2.3	10%
5	15.9%	1.2	2.0	15%
6	14.7%	1.4	1.5	10%
7	15.6%	1.4	2.3	15%
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15	10.4%	1.9	2.1	10%
16	12.8%	1.5	2.3	10%

1. Introduction

Southern California Edison (SCE) engaged TRC to provide a cost effectiveness study to support nonresidential new construction reach code requirements above 2016 Title 24 Building Energy Efficiency Standards (T24), in all California climate zones (CZs). The T24 Standards are the minimum energy efficiency requirements for building construction in California, and a reach code would require energy performance beyond the minimum. The 2016 T24 Standards became effective on January 1, 2017.

Based on the results of TRC's analysis, the cities in all California CZs may move forward with a reach code requiring that nonresidential buildings improve energy performance by at least 10% better than the state minimum requirements, and 15% better in CZs 1, 3, 5, and 7.

1.1 Scope and Limitations

TRC attempted to show that nonresidential new construction can comply with a 10% reach code cost effectively by using CEC-approved compliance software and without triggering federal preemption.[1] The 10% compliance margin improvement is measured in terms of Time Dependent Valuation (TDV), described further in Section 2.1.1. TRC researched measures drawn from multiple sources in efforts to develop cost effective packages. Measures were simulated in compliance software to inform energy impacts, and costs were attained through expert interviews and online research. Final measure packages represent one possible way to achieve higher compliance margins, and are not intended to represent a mandatory or prescriptive set of measures.

This study has the following scope limitations:

- **Prototype.** The only building studied is a medium office prototype, further described in Section 2.2.3, because the California Energy Commission (CEC) nonresidential new construction forecast lists offices as being the most widely built building type for 2017 through 2019. Findings may not pertain to high-rise residential or other commercial spaces, such as restaurants and fitness centers, which have very different space conditioning loads and occupancy schedules. However, findings may be more pertinent to other nonresidential spaces, such as retail and school buildings, which have similar occupancy schedules, internal conditioning loads, and domestic water heating loads as office spaces. Using one representative prototype to estimate impacts on a broad range of building types aligns with analyses methods used in previous Title 24 Code and Standards Enhancement (CASE) studies and local reach code studies. Nonetheless, local jurisdictions can choose to analyze other prototypes during the Reach Code adoption process.
- **Federal Preemption.** The Department of Energy (DOE) regulates the minimum efficiencies required for all appliances, such as space conditioning or water heating equipment. State or city codes that mandate appliance efficiencies higher than the DOE's risk litigation by manufacturer industry organizations. Thus, TRC did not use increased equipment efficiencies as reach code measures, although these measures are often the simplest and most affordable measures to increase energy performance. While this study is limited by federal pre-emption, developers can use any package of measures to achieve reach code goals, including the use of high efficiency appliances that are federally regulated.
- **Modeling Capability.** TRC used CEC-approved compliance software, CBECC-Com, to ensure that a free and readily available software could be used by permit applicants to show compliance with the reach code. CEC-approved compliance software does not have the capability to model the energy

[1] List of CEC-approved simulation software available at: http://www.energy.ca.gov/title24/2016standards/2016_computer_prog_list.html

performance of some measures typically associated with energy savings, such as radiant systems, variable refrigerant flow, or chilled beams. TRC limited the packages to include measures that could be modeled in CEC-approved compliance software.

- **Non-Regulated Loads.** Energy consuming end-uses that are not regulated by the CEC, such as receptacle and process loads (e.g., computers and elevators), have been explicitly excluded from the scope of this study. CEC-approved simulation software does not allow compliance credit for energy efficiency improvements in these end-uses.
- **Renewable Generation, including Solar PV.** TRC did not consider on-site or off-site renewable solar generation as a means of complying with the reach code. The reach code measures solely improve the efficiency of building systems. Furthermore, the CEC does not currently allow compliance credit for solar generation.

2. METHODOLOGY

TRC assessed the cost effectiveness of 2016 reach code packages by analyzing several energy efficiency measures applied to prototype buildings. TRC's analysis consisted of two methods to capture benefits and costs:

1. **TDV:** The CEC Life Cycle Cost (LCC) methodology using 2016 Time Dependent Valuation (TDV) of energy, and
2. **On-Bill:** Customer cost effectiveness using utility rate schedules to value On-Bill energy impacts.

Both methodologies require estimating and quantifying the value of the energy impact associated with energy efficiency measures over the life of the measures (15 years) as compared to the baseline T24 medium office prototype. The main difference between the methodologies is how they value energy and the associated cost savings of reduced energy consumption, described in Section 2.1.

Both methodologies also require quantifying the incremental costs for the construction, maintenance, and replacement of the proposed measure relative to the 2016 Title 24 Standards prescriptive requirements. Incremental costs for each measure are described in Section 3.

2.1 Cost Effectiveness Methodologies

With each of the cost effectiveness methodologies (TDV and On-Bill), TRC determined cost effectiveness by comparing the incremental costs of a measure to the energy cost savings, in a combined Benefit to Cost (B/C) Ratio metric. The B/C Ratio is the incremental energy costs savings divided by the total incremental costs. When the B/C ratio is greater than 1.0, the added cost of the measure is offset by the discounted energy cost savings, and the measure is cost effective.

2.1.1 Life Cycle Cost Methodology Using Time Dependent Valuation

The CEC LCC Methodology is approved and used by the CEC to establish cost effective statewide building energy standards.[2] The methodology uses 2016 TDV of energy savings as the primary metric for energy savings, which reflects not only the retail costs to the end-user, but also the value of reduced energy demand, such as reduced greenhouse gas emissions and reduced strain to the electric grid.[3] The TDV methodology assigns dollar values to electricity and natural gas delivered for each hour in the year. TDV accounts for retail rates, greenhouse gas emissions, and several other factors to value electricity generation. The TDV of gas generally hovers around one value in the spring and summer, and higher value in the fall and winter, without much fluctuation.

TDV values are based on long term discounted costs over 15 years. The period of analysis is associated with the associated measure life – lighting, air conditioning, or water heating measures may only be in place for 15 years. Envelope measures, such as windows and roofs are typically operational for 30 years, but TRC assumed a 15 year period of analysis for simplification.

The CEC developed the 2016 TDV values for all climate zones used in this study. TDV energy estimates are presented in terms of "TDV kBtus," which combine electricity and natural gas energy units. [4] Compliance

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[2] Architectural Energy Corporation (January 2011) Life-Cycle Cost Methodology. California Energy Commission. Available at: http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/2011-01-14_LCC_Methodology_2013.pdf

[3] E3 (July 2014) Time Dependent Valuation of Energy for Developing Building Efficiency Standards: 2016 Time Dependent Valuation (TDV) Data Sources and Inputs. California Energy Commission. Available at: http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-09_workshop/2017_TDV_Documents/

[4] kBtus = thousands of British Thermal Units.

software calculates TDV energy savings in terms of per-square-foot of the building. The present value of the energy savings is calculated by multiplying the TDV savings/ft^2 by the building conditioned floor area, and then by the Net Present Value (NPV) factor. The NPV factor is $0.089/TDV kBtu for all nonresidential measures with a 15-year useful life.

2.1.2 Customer Cost Effectiveness Using On-Bill Impacts

The customer cost effectiveness methodology captures the energy cost savings from energy efficiency measures resulting from lower energy bills. TRC determined the NPV of the On-Bill savings over a 15-year lifetime, including a 3% discount rate and a 3% energy cost inflation rate.

On-Bill savings were estimated by calculating monthly electricity (kWh) and natural gas (therms) savings resulting energy efficiency measures using current commercial utility (IOU) rate schedules as shown in Figure 2. The commercial IOUs represent a large majority of California residents, and were the primary supporters of this study. Please see *Appendix B – Utility Rate Schedules* for further detail.

Figure 2. Investor-Owned Utility (IOU) Rate Schedules

Climate Zones	Utility	Commodity	Schedule
1, 2, 3, 4, 5, 11, 12, 13, 16	Pacific Gas and Electric Company	Electric	A-10 (TOU)
		Gas	G-NR1
6, 8, 9, 14, 15	Southern California Edison	Electric	TOU-GS-2-A
	Southern California Gas Company	Gas	G-10
7, 10	San Diego Gas and Electric Company	Electric	AL-TOU
		Gas	GN-3

2.2 Measure Analysis

TRC used CBECC-Com 2016.2.1 (build 868) for simulating energy efficiency measures in the medium office prototype.[5] CBECC is a free public-domain software developed by the CEC for use in complying with the Title 24 Standards. Software algorithms are updated continuously, and new versions of the software are released periodically. CBECC-Com 2.1 uses EnergyPlus v8.5 as the simulation engine to perform the analysis.

2.2.1 Energy Savings

CEC approved compliance software simulations output TDV, kWh, and therms energy totals for a proposed building, and compare them to a prescriptive standard building. The 10% compliance margin goal is determined by comparing the proposed building TDV energy usage to the standard building TDV energy usage – the proposed building should use 10% less than the standard building's TDV energy usage. The TDV energy budget

[5] More information on CBECC-Com available at: http://bees.archenergy.com/software.html

and compliance margin is a standard output for building permit applicants completing a performance calculation. The TDV energy budget requirements are described in 2016 T24 Sections 100.2 and 140.1.

Because TDV combines electric and gas energy impacts, different energy efficiency measures can have different kWh and therms impacts while having the same TDV impact. The measure packages in Section 4 represent one possible way to achieve a higher compliance margin – these packages are not intended to represent a mandatory set of reach code measures. Other packages of measures can also achieve higher compliance margins, but will have different kWh and therms impacts.

TRC investigated potential energy efficiency measures to apply to the medium office prototype in each climate zone. TRC utilized previous reach code studies and program experience to investigate reach code measures that would have the greatest impact on reducing the largest energy consuming end uses (see Figure 6). TRC conducted market research to assess measure feasibility, costs, and potential energy impact.

2.2.2 Costs

TRC gathered costs for four regions within California to best represent localized costs (Figure 3). TRC reviewed previous studies for relevant cost data, such as Codes and Standards Enhancement (CASE) studies, if available. TRC conducted cost research by accessing online retailers and interviews with contractors and distributors serving each region. Costs include upfront costs, maintenance, and replacement if the end of useful life is prior to the end of the measure life for a product. For replacements, a three percent (3%) inflation rate was assumed. Detailed costs are provided in *Appendix A – Cost Data*.

The main cause of variation in costs among the regions is due to labor rates, based on RS Means research. There are also slight changes in material costs from region to region, based on local quotes received. Taxes and contractor markups were added as appropriate.

Figure 3. Climate Zones Grouped by Geographic Region

Region	Climate Zone
North Coastal	1-5
South Coastal	6-10
Central	11-13
Inland	14-16

Specifically, when gathering cost data on windows and lighting improvements, TRC found that stakeholders were supportive of the potential measures and in general agreement on TRC's assumptions for potential costs, but would not provide specific cost data themselves. Further detail is provided in Section 3.

2.2.3 Prototype

TRC used a 53,628 ft^2 medium office prototype to run simulations in all California CZs. This prototype is a DOE building model used for analysis of ASHRAE Standard 90.1, but is often used to justify nonresidential T24 standard enhancements and is summarized in the 2016 T24 Nonresidential Alternative Calculation Method

(ACM) Reference Manual.[6] TRC chose an office prototype because, according to the CEC new construction forecast, offices are projected to be the most widely built building type during the 2016 T24 code cycle (Figure 4). TRC chose the medium office (as opposed to a small or large office) to represent an average sized office, and a building type that is likely to get built in both small and large California cities.

