Peninsula Advanced Energy Community (PAEC)

Task 2.6: Final Benefit-Cost Analysis Report of Potential Ordinances

Prepared for
California Energy Commission
1516 Ninth St., MS-51
Sacramento, CA 95814

Prepared by
DNV GL
155 Grand Ave #500
Oakland, CA 94612
www.dnvgl.com

June 2017

Table of Contents

Tables

About DNV GL

DNV GL is a global energy and climate consulting practice serving government, utility and private sector clients with 15,000 employees in more than 100 countries. DNV GL – Energy's 2,300 experts offer a broad range of energy consulting services spanning all links in the energy value chain including renewable and conventional power generation, power and natural gas transmission and distribution, smart cities and smart grids, sustainable energy use, and energy markets and regulations.

Visit us online at www.dnvgl.com

About the Clean Coalition

The Clean Coalition is a nonprofit organization whose mission is to accelerate the transition to renewable energy and a modern grid through technical, policy, and project development expertise.

The Clean Coalition drives policy innovation to remove barriers to procurement and interconnection of distributed energy resources (DER)—such as local renewables, advanced inverters, demand response, and energy storage—and we establish market mechanisms that realize the full potential of integrating these solutions. The Clean Coalition also collaborates with utilities and municipalities to create near-term deployment opportunities that prove the technical and financial viability of local renewables and other DER.

Visit us online at www.clean-coalition.org.

Legal Disclaimer

This document was prepared as a result of work sponsored by the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees, or the State of California. Neither the Commission, the State of California, nor the Commission's employees, contractors, nor subcontractors makes any warranty, express or implied, or assumes any legal liability for the information in this document; nor does any party represent that the use of this information will not infringe upon privately owned rights. This document has not been approved or disapproved by the Commission, nor has the Commission passed upon the accuracy of the information in this document.

I. Introduction

The Clean Coalition's Peninsula Advanced Energy Community (PAEC), supported by numerous local governments and PG&E, will accelerate the planning, approval, and deployment of an Advanced Energy Community (AEC) within a diverse community in the southern portion of San Mateo County. The PAEC core region encompasses the cities of Atherton, East Palo Alto, Menlo Park, and Redwood City as well as surrounding unincorporated areas. The PAEC region -largely built-out yet also experiencing enormous commercial and residential growth pressure - is representative of similar regions throughout California, ensuring that the PAEC's success can be replicated statewide. The PAEC project will include the key components necessary to define an AEC: abundant solar electricity, energy storage, and other Distributed Energy Resources (DER,) low or zero net energy (ZNE) buildings, Solar Emergency Microgrids (SEM) for power management and islanding of critical loads during outages, and charging infrastructure to support the rapid growth in electric vehicles.

AEC projects can provide significant energy, environmental, economic, and security benefits, but significant barriers too often impede their planning and deployment. Finding viable sites, securing project financing, and connecting AEC projects to the grid all represent significant challenges. The PAEC project is designed to overcome these barriers and establish a replicable model that can be used by other communities across California and beyond. The results of the PAEC will inform future action by policymakers, municipalities and other governmental agencies, utility executives, and other relevant audiences.

The goals and objectives of this project are to:

- Incentivize and accelerate the planning, approval, financing and deployment of AECs
- Reduce the time, cost, and uncertainty associated with permitting and interconnecting commercial-scale solar and other DER
- Leverage ZNE, efficiency, local renewables, energy storage, and other DER to reduce 25 MW of peak energy across San Mateo County, which will strengthen the grid,
- Reduce use of natural gas, and minimize the need for new energy infrastructure
- Create a model project and project elements that can be replicated throughout California and beyond



In order to assess how the risks and uncertainties surrounding the design, permitting, and planning of Advanced Energy Communities can be minimized or addressed, DNV GL performed a benefit-cost analysis on policy, codes, and ordinances relevant to Advanced Energy Communities. Based on the results of these analyses, DNV GL will work with Clean Coalition to develop 2-3 proposed policies/codes/ordinances for implementation.

II. Purpose

As part of Task 2.1, the PAEC project team developed a comprehensive list of potential policies/codes/ordinances to analyze for energy, economic, and environmental benefits and barriers. This report outlines how a subset of policies were selected for further benefit-cost analysis, describes the benefit-cost methodology, results, and next steps.

1. Methodology

This benefit-cost analysis builds upon previous tasks that summarized best practices related to clean energy advanced communities. The results of the best practices review (see *Task 2.1 Best Practices Draft Report*) were presented to local jurisdictions through the San Mateo Regionally Integrated Climate Action Planning Suite (RICAPS) monthly working groups.

Following the presentation of the best practices to all 20 cities and the County of San Mateo, the PAEC project team engaged local jurisdictions with both an online survey and a focus group of four targeted jurisdictions (cities of Redwood City, East Palo Alto and Menlo Park, and the unincorporated County) to prioritize the measures in terms of their applicability to local municipalities and jurisdictions.

Based on the input received via these channels, DNV GL selected a subset of 8 policies for further benefit-cost analysis to help inform the development of 2-3 model policies and ordinances. DNV GL focused on policies where:

- **No model ordinances currently existed, or were under development.** For instance, the PAEC project team was aware of numerous concurrent efforts by California investor-owned utilities, Bay Area Regional Energy Network (BayREN), California Energy Commission to develop model ordinances related to mandatory rooftop solar photovoltaic (PV), and energy disclosure ordinances for residential. Therefore, these were not selected for further analysis under the PAEC project.
- **Local jursidictions had prioritized interest in benefits or specific ordinances.** Based on the online survey and focus group, the cities prioritized benefits related to greenhouse gas reductions and community resiliency. Specific poliices of interest were related to 100% renewable energy, electric vehicles and solar or zero carbon water and space heating.

