Clean Coalition
Making Clean Local Energy Accessible Now

Peninsula Advanced Energy Community (PAEC)

Task 9.2: Final Case Study of the PAEC Development
Master Case Study

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Table of Contents

I. About the Authors 5
II. Legal Disclaimer 7
III. Executive Summary and Introduction 8
a. Executive Summary 8
b. Introduction 15
IV. Advanced Energy Community Definition 16
V. Policy Goals and Existing Regulatory Structure 17
a. State goals 17
b. Local jurisdictions 20
VI. Key Challenges to AEC Deployment 21
a. Economic Challenges 21
b. Policy challenges 25
VII. Best Practices 27
a. Economics 28
b. Policy 30
c. Technology 32
VIII. Key PAEC Findings 32
a. Economics 32
b. Policy 37
c. Technical 40
IX. Case Studies 42
a. Stanford Redwood City - Community Microgrid Case Study 42
b. Hoover School SEM Design 52
c. Atherton Civic Center Case Study 56
X. Tools to Accelerate Deployment of AECs 59
a. Economic tools 60
b. Policy Tools 64
c. Technical Tools 67
XI. AEC Project Benefits 67
a. General benefits for California 68
b. Specific benefits 69

XII. Areas for Future Study ... 70
a. Economics ... 71
b. Policy ... 71
c. Technical ... 73
XIII. Conclusion ... 74
XIV. Appendix - Supplemental Case Studies ... 76
a. Stanford University ... 76
b. Jewish Community Center ... 84
c. Kaiser Permanente ... 87
d. Palo Alto Bryant St. Garage EVCI - supporting electric vehicle adoption with groundbreaking charging solution ... 90
e. Redwood City Corporate Yard ... 94
f. Facebook – Sustainability leader – locally, nationally, and internationally ... 99
XV. List of PAEC Technical Product Deliverables and Technology/Knowledge Transfer Product Deliverables Submissions to the CEC ... 103

Table of Figures

Figure 1: PAEC project goals ... 8
Figure 2: PAEC infographic about Advanced Energy Communities ... 13
Figure 3: Advanced Energy Community ... 16
Figure 4: Number of buildings in California ... 23
Figure 5: Days to receive fast track interconnection approval ... 26
Figure 6: Summary of AEC best practices ... 28
Figure 7: Energy storage saves money by peak shaving ... 33
Figure 8: Five building types analyzed for energy efficiency ... 34
Figure 9: Economic analysis of energy efficiency measures for five building types ... 35
Figure 10: Framework for considering a range of AEC regulatory and policy changes ... 38
Figure 11: Map from PAEC solar siting survey tool ... 40
Figure 12: Map of level 2 EV charges ... 41
Figure 13: Map of DC fast chargers ... 41
Figure 14: Stanford Redwood City Community Microgrid plans ... 43
Figure 15: Stanford RWC PV Schematic ... 49
Figure 16: Hoover SEM satellite map ... 52
Figure 17: Energy storage shifts solar power generation to evening peak demand ... 53
Figure 18: Projected Atherton Civic Center energy usage to typical building construction ... 56
Figure 19: Baseline Energy Use Intensity (EUI) of civic center programs compared to EUI design goals ... 57
Figure 20: Comparison of energy demand with and without thermal storage ... 58
Figure 21: Close-up image of Solar Siting Survey map ... 67

Figure 22: CAISO duck curve ... 70
Figure 23: Stanford Annual Heating & Cooling Profile ... 77
Figure 24: Stanford University campus solar rooftop installation map ... 78
Figure 25: Sample comparison of energy usage with and without CEPOM ... 79
Figure 26: Central Energy Facility Control Room ... 79
Figure 27: Sample optimal CEF dispatch plan ... 80
Figure 28: Stanford University's Electricity Consumption ... 81
Figure 29: Annual Energy Costs Pre- and Post-Retrofit ... 82
Figure 30: Stanford University Hybrid Shuttle ... 83
Figure 31: Electric vehicle chargers at Stanford University ... 83
Figure 32: AEC Components at Oshman Family Jewish Community Center ... 84
Figure 33: Basic Heat Pump Configuration ... 85
Figure 34: Existing diesel backup generator ... 86
Figure 35: Solar emergency micro-grid alternative ... 87
Figure 36: Solar hot water demonstration installation in Santa Clara, 1980 ... 88
Figure 37: 50-kW photovoltaic system at Modesto Medical Center, 2008 ... 88
Figure 38: Solar panels cover parking structure in Santa Clara ... 89
Figure 39: EV charging station in Vacaville, CA ... 90
Figure 40: Navigating process to permit and install EV chargers in Palo Alto ... 91
Figure 41: Summary report from WattPlan for an EV purchase ... 91
Figure 42: Opening Bryant St. Garage; Clean Coalition Executive Director, Craig Lewis ... 93
Figure 43: EV chargers in Bryant Street garage ... 93
Figure 44: Electric vehicle chargers at City of Palo Alto ... 94
Figure 45: Redwood City Corporate Yard overview map ... 95
Figure 46: Redwood City Corporate Yard Geli optimization results; PG&E E19S tariff and 150 kW solar ... 96
Figure 47: Redwood City Yard solar + storage savings plot modelled with PG&E's E19S tariff, 150 kW solar and 29 kW 60 kWh energy storage ... 97
Figure 48: Redwood City Yard solar + storage savings plot modelled with PG&E's E19S tariff, 150 kW solar and 58 kW 240 kWh energy storage ... 98
Figure 49: Facebook Green Roof ... 99
Figure 50: Grid Alternatives ... 100
Figure 51: Facebook's Key Sustainability Indicators ... 101
Figure 52: Facebook's Per User Carbon Emissions ... 101

Table of Tables

Table 1: Payback analysis for eight AEC model ordinances ... 36
Table 2: Summary of benefits from the Stanford RWC community microgrid ... 46
Table 3: Solar PV systems planned at Stanford RWC campus ... 49
Table 4: Energy storage value estimation ... 51
Table 5: Comparison of design scenario results ... 53
Table 6: Summary of scoring of potential mandatory ordinances ... 62
Table 7: Whole Building Energy Retrofit Program (WBERP) case studies ... 81

I. About the Authors

Appraccel

Appraccel provides sustainability consulting services to government agencies, private sector and non-profit clients in the region, state and nationally. This sustainability project management firm is located in the Bay Area and provides services such as communications, marketing and outreach, and energy auditing. Appraccel works on topics such as clean energy, energy efficiency, transportation and waste prevention.

Recent projects have included energy efficiency audits for 42 buildings at NASA Ames Research Center, energy efficiency lectures to Chinese delegations, transportation mode shift outreach for the City of Palo Alto, a residential food waste prevention media campaign in the Bay Area, and reusable transportation packaging marketing.

What ties these projects all together is the emphasis on change management. Appraccel's expertise involves taking complex, technical information, interpreting it for the target audience, identifying barriers to change, and motivating the target audience to implement more sustainable systems and behaviors.

Read more about Appraccel's approach at www.appraccel.com.

Kristin Kuntz-Duriseti

Kristin Kuntz-Duriseti is Managing Editor of Climate Change, an international journal publishing interdisciplinary research on the description, causes, and implications of climate change. To support responsible and progressive sustainability policies, promote renewable energy projects, and shift out community to a low carbon future. Kristin has served as an Environmental Quality Commission for Menlo Park and is a current Board Member for Menlo Spark, a non-profit initiative working toward climate neutrality in Menlo Park.

Clean Coalition

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. Clean Coalition drives policy innovation to remove barriers to procurement and interconnection of distributed energy resources (DER) such as local renewables, energy storage, and demand response. Clean Coalition also establishes programs and market mechanisms that realize the full potential of integrating these solutions. In addition to being active in numerous proceedings before state and federal agencies throughout the United States, Clean Coalition collaborates with utilities (and other Load Serving Entities) and municipalities (and other jurisdictions) to create near-term deployment opportunities that prove the technical and economic viability of local renewables and other DER.

Ultimately, Clean Coalition envisions the United States being 100% powered by renewable energy, substantially from local sources. To make this goal a reality, Clean Coalition is working to achieve the following objectives by 2025:

- From 2025 onward, at least 80% of all electricity from newly added generation capacity in the United States will be from renewable energy sources.
- From 2025 onward, at least 25% of all electricity from newly added generation capacity in the United States will be from local renewable energy sources.
  - Locally generated electricity does not travel over the transmission grid to get from the location it is generated to where it is consumed.
- By 2025, policies and programs are well established for ensuring successful fulfillment of the other two objectives.
  - Policies reflect the full value of local renewable energy.
  - Programs prove the superiority of local energy systems in terms of economics, environment, and resilience; and in terms of timeliness.

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

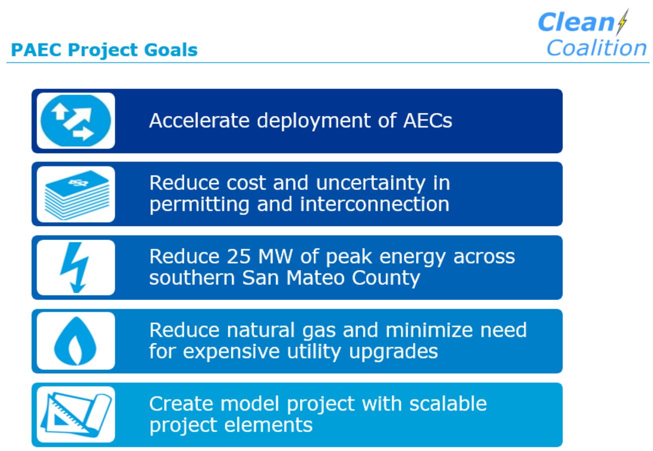
II. Legal Disclaimer

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.

III. Executive Summary and Introduction

a. Executive Summary

Figure 1: PAEC project goals



Source: Clean Coalition

The Peninsula Advanced Energy Community (PAEC) initiative is a groundbreaking initiative focused on streamlining policies and showcasing projects that facilitate local renewables and other advanced energy solutions like energy efficiency, energy storage, and electric vehicle charging infrastructure.

At the state and local level, California has policy goals and a regulatory structure that support the development of clean local energy systems. The scaffolding is in place to build a clean energy future. PAEC Phase 1 project studied what is still holding us back. The project looked at key challenges, discovered best practices, developed findings, and created tools that will accelerate the deployment of Advanced Energy Communities (AEC). (*See Figure 1)*

i. Key challenges

Barriers facing AEC components are surmountable but numerous. Economic challenges include:

- The preference of building owners to choose capital costs over life cycle costs,
- Budgeting conflicts between capital costs versus operating costs,
- Split incentives between the building owner and tenant,
- Newer technologies competing financially with older technologies that enjoy economies of scale,
- Limited financing options, and
- The question of who should fund and who should own AEC components.

Policy challenges mainly revolve around inconsistent and opaque permitting processes, as well as insufficient permitting staff to handle the increasing volume of permitting requests for AEC projects.

ii. Best practices

PAEC studied projects that incorporate one or more AEC components and found dozens of projects worthy of emulation because they overcome economic or policy barriers. Many of the best practices fall under one of these economic tools:

- Incentives and rebates
- Purchasing aggregation strategy
- PACE loans
- Pay As You Save (PAYS)
- Community Choice Aggregation (CCA)
- Revolving funds
- Climate impact fees

Best policy practices studied include:

- Zero net energy reach codes and plans
- District approaches
- Required renewable energy goals
- Feed-in-tariffs
- Residential Energy Conservation Ordinance/Commercial Energy Conservation Ordinances

The opportunity is how to facilitate easier adoption of best practices by other jurisdictions.

iii. Key findings

Through dozens of PAEC reports, the team uncovered key findings about where to focus attention when developing AECs. The highlights fall into three areas: economic, policy, and technical.

Economic findings:

- Energy storage (ES) projects finally have become financially viable due to dramatically reduced prices. However, they have positive net present value only when doing double duty: storing renewable energy, backup power, peak shaving, power conditioning, spinning reserves, or load shifting. PAEC expects the prices to continue to fall thereby improving the economics and broadening the number of viable ES installations.
- Building owners often cherry pick the top one or two energy efficiency measures to implement when they could be implementing seven or eight at a time. PAEC found that the internal rate of return (IRR) for a bundle of measures would still be more attractive than the returns from most other potential investment options.
- PAEC studied eight model ordinances to determine if they would pay for themselves over the life of the project. Four of the eight model ordinances were net present value positive: upgrading heating system, insulation, windows, and LEDs. The availability of cheap natural gas limits fuel switching as an economically competitive option.
- An uneven patchwork of financial tools exists to fund AEC components when an entity does not have funding available to pay for the project up front. A few options that should be expanded include on-bill financing and public-private partnerships.

Policy findings:

- The Wholesale Distributed Generation Fast Track permitting program needs to be streamlined to provide transparency and consistency. Clean Coalition studied 209 applications for commercial solar interconnection approval and 82% dropped out at some point. Those applications that were approved took 6 months to 2.3 years.
- Municipalities also need to provide more transparency and consistency in the permitting process for AEC components besides photovoltaic (PV) systems, which already benefit from a streamlined process.