Figure 4. CEC Nonresidential New Construction Forecast

Building Type	2017 2019 Forecasted Construction (% of total)
Small, Medium, and Large Office	22%
Retail	16%
Warehouse	14%
Restaurant/Food	7%
School	5%
Hotel	5%
College	4%
Hospital	4%
Miscellaneous	23%

TRC initialized the medium office prototype to be exactly compliant with the prescriptive minimum 2016 T24 requirements (0% compliance margin) in each climate zone, summarized in Figure 5. The prototype has a 33% window-to-wall ratio area (WWR) with the glazing area evenly distributed in the four geometry facings – north, east, south, and west – to ensure that results are applicable regardless of the orientation of a building. The TDV of energy savings for energy efficiency measures were derived by applying packages to the minimally code compliant prototype.

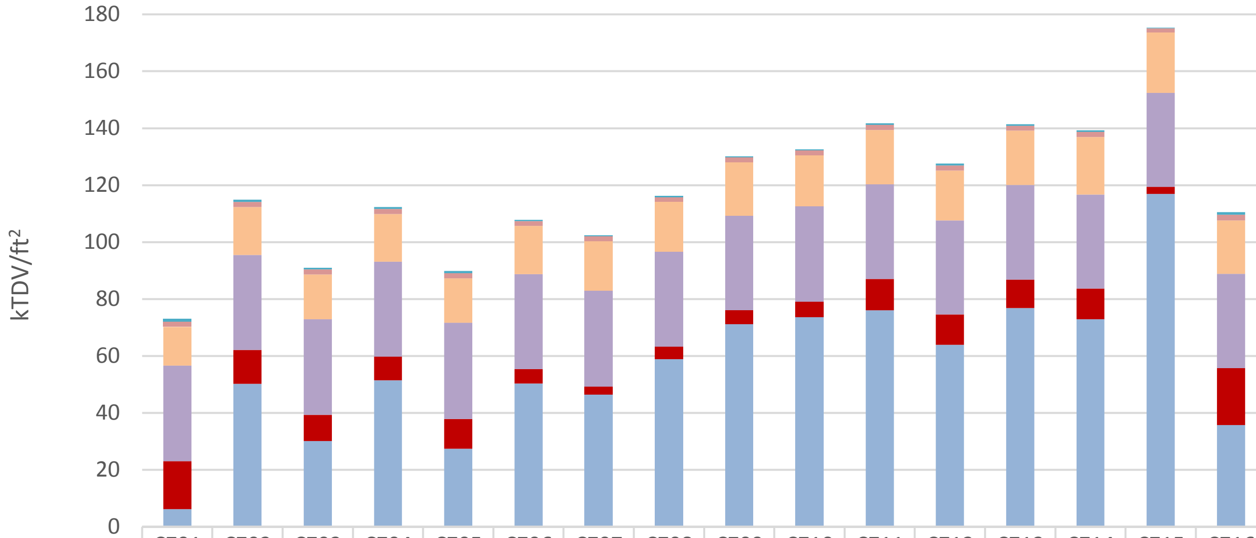
[6] Available at: http://www.energy.ca.gov/title24/2016standards/nonresidential_manual.html

Figure 5. Medium Office Prototype Summary

<table>
<tr><th colspan="2">Building Type</th><th>Medium Office</th></tr>
<tr><td colspan="2">Floor Area (ft2)</td><td>53,628</td></tr>
<tr><td colspan="2"># of floors</td><td>3</td></tr>
<tr><td colspan="2">Window-to-Wall Area Ratio</td><td>33%</td></tr>
<tr><td colspan="2">HVAC Distribution System</td><td>3x Packaged Variable Air Volume with VAV Hot Water Reheat</td></tr>
<tr><td colspan="2">Cooling System</td><td>Direct Expansion, 9.8 EER, Economizer</td></tr>
<tr><td colspan="2">Heating System</td><td>Boiler, 80% Thermal Efficiency</td></tr>
<tr><td colspan="2">Conditioned Thermal Zones</td><td>15</td></tr>
<tr><td colspan="2">Domestic Water Heating</td><td>Natural Gas Small Storage, EF = 0.64</td></tr>
<tr><td colspan="2">Roof Insulation (U-Value)</td><td>0.034 / 0.049 depending on CZ</td></tr>
<tr><td colspan="2">Low-sloped Roof Solar Reflectance</td><td>0.63</td></tr>
<tr><td colspan="2">Metal-framed Wall Insulation (U-Value)</td><td>0.062 / 0.069 / 0.082 depending on CZ</td></tr>
<tr><td rowspan="3">Window (fixed)</td><td>U-factor</td><td>0.36</td></tr>
<tr><td>Solar Heat Gain Coefficient (SHGC)</td><td>0.25</td></tr>
<tr><td>Visible Transmittance (VT)</td><td>0.42</td></tr>
<tr><td colspan="2">Lighting Power Density (W/ft^2)</td><td>0.75</td></tr>
</table>

The minimally compliant energy consumption of the medium office prototype in each climate zone is summarized by end-use in Figure 6. Note that outdoor lighting, receptacle and process loads (such as computers or elevators) are not regulated end uses in T24, and thus cannot count be modeled as efficiency measures. Except for CZ 1, the largest energy consumers in the medium office prototype are space cooling and indoor lighting. The total energy values in Figure 6 represent only the regulated energy end uses.

Figure 6. Medium Office Prototype Compliance kTDV/ft²by End-use



	CZ01	CZ02	CZ03	CZ04	CZ05	CZ06	CZ07	CZ08	CZ09	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Pumps & Misc	1	1	1	1	1	0	0	0	0	0	1	1	1	1	0	1
DHW	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Indoor Fans	14	17	16	17	16	17	17	18	19	18	19	18	19	20	21	19
Indoor Lighting	34	33	33	33	34	33	34	33	33	33	33	33	33	33	33	33
Heating	17	12	9	8	10	5	3	4	5	5	11	11	10	11	2	20
Cooling	6	50	30	51	27	50	46	59	71	74	76	64	77	73	117	36

3. Measure Descriptions and Costs

This section provides a description, general modeling parameters, market overview, and summarized costs for energy efficiency measures. After initial investigation and analysis of several energy efficiency measures, TRC selected the measures described below and the subsequent packages described in Section 4 based on cost effectiveness and technical feasibility in the California nonresidential new construction market:

- Lighting measures
  - Reduced lighting power density (LPD)
  - Open office occupancy sensors
  - Daylighting dimming-plus-off
  - Institutional tuning
- Envelope measures
  - Cool roof
  - Reduced window solar heat gain coefficient (SHGC)

Detailed measure costs are available in *Appendix A – Cost Data*.

TRC investigated the possible inclusion of several heating, ventilation, and air-conditioning (HVAC) measures, but was unable to find a market-ready measure that would not trigger federal pre-emption (such as improving IEER or AFUE values) and was able to be modeled in CBECC-Com. Furthermore, HVAC systems are highly integrated – meaning it is difficult to isolate a singular component to improve in efficiency without effecting other parts of the system, and subsequently requiring a whole system redesign. All of these issues proved challenging to isolating costs and energy impacts, and thus cost effectiveness, within the scope of this study.

3.1 Lighting Measures

TRC proposed lighting measures are all Power Adjustment Factors (PAFs) in 2016 Title 24, except the Reduced LPD measure. For Title 24 compliance, PAFs allow a building to install wattages that are higher than prescriptively allowed, due to improvements in controls. For the analysis, TRC did not assume that the PAF was being used to install higher wattages elsewhere in the building, as this would negate any energy impact from the measures.

3.1.1 Reduce Lighting Power Density

This measure reduces the lighting power density (LPD) from the 2016 Title 24 prescriptive requirement of 0.75 W/ft^2 for open office areas to 0.65 W/ft^2. TRC's analysis assumes LED as the primary light source type to achieve this lower LPD. Lighting design varies depending on lighting goals, interior layout, and technology types. TRC reached out to several lighting manufacturer representatives, but because of the large variety of lighting designs possible, representatives were reticent to provide general cost data points. Where necessary, TRC calculated the lighting layouts using Visual Interior Tool v2.0.3.1, and products recommended by manufacturer representatives. In addition to cost data provided by manufacturer representatives, TRC used product costs available on retail websites such as 1000bulbs.com, lightingdirect.com, grainger.com, globalindustrial.com, cesco.com, and homedepot.com.

Lighting costs are dependent on a variety of factors, including lighting output, number of luminaires in the space, and product quality. TRC's Cost research shows that, depending on the lighting design goals and product quality, some T8 fluorescent luminaires may be more costly than LED luminaires. This is because fluorescent fixtures require dimming ballasts to comply with Title 24 multilevel lighting requirements, while most LED fixtures include a dimming driver automatically. In many cases, the cost may be equivalent or very similar once the dimming ballast cost is considered. Lighting manufacturer representatives and online retail sources show cost equivalency for linear fluorescent troffers with dimming ballasts and LED troffers. Although several manufacturer representatives would not provide cost data, their general feedback is that LEDs are now considered the market standard design and that it is feasible to design a project with LEDs at a lower LPD than prescriptive requirements with no incremental cost.

TRC's found that it is technologically feasible to achieve 0.65 W/ft^2 design at no incremental cost. The products in Figure 7 represent basic quality luminaires that provide 50 footcandles of illuminance to the space (calculated with no internal furniture or cubicle walls). Although the cost analysis is based on LEDs, research identified that it is feasible to reach an LPD of 0.65 with some fluorescent luminaires at no additional cost. For example, Cooper Lighting 2AC 232 UNV EB81 U linear fluorescent troffer can achieve this LPD, depending on layout, and is less expensive than some fluorescent luminaires meeting the prescriptive LPD.

Figure 7. Reduced LPD Incremental Cost Summary

Base Case	Proposed Measure	Base Case Cost ($/ft^2)	Proposed Case ($/ft^2)	Incremental Cost ($/ft^2)	Total Incremental Cost ($/bldg)
Linear Fluorescent Troffer at 0.75 W/ft^2 + Dimming Ballast	LED Troffer at 0.65 W/ft^2	$2.33	$2.06	($0.27)	None

3.1.2 Open Office Occupancy Sensors

This measure draws from the findings of the 2013 Indoor Lighting Controls CASE Report.[7] This CASE report investigates the use of occupancy controls in open office spaces at various control group sizes and proposes one occupancy sensor for every four workstations (approximately 500 ft^2). The energy savings associated with occupancy sensors are based on the 0.20 PAF credit in Table 140.6-A of the 2016 T24 Standards. In other words, TRC assumes that installing open office occupancy sensors is equivalent to a 20% reduction in installed LPD in open office areas. TRC assumes that 53% of the building is open office, equating to a net reduction of 11% in LPD.

Occupancy controls have been commercially available for several decades, and the technology is readily available from a wide variety of manufacturers. Both passive infrared and ultrasonic occupancy sensors are widely accepted in office buildings, have been acknowledged to save energy successfully, and are frequently required by codes. The incremental costs for this measure include the costs of the sensors and installation labor, according to the CASE report. The cost for the sensor from online retailers and a manufacturer rep is $126.47 per sensor. The cost for installation and commissioning varies by region. Costs summarized in Figure 8 assume 59 sensors for the medium office and that recommissioning would occur in year 10 after initial commissioning. Costs can be reduced in areas where daylighting sensors will be installed if the selected controls include both passive infrared and daylighting sensing abilities.