- **Requirements would push boundaries of AEC for innovation.** The selected policies for benefit-cost analysis are aimed at new concepts for local policies and ordinances to help transform our cities into advanced energy communities. DNV GL recognizes that new models for AEC technology deployment are needed, and that local government have unique regulatory powers related to community development. Therefore, the analysis in this task is aimed at exploring the boundaries of new AEC local government policy.

2. Summary of Policies for Benefit-Cost Analysis

The PAEC project focuses on transforming our non-residential building sectors including multi-unit residential buildings. Therefore, the selected policies for benefit-cost analysis focus on both new and existing multi-unit dwellings and commercial buildings. Based on input from local jurisdictions and industry experts, the following policies were selected for benefit-cost analysis:

1. **Policy 1-EV-MF. Electric Vehicle Charging Infrastructure (EVCI) cost-share for existing multi-unit residential buildings**. It is well-known that there are significant barriers for tenants of multi-unit residential buildings to access electric vehicle charging infrastructure for overnight charging, compared with residents of single family homes. Existing state law requires multi-unit residential building owners to allow tenants to install EVCI. The benefit-cost analysis explores the financial and environmental impacts of requiring the building owner to provide a 50% cost-share.
2. **Policy 2-EV-NC. Electric vehicle fast chargers for new retail buildings.** Many cities are exploring reach codes that extend beyond the California Green Building Standards Code to require pre-wiring or full installation of EVCI in new construction. The benefit-cost analysis explores the financial and environmental impacts of requiring electric vehicle fast chargers at retail new construction, to supplement workplace and home charging networks and address "range anxiety" with longer electric vehicle trips.
3. **Policy 3-PV. Solar carports for new commercial buildings.** While some cities are exploring mandatory rooftop solar PV requirements for new construction, parking lots potentially offer cost-effective opportunities for larger distributed solar projects with favorable economics. The benefit-cost analysis explores the financial and environmental impacts of a local requirement for large public and private surface-level parking lots to install solar carports. The ordinance also applies to the upper-most level of multi-story parking garages that are open-air (i.e., not covered).
4. **Policy 4-HP-MF. Electric heating system installation for new multi-unit residential buildings.** As our electricity mix becomes cleaner and closer to 100% renewable, cities are particularly interested in technologies and initiatives to reduce natural gas consumption in buildings. This benefit-cost analysis explores the

financial and environmental impacts of a local requirement for all new multi-unit residential buildings to utilize heat pump technology for space and water heating.

5. **Policy 5-HP-NC. Electric heating system installation for new commercial buildings.** Similar to Policy 4-HP-MF, this benefit cost-analysis explores the financial and environmental impacts of a local requirement to utilize heat pump technology for space and water heating for all new commercial buildings.
6. **Policy 6-EE-MF. Time of sale audit and disclosure for existing multi-unit residential buildings**. In the past few years, cities have struggled to adopt new time-of-sale energy use disclosure requirements for single family residential, due to the opposition of well-organized local realtors. In the effort to support local efforts, this benefit-cost analysis examines the financial and environmental impacts of requiring an energy audit with energy efficiency recommendations for existing multi-unit residential at time-of-sale.
7. **Policy 7-EE-COMM. Time of sale audit and disclosure for existing commercial buildings.** Existing state law Assembly Bill 802 requires energy use disclosure for existing commercial buildings. This benefit-cost analysis explores a requirement for an energy audit at time-of-sale, with recommendations for energy efficiency upgrades, in addition to the state requirement.
8. **Policy 8-EE-NC. Measurement & verification for new commercial buildings.** Recognizing that the California Building Energy Efficiency Standards focuses on the design of new buildings (and major alterations) with no enforcement beyond certificate of occupancy, some cities are interested in exploring policy approaches to ensure that occupied buildings perform as designed. The benefit-cost analysis explores a city policy that requires measurement and verification of new commercial buildings.

To support cities and their need to justify the benefits of these types of AEC policies to their local building owners and constituents, the financial portion of the benefit-cost analysis is performed from the building owner perspective. However, the societal benefits are captured as part of the environmental benefits related to greenhouse gas emissions reductions, reduced fossil fuel usage and other criteria. Other co-benefits are also captured qualitatively.

3. Key Assumptions

For each policy, the team conducted extensive research into the current industry and market to estimate the costs to install, operate, and maintain the various aspects of the policies, including equipment, design, permitting, etc., when available and verifiable. Additionally, current incentive and rebate programs were assessed for applicability and included in the analysis.

Table 1 and Table 2 summarizes the high-level assumptions associated with energy costs and emissions factors. The benefit-cost analysis assumes full launch of Peninsula Clean

Energy across the County, utilizing current rates of opt-out to PG&E, ECO50 and ECO100 uptake.

Table 1: Assumptions – utility rates for all policies

Electric ($/kWh)	0.23635
Gas ($/therm)	1.12175

Table 2: Assumptions – emission factors for all policies

Peninsula Clean Energy (PCE) Electricity (MT CO2/kWh)	0.0001067
Gasoline (MT CO2/gallon)	0.00869

III. Results

The team analyzed each policy for applicable quantitative and qualitative benefits and costs, summarized below in Table 3 and Table 4. To support cities and their need to justify the benefits of these types of AEC policies to their local building owners and constituents, the financial portion of the benefit-cost analysis is performed from the building owner perspective.