Technical findings:

- PAEC's Solar Siting Survey discovered 65 MW of commercial solar potential in southern San Mateo County mostly on school rooftops, over parking lots, and over parking garages. This is significant for an area that is already highly developed and has a dense tree canopy.
- PAEC's EV Charging Infrastructure Master Plan mapped current locations of Level 2 chargers and fast chargers in the PAEC region and summarized discussions with building owners who are now interested in EVCI chargers for their multi-family buildings. Installing more EV charging stations will combat range anxiety and encourage more people to switch to EV vehicles.

iv. Case studies

A few exciting projects in the planning stages that incorporate multiple AEC components include the following case studies:

- The Stanford University Redwood City Community Microgrid
- Hoover School Solar Emergency Microgrid (three scenarios)
- The Town of Atherton's new Zero Net Energy Civic Center

v. Tools to accelerate deployment

This is the heart of the PAEC initiative: the tools PAEC developed or applied to overcome challenges and accelerate deployment of AECs.

Economic tools:

- Life-cycle cost approach
- Non-monetary metrics
- Scenario analysis

Policy tools:

- Streamlined permitting
- Model ordinances
- Model interconnection process checklist
- Green lease language

Technical tools:

- Solar Siting Survey
- EVCI Master Plan

- Building Management System product list

vi. Project benefits

PAEC studied the benefits of AECs generally for California and specifically for energy consumers, the PAEC community, and ratepayers. At the state level, benefits include:

- Meeting clean energy policy goals
- Enhancing grid resilience and security
- Obviating the expense of new power plant construction
- Modernizing the grid
- Increasing the percentage of renewable energy per California's Renewable Portfolio Standard
- Improving interconnection policies to accelerate adoption of distributed energy resources
- Creating green jobs installing equipment and retrofitting systems

At a local level, benefits that will accrue to energy consumers, the PAEC community, and ratepayers include the following:

- Reducing the costs of clean local energy
- Saving energy consumers money on their energy bill
- Hedging against future energy rate increases for building owners and tenants who install on-site PV and essentially pre-pay their electricity bills for the next 25 years
- Using solar emergency microgrids to provide renewable-based backup power at critical facilities such as hospitals, municipal emergency response centers, and emergency shelters
- Accelerating development of local solar generation
- Stimulating the economy
- Creating environmental benefits – each year, PAEC is projected to reduce greenhouse gas emissions by nearly 40 million pounds and save 7 million gallons of water.
- Avoiding financial losses from outages, plus improving reliability
- Utilizing energy storage to bridge the gap between over generation by PV during peak sunlight hours and peak energy demand later in the evening

Altogether, investing in a clean energy future will yield numerous valuable financial and environmental benefits at the individual, organizational, community, state level, and beyond.

vii. Areas for future study

While the PAEC initiative answered many questions, the team also developed a list of areas for future study. PAEC seeks to expand AECs that implement clean local energy systems and see nearly endless opportunities to do so. In California, less than 1% of the 9 million single-family homes, 3.1 million multi-family dwellings, and 600,000 commercial buildings are net zero energy. Very few of the 345 hospitals and 482 municipalities in California have solar emergency microgrids. We need to plan more and create more financial tools to accelerate AEC projects.

California needs more funding streams to finance AECs. Utility user taxes, carbon fees, and feed-in tariffs would encourage development of AEC components and fund improvements. We need more and better financial tools for all types of sectors and buildings. On-bill financing at 0% interest is available to the commercial and municipal sector but not residential. Many homeowners can use PACE loans to finance energy efficiency retrofits and solar in many communities, but these loans have a relatively high interest rate. Pay As You Save has been a successful financial tool used in a few areas around the US to fund energy efficiency and water conservation in multi-families where the split incentive cripples progress. Figuring out how best to fund the expansion of deep energy retrofits, energy storage, electric vehicle charging infrastructure and solar emergency microgrids should be an area for future study.

From a policy angle, communities that have developed reach codes to move beyond the minimum state requirements have been saddled with high costs to develop them. Making the process of exceeding state requirements easier should also be an area for future study.

Finally, successful AECs profiled in this report have had the benefit of sophisticated integrated technology solution providers, of which there are few. Developing and publicizing a database of integrated solution providers would help entities seeking to implement AECs realize their goals.

PAEC's intent with this Master Case Study, which highlights dozens of PAEC reports, was to ask questions, discover findings, and develop tools. We hope that this synthesis report will help guide future action of policymakers, government agencies, utility executives and other key decision makers to accelerate deployment of advanced energy communities (AECs).

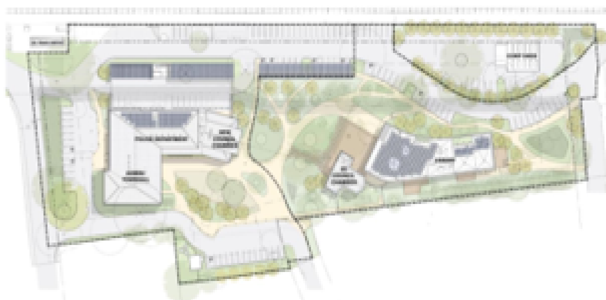
Figure 2: PAEC infographic about Advanced Energy Communities

Peninsula Advanced Energy Community

Advanced Energy Community Components

1. Energy efficiency
2. Renewable energy
3. Zero net energy
4. Electric vehicle charging infrastructure
5. Energy storage

Planned Atherton Civic Center



Benefits

1. Reduces need for new energy transmission + distribution infrastructure
2. Promotes grid reliability + resilience
3. Financially attractive
4. Replicable + scalable

PAEC Report Highlights

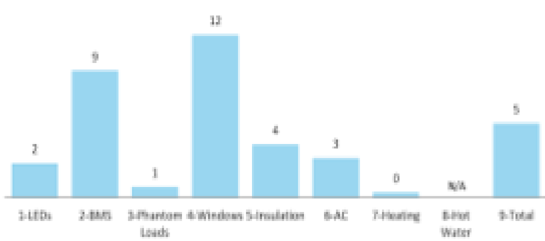
Challenges

- Inconsistent permitting processes (documentation requirements, costs, reviews, timelines) at municipalities and utilities
- Inconsistent financial instruments available to fund investments for AECs in commercial, residential, and public sectors
- Split incentives between building owners + tenants
- Tension between capital expenses + operating expenses
- Tendency to favor initial cost over life cycle costs
- Range anxiety - Lack of EV fast chargers

Recommendations

- Implement bundles of energy efficiency measures. Average 5-year payback = 18% return, better than returns from most other investment options.

Energy efficiency ROI for office Building



- Focus on the following in southern San Mateo County:
  - Deep energy retrofits for residential + commercial properties
  - Financial options that allow energy savings to fund capital investments
  - Zero net energy for new developments
  - Increasing EV charging infrastructure with battery storage
- Municipalities should develop EV-ready codes for multi-unit dwellings
- Continue subsidizing energy storage in the near term as the market brings the price down

Tools

- Streamlined permitting
- Model interconnection process checklist
- Model ordinances
- Green lease language
- Solar siting survey
- Electric vehicle charging infrastructure master plan

Benefits of AEC Projects

Customers

- Implementing energy efficiency means:
  - Customers save on their energy bill
  - Improved comfort, health + worker productivity
- Installing solar PV allows customers to prepay their electricity bill for the next 25 years, a hedge against future price increases

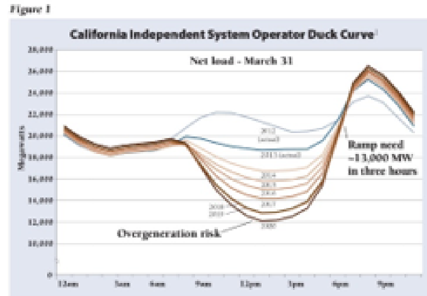
Community

- Provides clean local energy
- Creates clean energy jobs
- Obviates expense of new power plant construction
- Builds resilience
- Addresses climate change

Ratepayers

- Energy storage bridges the gap between overgeneration by solar PV during peak sunlight hours and peak energy demand later in the evening

Figure 1



AEC Leaders

Existing Projects with AEC Components

Palo Alto Bryant Street Garage (improving feed-in tariff)
- Solar PV
- EV charging
- Energy storage

Facebook (including water treatment in energy footprint)
- On-site black water treatment
- Energy efficiency
- Solar PV
- EV charging
- Energy storage

Jewish Community Center (maximizing existing technologies)
- Energy efficiency
- Air-source heat pump
- Solar PV
- EV charging

Kaiser Permanente (life-cycle cost solution to split incentive problem)
- Energy efficiency retrofits
- Solar PV power purchase agreement
- EV charging

Redwood City Corp Yard (solar emergency microgrid)
- Solar PV
- EV charging
- Energy storage

Stanford University (district-level projects)
- Energy efficiency
- District-scale heat exchange system
- Solar PV
- EV charging

b. Introduction

Natural disasters that struck the United States in 2017 drove home the importance of upgrading to resilient energy systems. Wildfires throughout California and hurricanes that hit Texas, Florida, and Puerto Rico highlighted how vulnerable the United States' aging energy infrastructure is to natural disaster shocks. Climatologists expect prolonged droughts and increasingly strong storms in the future, and yet we are not investing enough to upgrade to clean local energy systems that will be resilient in the face of future challenges.

Now is the time to accelerate deployment of AECs that employ five key components: energy efficiency, renewable energy, zero net energy, electric vehicle charging infrastructure, and energy storage.

California has set ambitious policy goals to address climate change. PAEC initiative plays a key role in California's ability to meet those policy goals. With this project, the PAEC team demonstrates that AECs are feasible – from both a technical and financial perspective – and offer multiple benefits to consumers, ratepayers and communities.

This Master Case Study report aggregates findings from several dozen of PAEC reports that studied the technical, financial and policy barriers to AECs and developed recommendations to overcome them. PAEC's recommendations were based partly on best practices piloted at various jurisdictions and organizations within and outside of the PAEC region in southern San Mateo County. Case studies that PAEC developed about projects with one or more AEC components, that are already in existence or far along in the planning stages, demonstrate the viability of clean local energy systems.

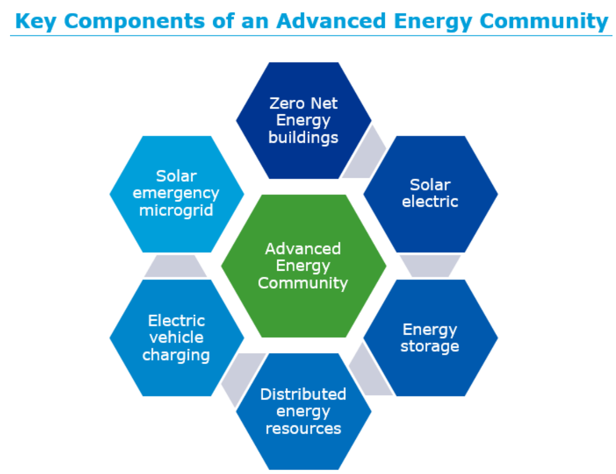
PAEC initiative also developed technical and policy tools that will help other organizations and jurisdictions speed deployment of the five key components of AECs. Finally, after considering all of this work, the PAEC team compiled remaining questions and developed a section in this Master Case Study that outlines areas for future study.

This Master Case Study encompasses information gathered and wisdom gained. The hope is that this project will help the CEC, utilities, building and planning departments, developers, building owners, and elected municipal officials determine where to focus effort to accelerate deployment of AECs. Doing so will create more resilient, decarbonized energy systems that benefit consumers, ratepayers, and communities.

IV. Advanced Energy Community Definition

An AEC requires all new buildings (including major renovations) to meet Zero Net Energy (ZNE) standards, including enough on-site renewable energy generation to be grid positive, with Solar Emergency Microgrids (SEM) on all large campuses (e.g., schools, hospitals, shopping centers, office parks, civic centers >250,000 sq. ft.), reduced fossil fuel use in buildings, and EV charging available at all buildings. Additionally, all new city vehicles will be electric or zero carbon, where feasible.

Figure 3: Advanced Energy Community



Source: DNV GL

In addition to the above requirements for new buildings and transportation, the AEC will actively promote deep energy retrofits. The initial focus will prioritize retrofitting the most inefficient existing buildings serving low-income tenants through subsidies, rebates and on-bill financing to ensure zero upfront costs. The AEC will similarly promote renewable energy, efficiency and ZNE retrofits with a combination of incentives and low-cost financing. The AEC will assist businesses with the installation of EV chargers on existing parking facilities, with the charger count based on site specific information and funding availability.

Per the GFO-15-312, from which PAEC was awarded grant funding, the CEC defines an AEC as one that:

- Minimizes the need for new energy infrastructure costs such as transmission and distribution upgrades.
- Provides energy savings by achieving and maintaining zero net energy community status (accounting for behavior and increasing loads from vehicle and appliance electrification).
- Supports grid reliability and resiliency by incorporating technologies such as energy storage.
- Provides easier grid integration and alignment with the California Public Utilities Commission's (CPUC) Long-Term Procurement Plan, and the California Independent System Operator's (CAISO) local capacity requirements process.
- Can be replicated and scaled up to further drive down costs.
- Is financially attractive from a market standpoint (developers, home buyers, renters).
- Provides affordable access to renewable energy generation, energy efficiency upgrades, and water efficiency and reuse technologies that reduce electricity consumption for all electric ratepayers within the community.
- Makes use of smart-grid technologies throughout the community.

- Aligns with other state energy and environmental policy goals at the community level such as the Sustainable Communities and Environmental Protection Act (Senate Bill 375 (Steinberg, Chapter 728, Statutes of 2008) and Governor Brown's Executive Order B-29-15 for the drought.

V. Policy Goals and Existing Regulatory Structure

California already has created the scaffolding for future AEC development with a mix of policy goals and regulations about greenhouse gas reductions, energy efficiency, green building, zero net energy buildings, renewable energy, and electric vehicles. At the state and local level, goals and regulations are invaluable to move society toward clean, local energy for buildings and transportation. In doing so, communities will save money, create jobs and become more resilient.