[7] California Utilities Statewide Codes and Standards Team (October 2011) Nonresidential Indoor Lighting Controls Codes and Standards Enhancement Initiative. Available at: http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Indoor_Lighting_Controls_Oct_2011.pdf

Figure 8. Open Office Occupancy Sensors Incremental Costs Summary

CA Region	Base Case	Proposed Measure	PIR Sensor Cost ($/sensor)	Commissioning Cost ($/sensor)	Total Cost + Maintenance
North Coast	No occupancy sensors	Occupancy sensors in open office	$126.47	$75.35	$14,894
South Coast			$126.47	$55.81	$12,967
North Central			$126.47	$54.49	$12,837
Inland			$126.47	$51.86	$12,577

3.1.3 Daylight Dimming-Plus-Off

This measure revises the control settings for mandatory daylight sensors to be able to shut-off completely when adequate daylight levels are provided to the space. Current requirements are for sensors to dim lighting to 20% full power. TRC used a report by the Pacific Northwest National Laboratory for guidance on the feasibility of this measure.[8] To model this measure in CBECC-Com, TRC revised the daylight control type from Continuous (with a minimum dimming light and power fractions of 0.20), to Continuous Plus Off (which effectively reduces the dimming light and power fractions to 0).

There is no associated cost with this measure, as the 2013 T24 Standards already require multilevel lighting and daylight sensors in primary and secondary daylit spaces. This measure is simply a revised control strategy, and does not increase the number of sensors required or labor to install and program a sensor.

3.1.4 Institutional Tuning

Institutional tuning is currently a PAF in the 2016 T24 Standards. To show compliance with this measure, a designer should meet the requirements of 2016 Title 24 Section 140.6(d). This measure works in conjunction with dimmable ballasts, which were adopted as a requirement in the 2013 T24 Standards. Tuning addresses the frequent practice of designing light levels in a space to exceed that needed for the tasks of the space. Based on space factors and normal lighting design practices, a lighting designer typically overdesigns the light levels specified for a space to ensure adequate lighting is provided. The higher light levels are often a result of designing a space to meet the required light levels while satisfying the luminaire spacing or ceiling layout. The resulting design provides more light (e.g. 65 footcandles) than is necessary or recommended in the space (e.g. 50 footcandles). [9]

Institutional tuning sets the maximum light levels in a space at a lower level than the fully installed light levels, but still at an acceptable level for occupants. The maximum power use is thus lower and energy is continuously saved. Tuning requires that lighting designers commission the lighting system after installation and tune down the lighting to meet the design criteria. In the previous example, the lighting designer may tune down the

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[8] Pacifica Northwest National Laboratory (August 2013) Analysis of Daylighting Requirements within ASHRAE 90.1. Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22698.pdf

[9] A footcandle is the illuminance on a one square foot surface from a uniform source of light. It is a commonly used metric for lighting design.

lighting from 65 footcandles to 55. The designer wants to maintain initial light levels above the minimum requirement to account for depreciation in lamp efficacy over time.

TRC conservatively assumes a 10% reduction in LPD for an office (assuming this measure is in conjunction with the LPD reduction measure above), in line with the PAF factor of 0.10 in Table 140.6-A. Note in this table that institutional tuning has a lower PAF of 0.05 for daylit spaces. TRC did not use this lower PAF in daylit spaces because CBECC-Com already models the impact of daylighting, thus the interactive effects of tuning and daylighting controls do not need to be manually accounted for in the reduced LPD.

The additional cost for this measure is the labor required to tune the lighting in each space, as shown in Figure 9. This cost is dependent on the particular design of an office and the number of unique areas that a lighting designer must address. Based on a field study report by Seventhwave[10] the labor cost required to implement institutional tuning is $0.06 per square foot of space where tuning occurs. The study is representative of lighting installations in Minnesota. TRC used RSMeans Online to compare Minnesota labor rates with California labor rates for interior commercial LED installations. On average, considering several California city labor rates, the Minnesota labor rate and California labor rates are close in value; therefore, the cost estimate applies in California.

Figure 9. Institutional Tuning Incremental Costs Summary

Base Case	Proposed Measure	Commissioning Cost	Total Cost
0.75 W/ft^2 (no tuning)	0.68 W/ft^2 (with tuning)	$0.06/ft^2	$3,218

3.1.5 Modeling All Lighting Measures

Figure 10 summarizes the LPD impact from the lighting measures described above. The final LPD modeled in CBECC-Com is 0.52 W/ft^2. The impact of daylighting dimming-plus-off is not captured through a reduced LPD, but rather through a separate simulation control, and so is not included in Figure 10.

Figure 10. LPD Impact from All Lighting Measures

Base Case	+ LED Fixtures	+ Open Office Occupancy Sensors (11% LPD Reduction)	+ Institutional Tuning (10% LPD Reduction)
0.75 W/ft^2	0.65 W/ft^2	0.58 W/ft^2	0.52 W/ft^2

[10] Schuetter, S., Li, J., and M. Lord. 2015. Adjusting lighting levels in commercial buildings: energy savings from institutional tuning. August 2015.

3.2 Envelope Measures

3.2.1 Reduced Window Solar Heat Gain Coefficient

2016 Title 24 prescriptive requirements vary by fenestration type, including fixed windows, curtainwalls, and storefront windows. TRC used fixed windows for the analysis, which have prescriptive requirements for a maximum U-factor of 0.36, a maximum relative solar heat gain coefficient (RSHGC) of 0.25, and a minimum visual transmittance (VT) of 0.42. The U-factor depicts the rate of heat transfer of a product, and includes the entire window assembly (glass and frame). The RSHGC is reflective of the heat gain through a window from direct sun exposure, and can be impacted by coatings and tints. The VT is a metric that describes the appearance of a window and ability of light to enter in through the window. A higher VT allows for more light to enter the space and promotes daylighting. In currently available products, RSHGC and VT are linked because factors that may lower RSHGC – such as tinting – can also reduce VT. TRC considered several window values to balance the benefits from reducing RSHGC and increasing daylighting with higher VT. Additionally, higher VTs are more market acceptable for appearance and occupant comfort.

TRC analyzed windows ranging from RSHGC 0.20 to 0.23 with VTs greater than or equal to 0.42, which is the prescriptive minimum value. To be conservative, TRC modeled all windows with the prescriptive minimum VT of 0.42 even though windows were identified with higher VT (which will provide more daylighting energy savings benefits). Based on feedback from glass manufacturers and window fabricators about market acceptance of low RSHGC windows, which tend to be heavily tinted, TRC selected RSHGC 0.22, which has a wider range of product availability without significant tinting.

However, in Climate Zone 15, which has a substantial cooling load, TRC used an RSHGC of 0.20. TRC initially considered 0.20 RSHGC for all climate zones, but feedback indicated that the commercial market is generally unaccepting of most products that can achieve this lower RSHGC because of heavy tint that may give a blue or green appearance.

To gather costs associated with reduced RSHGC, TRC contact several window fabricators and glass manufacturers. Window components are often manufactured at separate facilities under independent organizations, and then a fabricator will design and combine the final product; therefore, the individuals TRC contacted often did not feel confident providing pricing if they only deal with one component, such as the glass. Additionally, contacts noted that the price of windows can fluctuate substantially by the size of the project and the windows, further adding to the hesitation to provide cost information. TRC overcame this barrier by identifying or asking about similar products from each manufacturer that only varied in solar heat gain coefficient (SHGC) value. SHGC is only a feature of the glass, so isolating this value eliminated variation in price from components that do not impact SHGC, such as framing, and allowed the analysis to use costs provided for only the glass.

The cost for reducing the SHGC of a fixed window from 0.25 to 0.22 and 0.20 is summarized in Figure 11. The prototype building has 7,027 ft^2 of fenestration. Based on discussions with window manufacturers and fabricators, cost increases are not directly correlated with SHGC reductions because of the variety of coating and tinting available. There is not a significant cost escalation for going to an SHGC of 0.20 versus 0.22 for the particular products that TRC researched.

Note that Title 24 also allows for modelers to reach an RSHGC of 0.20 by using permanent exterior shading through overhangs or fins, as well as interior automated blinds. For the purposes of the cost effectiveness analysis, TRC modeled and assumed costs for a window with SHGC of 0.20 in Climate Zone 15 instead of exterior shading elements, but notes that shading is an alternative option for builders who want low RSHGCs but want to avoid blue or green appearances on their windows.

Figure 11. Reduced Window RSHGC Incremental Cost Summary

Source	RSHGC	Incremental Cost ($/square foot of window)	Incremental Cost per Building ($)
Manufacturer 1	0.25 (baseline)	n/a	n/a
	0.22 (proposed)	$3.59	$25,227
	0.20 (proposed)	($3.88)	($27,265)
Manufacturer 2	0.25 (baseline)	n/a	n/a
	0.22 (proposed)	$5.00	$35,135
	0.20 (proposed)	$10.00	$70,270
Average 0.22 RSHGC		**$4.44**	**$31,172**
Average 0.20 RSHGC		**$4.45**	**$31,256**

3.2.2 Cool Roofs

The 2016 T24 Standards prescriptively require a Cool Roof Rating Council certified minimum 3-year aged solar reflectance (ASR) based on roof pitch, where steep slope is defined as a slope of > 2:12, and low slope is ≤ 2:12. Low slope cool roofs are typically constructed of field applied coatings, modified bitumen, or single ply thermoplastic roofing. Steep slope roofs are typically constructed of asphalt or tile shingles. Low-sloped roofs are much more common for offices and other commercial buildings, and the medium office prototype has a low-sloped roof. This measure proposes an aged solar reflectance ASR = 0.70 for low slopes, compared to ASR = 0.63 prescriptive requirements. TRC maintained the modeling default of Thermal Efficiency (TE) = 0.85 because most products can achieve this value.

TRC conducted interviews regarding low slope roof products with roofers and roof supply distributors throughout California, and supplemented the interviews with costs available through online retailers. Multiple roofers and product distributors made the statement that there is little or no additional labor to install cool roof products, and in some instances, there is even material cost savings associated with choosing a low sloped cool roof. The cost of cool roof products meeting the Reach Code ASR can be cheaper than their darker, non-cool roof counterparts, depending on the product type. Additionally, according to Cool Roof Rating Council[11] certified product directory, there are about three times as many cool roof products available at the proposed ASR = 0.70 value than at the current required ASR = 0.63.

Costs for cool roof materials varied by climate zone region and tend to be highest in the North and South Coast regions where cool roofs may not be as prominent. Lowest costs tend to be in the North Central and Inland regions with significant cooling loads. To be conservative, TRC estimated an incremental cost in all climate zones by climate region for products that meet the proposed nonresidential low sloped cool roof requirements (ASR = 0.63 to ASR = 0.70), summarized in Figure 12. This incremental cost represents product types that may have

[11] Available at: http://coolroofs.org/products/results

higher costs to meet the proposed values, and varies by region. To estimate this cost, TRC averaged the incremental costs for all cool roof types to meet the proposed ASR value. The incremental cost for a cool roof ASR = 0.70 ranges from $0.05 to $0.20 per square foot of roof, depending on the California region. Individual product types range from $(0.10) to $(0.51) per square foot of roof depending on climate region and product type; membranes (e.g. cool caps) are the most expensive cool roof option. Based on product specification sheets, TRC assumed that a cool roof would need maintenance or an entirely new roof after 10 years. The cost for a new roof after 10 years with a 3% inflation rate is included in the total cost estimate in Figure 12.