When available, the total annual energy savings was calculated and converted into annual cost savings and/or annual profit. The calculated results were coverted into payback period for the building owner, when available. If there was no cost savings or profit associated with the policy, the payback was considered not applicable, noted as "No Payback." Lastly, energy savings, or in the case of electric vehicle chargers, gasoline savings, were converted into annual greenhouse gas (GHG) reduction.

For the electric heating system policies (Policy 4-HP-MF and Policy 5-HP-NC), the analysis was separated into space heating and water heating systems due to the technological and energy use differences between end use types. While both water and space heating have the opportunity to utilize heat pump technology to increase product efficiency, the installation methods, incremental savings, payback, and barriers to implementation are not exactly the same for space versus water heating.

Table 3: Quantitative benefit-cost analysis results – all policies

Policy #	Total Annual Energy Savings	Annual Profit and/or Cost Savings ($/yr)	Payback (years)	Annual GHG Reduction (MT CO2)
1-EV-MF	630 gallons of gasoline	$ 1,028	2.5	5
2-EV-NC	10,005 gallons of gasoline	$ 5,713	5.7	87
3-PV	143,052 kWh	$ 33,811	7.0	15
4-HP-MF (space heating)	4,920 kWh*	$ (1,159)	No payback	1
4-HP-MF (water heating)	15,010 kWh*	$ (515)	No payback	2
5-HP-NC (space heating)	9,592 kWh*	$ (286)	No payback	1
5-HP-NC (water heating)	4,939 kWh*	$ (167)	No payback	1
6-EE-MF	21,701 kWh*	No cost savings for seller	No payback	2
7-EE-COMM	54,626 kWh*	No cost savings for seller	No payback	6
8-EE-NC	29,300 kWh*	$ 6,925	15.9	3

*Denotes net energy savings (based on both therms and electricity)

In addition, based on input from local jurisdictions in San Mateo County, each policy was also evaluated against a set of qualitative criteria for societal benefit, including:

- **Minimize fossil fuel use.** At the building project scale, what is the relative impact on reducing fossil fuel usage?
- **Innovate on technology or deployment.** To what extent does the policy promote or remove barriers to the deployment of new clean energy technology?
- **Regulatory ease.** From a political and city staff effort perspective, how easy would it be to pass the ordinance through a public process with Council approval?
- **Community benefits** (health, jobs, and infrastructure). To what extent are there multiple co-benefits beyond simply energy, cost and greenhouse gas emissions savings?

Table 4: Qualitative assessment of benefit-cost criteria – all policies

Policy #	Minimize Fossil Fuel Use	Innovate on tech or deploy	Regulatory Ease	Community Benefits (health, jobs, etc.)
1-EV-MF	high	med	low	low
2-EV-NC	high	high	low	med
3-PV	low	med	high	med
4-HP-MF (space heating)	high	high	low	low
4-HP-MF (water heating)	high	high	low	low
5-HP-NC (space heating)	high	high	low	low
5-HP-NC (water heating)	high	high	low	low
6-EE-MF	low	med	med	med
7-EE-COMM	low	med	med	med
8-EE-NC	low	low	med	med

Below, more detailed information is provided related to the assumptions and benefit-cost results for each policy.

1. Policy 1-EV-MF. Electric vehicle charging stations for existing multi-unit residential buildings

Governor Brown's Executive Order of March 2012, directs state government to support and facilitate the rapid commercialization of Zero-Emission Vehicles (ZEVs), with a target of having 1.5 million ZEVs on California roadways by 2025. In order to meet this goal and in order for electric vehicles to proliferate, it is important that early consumers have a positive experience and that facilities be readily available to provide convenient charging stations for the electric vehicles.

In support of the Governor's Executive Order, California Assembly Bill (AB) 2565 provides that for a residential lease executed, extended, or renewed after July 1, 2015, "a lessor of a dwelling shall approve a written request of a lessee to install an electric vehicle charging station at a parking space allotted for the lessee that meets the requirements of this section and complies with the lessor's procedural approval process for modification to the property." The law assumes that the lessee pays the full cost of the charging station installation.

Local jurisdictions are very interested in programs and policies to promoting the use of electric vehicles to meet the requirements of climate change and city climate action plans. While AB 2565 requires a lessor of a dwelling to approve a written request of a lessee to install an electric vehicle charging station at a parking space allotted for the lessee, there is a split-incentive problem that discourages investment in charging stations for leased property. The cost of the installation is born entirely by the lessee even though significant components of the charging station are permanent modifications to the lessor's property.

Split-incentives are a market failure for leased properties related to a range of energy efficiency and clean energy project, including electric vehicle charging stations. This benefit-cost analysis examines how a city ordinance could help overcome one of the most significant barriers to EV charging stations in leased property through requiring a cost-share by the lessor and lessee.

In the benefit-cost analysis scenario below, the tenant (i.e. the owner of the electric vehicle) initiates the installation of a simple EV Level 2 charger linked to the tenant's electric meter and paid via the tenant's personal utility bill, with a 50% cost-share by the building owner. The 50% cost-share is an assumed scenario for the purposes of the analysis, which also assumes pedestal-type charger, curbside installation, and 30 feet conduit/trenching length.