The following are highlights of relevant laws, goals, policies, plans, executive orders and programs at the state and local level that support development of AECs.

a. State goals

i. Landmark AB 32 – Global Warming Solutions Act of 2006

AB 32 commits the state to reduce its greenhouse gas emissions (GHGs) to 1990 levels by 2020, with 15 percent below 2005 levels by 2020 to be considered an equivalent goal. In 2016, the California State Senate extended the state's targets for reducing GHGs from 2020 to 2030 (SB 32). Under Senate Bill 32, the state will reduce greenhouse gas emissions 40 percent below 1990 levels by 2030, through an increase in renewable energy (wind, solar, geothermal, wave, and small hydroelectric) from 33 percent (set in 2002) to 50 percent by 2030 and requires a doubling of energy efficiency savings for both electricity and natural gas.

ii. Title 24 Building Code

Established in 1977, the CEC Building Energy Efficiency Standards for Residential and Non-residential Buildings (Title 24, Part 6 of the California Code of Regulations) set building standards that are cost effective for homeowners over the 30-year lifespan of a building and have been successful at maintaining per capita electricity use, despite a growing economy and population. The CEC is required to update standards every three years. The most recent revision was implemented in 2016 (effective 1 January 2017) and the next cycle is scheduled for 2019 (effective 1 January 2020).

On average, the 2016 Building Energy Efficiency Standards will increase the cost of constructing a new home by about $2,700, but will save $7,400 in energy and maintenance costs over 30 years (approximately $13 per month). Single family homes built to the 2016 standards will use about 28% less energy than those built to the 2013 standards. Over 30 years, the energy savings will be sufficient to power 2.2 million homes and reduce the need to build 12 additional power plants.

iii. CalGreen

The California Green Building Standards Code (Part 11 of Title 24 regulations), better known as the CALGreen Code, is the first statewide green building standards code in the nation. All newly constructed buildings on new or existing sites shall comply with the CALGreen Code. Voluntary measures, noted as Tier 1 and Tier 2 options, serve as a guideline to further encourage building practices that surpass the mandatory measures.

iv. CPUC Long-Term Energy Efficiency Strategic Plan

The CPUC Long-Term Energy Efficiency Strategic Plan (adopted in 2008 and updated in 2011) establishes goals for ZNE buildings:

- all new residential construction by 2020,
- all new commercial construction by 2030,
- all new state buildings and major renovations by 2025, and
- 50% of existing commercial buildings retrofitted to ZNE by 2030.[1]

In addition, the 2008 Strategic Plan advances a goal to reduce energy consumption by 40% in existing homes by 2020. Typically, homes (that have not yet taken any steps towards efficiency) can increase energy efficiency 30% to 40% with comprehensive energy efficiency upgrades.

v. CPUC Integrated Resource Plan and Long-Term Procurement Plan

The CPUC Integrated Resource Plan and Long-Term Procurement Plan (IRP-LTPP) is the primary mechanism for implementation of SB 350.[2] As infrastructure planning in California is split among the CPUC, CEC, and CAISO, these agencies must collaborate on an Integrated Resource Planning (IRP) that will ensure that California has a safe, reliable, and cost-effective electricity supply and that load serving entities meet targets consistent with the state's GHG reduction goals. The assumptions used to model energy sector projections are developed in conjunction with the CEC (which provides the demand forecast) and CAISO (which uses the same assumptions for transmission planning). California state policies mandate that energy efficiency and demand response be pursued first, followed by renewables and lastly clean-fossil generation. To comply with these standards, an investor-owned utility (IOU) must show that the proposed procurement will provide safe, reliable capacity at the least cost to ratepayers in compliance with state policies.

One of the most powerful mechanism to support AECs, from increasing the percentage of renewables in the energy portfolio to expanding distributed energy to electrification of

[1] California Energy Efficiency Strategic Plan. See more at http://www.cpuc.ca.gov/ZNE/

[2] SB-350 Clean Energy and Pollution Reduction Act of 2015. Find the full text at https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350

energy, is Community Choice Aggregation (CCA). Created under Assembly Bill 117 and governed by the CPUC, CCA allows cities and counties to aggregate their purchasing power in the procurement of renewable energy outside the local energy provider, e.g., PG&E in San Mateo County. Peninsula Clean Energy (PCE) was created in February 2016 when all 20 towns/cities in San Mateo County, plus the County of San Mateo, voted unanimously to form a Joint Powers Authority to administer the program. PCE is a public, locally-controlled electricity provider that gives PG&E customers in San Mateo County the choice of having 50% (ECOplus) or 100% (ECO100) of their electricity supplied from clean, renewable sources.

vi. Other state regulations that are relevant for AECs

- Senate Bill 1275 (SB 1275) Charge Ahead Initiative - Sets a goal of 1 million zero- and near-zero-emission vehicles by 2020 (passed September 2014).
- Assembly Bill 2565 (AB 2565) Electric vehicle charging stations for rental properties - Requires property owners to allow residents to install an electric vehicle charging station in their assigned parking space (effective July 2015).
- Assembly Bill 2188 (AB 2188) Solar Energy Permits - Streamlines permits for solar residential projects (approved September 2014).
- Assembly Bill 327 (AB 327) California Renewables Portfolio Standard Program - Promotes small-scale distributed renewable energy by extending Net Energy Metering (NEM) and removing the cap on renewable energy in the Renewable Portfolio Standard (RPS) (approved October 2013).
- Assembly Bill 2514 (AB 2514) Energy Storage System - Requires California Investor Owned Utilities (IOUs) to procure viable and cost-effective energy storage systems through rate-based purchases and contracts (approved September 2010). In 2013, the CPUC created a program that requires 1.3 GW of energy storage to be available by 2020.
- Assembly Bill 197 (AB 197) State Air Resources Board GHG Regulations - Requires the California Air Resources Board (ARB) to "protect the state's most impacted and disadvantaged communities … [and] consider the social costs of the emissions of greenhouse gases" in regulations governing climate change reduction goals (passed September 2016).
- Senate Bill 375 (SB 375) Sustainable Communities and Climate Protection Act - Regulates emissions from transportation and land use, specifically housing, to support meeting the standards set by AB 32 (effective 1 January 2009).
- Executive Order B-29-15 - Directs the CEC to implement a statewide rebate program to incentivize the replacement of inefficient household appliances as a measure to increase water conservation and efficiency.

b. Local jurisdictions

i. County regulatory context

San Mateo County has demonstrated a strong commitment to clean energy, climate, and sustainability by establishing an Office of Sustainability in July 2014. The County's Climate Action Plan identifies a GHG emissions reduction target of 17% below 2005 baseline levels by 2020 for the County, which goes beyond the 15% required by the state by 2020. The County also is committed to develop a plan to reduce 2005 emissions by 80% by 2050.

Zero Net Energy is also a priority for San Mateo County with a goal to have 50% of all new buildings built to ZNE in 2025.

The County's Office of Sustainability promotes energy efficiency through its work with:

- Bay Area Regional Energy Network (BayREN) – energy efficiency implementation programs with residents, business owners, and contractors.
- SMC Energy Watch – an energy efficiency program for local governments, small businesses, schools, farms, non-profit organizations, and some low-income residences. Assists cities with climate action planning and GHG inventorying.

ii. Municipal regulatory context

PAEC Initiative focuses on four cities in San Mateo County: Redwood City, Atherton, Menlo Park, and East Palo Alto. Although each city has a unique profile, they each provide illustrative case studies about how to implement an AEC.

Along with all the other cities in San Mateo County, these four cities are members of Peninsula Clean Energy (PCE) and have adopted Climate Action Plans.

Redwood City has been recognized by the SolSmart program, a U.S. Department of Energy SunShot Initiative, as a leader in advancing solar energy. The city was awarded a Gold designation in 2016 for streamlining the solar permitting and inspection process, updating solar codes, providing PACE financing options, and supporting Bay Area Sunshares, a Bay Area group purchase program for solar energy.

The Town of **Atherton** has agreed to 100% renewable energy for its municipal buildings through the PCE ECO100 option. Notably, the town has plans for a net positive energy campus for the new civic center (police department and administrative offices), council chambers, and library. Plans also include a SEM that combines rooftop solar and battery storage and can sustain critical operations during an electricity outage and function as an emergency shelter.

In 2008, **Menlo Park** adopted an ambitious goal to reduce greenhouse gas emissions by 27% relative to 2005 levels by 2020. Because of the success of PCE, Menlo Park is on track to meet its target ahead of 2020. Recently adopted updates to the General Plan include new zoning regulations that require all new construction in the Bayfront district to meet 100% of energy demand (electricity and natural gas) through renewable sources including on-site generation, and any combination of the following measures:

- Purchase of 100% renewable electricity through PCE or PG&E in an amount equal to the annual energy demand of the project;
- Purchase and installation of local renewable energy generation within the City of Menlo Park in an amount equal to the annual energy demand of the project; or,
- Purchase of certified renewable energy credits annual in an amount equal to the annual energy demand of the project.

The new zoning also requires on-site energy generation of 30% of the maximum extent feasible as determined by an On-Site Renewable Energy Feasibility Study, and enrollment in EPA's Energy Star Building Portfolio Manager to benchmark and monitor building energy performance. After construction, the City of Menlo Park will receive reports on energy use, and if users exceed certain limits they will be required to offset the excess through energy efficiency, reduced consumption, increase energy production, or paying a fee. In addition, new buildings must be LEED Silver for 10,000 to 100,000 square feet, and LEED Gold for over 100,000 square feet. LEED standards will also apply to major renovations.

East Palo Alto has set and adopted a Climate Action Plan in 2011 with policies and programs aimed at reducing greenhouse gas emissions. The city also joined Peninsula Clean Energy in 2016 in order to provide clean energy to the commercial and residential sectors.

By leveraging existing regulations and programs, collaborating effectively, and exhibiting leadership, San Mateo County and the cities discussed in this document are already well on their way to becoming model AECs.

VI. Key Challenges to AEC Deployment

When looking at the gap between the Advanced Energy Communities we want to build and where our energy system is today, clearly there is work ahead of us. The first step to bridge the gap is to better understand the challenges we face. Some challenges are economic while others involve policy barriers. Parsing these barriers into distinct issues will help us build solutions that can overcome these challenges.

a. Economic Challenges

Building advanced energy communities involves investment in new equipment. We need energy efficient lighting and HVAC systems run by building energy management systems to replace inefficient, manually controlled electrical, and mechanical building systems. Solar panels on individual buildings will reduce our need to build large fossil fuel burning power plants. Electric vehicles will continue to replace internal combustion engine vehicles. These upgrades require investment using innovative financing instruments that spread costs out over the lifetime of the equipment.

Economic barriers to these investments include life cycle cost considerations, capital versus operating costs, split incentives, economies of scale, limited financing options, and questions about who should fund these projects. Let's consider each of these challenges separately.

i. Life cycle cost assessments

Frequently, a building owner's decision about whether or not to invest in a more efficient electrical or mechanical system comes down to the upfront cost. When faced with a few options, it is tempting to choose the lower cost option. Those building owners who take a first cost approach as the only factor in decision-making may end up paying more in the long run. If operating costs are higher with less expensive equipment, savings on the initial equipment purchase may be less than the unrealized operational savings. Building owners should consider all life cycle costs.

ii. Capital costs v. operating costs

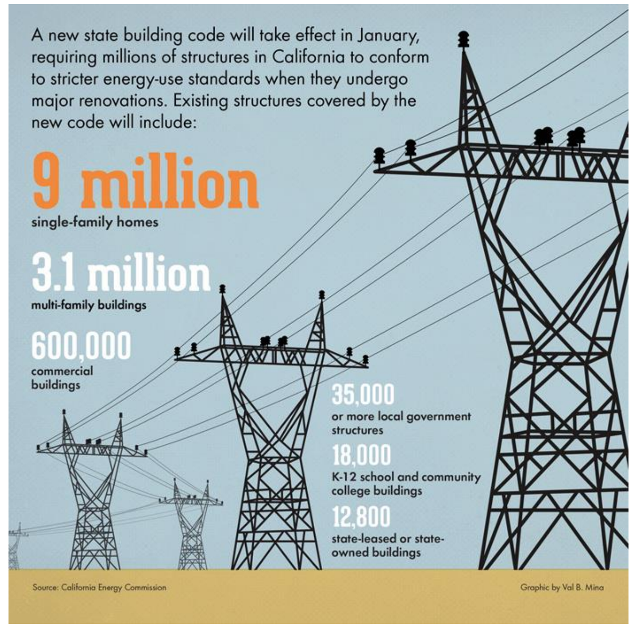
In situations where the same entity owns the buildings and pays the energy bill, there is often budgetary tension between the person overseeing capital investments in a building and the person managing operating costs. Both want to reduce their costs. The operations manager wants to see a reduction in operating costs but needs more capital investment to be made in order to reduce operating costs. Meanwhile, the person overseeing capital costs may already be struggling with budget reductions.

In order to enjoy reduced costs later, the person managing both the Facilities Manager and the Operations Manager hopefully will see the benefit of investing in AEC components for the organization's greater good. This situation applies where the building owner also pays the energy bill.

iii. Split incentives

For situations where the entity paying the energy bill is different from the entity that owns the building, the challenge of the split incentives comes into play. The CEC estimates, as seen in Figure 4, that there are about 3.1 million multi-family buildings and 600,000 commercial buildings in California. A majority of these are subject to the split incentive challenge. Many of these buildings need to be retrofitted for energy efficiency and renewable energy, and yet both parties must figure out how to divide the costs and benefits of the retrofits equitably between them.