Figure 12. Cool Roof Incremental Cost Summary

CA Region	Base Case	Proposed Case	Incremental Cost[12] ($/square foot of roof)	Incremental Cost ($/building)
North Coast	ASR = 0.63 TPO/PVC, Membrane, or Field Applied Coating	ASR = 0.70 TPO/PVC, Membrane, or Field Applied Coating	$0.15	$6,106
South Coast			$0.20	$8,279
North Central			$0.11	$4,762
Inland			$0.05	$2,040

An important consideration in cool roof design is the potential for condensation and ice to build up under the roof membrane in cold climates. In traditional roof construction (non-cool roofs), the roof heats up in between periods of precipitation, allowing any wet areas on the roof or under points of roof failures to dry out. Cool roofs may prevent roofs from getting hot enough to completely dry out in between periods of precipitation, and moisture continues to accumulate. The cool roof is not the sole cause of moisture issues; there must be a failure that allows water to enter from the exterior or significant interior humidity levels, both which allow moisture to enter the assembly. Important practices to ensure that cool roofs do not exacerbate moisture-related roof failures are to:

- Ensure proper roof construction and drainage[13]
- Maintain appropriate interior relative humidity[14]
- Add insulation above the roof deck[14] (as per Joint Appendix JA4)

TRC assumed that these practices are part of standard design practice for new construction in a high precipitation climate, and did not assume any additional costs to prevent condensation solely resulting from the construction of a cool roof. The majority of cited condensation and moisture issues with cool roofs are for re-roofs where an existing failure had been maintained by periods of drying, and this wet/dry balance being upset by the addition of a cool roof.

[12] Incremental cost assumes that reroof will occur in year 10 after construction.

[13] Department of Energy. Available at: https://energy.gov/energysaver/cool-roofs

[14] Dregger, P. 2012. "Cool" Roofs Cause Condensation – Fact or Fiction? *Western Roofing*, January/February 2012, 48-62 or March 2013, 19-26. Available at: http://www.epdmroofs.org/attachments/2012-jan_coolroofscausecondensation_dregger_wr01123.pdf

4. Cost Effectiveness Results and Recommendations

The results for the medium office energy efficiency packages are presented in this section for each climate zone. TRC determined cost effectiveness by comparing the incremental cost of each package to the NPV of energy cost savings over the 15-year period. Incremental costs represent the construction, maintenance, and replacement costs of the proposed measure relative to the 2016 Title 24 Standards prescriptive requirements.

Results include measure compliance margin, present value of energy savings, costs, and benefit to cost (B/C) ratio. The B/C ratio is the incremental energy costs savings divided by the total incremental costs. When the B/C ratio is greater than 1.0, the added cost of the measure is offset by the discounted energy cost savings and the measure is cost effective. See Section 2.1 for further detail.

Nonresidential buildings in all California CZs have a market-ready and cost effective set of measures to achieve at least 10% higher than the Title 24 Standards, both through the TDV and On-Bill cost effectiveness methodologies. Thus, all California jurisdictions have proper justification for adopting a 10% nonresidential reach code meeting the requirements of Section 10-106 of the California Code of Regulations Title 24, Part 1. Furthermore, TRC found 15% compliance margins cost effective in CZs 1, 3, 5 and 7.

Note that the only prototype that required use of an RSHGC-0.20 window to achieve the 10% compliance margin cost effectively was in Climate Zone 15 – all other climate zones could achieve a 10% compliance margin using a 0.22 RSHGC window.

4.1 Life Cycle Cost Methodology Using TDV

The CEC LCC Methodology uses a Time Dependent Valuation (TDV) of energy savings, intended to capture the concept that energy efficiency measure savings should be valued differently depending on which hours of the year the savings occur to the utility system, to better reflect the actual costs of energy to consumers. The net present value is calculated using a 15-year lifetime.

As shown in Figure 14, all climate zones achieve a 10% or greater compliance margin cost effectively, indicated by the B/C ratio being equal to or greater 1.0. Climate zones 1, 3, 5, and 7 can achieve a 15% compliance margin cost effectively.

Figure 13. TDV Cost Effectiveness Results

CZ	Cool Roof ASR	Reduced RSHGC	Reduced LPD	Institutional Tuning	Lighting Controls (Daylight Dimming Plus Off, Open Office Occupancy Sensors)	Compliance %	NPV of Savings (kTDV)	Incremental Cost	B/C Ratio
1	n/a	n/a	0.65	x	x	15.7%	$55,509	$18,112	3.0
2	0.70	0.22	0.65	x	x	12.8%	$70,400	$48,902	1.4
3	0.70	0.22	0.65	x	x	15.5%	$67,202	$55,390	1.2
4	n/a	0.22	0.65	x	x	13.1%	$70,448	$49,284	1.4
5	0.70	0.22	0.65	x	x	15.9%	$68,300	$55,390	1.2
6	0.70	0.22	0.65	x	x	14.7%	$75,603	$55,636	1.4
7	0.70	0.22	0.65	x	x	15.6%	$76,319	$55,636	1.4
8	0.70	0.22	0.65	x	x	13.7%	$75,984	$55,636	1.4
9	0.70	0.22	0.65	x	x	12.6%	$78,466	$55,636	1.4
10	0.70	0.22	0.65	x	x	11.6%	$73,646	$48,676	1.5
11	0.70	0.22	0.65	x	x	11.0%	$74,075	$47,098	1.6
12	0.70	0.22	0.65	x	x	11.8%	$71,546	$51,988	1.4
13	0.70	0.22	0.65	x	x	10.8%	$73,216	$47,098	1.6
14	0.70	0.22	0.65	x	x	11.0%	$73,264	$45,781	1.6
15	0.70	0.20	0.65	x	x	10.4%	$87,058	$45,865	1.9
16	0.70	0.22	0.65	x	x	12.8%	$67,298	$45,781	1.5

4.2 Customer Cost Effectiveness Using On-Bill Impacts

The customer cost effectiveness methodology uses utility rate schedules to estimate the retail On-Bill cost savings of energy efficiency to the customer. The net present value is calculated using a 15-year lifetime, including a 3% rate of energy inflation and a 3% discount rate. TRC used Time of Use (TOU) rate schedules, which results in more value applied to energy savings that occur during peak periods.

Using customer cost effectiveness results, B/C ratios improve over the TDV cost effectiveness results. As shown in Figure 14, all climate zones achieve a 10% or greater compliance margin cost effectively, and CZs 1, 3, 5, and 7 can achieve a 15% compliance margin cost effectively.

Figure 14. On-Bill Cost Effectiveness Results

CZ	Cool Roof ASR	Reduced RSHGC	Reduced LPD	Institutional Tuning	Lighting Controls (Daylight Dimming Plus Off, Open Office Occupancy Sensors)	Compliance %	Annual kWh Savings	Annual Therm Savings	On Bill Savings	Incremental Cost	B/C Ratio
1	n/a	n/a	0.65	x	x	15.7%	26,084	(366)	$95,361	$18,112	5.3
2	0.70	0.22	0.65	x	x	12.8%	31,026	(433)	$114,859	$41,164	2.8
3	0.70	0.22	0.65	x	x	15.5%	29,508	(405)	$109,322	$45,243	2.4
4	n/a	0.22	0.65	x	x	13.1%	31,028	(322)	$114,311	$43,339	2.6
5	0.70	0.22	0.65	x	x	15.9%	30,179	(414)	$111,303	$45,243	2.5
6	0.70	0.22	0.65	x	x	14.7%	32,792	(185)	$82,359	$55,636	1.5
7	0.70	0.22	0.65	x	x	15.6%	32,678	(222)	$129,100	$44,389	2.9
8	0.70	0.22	0.65	x	x	13.7%	33,398	(240)	$83,662	$44,389	1.9
9	0.70	0.22	0.65	x	x	12.6%	33,510	(242)	$85,235	$44,389	1.9
10	0.70	0.22	0.65	x	x	11.6%	32,649	(244)	$121,226	$40,469	3.0
11	0.70	0.22	0.65	x	x	11.0%	32,640	(351)	$118,022	$40,373	2.9
12	0.70	0.22	0.65	x	x	11.8%	31,968	(371)	$116,533	$44,214	2.6
13	0.70	0.22	0.65	x	x	10.8%	32,744	(325)	$119,413	$40,373	3.0
14	0.70	0.22	0.65	x	x	11.0%	33,216	(353)	$80,520	$39,290	2.0
15	0.70	0.20	0.65	x	x	10.4%	38,959	(181)	$96,324	$45,320	2.1
16	0.70	0.22	0.65	x	x	12.8%	30,153	(603)	$106,614	$39,290	2.7

4.3 Greenhouse Gas Savings

New construction commercial buildings complying with the reach code will reduce energy consumption and thereby reduce greenhouse gas (GHG) emissions. TRC multiplied saved energy by a factor of 0.65 lbs of CO_2 equivalent (CO_2e) per kWh, and 11.7 lbs of CO_2e per therm, as per Environmental Protection Agency research, to attain estimates of GHG savings.[15] Jurisdictions adopting a reach code can use Figure 15 below to approximate the typical reductions of GHG emissions in a typical nonresidential building, expressed in pounds of carbon dioxide equivalent (lbs CO_2e)

Figure 15. Estimated GHG Savings per Building

Climate Zone	kWh Savings / Bldg	Therms Savings / Bldg	Lbs CO2e Avoided/Prototype	Lbs CO2e Avoided/ft^2	% GHG Savings per Bldg
1	26,084	(366)	12,686	0.24	4%
2	31,026	(433)	15,111	0.28	4%
3	29,508	(405)	14,454	0.27	5%
4	31,028	(322)	16,413	0.31	5%
5	30,179	(414)	14,789	0.28	5%
6	29,806	(219)	16,819	0.31	5%
7	32,678	(222)	18,655	0.35	6%
8	33,398	(240)	18,912	0.35	6%
9	33,510	(242)	18,962	0.35	6%
10	32,649	(244)	18,378	0.34	5%
11	32,640	(351)	17,120	0.32	5%
12	31,968	(371)	16,455	0.31	5%
13	32,744	(325)	17,494	0.33	5%
14	33,216	(353)	17,472	0.33	5%
15	38,959	(181)	23,216	0.43	6%
16	30,153	(603)	12,556	0.23	3%

These GHG reduction estimates are based on complying with the 10% packages using the measures analyzed in this study. Compliance with the 10% Reach Code may be achieved through a variety of measures, each of which will have varying electric and natural gas usages, and therefore varying GHG savings. Note also that these are percentage savings of the total greenhouse gas emissions from the buildings, including unregulated loads, which currently are not regulated within the constraints of Title 24, Part 6.

Each jurisdiction can estimate annual city-wide GHG savings by multiplying the CO_2e savings per square foot by the new construction commercial square footage constructed within city limits during an average year.

4.4 Reach Code Recommendations

TRC recommends that California jurisdictions adopt reach codes meeting the compliance margin requirements in Figure 16. Recommended reach code values are more lenient than the levels found to be cost effective –

[15] United States Environmental Protection Agency. 2015. "Emission Factors for Greenhouse Gas Inventories." Available at: https://www.epa.gov/sites/production/files/2015-12/documents/emission-factors_nov_2015.pdf.

compliance margins are rounded down. Final measure packages represent one possible way to achieve higher compliance margins, and are not intended to represent a mandatory or prescriptive set of measures.