Table 5: Project assumptions for Policy 1-EV-MF

Building type	Multi-family building, apartment
Type of installation	Curbside
Location	Wall mount
Conduit/Trenching length	30 ft
Type of charger	Level 2
Building owner cost-share	50%

Table 6: Benefit-cost analysis results for Policy 1-EV-MF

Benefit/Cost	**Units**	**Source**
Cost to Install	$1,150	Sales platform averages and DNV GL professional experience. 50% cost share applied to building improvement costs.
Incentives Available	$115	California Capital Access Program (CalCAP)
Incremental Operations & Maintenance	$38	US DOE
kWh/mile	0.30	Average of typical EVs
Annual cost of electricity	$956	DNV GL calculation
Cost of gas avoided	$2,021	NY Times $/mile gas price calculator and DNV GL calculation
Gallons of gas saved	630	US DOT and DNV GL calculation

In this scenario, the tenant/vehicle-user pays 50% of the installation and nets the cost savings associated with gallons of gas saved resulting in a **1.97 year payback**. Without the cost-share, the payback was estimated at 2.5 years.

2. Policy 2-EV-NC. Electric vehicle charging infrastructure for new retail buildings

In-line with state policy and local climate action plans, local jurisdictions understand that mass-market adoption of electric vehicles depends upon convenient access to charging. Furthermore, the ability to serve electric vehicles in existing buildings is commonly limited by the electrical system capacity of the building. The most cost-effective time to prepare building electrical infrastructure for electric vehicle charging is when electric service is installed or upgraded due to construction, because workers are already on-site, utility service upgrade costs are lower, permitting and administrative costs are lower, and it is more cost-effective to include such systems in existing construction financing.

The California Green Building Code currently only requires a limited number of "EV ready" parking spaces, defined as parking spaces with a raceway installed at time of construction and adequate electrical service panel for the limited number of identified spaces. Several local jurisdictions in California have adopted more stringent ordinances requiring full circuitry to be installed, as well as a higher percentage of parking spaces to be "EV ready."

Furthermore, while workplace and residential EV charging infrastructure is critical for EV owners, there remains a gap in EV charging infrastructure for public charging. This ordinance seeks to increase the availability of public charging infrastructure through requirements for new retail buildings to provide EV fast charging to support longer vehicle trips that may be outside of normal commute patterns to reduce EV owner "range anxiety." EV fast charging provides up to 40 miles of range for every 10 minutes of charging, compared with Level 2 chargers providing 70 miles of range per hour of charging.[1]

Some retail locations like Whole Foods and some shopping malls around the San Francisco Bay Area are already offering EV charging as an amenity to draw new customers. The benefit-cost analysis focuses on examining a policy requiring EV fast chargers for new retail construction, given the shorter visit time to retail locations such as a Whole Foods or Target, compared with workplace or residential charging Policy.

The analysis assumes pedestal-type charger, curbside installation, 30 feet conduit/trenching length, and utilizing the ChargePoint network with an annual $280 fee with an additional 10% of the total dollar per kWh per year charged to the vehicle-users.

[1] https://pluginamerica.org/understanding-electric-vehicle-charging/

The cost to charge at the station is assumed to be $0.46 per kWh calculated from an average of comparable DC chargers located in San Mateo County.

Table 7: Project assumptions for Policy 2-EV-NC

Type of installation	Curbside
Location	Pedestal
Conduit length/ Trenching distance	30 ft
Type of charger	Direct current (DC) fast charger
Cost to EV Owner	$0.46 per kWh
Annual Network Fees - ChargePoint	$280 + 10%
EV kWh/mile	0.30

Table 8: Benefit-Cost Analysis Results for Policy 2-EV-NC

Benefit/Cost	Units	Source
Total cost to install	$42,500	NYC Taxi Study 2013, Aerovironment Costs and MSRP from Chargepoint for CPE-100
Incentives Available	$4,250	California Capital Access Program (CalCAP)
Incremental Operations & Maintenance	$1,250	NYC Taxi Study 2013, Aerovironment Costs
Annual Charger Fee	$280	ChargePoint
Annual Cost of Electricity	$19,583	DNV GL Rate Analysis calculated on PGE E-19 TOU Rate
Annual Charge to EV Owner	$29,807	Average $/kWh in region Annual kWh from Rate Analysis
Gross Revenue to Property Owner	$26,827	ChargePoint 10% network fee
Enabled EV Miles Driven	214,133	Average EV efficiency Annual kWh from Rate Analysis
Gallons of gas saved	10,005	DNV GL Calculation

The building owner pays for installation, yearly operation and maintenance (O&M), the annual cost of electricity, and the annual network fee but also nets the annual charge to the vehicle owner resulting in a **5.7 year payback.**

Additionally, for the EV owner, the gas savings associated with the DC fast charger is calculated by estimating the EV-enabled vehicle miles driven from the calculated kWh per year and the average EV vehicle efficiency in kWh per mile. The resulting 10,005 gallons of gasoline saved reduces greenhouse gas (GHG) emissions by of 87 MT CO_2 per year.

3. Policy 3-PV. Solar carports for new commercial buildings

Cities around the world have instituted policies supporting renewable energy, which can include solar power, wind power, hydroelectric power, geothermal energy and wave or tidal power. In California, the most common local renewable programs are focused on solar or photovoltaic (PV) power. Many municipalities in the Bay Area have adopted mandatory ordinances requiring rooftop solar PV for new or renovated buildings.

In order to maximize the use of solar PV in our communities, we consider a policy that requires all new commercial developments with more than 50 surface-level parking spaces to install PV panels to cover at least half of the surface-level parking spots. The analysis assumes a 30,000 sf building with a building EUI of 60 kBtu/sf, resulting in 491,400 kWh per year. The PV size is assumed to be 100 kW with an output of 143,052 kWh per year, and the cost of installation is $3 per Watt based on California Energy Commission data.