Figure 4: Number of buildings in California



Source: California Energy Commission

The building owner may theoretically see the benefits of upgrading for energy efficiency, installing electric vehicle charging infrastructure and siting solar on the roof or above the parking structure; however, if the building owner does not pay the energy bill, they will not realize the financial benefits. Conversely, the building tenant may want to see their energy bill lowered, but they do not own the building. They probably will not want to invest in a building that someone else owns. This split incentive problem keeps buildings from being upgraded.

iv. Falling prices have not fallen far enough yet

Energy efficiency and renewable energy retrofits have been helped by dramatic reductions of equipment costs in many cases but not all. Energy storage system prices dropped 40% between 2014 and 2016, and prices are expected to fall further over the next four years as battery system sales teams are incentivized to close as many deals as they can to make the market.[3] However, at this time prices are still not low enough to warrant wide-scale adoption. For example, energy storage systems are still net present value negative, meaning the owner does not generally recoup their investment through operational cost savings within the expected life of the systems, unless the energy systems do double duty.[4] Quite often, technology is not the problem, as many advanced energy solutions are proven technologies. The barrier to its adoption at this point is economically based.

[3] Clean Coalition, Task 2.8 - Interview with Public Agencies, Installers, and Vendors (Sovereign Energy)
[4] See Executive Summary—Key Findings.

v. Economies of scale

Energy storage systems do not yet enjoy the economies of scale that conventional, energy inefficient equipment enjoys. With economies of scale, the increased level of production realizes proportionately greater saving in costs. A good example is natural gas water heaters. Over time, AEC components, such as electric water heaters, will realize economies of scale, but at this point, equipment such as this is for the most part still disadvantaged economically.

vi. Limited financing programs

Innovative financing tools for AEC components have been rolled out for some applications in some sectors. PG&E offers an attractive on-bill financing program for businesses and municipalities designed to make it easy for them to purchase and install energy efficient electrical and mechanical technologies. Through the on-bill financing program, PG&E offers zero percent financing, pays for the equipment and installation up front, and rolls the costs into the business or municipal agency's energy bill. Homeowners can apply for financing for energy efficiency projects, but the financing rate is higher than the zero percent interest on-bill financing available to the commercial and municipal sectors.

Financing for renewable energy, electric vehicle charging infrastructure, and energy storage is piecemeal, and in some cases, much more expensive than financing for more established technologies.

vii. Who should fund AECs?

These economic challenges all beg the question of who should be funding these investments and at what financing rate? Should they be subsidized by the utilities so the utilities do not have to invest in a larger number of new power plants later, assuming California's population will continue to grow in the future, as projected? Should the private sector fund investments in AECs, which will come at a cost premium as the private sector expects interest on their investments? Should the public sector make these investments since a clean energy future will benefit society and our environment?

Or is the public-private partnership model an attractive model for future growth? We need financially viable economic models that will maximize investment in energy efficiency, renewable energy, zero net energy, electric vehicle charging infrastructure, and energy storage. Our society appears to find public-private partnerships appealing because they harness the power of the private sector to rapidly deploy clean energy while providing value to society by delivering more resilient, decentralized systems that build a carbon free energy system.

b. Policy challenges

In terms of policy challenges, two gatekeepers for implementation of advanced energy community components are jurisdictions and utilities. While municipalities have developed climate action plans that need implementation of AECs to realize their goals, these same municipalities also oversee the permitting processes of AEC components. Utilities are the other gatekeeper. The important task of ensuring the safety and reliability of the electric grid falls to the utilities, which is why they also decide which renewable energy projects can interconnect to the grid. Both municipalities and utilities have important roles to play in overcoming policy challenges facing the development of AECs.

PAEC studied policy challenges currently facing AECs on these two fronts. Challenges include inconsistent permitting requirements, insufficient staffing, a sometimes-inflexible budgeting process, and an onerous process to develop reach codes. Each of these barriers are considered below to better understand the solutions to overcome them.

i. Inconsistent permitting requirements

As more and more entities seek permits for energy efficiency projects, renewable energy projects, ZNE buildings, EV charging infrastructure and energy storage projects, each jurisdiction and utility has developed its own permitting process. This has resulted in timelines, documentation requirements, review processes, and costs that vary widely.[5]

The State of California helped standardize permitting costs for residential solar once it became clear there was strong demand for residential solar and municipalities had wildly different permitting fees. Consistency, transparency, and cost certainty in the permitting process for other AEC components would help accelerate adoption as well.

Commercial solar is one example of a permitting process that would benefit from similar streamlining. PAEC studied PG&Es Fast Track permitting process which reviews 10kW to 5 MW Wholesale Distributed Generation projects, also known as commercial solar, that seek to connect to the electric grid.

[5] DNV GL, Task 2.14 - AEC Regulatory and Permitting Recommendations

One PAEC report studied how well PG&E's utility permitting process works for commercial solar projects.[6] The study found that among 209 permit applications since 2012, only 18% received approval. Of the initial 209 applicants, 61 withdrew prior to either completing the application process or receiving the results of the Initial Review, and 138 projects failed Initial Review. In total, only 37 out of 209 projects signed a Generator Interconnection Agreement.

Part of the problem is that the Fast Track program is effective only for a subset of photovoltaic projects and all others are subject to longer review. Figure 5 shows the minimum, maximum and number of days each stage in the Fast Track approval process typically takes.

Figure 5: Days to receive fast track interconnection approval

WDG Rooftop 1 MW Fast Track Project Development (Project where ICA map indicates sufficient capacity)	Timeframe (business days) Max	Minimum	Typical
PRELIMINARY WORK AND SITE CONTROL	**180**	**60**	**120**
Site Selection	2	1	1
Preliminary site evaluation and project screening	2	1	2
Preliminary layouts and performance models	2	1	2
Site control (Lease Option Agreement)	180	60	90
Pre-application reports	60	30	45
Other site research and selection	120	30	75
INTERCONNECTION INITIAL REVIEW	**160**	**55**	**110**
Prepare and submit interconnection application	120	30	75
Utility deems application complete	10	10	10
Initial review results (if pass, go to GIA cost estimate or GIA)	15	15	15
Developer requests initial review results meeting or proceeds to supplemental review	10	0	5
Initial review results meeting (if successfully identified, go to GIA cost estimate or GIA)	5	0	5
INTERCONNECTION SUPPLEMENTAL REVIEW	**55**	**35**	**45**
Decide to proceed to Supplemental Review	10	0	5
Supplemental review results (if pass, go to GIA cost estimate or GIA)	20	20	20
Developer requests supplemental review results meeting	15	0	5
Supplemental review results meeting (if successfully identified, go to GIA cost estimate or GIA)	5	0	5
Provide GIA cost estimate	15	15	15
POWER SALE CONTRACT	**180**	**60**	**120**
Lease negotiation	180	60	90
Site due diligence (structural, roof condition, soils, electrical/services, etc.)	50	20	30
Negotiate GC/EPC and engineering contracts	30	10	20
Final system engineering, design and integration; performance modeling	20	5	10
Permits	80	40	60
Financing pre-commitment			
Review power sales options	90	30	60
Obtain Power Purchase Agreement	90	30	60
GENERATOR INTERCONNECTION AGREEMENT (GIA)	**95**	**17**	**50**
Request GIA	15	1	5
Utility provides GIA	15	15	15
GIA negotiations and signatures (90 Calendar Day max time allowed)	65	1	30
GRID UPGRADES CONSTRUCTION**	**250**	**0**	**190**
Grid upgrade costs			
O&M costs (Cost of Ownership or COO)***			
Coordinate upgrade construction with utility, deed transfers			
PTO			
COD			
Totals (accounting for overlapping times)	**830**	**197**	**575**

Source: Task 4.2 – Best Practices: Interconnection for Local, Commercial-Scale, Renewable Energy Projects – Streamlining the Interconnection of Advanced Energy Communities

With a timeline that currently ranges between 6 months and 2.3 years, there are opportunities to streamline the Fast Track process while continuing to ensure a safe, reliable electric grid. According to the PAEC team's analysis, the Fast Track permitting process should be more transparent, efficient and cost-effective to better serve applicants.

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[6] Clean Coalition, Task 4.2 – Best Practices: Interconnection for Local, Commercial-Scale, Renewable Energy Projects – Streamlining the Interconnection of Advanced Energy Communities to the Grid

ii. Insufficient staffing

Municipalities and utilities are on the front lines of approving clean local energy projects for safety and interconnection. As more building owners and property managers engage in fuel-switching projects, municipalities and utilities are being asked to review an increasing number of energy efficiency upgrades, distributed generation projects, EV charging, microgrids, and energy storage projects. At the same time, municipalities and utilities may have inadequate staffing to meet demand, including limited staffing resources to develop needed polices to support an AEC. More personnel resources need to be allocated to managing staffing, budgets, and processes to ensure planning and permitting moves forward.

VII. Best Practices

PAEC initiative surveyed best practices within California, the United States, and across the globe to identify the most effective clean energy ordinances, reach codes, zoning, building and energy codes, policies, initiatives, permitting processes, and advanced energy technology programs. The results are summarized in Figure 6. The Best Practices Report[7] examines in greater detail measures particularly relevant for the PAEC region in the following categories:

- Renewables (RE)
- Energy Efficiency (EE)
- Zero Net Energy (ZNE)
- EV Charging Infrastructure (EVCI)
- Additional Clean Energy Measures

In this section, we will synthesize the results according to the best solutions to economic, policy, and technical barriers to accelerate advanced energy deployment strategies.

[7] Menlo Spark, Task 2.2 - Best Practices report

a. Economics

Municipalities have developed innovative financing tools to help bridge the gap between upfront investment costs and the deferred savings from reduced energy cost savings. PAEC's Task 2.2 Best Practices report and Task 3.2 Lending, Customer Compensation, and Government Incentive report[8] highlight several of these tools.

Figure 6: Summary of AEC best practices

Renewable Energy (RE)	Energy Efficiency (EE)	Zero Net Energy (ZNE)	Electric Vehicle Charging Infrastructure (EVCI)	Additional Clean Energy Measures
Model Municipal Ordinance Options				
Solar Rooftops [RE1] (mandatory ordinances) could also include solar water heaters, cool roofs, or other alternatives, e.g., San Mateo **Solar Carports [RE2]** over parking, could be coupled with energy storage and/or EV charging, e.g., Palo Alto or Green Charge **Zoning or Building Codes [RE3]** requiring 100% Renewable Energy, e.g., Menlo Park, covering electricity & gas **Solar or Zero Carbon Water Heaters [RE4]** requiring new or replacement water heaters to be solar (e.g., Hawaii) or a non-fossil fuel alternative such as heat pumps	**Reach Codes for New Construction [EE1]** Palo Alto & Santa Monica (e.g., 15% efficiency improvement over title 24) **Point of Sale [EE2]** energy audits and disclosure, e.g., Berkeley and Austin **ECBO: Existing Commercial Building Benchmarking Ordinance [EE3]**, e.g., San Francisco Buildings report energy use + audit each year ***or*** retro-commissioning every 5 years **Other Mandatory Requirements** Higher efficiency equipment, etc.	**Reach Codes [ZNE1]** for CA ZNE, e.g., Santa Monica **Financial Incentives [Fees2]:** New Climate Impact Fee, fully refunded for ZNE, e.g., Watsonville	**City Ordinance & Zoning [EVCI1]:** Minimum parking spaces required with pre-wiring or EV Chargers for **new** homes, multi-family, commercial or parking, e.g., City of San Francisco	**Fees [Fees1]** for Fossil Fuel Use or Carbon, e.g., Palo Alto Natural Gas offset fees
Additional Measures				
Financing: Rebates, PACE, on-bill financing, etc. **New technology** – in-pipe hydro, Pressure Relieving Valve (PRV)/Turbine technology, e.g., Portland – Lucid project **Permitting** improvements	**Audit programs** – NYC Retrofit Accelerator, Green @ Home, Green House Calls, PG&E audits **Incentives**, e.g., Energy Upgrade CA **Permitting**, e.g., fees waived and/or expedited, e.g. Encinitas **Building Electrification** / Natural Gas Replacement, Boulder	**District Approaches** (e.g., 2030 Districts, Fort ZED, Cambridge) **RFP & Lease Language** **Existing Building Retrofits** Energiesprong, ZNE overhauls with modular components	**City Charging Stations** (for city fleets and public use) **Incentives** (preferred parking, free charging or low/no cost charging) **Streamlined Permitting** **City EV "First" purchasing policy**, Palo Alto	**Innovations through CCEs** (aggregated solar, EV deployment) **Solar Emergency Microgrids** **Energy Storage**

Source: Menlo Spark, Task 2.2 - Best Practices report

i. Financing options

Many financing options to fund energy efficiency and renewable energy already exist but may be underutilized. We highlight strategies that have the potential to accelerate the adoption of advanced energy solutions.

Incentives and rebates

Numerous incentives and rebates at the federal, state, and local level (mostly through utilities) reduce the capital investment cost. PAEC's Task 3.2 Lending, Customer Compensation, and Government Incentive report provides relevant information regarding 34 currently available government incentives (federal, state, and county) and lending strategies and programs (loans, bonds, and aggregation mechanisms). Many municipalities offer generous incentives and rebates supporting renewable energy. Exemplary programs support ZNE construction, such as tiered incentives tied to energy reduction in New York (NYSERDA) and the Energy Saving Mortgage Program for energy efficient and ZNE houses in Colorado.