Figure 16. Compliance Margin and Cost Effectiveness Summary Results

Climate Zone	Cost Effective Compliance Margin	B/C Ratio		Recommended Reach Code Compliance Margin
		TDV Methodology	On Bill Methodology	
1	15.7%	3.0	5.3	15%
2	12.8%	1.4	2.3	10%
3	15.5%	1.2	2.0	15%
4	13.1%	1.4	2.3	10%
5	15.9%	1.2	2.0	15%
6	14.7%	1.4	1.5	10%
7	15.6%	1.4	2.3	15%
8	13.7%	1.4	1.5	10%
9	12.6%	1.4	1.5	10%
10	11.6%	1.5	2.5	10%
11	11.0%	1.6	2.5	10%
12	11.8%	1.4	2.2	10%
13	10.8%	1.6	2.5	10%
14	11.0%	1.6	1.8	10%
15	10.4%	1.9	2.1	10%
16	12.8%	1.5	2.3	10%

5. Appendix A – Cost Data

Figure 17. Reduced LPD Detailed Costs

Product	Lamp Technology	LPD[1]	Product Cost ($/luminaire)	Dimming Ballast Cost ($/ballast)	Total Cost per square foot[2] ($/ft²)
Lithonia 2RT8S 232 MVOLT GEB10IS + dimming ballast	Fluorescent	0.73	$138.74	$52.00	$2.29
2VT8 232 ADP GEB10IS + dimming ballast	Fluorescent	0.73	$145.60	$52.00	$2.37
Lithonia 2BLT4 40L ADSM EZ1 LP840	LED	0.60	$138.39	n/a	$2.06
Cooper Lighting 2AC 232 UNV EB81 U	Fluorescent	0.63	$123.50	$52.00	$1.83

[1] Normalized to provide 50 footcandles of illuminance
[2] Square footage covered to provide 50 footcandles of illuminance

Figure 18. Occupancy Sensor Detailed Costs

Product	Coverage (ft²)	Installation	Viewing Angle	Proposed Cost ($/unit)
Acuity Sensor Switch Occupancy Sensor	452	Ceiling	360 Degrees	$133.15
Acuity Sensor Switch Occupancy Sensor	500	Ceiling	360 Degrees	$115.20
Acuity Lithonia Occupancy Sensor	452	Ceiling	360 Degrees	$158.25
Acuity Lithonia Occupancy Sensor	452	Ceiling	360 Degrees	$146.40
Hubbel Wiring Device-Kellems Occupancy Sensors	450	Ceiling	360 Degrees	$150.75
Hubbel Wiring Device-Kellems Occupancy Sensors	450	Ceiling	360 Degrees	$110.95
Hubbel Wiring Device-Kellems Occupancy Sensors	450	Ceiling	360 Degrees	$159.25
Hubbel Wiring Device-Kellems Occupancy Sensors	450	Ceiling	360 Degrees	$154.25
Leviton Self-Contained	530	Ceiling	360 Degrees	$64.45
Leviton Occupancy Sensor	450	Ceiling	360 Degrees	$100.90
Leviton Occupancy Sensor	530	Ceiling	360 Degrees	$128.50
Leviton Occupancy Sensor	600	Ceiling	284 Degrees	$54.40

Leviton Ceiling Mount Dual tech	500	Ceiling	360 Degrees	$85.86
Sensor Switch CM9 D	500	Ceiling	360 Degrees	$107.90
Watt Stopper Occupancy Sensor	500	Ceiling	360 Degrees	$127.45
Watt Stopper Occupancy Sensor	500	Ceiling	360 Degrees	$123.50
Watt Stopper Occupancy Sensor	500	Ceiling	360 Degrees	$156.75

Figure 19. Reduced Window SHGC Detailed Costs

Source	Product	SHGC	VT	Incremental Cost from SHGC 0.25 ($/ft^2)
Manufacturer 1	VNE1-63 with silkscreen	0.25	53%	n/a
	VUE24-50	0.25	52%	n/a
	VNE1-53	0.23	49%	($4.61) to ($4.21)
	VNE8-63	0.22	44%	$3.39 to $3.79
	VNE6-53	0.20	42%	($4.08) to ($3.68)
Manufacturer 2	EFCO 325X F with SolarBan70XL	0.25	>42%	n/a
	EFCO PX32 F	0.23	>42%	$0 - $10
	EFCO 325X F with SunGuard SNX 51/23	0.20	>42%	$5 - $15

Figure 20. Low-Slope Cool Roof Detailed Costs

Product Type	ASR	Average Cost ($/ft²)			
		North Coast	South Coast	North Central	Inland
TPO	0.63	$0.75	$0.94	$0.75	$0.75
	0.70	$0.85	$0.85	$0.85	$0.85
Incremental Cost		$0.09	-$0.10	$0.09	$0.09
Membrane	0.63	$0.63	$1.13	$1.07	$1.07
	0.70	$1.07	$1.64	$1.19	$1.19
Incremental Cost		$0.44	$0.51	$0.12	$0.12
Field Applied Coating	0.63	$0.55	$0.60	$0.48	$0.57
	0.70	$0.46	$0.79	$0.61	$0.50
Incremental Cost		-$0.09	$0.19	$0.13	-$0.07
Average Incremental Cost		**$0.15**	**$0.20**	**$0.11**	**$0.05**

6. Appendix B – Utility Rate Schedules

Below are hyperlinks to the rates used for each utility. Detailed rate schedules are provided in subsequent sections.

- Southern California Edison
  - Electric: Schedule TOU-GS-2-A. Available at: https://www.sce.com/NR/sc3/tm2/pdf/ce329.pdf
- Southern California Gas
  - Electric: Schedule No. G-10. Available at: https://www.socalgas.com/regulatory/tariffs/tm2/pdf/G-10.pdf
- Pacific Gas and Electric
  - Electric: Schedule A-10, Table B (TOU). Available at: https://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_A-10.pdf
  - Gas: Schedule G-NR1. Available at: https://www.pge.com/tariffs/tm2/pdf/GAS_SCHEDS_G-NR1.pdf
- San Diego Gas and Electric
  - Electric: Schedule AL-TOU. Available at: http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_AL-TOU.pdf
  - Gas: Schedule GN-3. Available at: http://regarchive.sdge.com/tm2/pdf/GAS_GAS-SCHEDS_GN-3.pdf

6.1 Electric Rates

Figure 21. Southern California Edison Commercial Electric Rates (TOU-GS-2-A)

Southern California Edison (SCE) Commercial Electric Rates	
Rate TOU-GS-2-A	Effective 1/1/2017
Winter ($/kWh) (Oct 1 through May 31)	
Mid-Peak (8AM - 9PM weekdays except holidays)	$0.07589
Off-Peak	$0.06573
Summer ($/kWh) (Jun 1 through Sept 31)	
On-Peak (12-6PM weekdays except holidays)	$0.34167
Mid-Peak (8AM - 12PM and 6PM - 11PM weekdays, except holidays)	$0.11601
Off-Peak	$0.05918
Additional Charges	
Facilities Related Demand Charge ($/kW/meter/month)	$15.48
Customer Charge ($/meter/month)	$220.30
Single Phase Service ($/month)	($11.71)
Voltage Discount, Demand ($/kW)	
2kV to 50kV	($0.20)
50kV to <220kV	($6.79)
220kV	($11.27)
Voltage Discount, Energy ($/kWh)	
2kV to 50kV	($0.00165)

50kV to <220kV	($0.00391)
220kV	($0.00395)
CA Alternate Rates for Energy Discount (%)	100%
TOU Option ($/meter/month RTEM)	$71.01
CA Climate Credit ($/kWh)	($0.00416)

Figure 22. Pacific Gas and Electric Commercial Electric Rate (Schedule A-10, Table B)

Pacific Gas and Electric (PG&E) Commercial Electric Rates	
Rate Schedule A-10, Table B	Effective 3/1/2017
Winter ($/kWh) (Nov 1 through Apr 30)	
Mid-Peak (8:30AM-9:30PM, weekdays except holidays)	$0.13641
Off-Peak	$0.11935
Summer ($/kWh) (May 1 through Oct 31)	
On-Peak (12-6PM, weekdays except holidays)	$0.21972
Mid-Peak (8:30AM-12PM and 6-9:30PM, weekdays except holidays)	$0.16459
Off-Peak	$0.13652
Demand Charge ($/kW/meter/month)	
Summer	$16.78
Winter	$9.45
Additional Charges	
Customer Charge ($/meter/day)	$4.59959
CA Climate Credit ($/kWh)	($0.0038)

Figure 23. San Diego Gas and Electric Commercial Electric Rate (AL-TOU)

San Diego Gas and Electric (SDG&E) Commercial Electric Rates	
Rate AL-TOU	Effective 3/1/2017
Winter ($/kWh) (Nov 1 through Apr 30)	
On-Peak (5-8PM, weekdays except holidays)	$0.11085
Mid-Peak (6AM-5PM and 8-10PM, weekdays except holidays)	$0.09574
Off-Peak	$0.07492
Summer ($/kWh) (May 1 through Oct 31)	
On-Peak (11AM-6PM, weekdays except holidays)	$0.12252
Mid-Peak (6-11AM and 6-10PM, weekdays except holidays)	$0.11305
Off-Peak	$0.08294
Demand Charge ($/kW/meter/month)	
Non-Coincident	$24.51
Summer - On-Peak	$20.84
Winter - On-Peak	$7.57
Additional Charges	
Basic Service Fee ($/meter/month)	$116.44

6.2 Gas Rates

Figure 24. Southern California Gas Commercial Natural Gas Rate (G-10)

Southern California Gas (SCG) Commercial Gas Rates	
Rate G-10	Effective 3/10/2107
Base Charges ($/therm)	
TIER 1 (up to 250 therms)	$0.89387
TIER 2 (251 to 4,167 therms)	$0.65334
TIER 3 (>4,167 therms)	$0.49206
Additional Charges	
Customer charge ($/meter/day)	$0.49315

Figure 25. Pacific Gas and Electric Commercial Natural Gas Rates (G-NR1)

Pacific Gas and Electric (PG&E) Commercial Gas Rates	
Rate G-NR1	Effective 3/1/2017
Winter ($/therm) May 1 - Nov 30	
TIER 1 (up to 4,000 therms)	$1.13678
TIER 2 (>4,000 therms)	$0.83428
Summer ($/therm) Dec 1 - Apr 30	
TIER 1 (up to 4,000 therms)	$1.02592
TIER 2 (>4,000 therms)	$0.77060
Additional Charges	
Customer charge ($/meter/day) 0 - 5.0 ADU[1]	$0.27048
Customer charge ($/meter/day) 5.1 - 16.0 ADU[1]	$0.52106
Customer charge ($/meter/day) 16.1 - 41.0 ADU[1]	$0.95482

[1]ADU is Average Daily Usage. It is the usage for the entire billing period divided by the number of days within the billing period.