Table 9: Project assumptions for Policy 3-PV

Type	Surface parking
Building size (sf)	30,000
Building EUI (kBtu/sf)	60 kBtu/sf
Annual Energy Use (kWh/year)	491,400
Parking spots	78
Orientation	Maximize output and shading
Size of system (kW)	100
Output (kWh)	143,052
% Energy Use Provided PV	29.11
$/W	3.00

Table 10: Benefit-cost analysis results for Policy 3-PV

Benefit/Cost	Units	Source
Total capital cost	$300,000	DNV GL professional experience
Incentives Available	$14,305	City of Palo Alto Commercial Advantage Program
Incentives Available	$48,638	California Solar Initiative
Annual Grid Electricity Savings (kWh/yr)	143,052	PVWatt Calculator
Annual Electric Cost Savings ($/yr)	$33,811	DNV GL calculation

The annual electric cost savings of $33,811 results in a **7 year payback**. Additionally, the annual grid electricity energy savings of 143,052 kWh per year can be converted into GHG reduction of 15 MT CO_2.

4. Policy 4-HP-MF. Electric heating system installation for new multi-unit residential buildings

Across California, local government are making tremendous strides to procure cleaner electricity approaching 100% renewable due to the California Renewable Portfolio Standard (50% renewable by 2030) and community choice aggregation (offering 100% renewable products). Therefore, to meet California AB 32 and SB 350 mandates for greenhouse gas emissions reductions, cities are increasing looking for ways to dramatically reduce natural gas consumption in buildings. Local governments are exploring both energy efficiency and renewable methane sources. However, there is a limited supply of renewable gas (biogas) compared with natural gas consumption in buildings.

The predominant use of natural gas in the California commercial building stock is for water and space heating end uses.[2] In the past, utilizing gas for space and water heating systems was a wise choice due to the lower operating cost and the relatively high emissions associated with grid-supplied electricity. This is no longer the case. Improvements in heat pump technology have reduced the operating cost of electric heating systems, while the uptake of renewable energy in California's grid has made grid-supplied electricity the cleanest choice available. It has become clear that reducing carbon emissions in new building stock will depend on choosing electric solutions over natural gas solutions wherever possible.

In order to maximize renewable-ready equipment in new building projects, the team analyzed requiring electric heat pumps for a new prototypical multi-unit residential building in the PAEC region.

Table 11: Project assumptions for prototypical new multi-unit residential building for policy 4-HP-MF

Square footage (sf)	5,000
Space heating load energy use intensity (Btu/sf)	9.6
Water heating energy use intensity (Btu/sf)	12.6
Building characteristics	5 units, 20 residents
# of stories	2

[2] Commercial End Use Survey (CEUS, 2006)

a. Space heating

For the new multi-unit residential building, the analysis assumes that the baseline equipment is a 78% AFUE natural gas furnace. The benefit-cost analysis explores the installation of a 3.4 COP (coefficient of performance) split-system heat pumps. We have assumed that in the case of new construction, all new multi-family will be air conditioned. Opting for a heat pump when choosing an air conditioner results in a negligible cost differential. When factoring in the avoided cost of gas piping and a furnace required for gas heating systems, the additional cost for heat pumps is can be considered zero.

Table 12: Benefit-cost analysis results for Policy 4-HP-MF for space heating

Benefit/Cost	Units	Source
Equipment & Installation cost	$0	Assumed no incremental cost
Annual Electric Energy Savings (kWh/yr)	(6,800)	Modeled using IES VE
Annual Gas Energy Savings (kWh/yr)	11,720	Modeled using IES VE
Total Energy Savings (kWh/yr)	4,920	Modeled using IES VE
Annual Electric Cost Savings ($/yr)	$(1,607)	Calculated
Annual Gas Cost Savings ($/yr)	$448	Calculated
Annual Energy Cost Savings ($/yr)	$(1,158)	Calculated

Due to the artificially low cost of subsidized and fracked natural gas, there is no annual energy cost savings. The requirement would cost the building owner $1,159 more annually. Therefore, there is no payback in this scenario. Accounting for both the reduction in natural gas and increase in electricity consumption, the associated annual energy savings of 4,920 kWh results in an estimated GHG reduction of 1 MT CO_2 for this specific measure.

b. Water heating

For water heating, the analysis assumes a baseline equipment of a 78% efficiency natural gas water heater. For a multi-unit residential building, we assumed separate water heating systems for each unit.

Due to the relatively high hot water loads at multi-unit residential, the benefit-cost analysis explores the installation of an integrated solar hot water heater and electric heat pump water heater (3 EF).

Table 13: Benefit-cost analysis results for Policy 4-HP-MF related to water heating

Benefit/Cost	Units	Source
Equipment & Installation Cost	$700	Incremental cost per unit
Total Equipment & Installation Cost	$3,505	Total incremental cost (per 5 units)
PG&E Rebates for your Business	$1,500	PG&E
Annual Electric Energy Savings (kWh/yr)	(5,500)	Modeled using IES VE
Annual Gas Energy Savings (kWh/yr)	20,510	Modeled using IES VE
Total Energy Savings (kWh/yr)	15,010	Modeled using IES VE
Annual Electric Cost Savings ($/yr)	$(1,300)	Calculated
Annual Gas Cost Savings ($/yr)	$785	Calculated
Annual Energy Cost Savings ($/yr)	$(515)	Calculated

Due to the cost of fuel-switching, there is no annual energy cost savings. The requirement would cost the building owner $515 more annually. Therefore, there is no payback in this scenario. Accounting for both the reduction in natural gas and increase in electricity consumption, the net annual energy savings of 15,010 kWh results in a GHG reduction of 2 MT CO_2.