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[8] High Noon Advisors, Task 3.2 – Lending, Customer Compensation, and Government Incentive Report: Strategies and Incentives Available to Advanced Energy Communities In and Around San Mateo County, California

The CPUC's Self-Generation Incentive Program (SGIP) has been successful in promoting emerging distributed energy resources and renewable energy technologies including: wind turbines, waste heat to power technologies, pressure reduction turbines, fuel cells, and advanced energy storage systems. Between 2001 and 2015, 544 projects totaling 252 MW were completed under SGIP.

Purchasing aggregation strategy
Customers may aggregate their purchasing power to negotiate lower rates or qualify for wholesale pricing. Solarize allow groups of homeowners or businesses to collectively negotiate rates, competitively select an installer, and increase demand. San Francisco Bay Area cities have collaborated on the SunShares PV Buydown programs that leverage group purchasing among cities for wholesale solar pricing and discounts for residential customers, with some level of product screening among participating vendors.

Property Assessed Clean Energy (PACE) loans
PACE financing for renewable energy and energy efficiency upgrades already is available in San Mateo County. PACE loans, which are privately financed, but collected through a separate line item on the property tax bill, potentially could solve split incentives for leased properties where tenants pay part or all of the property tax bill. Because of relatively high interest rates, PACE loans may not be competitive for residential use, where Home Equity Line of Credit (HELOC) financing may be a more cost-effective option.

On-bill financing or Pay As You Save (PAYS) program
PAYS is an on-bill financing tool that enables utility customers to purchase and install cost-effective energy efficiency upgrades without upfront payment, personal loans, or property liens. PAYS programs currently are available for select Bay Area water utilities and commercial upgrades. Limited on-bill financing is available in San Mateo County, but the scope of projects is restricted and customer awareness is limited. For example, PG&E on-bill financing may be used for efficiency improvements, but not for renewable energy.

Community Choice Aggregation (CCA) or Community Choice Energy (CCE)
Authorized by California Assembly Bill 117, Community Choice Energy (CCE) is a power arrangement between local agencies, to procure power, and the utility, to manage distribution. Benefits of CCE include: competitive, often cheaper electricity rates; consumer energy choice; significant reductions in GHG emissions; new in-state and local renewable power development; and new jobs and energy programs for the community. CCE has great potential to direct the energy portfolio to support resilient microgrid technology comprised of local renewable energy, distributed energy, and energy storage. Surplus revenues of PCE (discussed above) could be used to fund AE projects.

Revolving funds
Revolving funds for energy efficiency and sustainability projects are replenished by cost savings generated by the projects. For example, the Silicon Valley Clean Energy Authority (SVCE), a partnership of 12 local governments formed in March 2016, has committed to providing its Santa Clara customers with 100% clean electricity. SVCE will be setting aside

a percentage of its revenue to invest in local renewable energy projects and energy programs.

Climate impact fee
In 2015, Watsonville established through The Carbon Fund Ordinance, a climate impact fee to encourage the implementation of renewable energy in development projects. Climate impact fees are reserved to fund citywide GHG reduction projects and ZNE development projects.

b. Policy

California's Title 24 energy code[9] is one of the most advanced in the world and the next cycle of Title 24 updates already includes plans for ZNE construction (new ZNE residential construction by 2020 and new ZNE commercial construction by 2030). To accelerate AE deployment, local policies would need to move faster than current state policy timelines.

i. Zero Net Energy (ZNE) building reach codes and action plans

Residential ZNE
Santa Monica recently adopted a ZNE reach code that requires all new single-family homes, duplexes and low-rise multi-family dwellings to be 15% above Title 24 2017 energy efficiency requirements and achieve an Energy Design Rating (EDR) of zero.

Commercial ZNE
Cambridge, MA, adopted a Net Zero 25-Year Action Plan in 2015 with a target for new buildings to achieve net zero beginning in 2020, starting with municipal buildings and phasing in the requirement for other building types between 2022 and 2030.

Municipal ZNE
Santa Clara County worked with Sage Renewables to create a ZNE Plan for the County's existing multi-city block government center, including county offices, courthouse and jails.

ii. District approach

Several examples exist that validate the feasibility of a district approach to managing energy use, e.g., 2030 Districts such as Seattle, WA, and "Green Steam" co-generation in Cambridge, MA. A McKinsey Report concludes that Green Districts recoup investments within three to five years.

Particularly impressive is the Fort Collins Zero Energy District ("Fort ZED") demonstration project; the first zero-energy district in the US achieves this accomplishment through peak load energy demand management, cogeneration energy supply (combined heat and power

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[9] California Energy Commission, 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, http://www.energy.ca.gov/2015publications/CEC-400-2015-037/CEC-400-2015-037-CMF.pdf

(CHP)), and extensive PV installations.

iii. Requiring renewable energy

Foundational to AEC is electrification of the energy supply through renewable resources, such as 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. Given widespread regulatory support for solar power and financially viable lease arrangement with solar providers, best practices include mandatory rooftop solar for new construction, e.g., Lancaster, Culver City, Sebastopol, San Francisco, and San Mateo. New zoning regulations in Menlo Park require 100% renewable energy through a combination of on-site solar – with a minimum 30% of feasible on-site PV installed – and community solar, green power purchasing, or the use of renewable energy credits.

iv. Creating a feed-in tariff

Taking full advantage of solar energy potential is constrained when the solar power generation capacity exceeds the on-site energy demand. Net energy metering (NEM) typically limits the value of surplus power generation by solar power thereby reducing the incentive for owners to over-size their PV system. A Feed-in-Tariff (FIT) solution transcends this restriction by leveraging power purchase agreements (PPA) that allow selling of excess energy, and encourages further expansion of PV.

v. RECOs and CECOs

As most of California's buildings were built prior to adoption of any energy performance criteria, building energy retrofits provide ample opportunity for advanced energy solutions.

A Residential Energy Conservation Ordinance (RECO) or its commercial counterpart, CECO, can improve the energy efficiency of existing homes or commercial properties and reduce GHG emissions. BayREN has developed RECO policy tools that build the capacity of local jurisdictions to adopt these policies, support regional consistency, and maintain flexibility for cities to tailor the policy to meet their local needs.

AEC prioritizes retrofitting the most inefficient existing buildings serving low income tenants through subsidies, rebates and on-bill financing to ensure zero upfront costs. New York City's Retrofit Accelerator offers free technical assistance to owners of buildings in low and moderate-income neighborhoods and assists with energy upgrades. Since its 2015 launch, Retrofit Accelerator has identified 1,000 projects for energy upgrades, which will result in $5 million in annual cost savings.

c. Technology

Technological barriers are not a significant constraint to AEC. The recommendations presented in the PAEC reports are for proven technologies highlighted in PAEC's case studies.

Early adopters of advanced technologies may pay a price premium for emerging technologies that are not produced at economies of scale or encounter shortages when production volumes may not ramp up sufficiently quickly to meet demand. Also, some best practices may not be feasible given the particular characteristics of the site or project. For example, the relatively mild climate throughout most of California makes geothermal heat pumps a less economically viable option than solar or wind.[10]

VIII. Key PAEC Findings

When stitching together findings from the dozens of reports PAEC developed for this initiative, a picture of the gaps and opportunities for AEC deployment emerges. California is leading the nation in implementing energy efficiency retrofits, renewable energy, ZNE buildings, EV charging infrastructure, and energy storage. Sophisticated programs to permit and finance AEC projects have been developed, and yet, there is still so much work to be done.

PAEC findings provide a roadmap for where we need to focus in the future to accelerate deployment of AECs. A few examples of findings include: determining which energy efficiency retrofit measures are most cost effective, developing suggestions for streamlining permitting, and mapping the opportunities for commercial solar and electric vehicle charging infrastructure. Some AEC components are net present value positive and some still need to be subsidized. This section discusses the highlights of PAEC report findings from the point of view of the economic barriers and policy barriers.

a. Economics

Prices of AEC components have fallen rapidly over the past decade. Solar photovoltaic panels now cost well below $1/watt. The weighted average cost of battery systems dropped 40% between 2014 and 2016. Yet, AEC project developers need to carefully choose which projects to fund based on which ones offer the best return when all subsidies, rebates, incentives or other government support are factored in.

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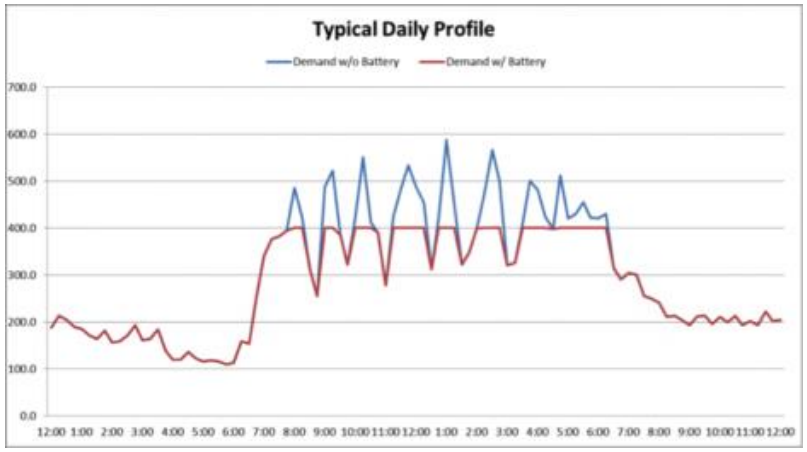
[10] DNV GL Task 3.14, Final BCA of Energy Efficiency and Fuel Switching Measures

i. Future financial viability of energy storage

As California sets higher and higher goals for renewable energy, energy storage allows these intermittent sources of energy to be integrated into the grid. Energy storage also provides the useful work of power conditioning, load shifting, peak shaving, spinning reserves, and backup power during blackouts. Until recently, the cost of energy storage has made it prohibitively expensive for most applications.

According to a PAEC study in which public agencies, installers and vendors were interviewed, energy storage prices have been falling and will continue to fall.

Figure 7: Energy storage saves money by peak shaving



Source: Cenergy Power

"The weighted average ($/kWh) battery system price has dropped by about 40% between 2014–2016, with the largest pricing pressure caused by the Tesla Gigafactory. In response to Tesla announcements, other manufacturers are dropping their prices to stay competitive.

The current expectation in the market is that cell manufacturers will bear the brunt of cost pressure in the supply chain due to the parent company's capability to take near term losses in order to create the market and make projects economically viable. Battery system sales teams are incentivized to close as many deals as possible between 2018 and 2022 to develop a portfolio of commercial-scale reference projects and increase the utilization rate of manufacturing lines."[11]

With 8,000 MWh of Tesla batteries and 500 MWh of stationary energy storage sold, the growth of automotive batteries continues to drive down the price of energy storage for other applications as well.

Energy storage equipment still requires financial support, though. According to a PAEC report about energy storage financing, "most projects, at today's equipment prices, require grants or other financial incentives to meet investor return expectations. However, equipment prices are declining rapidly, enabling new business models, and opening new markets."[12]

[11] Sovereign Energy, Task 2.8 report - Interviews with Public Agencies, Installers, and Vendors
[12] Sovereign Energy, Task 3.12 - Summary of Successful Energy Storage Financing Programs

Depending on what we include in net present value calculations, sometimes energy storage pencils out. Valuing resiliency, that is, when energy storage provides backup power in the event of a blackout, makes energy storage more financially attractive. In the situation where a power outage lasts long enough and the back-up diesel generator burns enough diesel fuel, resilient PV and storage systems would be net present value positive.[13]

ii. Bundling energy efficiency

Return on investment calculations provide a key metric that signals the viability of potential projects. If a project can stand on its own and is net present value positive, meaning it pays for itself before the end of the expected lifetime, the project will more likely be funded. Projects with an attractive return on investment, of one or two years, are even more likely to be funded.

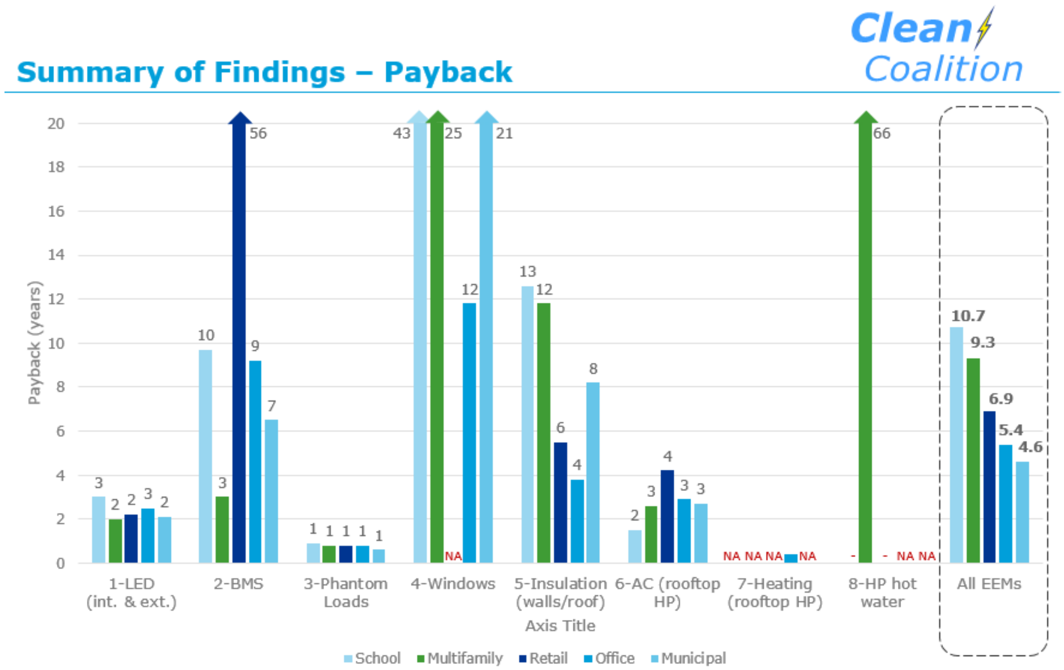
With this in mind, PAEC conducted economic analyses for bundles of energy efficiency measures. The PAEC report Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures was conducted for five different building types: office, multi-family, retail, municipal (fire station), and school. Figure 8 shows that bundling seven or eight energy efficiency measures still resulted in attractive paybacks: 10.7 years (school), 9.3 years (multi-family), 6.9 years (retail), 5.4 years (office) and 4.6 years (municipal).