Figure 26. San Diego Gas and Electric Commercial Natural Gas Rates (GN-3)

San Diego Gas and Electric (SDG&E) Commercial Gas Rates	
Rate GN-3	Effective 3/10/2017
Base Charges ($/therm)	
TIER 1 (up to 1,000 therms)	$0.80449
TIER 2 (1,001 to 21,000 therms)	$0.68176
TIER 3 (>21,000 therms)	$0.64710
Additional Charges	
Customer charge ($/meter/month)	$10.000

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

2016 Title 24, Part 6

Local Energy Efficiency Ordinances

Cost Effectiveness Study:

Statewide Nonresidential PV Cost Effectiveness Analysis

(New Construction and Retrofits)

Prepared for:

Christopher Kuch

Codes and Standards Program

Southern California Edison

Prepared by:

TRC

December 22, 2018

SDGE A Sempra Energy utility

SoCalGas A Sempra Energy utility

SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL® Company

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1 Introduction

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC, 2016b) is maintained and updated every three years by two state agencies, the California Energy Commission (CEC) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances, or reach codes, that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the CEC and file the ordinance with the BSC for the ordinance to be legally enforceable.

The goal of this study is to evaluate on-bill cost effectiveness of installing photovoltaic (PV) panels on nonresidential buildings for all sixteen climate zones in California. This investigation is in response to jurisdictions' interest in incorporating PV in the nonresidential Title 24 code:

1) Applicability
    a) All nonresidential new construction
    b) All high-rise multifamily residential new construction
    c) All nonresidential redevelopment at least 10,000 ft^2
2) Requirements
    a) Expand solar zone requirement for new nonresidential to include buildings with four to ten habitable stories
    b) Require PV systems with a capacity of either
        i) 80% of the building's modelled annual electric load
        ii) 15 DC watts per square foot of solar zone[1]

At the time of this memo, utility rate modeling and related energy cost calculations are finalized for PG&E and SCE territories. The utility rate modeling for SDG&E territory is being reviewed by the utility for all prototypes. **The analysis for SDG&E territory, including climate zones 7, 10 and 14, is excluded from this memo until full clarification is received from the utility.**

2 Methodology and Assumptions

2.1 Building Prototypes

TRC selected nonresidential new construction building types intended to represent boundary conditions for utility bill cost effectiveness analysis when accounting under net energy metering 2.0 (NEM 2.0). In other words, a large building and small building are likely to have different utility rate structures because they will have high and low energy usage, respectively. Thus they represent the boundaries that other building types would fall in between. If

[1] 2016 Title 24, Part 6, Section 110.10(b)1B: For high-rise multifamily (ten habitable stories or fewer) and nonresidential (three habitable stories or fewer), The solar zone shall be located on the roof or overhang of the building or on the roof or overhang of another structure located within 250 feet of the building or on covered parking installed with the building project and have a total area no less than 15 percent of the total roof area of the building excluding any skylight area.

both buildings are proven to be cost effective, then all buildings in between can be assumed to be cost effective. For the large building, TRC used High-Rise Multifamily prototype to represent multistory mixed-use new construction.

TRC modeled a retail strip mall of 9,375 ft^2 for the nonresidential redevelopment scenario to support cost effectiveness for alterations greater than 10,000 ft^2. TRC chose the retail strip mall prototype because it was the DOE prototype with a floor area closest to 10,000 ft^2. TRC assumed that the >10,000 ft^2 threshold in the proposed ordinance was chosen to ensure that 'large-enough' alterations projects would be subject to the ordinance – projects that have a high nominal cost. Because savings potential increases with building size, TRC assumed that demonstrating cost-effectiveness for an approximately 10,000 ft^2 prototype shows that the PV installations are economical for projects >10,000 ft^2.

TRC developed a total of 64 prototypes -- four building types in 16 climate zones. The four building types, based on the prototype selection include the following, described in more detail in Figure 1:

- New construction, large nonresidential building – three-story Medium Office - 53,628 ft^2
- New construction, small nonresidential building – single-story Small Office - 5,502 ft^2
- New construction high-rise residential building – twelve-story High-Rise Multifamily - 94,088 ft^2
- Existing (pre-1978 code), nonresidential – single-story Retail Strip Mall - 9,375 ft^2

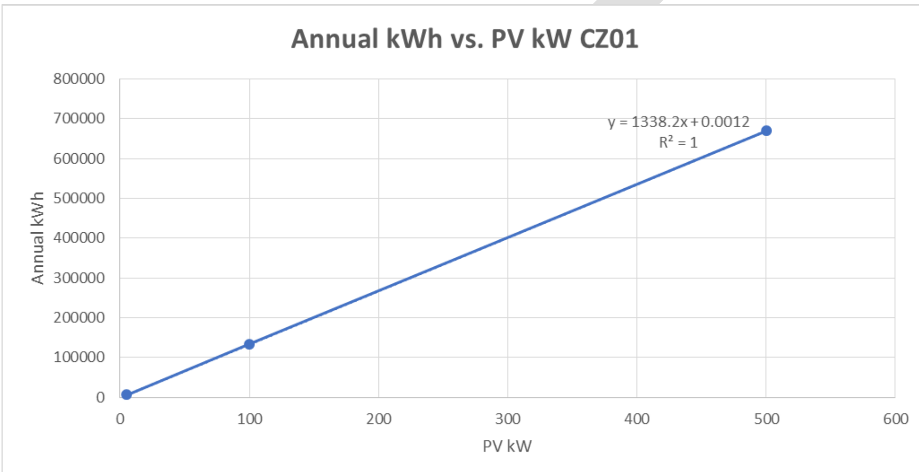
Figure 1. Prototype Characteristics Summary

Building Type	Medium Office	Small Office	High Rise Multifamily	Retail Strip Mall
Area (ft^2)	53,628	5,502	94,088	9,375
Roof Area (ft^2)	17,876	5,502	8,512	9,375
# of floors	3	1	12 (9-residential floors, 75-dwelling units)	1
Window-to-Floor Area Ratio	13%	11%	27.35%	8.21%
HVAC Distribution System	3x Packaged Variable Air Volume with VAV Hot Water Reheat	5x Packaged Single Zone Air Conditioners	*Common Areas:* PVAV *Dwelling Units:* Four-pipe fan coil	Single Zone Air Conditioner
Cooling System	Direct Expansion, 9.8 EER	Direct Expansion, 13 SEER	*Common areas:* Direct expansion *Dwelling Units:* Chilled Water	Direct Expansion, 13 SEER
Heating System	Boiler, 80% Thermal Efficiency	Furnace, 78% AFUE	Boiler, 80% Thermal Efficiency	Furnace, 78% AFUE
Conditioned Thermal Zones	18	5	40	4
Domestic Water Heating	Natural Gas Storage, 24 Gallon Tank, EF = 0.64	8x Natural Gas Storage, 2 Gallon Tank, EF = 0.71	Natural Gas Storage, 100 Gallon Tank, EF = 0.8	Natural Gas Small Storage, 14 Gallon Tank, EF = 0.65
Lighting Power Density (LPD)	0.75 W/ft^2	0.75 W/ft^2	Dwelling units – 0.5 W/ft^2; Corridor – 0.6 W/ft^2; Nonresidential areas – 0.7-1.2 W/ft^2	2.2 W/ft^2

2.2 Energy Simulations

TRC used CBECC-Com software version 2016.3.0 SP1 to simulate all the building prototypes and obtain the hourly consumption data without PV. CBECC-Com software does not have the capability to model PV in buildings. Hence, TRC simulated a residential building prototype in CBECC-Res software version 2016.3.0 (934 SP1) to obtain hourly PV generation output for each of the sixteen climate zones. TRC simulated three different PV system sizes covering a wide range of output (e.g., 5 to 500 kW) to obtain a relationship between PV system size and kWh generation for each building type. The analysis results in a linear relationship used to scale the PV generation for the desired PV sizes, an example shown in Figure 2 below.

Figure 2. Linear curve between annual PV generation (kWh) and installed PV size (kW) in Climate Zone 1



In summary, TRC performed the following simulations:

- CBECC-Com: All four prototypes under 16 climate zones, total 64 simulations
- CBECC-Res: One prototype, three PV system sizes and 16 climate zones, total 48 simulations

The final results overlay the scaled PV generation output to the hourly consumption output from CBECC-Com simulations to determine the net hourly consumption for the two desired PV definitions and four building types.

In other words,

Net hourly kWh consumption = Hourly kWh consumed (CBECC_Com) - Hourly kWh generated (CBECC_Res)

2.3 Cost Effectiveness

This section discusses how on-bill cost effectiveness is determined for the solar PV and solar ready measures.

2.3.1 Solar PV

TRC evaluated cost effectiveness of PV using the net present value (NPV) metric over 30 years, assuming a 3% discount rate and a 2% energy escalation rate. The analysis included benefit-to-cost (B/C) ratio and discounted payback metrics, defined as follows:

- **Net present value (NPV):** Present value of total benefits from utility bill savings minus present value of all costs including maintenance and replacement over 30 years. The criteria for cost effectiveness is NPV greater than 0.

- **Benefit-to-cost ratio (B/C): Ratio of present value of all benefits over present value of all costs over 30 years. The criteria for cost effectiveness is B/C greater than 1.0.**
- **Discounted payback:** Number of years it takes to break even from undertaking the initial expenditure, by discounting future cash flows and accounting for the time value of money.

Solar PV on-bill energy benefits and installation costs are estimated as discussed below.

2.3.1.1 Energy Cost Benefits

The on-bill cost-effectiveness methodology evaluates savings based on the customer's utility bills using rate structures of California's three major Investor Owned Utility (IOU) including Net Energy Metering (NEM) 2.0, shown in Figure 3 below.[2,3] Because climate zones 10 and 14 overlap with both SCE and SDG&E territory, TRC evaluated cost effectiveness under both utility rate structures in these climate zones.

Figure 3. IOU distribution by climate zone

IOU	Climate zones
Pacific Gas & Electric (PG&E)	1-5, 11-13, 16
Southern California Edison (SCE)	6, 8-10, 14, 15
San Diego Gas & Electric (SDG&E)	7, 10, 14

The specific electricity rate schedules within IOU territory are applied to each of the 64 prototypes based on the climate zone, estimated monthly peak load and annual kWh consumption (Figure 4). Utility territories and climate zones boundaries do not perfectly align; one utility territory contains multiple climate zones, and one climate zone can contain multiple utility territories. A prototype simulated in different climate zones will have different monthly peak loads, and may consequently fall under a different utility rate structure. For example, SCE rate TOU-GS-2-A may apply to the medium office prototype in one climate zone, while TOU-GS-3-A may apply in another climate zone.

Figure 4. Applicable rate schedules by building type

Building type	PG&E	SCE	SDG&E[4]
Small office	A-1 TOU	TOU-GS-1-A; TOU-GS-2-A	-
Medium office	A-10	TOU-GS-2-A; TOU-GS-3-A	-
HRMF	E-TOU A	TOU-D-T	-
Retail strip mall	A-10	TOU-GS-2-A	-

[2] More information on NEM available at: http://www.cpuc.ca.gov/General.aspx?id=3800

[3] The distribution of IOUs across sixteen climate zones is aligned with: Residential Retrofit High Impact Measure (HIM) Evaluation Report, *Prepared for California Public Utilities Commission (CPUC) Energy Division, February 8, 2010*

[4] The applicable rate schedules for SDG&E are still being reviewed and are subject to change.

For high-rise multifamily building utility bill calculations, two simplifying assumptions were necessary:

1. TRC approximated that each dwelling unit had the same energy consumption profile, because energy simulation software aggregates residential energy usage for all individual dwelling units. [5]
2. TRC performed energy calculations at an hourly level, even though utilities may determine bill amounts based on sub-hourly billing intervals for simplification.