5. Policy 5-HP-NC. Electric heating system installation for new commercial buildings

Given the prevalence of new office buildings being built in the southern portion of San Mateo County, this building type was also analyzed for electrification and other renewable energy project benefits and costs for new construction.

Table 14: Project assumptions for prototypical new office building for Policy 5-HP-COMM

Square footage	10,000
Building EUI (kBtu/sf)	50
Stories	2
Equipment Efficiency	78%
Building Class	Class B
Occupancy	50 occupants

a. Space heating

For the new office building, the analysis assumes that the baseline equipment is a 78% AFUE natural gas furnace. The benefit-cost analysis explores the installation of 3.4 COP (coefficient of performance) rooftop heat pumps. We have assumed that in the case of new construction, all new commercial facilities will be air conditioned. Opting for a heat pump when choosing a packaged air conditioner results in a negligible cost differential. When factoring in the avoided cost of gas piping and a furnace required for gas heating systems, the additional cost for heat pumps is can be considered zero.

Annual space heating energy usage was determined via energy modeling coupled with the use of energy use benchmarking data available via the California End Use Survey (CEUS).

Table 15: Benefit-Cost Analysis Results for Policy 4-HP-COMM for space heating

Benefit/Cost	Units	Source
Equipment & Installation cost	$0	Assume no incremental cost
Annual Electric Energy Savings (kWh/yr)	(3,300)	Modeled using IES VE
Annual Gas Energy Savings (kWh/yr)	12,892	Modeled using IES VE
Total Energy Savings (kWh/yr)	9,592	Modeled using IES VE
Annual Electric Cost Savings ($/yr)	$(780)	Calculated
Annual Gas Cost Savings ($/yr)	$494	Calculated
Annual Energy Cost Savings ($/yr)	$(286)	Calculated

Due to the low cost of natural gas compared with electricity, there is no annual energy cost savings associated with a heat pump for space heating at this time. The requirement would cost the building owner $286 more annually. Therefore, there is no payback in this scenario. Accounting for both the reduction in natural gas and increase in electricity consumption, the associated annual energy savings of 9,592 kWh results in an estimated GHG reduction of 1 MT CO_2 for this specific measure.

b. Water heating

Similar to the multi-unit residential, the analysis assumes that the same baseline equipment of a 78% efficiency natural gas water heater.

In contrast with a multi-unit residential building, office buildings have much lower water heating needs. Therefore, the benefit-cost analysis explores the installation of an electric heat pump water heater (3 EF) only.

Table 16: Benefit-cost analysis results for Policy 4-HP-COMM for water heating

Benefit/Cost	Units	Source
Equipment & Installation cost	$4,000	Task 3
PG&E Rebates for your Business	$300	PG&E
Annual Electric Energy Savings (kWh/yr)	(1,800.)	Modeled using IES VE
Annual Gas Energy Savings (kWh/yr)	6,739	Modeled using IES VE
Total Energy Savings (kWh/yr)	4,939	Modeled using IES VE
Annual Electric Cost Savings ($/yr)	$(425)	DNV GL calculation
Annual Gas Cost Savings ($/yr)	$258	DNV GL calculation
Annual Energy Cost Savings ($/yr)	$(167)	DNV GL calculation

Due to the low cost of natural gas compared with electricity, there is no annual energy cost savings associated with a heat pump for water heating. The requirement would cost the building owner $167 more annually. Therefore, there is no payback in this scenario. Accounting for both the reduction in natural gas and increase in electricity consumption, the associated annual energy savings of 4,939 kWh results in an estimated GHG reduction of 1 MT CO_2 for this scenario.

6. Policy 6-EE-MF. Time of sale audit and disclosure for multi-unit residential buildings

With the recent adoption of City of Berkeley's Building Energy Saving Ordinance (BESO) and City of San Francisco's update to their Commercial Energy Conservation Ordinance, cities across the Bay Area have been exploring opportunities for new time-of-sale ordinances for energy upgrades and/or disclosure. In 2016, StopWaste.org led a nine-county working group of cities to provide technical assistance and peer-to-peer support. Despite these efforts, no new time-of-sale energy ordinance has yet to be adopted by a California jurisdictions, due to the opposition of a well-organized realtor industry.

To support local efforts, DNV GL analyzed the benefits and costs of time of sale audit and disclosure of energy use for multi-unit residential buildings. This analysis leveraged work previously completed as part of the Task 3 Economic Analysis of Energy Efficiency Measures (EEMs) in five different building types, including multi-unit residential.

Table 17 and **Table 18** summarize assumptions associated with a prototypical multi-unit residential building and a set of potential energy efficiency measures. The analysis assumes that as a result of the time-of-sale ordinance, that the four EEMs costing $1,000 were installed (either by the buyer or the seller).