Figure 8: Five building types analyzed for energy efficiency

Source: DNV GL, Task 3.14 – Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures

[13] Sovereign Energy, Task 3.II - Back-up Power Valuation

Figure 9: Economic analysis of energy efficiency measures for five building types



Source: DNV GL, Task 3.14 – Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures

Prototypical building configurations were analyzed to see how various energy efficiency measures stacked up against each other. Figure 9 shows that a bundling of all energy efficiency measures (EEM) yields an attract return. This report found that the internal rate of return for these eight measures together is 18% -- a higher return than a commercial building owner would receive from most other investments.

These five studies make the case for implementing several energy efficiency measures rather than just cherry picking two or three with the best paybacks.

iii. Choosing which model ordinances to develop

The PAEC AEC Regulatory and Permitting Recommendations report also sheds light on which AEC projects offer the best payback by analyzing 10 different potential model ordinances.[14] For the analysis, San Mateo County jurisdiction discussed projects that could help fulfill their Climate Action Plan goals and brainstormed several different potential model ordinances. The following table shows which model ordinances were calculated to pay for themselves with savings before the end of the expected lifetime of the project.

[14] DNV GL, Task 2.14, AEC Regulatory and Permitting Recommendations

Table 1: Payback analysis for eight AEC model ordinances

Model Ordinance	**Total Annual Energy Savings**	**Annual Profit and/or Cost Savings ($/yr)**	**Payback (years)**	**Annual GHG Reduction (MT CO2)**
1. Electric vehicle chargers in multifamily buildings	630 gallons of gasoline	$1,028	2.5	5
2. Electric vehicle fast chargers for new retail buildings	10,005 gallons of gasoline	$5,713	5.7	87
3. Solar carports for new commercial buildings	143,052 kWh	$33,811	7.0	15
4. Electric heat pumps for space heating in multifamily buildings	4,920 kWh*	$(1,159)	No payback	1
4. Electric heat pumps for water heating in multifamily buildings	15,010 kWh*	$(515)	No payback	2
5. Electric heat pumps for space heating in new commercial buildings	9,592 kWh*	$(286)	No payback	1
5. Electric heat pumps for water heating in new commercial buildings	4,939 kWh*	$(167)	No payback	1
6. Time of sale energy audits and energy efficiency recommendations for existing multifamily buildings	21,701 kWh*	No cost savings for seller	No payback	2
7. Time of sale energy audits and energy efficiency recommendations for existing commercial buildings	54,626 kWh*	No cost savings for seller	No payback	6
8. Energy efficiency measurement and verification for new commercial buildings	29,300 kWh*	$6,925	15.9	3

* Denotes net energy savings (based on both therms and electricity)
Source: DNV GL, Task 2.6 - Benefit-Cost Analysis Report of Potential Ordinances

According to this analysis, EV chargers in multi-family complexes, electric fast chargers for new retail, solar carports for new commercial, and energy efficiency measurement and verification for new commercial buildings are cost effective measures. Electric heat pumps for space and water heating, as well as time of sale energy audits are not currently cost effective because of the low cost of natural gas. Having detailed benefit cost analyses like these helps consumers determine where to focus future efforts given limited personnel and funding resources.

iv. Financial tools

The next step, after a project passes the benefit-cost analysis (BCA) hurdle, involves finding the right financial tool to pay for the project. An uneven patchwork of financial tools is available for projects depending on the sector and type of project. There are different financial tools available to the commercial, municipal, and residential sectors.

One financial tool to fund energy efficiency projects in the commercial and municipal sector is on-bill financing from Pacific Gas & Electric. This zero-interest loan makes projects much easier for these two sectors. PG&E works closely to develop and pay for energy efficiency project equipment and installation up front and then rolls the costs into the customer's bill over five years for the commercial sector. The municipal sector can take up to ten years to pay back the zero-interest loan.

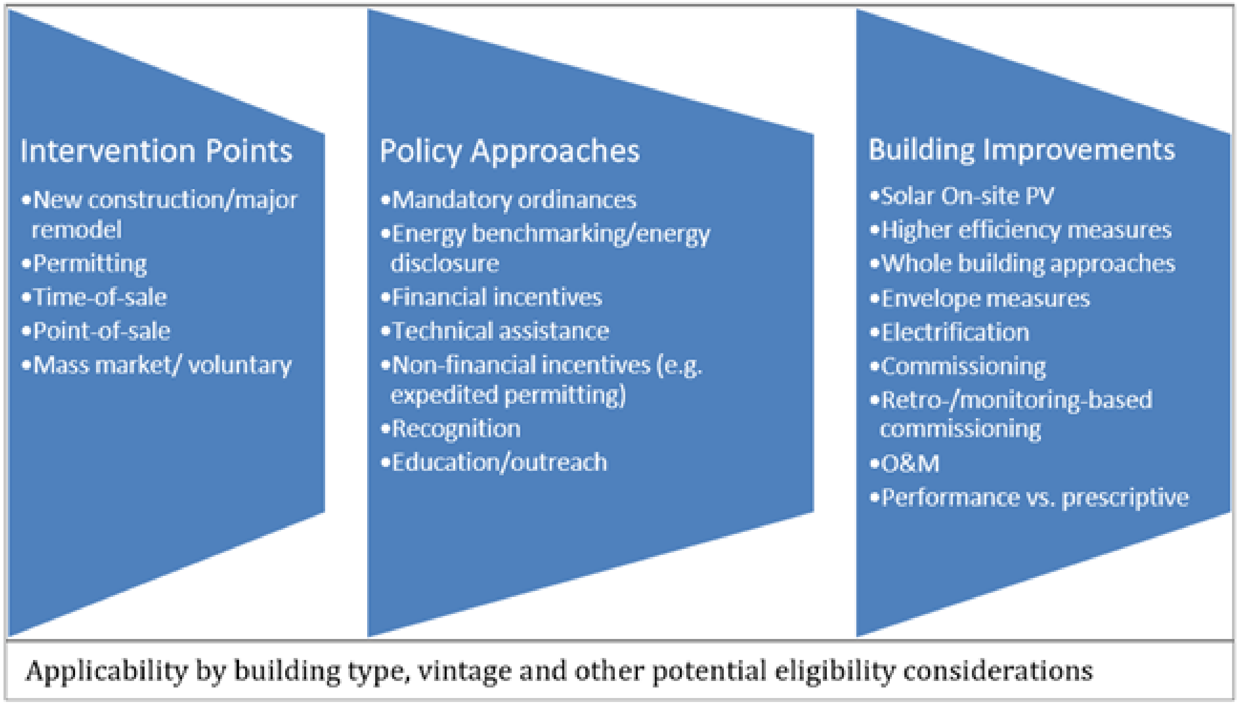
On-bill financing is not offered for the residential sector where administrative costs per project would be much higher than commercial or municipal projects, thus, making the program prohibitively expensive to administer. PACE funding is available for residences at variable interest rates often in the high single digits (typically more expensive than an equity line of credit).

Municipalities have developed innovative public-private partnerships to implement projects when funding is scarce. PAEC's Best Practices Report Task 2.2 highlights cost sharing for EV charging infrastructure and energy storage in Redwood City. Green Charge provided the capital up front for five EVCI/energy storage projects: two garages, two libraries and one community center. This public-private partnership between Redwood City and Green Charge Network resulted in shared savings.

b. Policy

Government plays a vital role to nudge the market to meet clean energy policy goals. Various policy approaches can be employed at various intervention points to encourage specific building improvements. See Figure 10 for PAEC's list.

Figure 10: Framework for considering a range of AEC regulatory and policy changes



Source: DNV GL, Task 2.14 - AEC Regulatory and Permitting Recommendations

PAEC's policy findings in several reports focus on mandatory ordinances and streamlining permitting. Section X in this report explains tools that can accelerate deployment of AECs such as model ordinances and a model interconnection process checklist. The most urgent policy finding of this project involves streamlining the permitting process for AEC components at the utility and municipal level. The reasons for doing so in these two sectors include:

- Utilities – provide consistency and transparency in the permitting process with respect to costs, timelines, documentation and reviews
- Municipalities – provide consistency between municipalities in the permitting process with respect to costs, timelines, documentation, inspections, and requirements

California has a sophisticated regulatory structure designed to ensure human and environmental health. This system has evolved over decades and now needs to be streamlined.

i. Focus on deep energy retrofits

The Gap Analysis Report[15] determined that an important hole needs to be filled when building out the AEC in southern San Mateo County. In this highly developed area, the Gap Analysis Report identifies deep energy efficiency retrofits that will drive down building energy use by implementing a bundle of measures with the greatest impact and recommends widespread electrification. Findings in the report describe specific opportunities at each jurisdiction in the PAEC scope of study:

- Atherton – Most homes were built before adoption of California Title 24 building codes. Given that residences in Atherton use three times more energy than the average household in San Mateo County, comprehensive energy efficiency upgrades and fuel switching from natural gas to electricity could reduce residential energy use by 30-40%. The jurisdiction could focus on voluntary assistance programs and mandatory upgrades at the point of sale or during major renovations.
- East Palo Alto – Energy bills in East Palo Alto generally range from 17-23% of a household's monthly earnings after taxes. As such, the focus in this town should be to help single family and multi-family residents to complete deep residential energy efficiency retrofits.
- Menlo Park – Menlo Park is planning for growth around the Bayfront area, which must meet recent building requirements, and also should encourage homes and businesses to retrofit to be more sustainable in the areas of energy efficiency, renewable energy, ZNE and EV charging infrastructure.
- Redwood City – Given how much development has happened recently and will happen in the near future, Redwood City should focus on helping buildings become ZNE and developing reach codes for sustainable building energy standards.

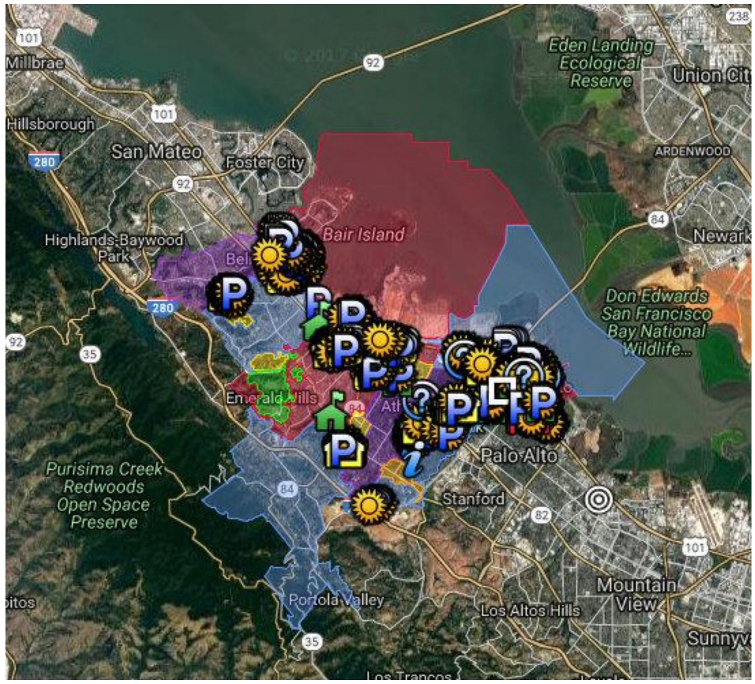
[15] Menlo Spark, Task 2.4 - Gap Analysis

All four cities currently go beyond the minimum the state of California requires for energy efficiency.

c. Technical

i. Solar Siting Survey

Figure 11: Map from PAEC solar siting survey tool



Source: Clean Coalition, Task 4.2 – Solar Siting Survey

PAEC's Solar Siting Survey[16] reviewed satellite maps of southern San Mateo County to determine how much commercial solar potential exists. Although the area has dense development and a thick canopy of trees, PAEC found 65 MW of commercial solar potential. The main areas that offered sites for solar of at least 100 kW each were school rooftops, parking lots and parking garages.