TRC does not expect these assumptions to significantly affect the overall results.

2.3.1.2 PV Installation Costs

TRC sourced the PV cost information from nationwide studies done by NREL and LBNL[6,7]. As shown in Figure 5 below, the cost includes the system cost, installation and inverter costs accounting for inflation rate and federal tax credits for nonresidential buildings. TRC applied savings from the federal income tax credit (ITC), although because it is scheduled to be phased out between 2020 and 2022, an average ITC of 16% is used for residential systems and 19% for commercial systems. TRC assumed inverter replacements at years 11 and 21. The cost for a PV retrofit is an additional $0.25/W, resulting in a total $1.97/W only for the retail strip mall prototype existing construction scenario. The federal incentive is applied to the combined system and retrofit cost.

Figure 5. Nonresidential New construction PV costs summary

Cost type	$/W
First Cost	1.72
System Cost	*2.13*
Federal Income Tax Credit	*19.2%*
Inverter Replacement at year 11	0.15
Inverter Replacement at year 21	0.12
Annual Maintenance	0.02

2.3.2 Solar Ready

Because the 'solar ready' measure is an enabling measure, rather than a requirement to install a solar system, there are no associated direct energy savings. Solar-ready measures include:

- Roof area be reserved for solar equipment

[5] Aggregated energy data impacts how utility bills are calculated. As an example in PG&E territory, the baseline allocation and minimum customer charge per unit is multiplied for 75 units of the building. So, the aggregated energy consumption of the building is compared to 75 times the baseline allocation for individual unit to calculate energy costs. Aggregation does not account for real-world variations in energy usage across the dwelling units.

[6] F. Ran et al. (September 2016) U.S. Solar Photovoltaic System Cost Benchmark: Q1 2016. National Renewable Energy Laboratory. Available at: https://www.nrel.gov/docs/fy16osti/66532.pdf

[7] Barbose, G. and Darghouth, N. (September 2017) Tracking the Sun 10. Lawrence Berkeley National Laboratory. Available at: http://eta-publications.lbl.gov/sites/default/files/tracking_the_sun_10_report.pdf

- A pathway for piping and/or conduit be indicated on plans
- Roof structural design loads be shown on plans
- Adequate electrical capacity be provided
- Spare electric breaker space be provided

Costs for reserving roof area, reserving a pathway for piping/conduit, and structural design load calculations are design costs, which are excluded in the CEC's LCC methodology, though realizing these measures will require additional attention from architects and designers. In summary, because a conventional cost-effectiveness analysis would compare zero energy savings to zero costs, no cost effectiveness analysis was performed.

3 Results

Results are provided in Figure 6 through Figure 13 in the following pages. To account for the multiple utilities within climate zones 10 and 14, there is an additional row added in each of the figures below to show cost effectiveness under both rate structures. 10-1 and 14-1 are for SCE utility rate results, and 10-2 and 14-2 are for SDG&E utility rate results (which are still under review by SDG&E, and are thus not presented).

Cost effectiveness results are evaluated for both the proposed PV system size definitions:

- **PV Measure Definition 1**: Generation equating to 80% of the total annual electric consumption
- **PV Measure Definition 2**: 15 Watts DC per square foot of solar zone

Both PV measure definitions are cost-effective for all four building types. Medium office and high-rise multifamily buildings have less roof space available than the single story buildings, resulting in smaller PV system sizes per Definition 2. Smaller PV systems result in lower costs as well as lower bill savings than Definition 1 for these prototypes, as seen when comparing Figure 8 vs. Figure 9 or Figure 10 vs. Figure 11.

The 'kWh savings' are similar across all climate zones for a particular prototype and PV definition because they are only attributable to the PV system generation. However, the 'life cycle bill savings' are influenced by both kWh savings and utility rate schedules. 'Life cycle bill savings' are similar across climate zones when under the same rate schedule, but differ when there are different rate schedules and/or utility territories.

As an example, in Figure 7, both CZ3 (under PG&E territory) and CZ6 (under SCE territory) show similar kWh savings but have significantly different bill savings of $117,445 and $78,957, respectively. TRC compared the PG&E rate to the SCE rate, and found that the SCE rates have lower volumetric charges but higher monthly fixed charges – thus the volumetric savings resulting from PV have a smaller impact on the bill when compared to minimum fixed charges

Even for the same building type within the same IOU territory, differences may occur across different climate zones because of climatic impacts on building energy consumption. Climate-dependent energy consumption, primarily space heating and space cooling, informs the on-peak and off-peak energy consumption along with the peak kW demand. These variabilities dictate both utility rate schedule selection and corresponding energy costs. For example, climate zones within SCE territory can follow under TOU-GS-1, TOU-GS-2 or TOU-GS-3 depending on their monthly loads, and each of these rate schedules have different structures.

High rise multifamily follows a residential rate schedule as opposed to commercial rates applied to the other three prototypes. Residential and commercial rate schedules are structured differently, the major difference being the peak load demand charges included in commercial rates only. PG&E's residential rate plan also includes a credit awarded for usage up to their baseline allocation. As a result, life cycle bill savings of high-rise multifamily building cannot be easily compared against the other prototypes of similar size or energy consumption.

TRC has attempted to model utility rates as accurately as possible and in coordination with the utilities, but has not identified an exhaustive set of causalities for any trends across the buildings, utilities, and climate zones.

Key takeaways include:

- Solar PV is cost effective with both sizing methods, across all building types, utility territories, and climate zones analyzed in this study. Benefit to cost ratios across all results range from 1.5 to 7.4. While TRC could not analyze all possible permutations of building sizes and rates, this suggests that these sizing methods are appropriate in the majority of possible cases.
- The Small Office has similar B/C Ratios using both PV Definitions for sizing PV systems.
- The Medium Office and HRMF prototypes have generally higher B/C Ratios with smaller PV systems (PV Definition 2) as compared to PV Definition 1. However, larger PV systems have higher NPV savings over 30 years.
- The Retail Strip Mall has higher B/C ratios with a larger PV system (PV Definition 1) as compared to PV Definition 2.

Figure 6. Cost effectiveness results – Small office – PV definition 1

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	A-1	29.3	39,217	$70,289	$230,936	$160,647	3.3	7
2	PG&E	A-1	28.4	44,422	$68,087	$262,268	$194,181	3.9	6
3	PG&E	A-1	26.6	42,035	$63,875	$247,967	$184,092	3.9	6
4	PG&E	A-1	28.0	45,152	$67,254	$266,207	$198,954	4.0	6
5	PG&E	A-1	25.0	42,133	$60,080	$247,451	$187,372	4.1	6
6	SCE	TOU-GS-1	28.9	45,664	$69,371	$180,640	$111,269	2.6	10
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-GS-2	30.1	47,559	$72,098	$220,008	$147,910	3.1	8
9	SCE	TOU-GS-2	29.6	48,277	$70,892	$223,082	$152,190	3.1	8
10-1	SCE	TOU-GS-2	30.8	50,202	$73,866	$226,056	$152,190	3.1	8
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	A-1	31.5	50,149	$75,540	$295,240	$219,699	3.9	6
12	PG&E	A-1	30.0	47,102	$71,989	$277,602	$205,613	3.9	6
13	PG&E	A-1	32.5	50,256	$77,997	$295,612	$217,615	3.8	6
14-1	SCE	TOU-GS-2	28.5	51,180	$68,326	$224,963	$156,637	3.3	7
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-GS-2	35.6	59,568	$85,408	$243,624	$158,216	2.9	9
16	PG&E	A-1	27.7	47,016	$66,388	$276,326	$209,938	4.2	6

Figure 7. Cost effectiveness results – Small office – PV definition 2

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	A-1	12.4	16,567	$29,693	$99,717	$70,024	3.4	7
2	PG&E	A-1	12.4	19,372	$29,693	$116,592	$86,899	3.9	6
3	PG&E	A-1	12.4	19,540	$29,693	$117,445	$87,752	4.0	6
4	PG&E	A-1	12.4	19,935	$29,693	$119,760	$90,067	4.0	6
5	PG&E	A-1	12.4	20,823	$29,693	$124,345	$94,652	4.2	6
6	SCE	TOU-GS-1	12.4	19,546	$29,693	$78,957	$49,265	2.7	9
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-GS-2	12.4	19,587	$29,693	$59,942	$30,249	2.0	15
9	SCE	TOU-GS-2	12.4	20,221	$29,693	$60,906	$31,213	2.1	15
10-1	SCE	TOU-GS-2	12.4	20,180	$29,693	$60,206	$30,513	2.0	15
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	A-1	12.4	19,712	$29,693	$118,521	$88,828	4.0	6
12	PG&E	A-1	12.4	19,428	$29,693	$116,843	$87,150	3.9	6
13	PG&E	A-1	12.4	19,132	$29,693	$115,046	$85,353	3.9	6
14-1	SCE	TOU-GS-2	12.4	22,241	$29,693	$63,850	$34,157	2.2	14
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-GS-2	12.4	20,710	$29,693	$57,101	$27,408	1.9	17
16	PG&E	A-1	12.4	21,029	$29,693	$126,070	$96,377	4.2	6

Figure 8. Cost effectiveness results – Medium office - PV definition 1

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	A-10	226.4	303,042	$543,148	$1,368,713	$825,566	2.5	10
2	PG&E	A-10	222.4	348,075	$533,510	$1,615,140	$1,081,630	3.0	8
3	PG&E	A-10	206.3	325,611	$494,786	$1,504,648	$1,009,862	3.0	8
4	PG&E	A-10	220.5	355,050	$528,839	$1,623,929	$1,095,090	3.1	8
5	PG&E	A-10	194.8	327,649	$467,219	$1,493,119	$1,025,900	3.2	8
6	SCE	TOU-GS-2	230.2	363,468	$552,169	$1,110,412	$558,243	2.0	16
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-GS-2	237.4	375,540	$569,306	$1,159,835	$590,529	2.0	15
9	SCE	TOU-GS-3	233.4	381,176	$559,732	$1,320,521	$760,789	2.4	13
10-1	SCE	TOU-GS-3	237.9	387,771	$570,554	$1,314,698	$744,144	2.3	13
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	A-10	244.2	388,810	$585,670	$1,760,419	$1,174,749	3.0	8
12	PG&E	A-10	235.8	370,084	$565,629	$1,683,325	$1,117,696	3.0	8
13	PG&E	A-10	254.7	393,559	$610,802	$1,772,341	$1,161,539	2.9	8
14-1	SCE	TOU-GS-3	217.4	390,525	$521,362	$1,297,029	$775,667	2.5	10
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-GS-3	280.1	468,546	$671,793	$1,495,913	$824,121	2.2	14
16	PG&E	A-10	199.8	339,442	$479,299	$1,516,862	$1,037,563	3.2	8