Table 17: Prototypical multi-unit residential building assumptions for Policy 6-EE-MF

Intervention point	Time of sale
Square footage	5,000
Units	5
Energy EUI (kBtu/sf-yr)	64
Annual Energy Use (kWh/year)	93,760

Table 18: Estimated energy savings from EEMs assessed

Measures	Cost	Annual Electric Energy Savings (kWh)	Annual Gas Energy Savings (therms)
Window Upgrade	$ 50,000	8,000	100
Lighting Upgrade	$ 7,000	15,000	(200)
Improving Insulation - exterior walls	$ 5,000	1,000	130
Improved Hot Water Heater	$ 7,000	(5,500)	700
BMS (Advanced thermostat)	$ 1,000	1,000	100
Replacing AC	$ 1,000	2,000	(20)
Replace Heating	$ 1,000	(3,500)	580
Phantom Load Reduction	$ 1,000	5,500	(90)

Assessing the benefits and costs for time of sale audits is challenging because the cost of the audit would fall on the building seller, while any energy savings benefits would be realized by the building buyer. The primary potential benefit to the seller is the prospect of an improved sale price for the property associated with a favorable energy disclosure for the building.

Although there are studies indicating that energy efficient and green labeled homes often have higher sale values, these studies are not conclusive due to difficulties in controlling for the many other factors that influence sale value. One study suggested that the potential increased value for an energy efficient home can equate to $20 increase in market value for every $1 increase in annual energy costs[3]. Utilizing this assumption means that by implementing the low-cost measures analyzed above, a multi-unit residential building might increase its market value by more than $36,000. In comparison, a 5,000 square foot,

[3] O'Neill, M. (2015, September 15). Selling? Energy Audit Before Selling a Home Might Also Boost Prices - Real Estate 101 - Trulia Blog. Retrieved from https://www.trulia.com/blog/energy-audit-before-selling-a-home-higher-listing-price/

5-unit multi-unit residential building sale price is estimated in the range of $1.3 to $5 million depending on specific location in the region.[4]

Other studies indicate a 9% increase in sale value for homes with a green label[5] and a 1.2-4.9% premium for ENERGY STAR homes[6]. Because of the uncertainties around increased market value and who would implement the EEMs, the team decided to analyze the payback without factoring in the potential increase in sale value, which results in a simple cost for the owner (approximately $200-600/unit for the audit) with no payback.

Table 19: Benefit-cost analysis results for Policy 6-EE-MF

Benefit/Cost	Units	Source
3rd party auditor	$2,900	Professional Quote
Low-cost EEMs Implementation Cost	$4,000	Costs from RSMeans and professional experience; location specific, labor costs included
Upgrade Incentives Available	$5,250	MF Upgrade Incentive from PG&E
Annual Electric Energy Savings (kWh/yr)	5,000	Modeled using IES VE
Annual Gas Energy Savings (therms/year)	570	Modeled using IES VE
Total Energy Savings (kWh/yr)	21,701	DNV GL Calculation
Annual Electric Cost Savings ($/yr)	$1,182	DNV GL Calculation
Annual Gas Cost Savings ($/year)	$639	DNV GL Calculation
Annual Energy Cost Savings ($/yr)	$1,821	DNV GL Calculation

Due the seller/buyer scenario, payback is not considering applicable to either the buyer or the seller, but there are estimated annual energy savings of 5,000 kWh and 570 therms associated with the low-cost measures, which results in an estimated GHG reduction of 2 MT CO_2. From a societal perspective, the payback of the investment in the audit, installation of EEMs, and recouped energy cost savings would be 0.91 years, including the rebate from the MF Upgrade Incentive program.

---

4 www.Loopnet.com

5 The Value of Green Labels in the California Housing Market. (n.d.). Retrieved from https://issuu.com/nilskok/docs/kk_green_homes_071912

6 Bruegge, C., Carrión-Flores, A., & Pope, J. C. (n.d.). Does the Housing Market Value Energy Efficient Homes? Evidence from the Energy Star Program. Retrieved from https://stanford.edu/~cbruegge/index_files/bruegge_et_al_rsue_2015.pdf

7. Policy 7-EE-COMM. Time of sale audit and disclosure for commercial buildings

Similar to the time of sale audit and disclosure for multi-unit residential buildings, the team assessed the benefits and costs of time of sale audit and disclosure for commercial buildings. The same challenges described above were faced regarding the cost of the audit and EEM installation falling on the building seller, while the energy savings benefits are realized by the building buyer.

As mentioned previously, research does suggest that energy efficient and green-labeled (mainly LEED and ENERGY STAR) buildings have higher sale values and higher rent premiums; however, it is difficult to discern the average increase in market value without controlling for other factors. An additional challenge is that many of the studies focus on labeled buildings rather than simply energy efficient buildings. Studies show a wide range in the increase of market value for energy efficient buildings, as well as those with an ENERGY STAR or LEED certification. For commercial buildings, one study estimated an 8% sales price premium for ENERGY STAR buildings and a 26.6% sales price premium for LEED buildings[7]. However, like the residential analysis, the studies are not conclusive and DNV GL excluded the potential for higher sale values from the payback analysis.

An energy audit at time-of-sale is estimated to cost the building seller approximately $2,500 - $8,000 depending on building size and complexity. For the purposes of the benefit-cost analysis, it is assumed that only the low-cost/no-cost EEMs were implemented.

Table 20 summarizes the assumptions associated with a prototypical office building and a set of potential energy efficiency measures.

Table 20: Prototypical commercial building assumptions for Policy 7-EE-COMM

Intervention point	Time of sale
Square footage	10,000
Energy EUI (kBtu/sf-yr)	50
Annual Energy Use (kWh/year)	146,500

[7] Watcher, S. Valuing Energy Efficient Buildings. Retrieved from http://gislab.wharton.upenn.edu/Papers/Valuing%20Energy%20Efficient%20Buildings.pdf.