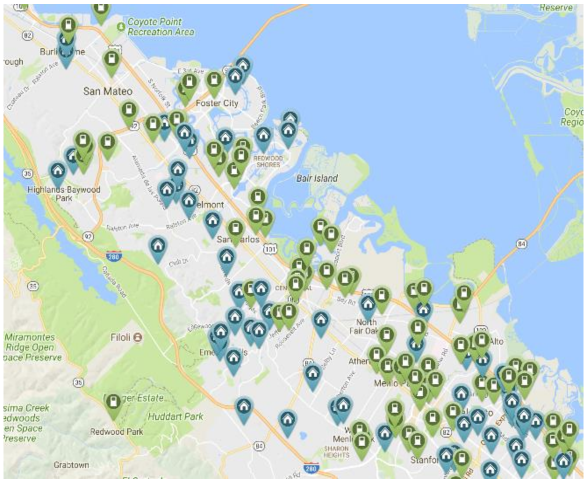
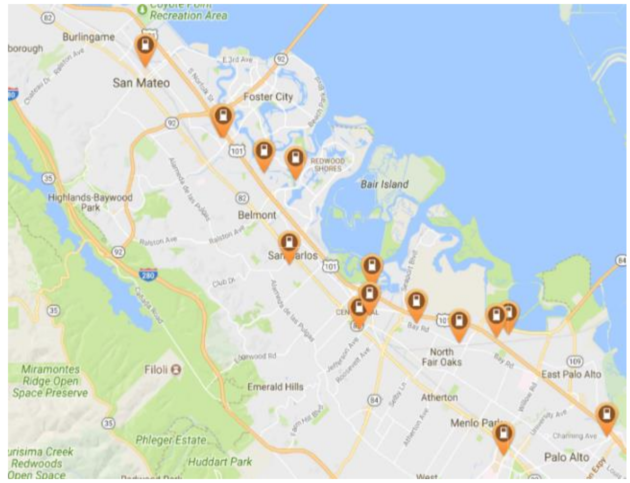
Information about each location with at least 100 kW of solar potential was loaded into a Google Map platform (see Figure 11), which is searchable for details about each property.

Each county in California would benefit from having a database of sites for commercial solar development.

ii. Electric Vehicle Charging Infrastructure (EVCI) Master Plan

A key component of AECs is EV charging infrastructure. Range anxiety limits the number of electric vehicle purchases but as EV charging stations have proliferated, adoption of electric vehicles has expanded. Currently there are several dozen Level 2 EV charging stations and over a dozen fast charging stations in the PAEC region (See Figures 12 and 13).

[16] Clean Coalition, Task 8 – Solar Siting Survey

Figure 12: Map of level 2 EV charges	***Figure 13: Map of DC fast chargers***
 Source: Google Maps	 Source: Google Maps

While conducting research for the PAEC EVCI Master Plan,[17] the team reached out in disadvantaged areas of the PAEC region and talked to several property owners about the availability of public funding for EV charging stations. This outreach resulted in commitments to install $504,000 of EV chargers. One multi-family complex in Redwood City will install 10 Level 2 chargers and a condominium complex in East Palo Alto will install 36 Level 2 chargers.

In multifamily complexes, Level 2 chargers work well for overnight charging. For people on the go who would like to recharge more quickly, fast chargers (FCs) more closely model themselves on the fast fill-up most people are used to at gasoline stations. The PAEC region would benefit from more Level 2 chargers at workplaces and multi-family locations, and fast chargers at commercial locations and near highways.

The PAEC EVCI Master Plan recommends the Staumbaugh-Heller area of Redwood City as the primary geographic location for additional chargers and East Palo Alto as a secondary location. Both geographic locations currently have the least dense charging infrastructure in San Mateo County, the potential for 80% to 90%+ EVCI funding via PG&E's Charge Network Program, and large and growing number of workplace and multi-unit dwelling potential hosts.

Finally, the EVCI Master Plan finds that San Mateo County Sustainability and Transportation Professionals would like to see more EVCI but want to make sure the cost

[17] Sven Thesen & Associates, Task 6.1 – Potential Locations for the Electric Vehicle Charging Infrastructure Master Plan

of installing additional public charging for a given Bay Area municipality is near or at zero. Public-private partnerships that share the costs and savings are useful for these situations.

iii. Building management systems

Approximately 60% of commercial buildings have building management systems (BMS) to help use energy efficiently. To increase the ease of finding a BMS, the PAEC team researched and created an inventory[18] of BMS system providers.

IX. Case Studies

As part of the objective to create pathways to cost-effective, clean local energy and community resilience, PAEC initiative is developing case studies that highlight best practices in our local communities to serve as exemplars and templates for broader dissemination and penetration.

The goal of this task is to create a SEM site design and deployment plan at one location within the core PAEC region. The SEM will provide renewables-driven power backup for critical facilities – police and fire stations, emergency operations centers, emergency shelters, and other facilities prioritized by the jurisdiction – over the agreement term. While the primary goal of the SEM is to provide renewables-driven backup power to critical facilities, boosting the environmental and resilience benefits for a site, a secondary goal is to provide economic benefits to the site through lower long-term energy costs and reduced utility charges (including demand charges) made possible using distributed energy resources (DER.)

a. Stanford Redwood City - Community Microgrid Case Study

The Stanford Redwood City ("Stanford RWC") Community Microgrid leverages the resources of a top-tier research university and showcases how distributed energy resources (DER) can be configured to provide energy cost savings and resilience at campuses and multi-building, multi-meter clusters nationwide. The project is representative of a replicable use case and ownership model for a Community Microgrid. During the project development process, the main challenge faced by the design team was reaching an agreement between the key stakeholders on the project scope and timeline for the Community Microgrid.

Community Microgrid projects implemented on sites undergoing new construction have stakeholders including all construction subcontractors (civil, architectural, electrical, etc.) and public utilities (electricity, gas, water and sewage) making it even more challenging to design and implement an additional layer of energy infrastructure. In addition, each stakeholder has different priorities, so a clear definition of the benefits to each party is key to finalizing a project scope and cost. This case study reviews the project elements and

[18] Task 3.14 – Building Management System Benchmarking Study

timeline and suggests alternative strategies for streamlining the design and deployment of Community Microgrids.

i. Background and project overview

Stanford RWC is a new, two-phase real estate development of more than a dozen buildings located in a disadvantaged community, per the CalEnviroScreen 3.0,[19] within Redwood City. Phase 1 construction began in August 2017, and is scheduled to be completed with full occupancy by July 2019. This Community Microgrid use case is for a large campus with multiple buildings and meters as well as highly customized energy solutions for central heating and hot water, while the ownership model is representative of a non-profit site owner/ project beneficiary.

Figure 14: Stanford Redwood City Community Microgrid plans

Source: Stanford University

Stanford RWC will be the first deployment site of DER assets, including 50 MWh of energy storage that will be incorporated into a broader Community Microgrid in the disadvantaged Stambaugh-Heller neighborhood of Redwood City. The broader Redwood City (RWC) Community Microgrid will include schools, municipal properties and commercial properties as outlined in the Master Community Design (MCD) of the Clean Coalition's PAEC project (Task 10 Report). By reducing energy costs and emissions, improving local air quality and providing energy resilience during grid outages, the broader RWC Community Microgrid will be an asset for the local community. The Stanford RWC Community Microgrid is an essential first step to achieving an AEC, and the lessons learned from this project will inform and streamline future deployments allowing for large-scale DER and Community Microgrid proliferation.

The Stanford RWC Community Microgrid will provide renewables-driven backup power to the campus data center (building A2 in Figure 14) and will also combine the loads from the data center with electric vehicle charging infrastructure (EVCI) loads and solar from the

[19] https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

parking garage (P1 in Figure 14) to minimize demand peaks. The project will reduce GHG emissions by 54% compared to standard PG&E electric generation and natural gas, and will provide resilience through an innovative combination of five distributed energy resources (DER) and a microgrid controller, as follows:

Energy efficiency
The Central Energy Facility (CEF) represents a fuel-switching, energy efficiency and thermal energy storage measure that will provide district-level heating, cooling, and hot water 50% more efficiently than a comparable gas boiler district thermal system. The CEF supplies Stanford RWC with 47.6 MWh of thermal energy storage in the form of hot and cold water storage tanks and reduces the campus' on-peak energy demand for heating and cooling by following retail energy market price signals. The CEF is a small-scale replica of the $500 million SESI project that has been operational at Stanford University's main campus since 2015 (see Appendix). The CEF uses electric heat pumps to support all Stanford RWC buildings and provides a unique opportunity to integrate thermal energy storage into a Community Microgrid.

Solar PV
895 kW of new Solar PV will be provided by West Hills Construction.

Energy storage
2.1 MWh of Tesla Powerpack lithium-ion batteries will enable electric energy storage.

Demand response
Building management system (BMS) by Distech Controls will enable demand response.

Vehicle-Grid-Integration (VGI)
VGI capable electric vehicle charging infrastructure (EVCI) will enable demand response with 52 ChargePoint. Inc. level 2 charging ports.

Microgrid controller
Johnson Control's Enterprise Optimization Solutions (EOS) software will serve as the master microgrid controller. EOS will integrate the CEF, BMS, solar, battery, and EVCI to co-optimize for daily energy operations; and for data center resilience benefits during grid outages. This project will explore unique co-optimization algorithms and will provide the CEC with recommendations to support rapid commercialization of multiple-DER microgrids.

ii. Benefits to the community and Stanford

The microgrid provides services and improvements to the residents of Redwood City, with key benefits including: ongoing jobs and access to electric vehicle charging, phone charging, and electricity for other critical equipment during grid outages. The Stanford RWC Community Microgrid has tremendous local community support from Redwood City 2020, a community group dedicated to improving the lives of local students and their families, as well as the Redwood City School District.

Island mode

The Stanford RWC Community Microgrid will be able to operate in grid-island mode, able to seamlessly enter island mode and support an average of 251 kW of load for five hours, with a maximum power output of 325 kW. The microgrid can support the entire data center load during short-term grid outages, which provides value to Stanford RWC because it allows communications operations to continue uninterrupted. During long-term outages, the microgrid will be able to support 67 kW of load indefinitely using renewable generation and energy storage; a combination of automatic and manual load-shedding will take place, so that 67 kW of critical load can be supported continuously. In disaster scenarios, the capability of the Stanford RWC Community Microgrid to operate with indefinite renewables-driven backup power will ensure that employees and the surrounding community may evacuate safely, and have access to EV charging, phone charging and electricity for other critical equipment.

GHG emissions reductions

The Stanford RWC Community Microgrid will reduce GHG emissions on the Phase 1 buildings by 54%. The huge reduction is due to the large amount of solar PV that will be installed for this project, and the fuel-switching and electrification measures of the CEF. The annual electrical energy needed to supply the entire campus heating and cooling load is about the same for a conventional HVAC system and district thermal system of the CEF; however, the CEF uses only renewable energy. The CEF uses 5.3 million kWh of electricity per year, which results in about 1.7 million pounds of CO2 per year (estimated using PG&E's projected CO2/kWh for 2018). Total campus heating demands for the conventional HVAC system requires 9 million kBtu, generating an additional 1.1 million lbs of CO2. Using renewable energy only leads to a 38% reduction in CO2. The proposed solar PV displaces another 1.4 million kWh of electricity, reducing CO2 by another 0.4 million lbs. This results in a cumulative net decrease in CO2 emissions of 54%.

Knowledge gained

The knowledge gained, experimental results, and lessons learned will be shared with the public and key decision makers through blog posts, public workshops and media releases in addition to the project fact sheet, presentation materials, photographs, and a technology transfer report.

PG&E ratepayer benefits

This project will provide significant public benefits, which include:

1) Increasing customer adoption and total deployment of DER through expanding the local hosting capacity, optimally utilizing existing grid capacity, and lowering interconnection costs;
2) Providing improved outage resilience with both enhanced fault ride-through during short-term outages and locally islanded continual operation;

3) Enhancing reliability through improved operation and mitigation of grid stress associated with high penetration of variable distributed energy resources;
4) Reducing emissions by widespread adoption of distributed solar generation, and with ramp and peak mitigation from energy storage;
5) Lowering costs of electricity from distributed generation; and
6) Lowering ratepayer costs related to reduced peak transmission and generation capacity requirements, and reduced energy losses.

Effective demonstration of microgrid design and application will encourage increased commercial adoption of microgrids and their constituent components, in particular PV, energy storage, and coordinated control systems. DER adoption and deployment are highly price sensitive and are therefore constrained by distribution grid hosting capacity limits above which substantial additional costs are incurred for grid upgrades. A microgrid approach mitigates or fully avoids hosting capacity constraints, allowing increased DER adoption without grid upgrade costs for either the applicant or ratepayers.

Quantitative estimates of potential benefits are provided in the table below based on a microgrid supporting a 25% increase in distribution grid hosting capacity, with net customer benefits equal to or greater than those with DER adoption in the absence of a microgrid.

Table 2 shows projected impacts on California electricity ratepayers on a per MW basis, with an increase in annual deployments of 90 MW/yr and a total projected impact of 1,800 MW of additional PV deployment over 20 years. This individual proposed microgrid will include 0.9 MW of PV and 2.1 MWh of battery storage, plus thermal energy storage. While 1 MW is widely applicable to large commercial settings, the DER components, facilities, and control systems integrating these are fully scalable for systems of all sizes.

Table 2: Summary of benefits from the Stanford RWC community microgrid

Impacts	Annual per MW deployed	20 year cumulative per MW	Annual 90 MW addition system-wide	System-wide annual total at year 20
Formula	Base value	BV x 20	BV x 90	BV x 1800
Peak Capacity Savings	$24,000 @ 20% ECC	$480,000	$2,160,000	$43,200,000
T&D Line Loss Savings	$11,835	$236,700	$1,065,150	$21,303,000
New Transmission Capacity Savings	$30,500	$610,000	$2,745,000	$54,900,000
Energy Purchase Reduction	1,550MWh	31,000MWh	139,500MWh	2,790,000MWh
Energy Cost Savings	$71,920	$1,438,400*	$6,472,800	$129,456,000
Reliability Value	$1,766	$35,320	$158,900	$3,178,800
CO2 Reduction	513 MT	10,260 MT	46,170 MT	923,400 MT
NOx Reduction	1.39 MT	27.85 MT	125 MT	2,506 MT

Water Savings	0.03 M gal	0.6 M gal	2.7 M gal	54 M gal

Source: Clean Coalition

Qualitative ratepayer benefits
Ratepayers will benefit in ways not directly related to their electric bills. The demonstration of microgrid capabilities and value in commercial application will promote rapid adoption of these technologies. This will result in:

- Reduced growth in demands on existing infrastructure will lower costs to ratepayers associated with integrating new loads and electrifying GHG sources;
- Benefits for critical facilities and other services maintaining operation in the event of interruption of grid services, including long-term outages; and
- Improved opportunities for customers to adopt behind-the-meter mitigation of energy costs, including local customer aggregations in which residential buildings or developments may adopt microgrid services.