Figure 9. Cost effectiveness results – Medium office - PV definition 2

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	A-10	40.2	53,825	$96,472	$353,359	$256,887	3.7	6
2	PG&E	A-10	40.2	62,941	$96,472	$408,113	$311,641	4.2	6
3	PG&E	A-10	40.2	63,487	$96,472	$397,970	$301,498	4.1	6
4	PG&E	A-10	40.2	64,769	$96,472	$410,637	$314,165	4.3	6
5	PG&E	A-10	40.2	67,654	$96,472	$430,527	$334,055	4.5	5
6	SCE	TOU-GS-2	40.2	63,503	$96,472	$346,995	$250,523	3.6	7
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-GS-2	40.2	63,637	$96,472	$355,618	$259,146	3.7	6
9	SCE	TOU-GS-3	40.2	65,697	$96,472	$391,040	$294,568	4.1	6
10-1	SCE	TOU-GS-3	40.2	65,566	$96,472	$393,515	$297,043	4.1	6
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	A-10	40.2	64,045	$96,472	$417,553	$321,081	4.3	5
12	PG&E	A-10	40.2	63,121	$96,472	$406,773	$310,300	4.2	6
13	PG&E	A-10	40.2	62,160	$96,472	$408,211	$311,738	4.2	6
14-1	SCE	TOU-GS-3	40.2	72,262	$96,472	$411,201	$314,729	4.3	5
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-GS-3	40.2	67,285	$96,472	$426,125	$329,653	4.4	5
16	PG&E	A-10	40.2	68,322	$96,472	$412,717	$316,245	4.3	5

Figure 10. Cost effectiveness results – High-rise multifamily - PV definition 1

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	E-TOU	238.4	322,852	$571,845	$2,025,220	$1,453,375	3.5	7
2	PG&E	E-TOU	225.6	371,193	$541,137	$2,187,767	$1,646,630	4.0	6
3	PG&E	E-TOU	210.5	344,653	$504,938	$2,040,935	$1,535,997	4.0	6
4	PG&E	E-TOU	221.9	376,983	$532,167	$2,226,673	$1,694,506	4.2	6
5	PG&E	E-TOU	197.6	348,463	$473,866	$2,011,233	$1,537,367	4.2	6
6	SCE	TOU-D-T	226.5	300,595	$543,263	$2,060,969	$1,517,706	3.8	6
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-D-T	233.3	312,666	$559,574	$2,143,444	$1,583,870	3.8	6
9	SCE	TOU-D-T	231.4	323,601	$555,088	$2,199,218	$1,644,131	4.0	6
10-1	SCE	TOU-D-T	235.7	330,150	$565,263	$2,235,530	$1,670,267	4.0	6
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	E-TOU	249.0	421,808	$597,311	$2,400,718	$1,803,407	4.0	6
12	PG&E	E-TOU	237.4	397,092	$569,400	$2,230,664	$1,661,264	3.9	6
13	PG&E	E-TOU	256.3	425,413	$614,846	$2,354,303	$1,739,457	3.8	6
14-1	SCE	TOU-D-T	220.5	339,752	$528,831	$2,305,881	$1,777,050	4.4	5
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-D-T	275.4	403,210	$660,453	$2,719,247	$2,058,794	4.1	6
16	PG&E	E-TOU	211.1	377,068	$506,410	$2,290,624	$1,784,213	4.5	5

Figure 11. Cost effectiveness results – High-rise multifamily - PV definition 2

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	E-TOU	19.2	25,630	$45,937	$273,401	$227,464	6.0	4
2	PG&E	E-TOU	19.2	29,970	$45,937	$320,775	$274,838	7.0	3
3	PG&E	E-TOU	19.2	30,231	$45,937	$313,753	$267,816	6.8	3
4	PG&E	E-TOU	19.2	30,841	$45,937	$329,443	$283,506	7.2	3
5	PG&E	E-TOU	19.2	32,215	$45,937	$328,745	$282,808	7.2	3
6	SCE	TOU-D-T	19.2	30,238	$45,937	$286,837	$240,900	6.2	4
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-D-T	19.2	30,302	$45,937	$290,631	$244,694	6.3	4
9	SCE	TOU-D-T	19.2	31,283	$45,937	$299,840	$253,903	6.5	4
10-1	SCE	TOU-D-T	19.2	31,221	$45,937	$300,028	$254,091	6.5	4
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	E-TOU	19.2	30,496	$45,937	$340,273	$294,336	7.4	3
12	PG&E	E-TOU	19.2	30,056	$45,937	$328,635	$282,698	7.2	3
13	PG&E	E-TOU	19.2	29,599	$45,937	$319,894	$273,957	7.0	3
14-1	SCE	TOU-D-T	19.2	34,409	$45,937	$322,608	$276,671	7.0	3
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-D-T	19.2	32,039	$45,937	$329,110	$283,173	7.2	3
15	PG&E	E-TOU	19.2	32,039	$45,937	$340,897	$294,960	7.4	3

Figure 12. Cost effectiveness results – Existing Retail strip mall – PV definition 1

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	A-10	84.0	112,424	$218,442	$510,358	$291,916	2.3	13
2	PG&E	A-10	84.6	132,460	$220,099	$611,335	$391,237	2.8	9
3	PG&E	A-10	77.0	121,554	$200,239	$561,986	$361,746	2.8	9
4	PG&E	A-10	83.0	133,623	$215,763	$609,041	$393,279	2.8	9
5	PG&E	A-10	71.9	120,997	$187,046	$551,377	$364,331	2.9	8
6	SCE	TOU-GS-2	86.7	136,919	$225,491	$418,301	$192,811	1.9	17
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-GS-2	90.0	142,367	$233,969	$439,701	$205,731	1.9	17
9	SCE	TOU-GS-2	88.3	144,288	$229,691	$444,818	$215,127	1.9	16
10-1	SCE	TOU-GS-2	92.6	150,878	$240,662	$461,482	$220,820	1.9	17
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	A-10	91.9	146,301	$238,904	$658,800	$419,896	2.8	9
12	PG&E	A-10	88.8	139,284	$230,777	$626,075	$395,299	2.7	9
13	PG&E	A-10	96.4	149,044	$250,763	$664,580	$413,816	2.7	10
14-1	SCE	TOU-GS-2	82.6	148,433	$214,824	$446,955	$232,131	2.1	15
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-GS-2	107.0	178,916	$278,095	$528,901	$250,806	1.9	17
16	PG&E	A-10	78.5	133,261	$203,988	$593,882	$389,894	2.9	9

Figure 13. Cost effectiveness results – Existing Retail strip mall - PV definition 2

Climate zone	Utility	Rate schedule	PV size	kWh savings	Life cycle Costs	Life cycle bill savings	Net savings (NPV)	B/C ratio	Discounted payback (yrs.)
1	PG&E	A-10	21.1	28,229	$54,848	$141,450	$86,602	2.6	10
2	PG&E	A-10	21.1	33,009	$54,848	$169,518	$114,670	3.1	8
3	PG&E	A-10	21.1	33,295	$54,848	$171,209	$116,361	3.1	8
4	PG&E	A-10	21.1	33,968	$54,848	$172,320	$117,472	3.1	8
5	PG&E	A-10	21.1	35,481	$54,848	$183,129	$128,281	3.3	7
6	SCE	TOU-GS-2	21.1	33,304	$54,848	$84,760	$29,912	1.5	26
7	SDG&E	-	-	-	-	-	-	-	-
8	SCE	TOU-GS-2	21.1	33,374	$54,848	$86,054	$31,205	1.6	25
9	SCE	TOU-GS-2	21.1	34,455	$54,848	$88,645	$33,796	1.6	24
10-1	SCE	TOU-GS-2	21.1	34,386	$54,848	$87,635	$32,787	1.6	24
10-2	SDG&E	-	-	-	-	-	-	-	-
11	PG&E	A-10	21.1	33,588	$54,848	$163,366	$108,518	3.0	8
12	PG&E	A-10	21.1	33,103	$54,848	$161,184	$106,336	2.9	8
13	PG&E	A-10	21.1	32,600	$54,848	$157,723	$102,875	2.9	9
14-1	SCE	TOU-GS-2	21.1	37,898	$54,848	$94,785	$39,936	1.7	19
14-2	SDG&E	-	-	-	-	-	-	-	-
15	SCE	TOU-GS-2	21.1	35,287	$54,848	$86,315	$31,467	1.6	25
16	PG&E	A-10	21.1	35,831	$54,848	$173,246	$118,398	3.2	8

RESOLUTION NO: 19-0814-1a.ii

STATE OF CALIFORNIA

STATE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION

RESOLUTION APPROVING THE CITY OF DAVIS'S LOCAL BUILDING ENERGY EFFICIENCY STANDARDS ORDINANCE NO. 2554

RESOLUTION: California Energy Commission approval of the City of Davis's locally adopted building energy standards, Ordinances CS-347 and CS-348, to require greater or equivalent energy efficiency than the *2019 Energy Code*, provided in California Code of Regulations, Title 24, Part 6, and associated administrative regulations in Part 1, Chapter 10.

WHEREAS, on April 23, 2019, the City of Davis adopted an ordinance to exceed the *2019 Energy Code* (the Ordinance); and

WHEREAS, Public Resources Code Section 25402.1, Subdivision (h)(2), and California Code of Regulations, Title 24, Section 10-106, establish a process for local governments to apply to the Energy Commission for approval of local energy standards that are different from, but which must be at least as stringent as, the *2019 Energy Code*; and

WHEREAS, the City of Davis submitted an application to the Energy Commission for the Ordinance that meets all of the documentation requirements pursuant to Public Resources Code Section 25402.1, Subdivision (h)(2), and California Code of Regulations, Title 24, Section 10-106; on May 14, 2019; and

WHEREAS, the City of Davis, in their application to the Energy Commission, indicated that there is no possibility that the implementation of the Ordinance will have a significant negative impact on the environment, and therefore the adoption of the ordinance is exempt from the California Environmental Quality Act codified in California Public Resources Code section 21000 et seq. (CEQA), pursuant to Subdivision (b)(3) of Section 15061 of the CEQA Guidelines, codified in Title 14 of the California Code of Regulations; and

WHEREAS, the City of Davis has made a written commitment to actively enforce compliance with both the *2019 Energy Code* and with the amendments in its Ordinances, and

WHEREAS, the Energy Commission has analyzed whether the Ordinance will require the diminution of energy consumption levels permitted by the *2019 Energy Code*.

THEREFORE BE IT RESOLVED, the Energy Commission finds that the City of Davis's Ordinance will require the diminution of energy consumption levels permitted by the *2019 Energy Code*; and

THEREFORE BE IT FURTHER RESOLVED, that the Energy Commission finds that granting the application of the City of Davis regarding the Ordinance will not result in a direct or reasonably foreseeable indirect physical change to the environment, and is therefore exempt from CEQA pursuant to Subdivision (b)(3) of Section 15061 of the CEQA Guidelines, codified in Title 14 of the California Code of Regulations; and

THEREFORE BE IT FURTHER RESOLVED, the Energy Commission applauds the City of Davis for seeking to achieve additional energy demand reductions, energy savings and other benefits exceeding those of the *2019 Energy Code*; and

THEREFORE BE IT FURTHER RESOLVED, that on August 14, 2019, the Energy Commission grants the application of the City of Davis; and

THEREFORE BE IT FURTHER RESOLVED, that the Energy Commission directs the Executive Director to take all actions necessary to implement this Resolution, including but not limited to filing the appropriate notices with the Office of Planning and Research. (See, e.g., Cal. Code Regs., Tit 14, § 15062.)

CERTIFICATION

The undersigned Secretariat to the Commission does hereby certify that the foregoing is a full, true, and correct copy of a Resolution duly and regularly adopted at a meeting of the California Energy Commission held on August 14, 2019.

AYE: [List of Commissioners]
NAY: [List of Commissioners]
ABSENT: [List of Commissioners]
ABSTAIN: [List of Commissioners]

Cody Goldthrite
Secretariat