Table 21: Estimated Energy Savings from EEMs Assessed

Measures	Cost	Incentives	Annual Electric Energy Savings (kWh)	Annual Gas Energy Savings (therms)
Window Upgrade	$ 70,000		22,000	700
Lighting Upgrade	$ 27,000	$ 4,000	41,000	(450)
BMS	$ 10,000		1,500	80
Improving Insulation	$ 5,000		9,000	430
Improved Hot Water Heater	$ 4,000	$ 300	(2,000)	275
Replacing AC	$ 2,000		3,000	-
Replace Heating	$ 2,000		18,600	900
Phantom Load Reduction	$ 1,500		9,000	(80)
Total for all measures implemented together*			*86,000*	*1,200*

*Combined savings for all measures when implemented together vary slightly from the sum of each measure implemented individually.

Table 22 summarizes the results of the analysis, including the assumption of an ASHRAE Level 2 audit. The analysis assumes that as a result of the time-of-sale ordinance, that the three EEMs costing $2,000 or less would be installed.

Table 22: Benefit-cost analysis results for Policy 7-EE-COMM

Benefits/Costs	Units	Source
ASHRAE Level 2 audit	$2,500	Professional Quote
Low-cost EEMs Implementation Cost	$5,500	Costs from RSMeans and professional experience; location specific, labor costs included
Annual Electric Energy Savings (kWh/yr)	30,600	Modeled using IES VE
Annual Gas Energy Savings (therms/year)	820	Modeled using IES VE
Total Energy Savings (kWh/yr)	54,626	Modeled using IES VE
Annual Electric Cost Savings ($/yr)	$7,232	DNV GL Calculation
Annual Gas Cost Savings ($/year)	$920	DNV GL Calculation
Annual Energy Cost Savings ($/yr)	$8,152	DNV GL Calculation

Due the seller/buyer scenario, payback is not considering applicable to either the buyer or the seller, but there are estimated annual energy savings of 30,600 kWh and 820 therms, which would result in GHG reduction of 6 $MTCO_2$. From a societal perspective, the payback of the investment in the audit, installation of the EEMs and recouped annual energy cost savings, the payback would be 0.98 years.

8. Policy 8-EE-NC. Measurement & Verification for new commerical buildings

In developing local climate action plans, many cities are relying heavily on state action including increasing stringency of building energy codes to achieve zero net energy buildings by 2020 for new residential and by 2030 for new commercial. However, state building energy codes only regulate the design and construction of new buildings up to certificate occupancy, with little verification that new buildings are performing as originally designed. In 2012, the City of Seattle adopted the Seattle Energy Code with the nation's first alternative compliance path based on verified energy performance. Supported by BayREN, other Bay Area cities such as City of San Francisco is currently exploring a similar concept based on measurement and verification.

This benefit-cost analysis examines how city ordinances might offer policy incentives for building owners to design and implement a measurement and verification plan to ensure that their new commercial buildings perform as designed.

Table 23: Prototypical commercial building assumptions for Policy 8-EE-NC

Building size (sf)	10,000
Building EUI (kBtu/sf)	50
Annual Energy Use (kWh/year)	146,500

Measurement and verification (M&V) plans are often implemented by LEED-certified buildings as a way to provide ongoing accountability of energy use over time. LEED includes M&V as a credit worth up to 3 points based on the benefit that measuring actual energy use typically yields. The hardware needed for M&V varies depending on the size and complexity of the building. Often the upfront cost of the Building Management System (BMS) and submeters can pay off through the long-term energy savings, although it depends on the hardware needed based on the specific building. M&V can help to identify anomalies in equipment, operations procedures, and occupant usage. In addition to identifying opportunities for reducing energy consumption, M&V can also track and improve water use and indoor environmental quality.

Table 24: Benefit-cost analysis results for Policy 8-EE-NC

Benefit/Cost	Units	Source
M&V Plan Design and Development	$51,860	DNV GL professional experience
M&V Hardware	$11,505	DNV GL professional experience
M&V Implementation, Analysis, and Reporting	$46,600	DNV GL professional experience
Operations & Maintenance Savings (kWh/yr)	7,325	DNV GL professional experience
Systems Energy Savings (kWh/yr)	21,975	DNV GL professional experience
Total Annual Energy Savings (kWh/yr)	29,300	DNV GL calculation
Annual Energy Cost Savings ($/yr)	$6,925	DNV GL calculation

The annual energy cost savings of $6,925 results in a **15.9 year payback.** Additionally, the annual estimated energy savings of 29,300 kWh per year results in an estimated GHG reduction of 1 MT CO_2.

IV. Next Steps

Based on the results of this benefit-cost analysis and the AEC best practices review, the project team developed recommendations for AEC local ordinances and associated permitting considerations. Next steps included further stakeholder outreach with local jurisdictions to present the benefit-cost analysis and draft model policy ordinance considerations.

V. Conclusion

To achieve the vision of the PAEC requires innovation and leadership from our local jurisdictions. Based on the research conducted to-date, integrated clean energy technology opportunities are expanding rapidly and at a much faster rate than policy innovation. The results of the benefit-cost analysis demonstrate significant environmental and societal benefits of the policy innovations considered. However, a key challenge is to develop appropriate policy levers that realize the overall societal benefits without over-burdening specific stakeholders including building owners, renters and real estate agents. Therefore, a key priority for the PAEC project is to continue engaging effective stakeholders who can assist in the development of a replicable AEC model that can be used by other communities across California and beyond.