Labor, material, and incidental cost reductions in project design, installation, operation, and associated energy costs can be expected from both standardization and improved coordination of microgrid components. These cost reductions will increase consumer appeal of PV, battery and control system components, and microgrids. As part of the 90 MW per year of estimated increased distributed PV deployment across all communities, this will have significant regional employment impacts (65,000 job-years, if fully deployed).[20] Each additional MW also will result in $116,000 in state and local sales tax revenue from equipment and material sales, plus income tax and reduced social services expenditures associated with $1.4 million in wages.

Benefit-to-cost analysis methodology and underlying assumptions
Estimates of the anticipated benefit return on investment from EPIC funding for the microgrid project are described above. Net benefits per MW of added PV deployment resulting from increased hosting capacity and operating for 20 years:

Ratepayer impacts

- Customer energy savings of $1,438,400.
- Zero integration cost impact to nonparticipating ratepayers
- $0.58 million in ratepayer peak capacity savings
- $0.24 million in ratepayer savings statewide from avoided transmission losses
- $0.60 million in ratepayer savings statewide from avoided transmission proportional capacity related costs over 20 years.

Economic development impacts of 1 MW PV installation

- $4 million in new local private investment
- $4.6 million in total added regional economic output

[20] 25.4 job-years per MW from construction and installation, and 10.4 additional job-years (0.52 FTE) from operations and maintenance activity. NREL Jobs & Economic Development Indicator model results from $2.75/W(dc) PV estimated gross weighted average cost. Higher or lower costs by installation type or year installed will proportionately influence results.

- $1.4 million in local wages from construction and installation representing 635 near-term construction job-years (FTE)
- $0.6 million in wages from operations and maintenance over 20 years representing an additional 10.4 job-years (0.52 permanent jobs FTE, $29,600 in annual wages)
- $0.12 million in construction-related state sales tax revenues

Environmental benefits
- 10,260 MT GHG reduction
- 0.6 million gallons of water saved
- 7.5 acres land preserved through secondary use of roof and parking lot areas

Reliability and resilience
- $35,320 for businesses from avoided average local outage

iii. Site design and design process

The initial design of the Stanford RWC Community Microgrid involved incorporating solar PV onto all building rooftops, parking garages, and parking lots on-site. This initial site design included four separate energy storage sites and enabled indefinite renewables-driven backup power for the gym, which was an excellent candidate for a community emergency shelter. Additionally, the energy storage would support peak shaving of intermittent high-power loads associated with the 52 Level 2 EVCI charging ports. During stakeholder review, several of these ideas were eliminated due to challenges incorporating them into the existing site design. Stanford stakeholders were not interested in allowing EV charging stations to be used by the general public due to enforcement challenges. Additionally, Stanford stakeholders were not interested in utilizing the property as an emergency shelter for the community.

In the second design, the solar was reduced to five buildings only; some buildings were not candidates for solar due to their aesthetic architectural nature, while others were not considered good sites due to possible reconstruction within the next 10 years. The energy storage was limited to a single battery site inside a parking garage, because there were no other viable siting opportunities for energy storage on the new campus. Stanford values each parking space with an NPV of $50,000, so even occupying two parking spaces for a battery was challenging. The five solar arrays were designed to be net metered with the building loads of the associated meter. During a grid outage, the system would utilize all five solar arrays (in combination with battery storage) to provide indefinite power backup to the campus data center and communications hub.

The final design scope is similar to that described above, with one key difference -- during a grid outage the data center load would be supported only by solar from the adjacent parking structure (which is behind the same meter as the data center.) This was due to expected project delays and costs associated with coordinating with PG&E to enable and allow underground distribution lines to connect the other solar arrays to a data center during a grid outage.

Table 3: Solar PV systems planned at Stanford RWC campus

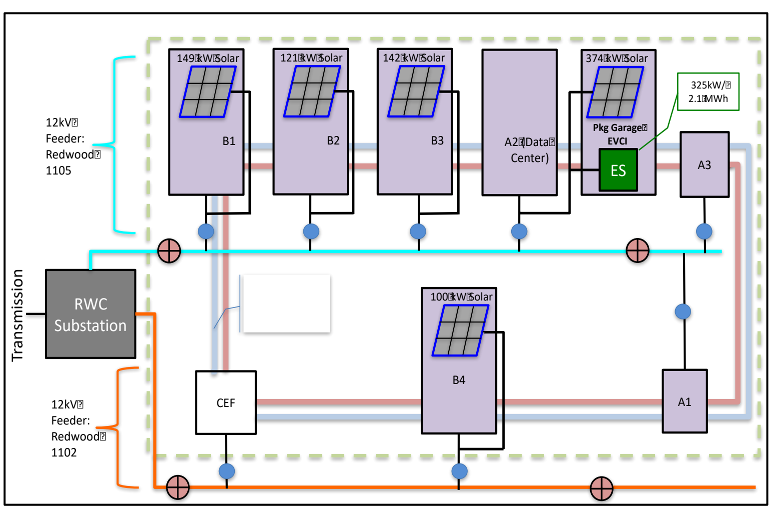
Building #	Building type	PV size [kW]	Annual production [MWh]	Energy storage capacity [kWh]	L2 EVCI ports
CEF	Energy	-	-	47,600	-
P1	Parking	374	586	2,100	52
A2	Data-center	-	-	-	-
B1	Office	149	249	-	-
B2	Office	121	199	-	-
B3	Office	142	235	-	-
B4	Office	100	167	-	-
TOTAL		886	1,436	49,700	52

Source: Stanford University

The Stanford RWC Community Microgrid will be built for Phase 1 and includes the Central Energy Facility, five buildings, and one parking structure. The core of the Stanford RWC Community Microgrid will combine the data center load with 374 kW of solar on the parking garage, 2.1 MWh of lithium battery energy storage, and 52 Level 2 EV charging ports to minimize peak demand charges, minimize Stanford RWC's impact to the PG&E grid and maximize energy cost savings for Stanford. The DER elements will be integrated into, monitored and controlled by EOS, a product by JCI that enables high DER penetration microgrids. The project will also deploy 512 kW of solar across four buildings (B1-B4) to provide Stanford RWC with more carbon-free generation. All solar will be provided as a PPA with a rate at or below 11.5 cents/kWh.

The project will include a 2.1MWh Tesla Powerpack sited at the parking garage and routed to the data center's electrical panel. The lithium ion batteries will use demand charge management as the primary revenue stream by shaving peaks associated with the intermittent EVCI loads. During grid-connected operation, 1.6 MWh of the total battery capacity will be used to provide 251 kW of load shifting for five hours during the peak time-of-use (TOU) period. This corresponds to time-shifting the entire data center and EVCI load away from the peak TOU period. The battery will also bring energy resilience to the data center by enabling backup power for up to 251 kW of load during short term grid outages and indefinite renewables-driven backup power for up to 67 kW of load during long term grid outages, greatly improving local reliability. The

Figure 15: Stanford RWC PV Schematic



solar and energy storage combination will potentially obviate the need for a backup fossil-fuel generator, leading to local emission reductions, pending discussions with the permitting agencies and fire district. The 2.1 MWh battery will require approximately 500 sq. ft. in the southwest corner of P1 (see the map in Figure 15) and the on-board battery controller will be integrated into EOS.

The project will deploy 52 Level 2 ChargePoint charging ports enabled with smart EV charging. The EVCI will facilitate EV proliferation and will also accommodate Demand Response (DR) as a revenue stream. Smart EVCI will also enable future resilience by setting the stage for vehicle-to-grid (V2G) capabilities that allow the batteries within electric vehicles to provide power into the core of the Stanford RWC Community Microgrid. The master microgrid controller, provided by Johnson Controls' EOS, will co-optimize the DER resources to optimize for daily energy operations and for data center resilience benefits during grid outages. Ensuring that EOS can communicate with, monitor and control each of the DER elements will be critical to this project and the goal of developing commercial microgrids.

iv. Economics

The Stanford RWC combined solar and energy storage was modeled on the Storage Value Estimation Tool SVET V1.0.1.81. An SVET Sample Office load profile was used, which exhibits a very similar load shape at a larger, but comparable, magnitude. Because the Sample Office load is larger than the SRWC forecast load (the buildings are under construction and not yet occupied), it does allow full utilization of the planned PV and ES capacity, and the resulting impact of the DER investment is identical when comparing the difference between the Base Case (PV without ES) and the Investment Case (PV+ES). Utilizing the applicable PG&E E-19 TOU Secondary Retail Tariff, the reduction in hourly loads and demand charges should be identical and the SVET valuation resulting from this should not be affected by the larger than planned remaining base load.

Stanford RWC project specifications include 886 kW PV; 1600 kWh energy storage with a maximum PV charging rate of 325 kW and discharge rate of 251 kW; Ownership Model: Independent Power Producer (IPP); 4% debt interest rate; 27% debt and 11% equity which is the default value on the software. Incentives include the investment tax credit (ITC), but does not include SGIP.

The scenario was run with and without participation in demand response programs. Battery replacement was required after 12 years based on calculated cycling and degradation. Due to the higher customer value associated with reductions in demand charges and TOU energy time shifting, the model prioritized these uses; they were identical in the two alternatives. When demand response participation was allowed, it added 5% to the total customer value.

Table 4: Energy storage value estimation

Year	Demand Charge	Retail Energy Time Shift	Demand Response	Total
2019	$71,833	$21,842	$7,748	$101,424
2029	$87,564	$26,626	$8,559	$122,749
2038	$104,647	$31,820	$9,360	$145,828
20- year total	$1,764,800	$536,620	$171,080	$2,472,520

Source: Clean Coalition

The Benefit-Cost Ratios for the storage project are Participant Cost Test (PCT): 3.388, Total Resource Cost (TRC): 1.434, net cost of capacity = 0, total project NPV = $70,858, and break-even capital cost $847/kW-year.

v. Technical feasibility

The Stanford RWC Community Microgrid proposed technical design is based on integrating multiple existing and proven technologies into an innovative configuration. All DER will interoperate with EOS. The BMS and EVCI will interoperate with PG&E's existing DERMS technology to enable demand response. Thus, this project integrates multiple existing equipment and software technologies and applies them to a more valuable and scalable campus energy network product configuration. The project will leverage existing technologies as described below.

The CEF district heating and cooling system at Stanford RWC is a fuel-switching and energy efficiency measure that is the core component of the Stanford RWC Community Microgrid. In this arrangement, separate HVAC systems for each building are replaced by a cold-water loop and hot-water loop for the entire campus that is maintained by the CEF. In conventional heating, a tremendous amount of waste heat from boilers and furnaces is transferred to the atmosphere. The CEF makes use of this waste heat by using the plumbing and distribution design of a conventional district energy system. At each building, heat exchangers create warm and cool air from hot and cold water delivered from the CEF, and systems mix the air to the needed temperature for each area within a building. They used cold and warm water loops returning to the CEF, where large-scale chillers lower the temperature of the cold-water loop and raise the temperature of the hot-water loop.

vi. Challenges

The number one challenge in designing the Stanford RWC Community Microgrid was determining a project scope. There were many factors that contributed to this including different expectations and goals for the project from each stakeholder, inability to secure an Engineering Procurement and Construction (EPC) contractor early on, lack of interest for this type of research and development project from the utility company, and the timing of this project feasibility assessment within the timeline of the greater Stanford RWC construction project. Each of these contributing factors are described below in more detail.

The stakeholders involved in this project include the following:

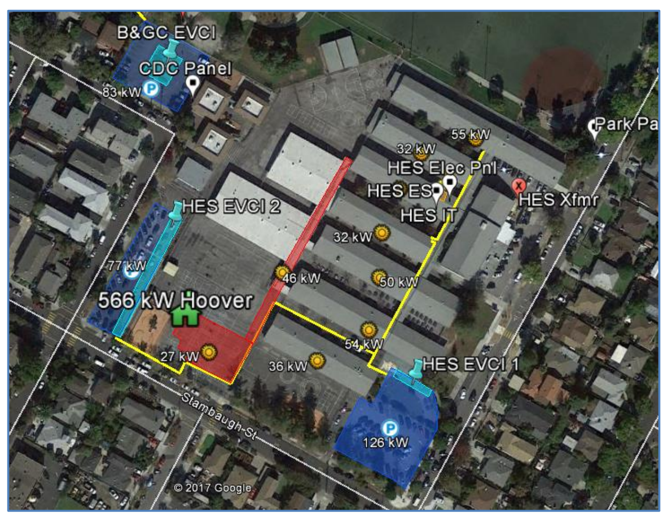
- Stanford University serve as the site host and off-taker of solar PPAs.
- West Hills Construction (WHC) will serve as the main technology and the engineering, procurement, and construction (EPC) partner for the solar and battery as well as engineering support for the development of EOS. WHC will also serve as the solar and battery owner.
- Johnson Controls (JCI) will serve as the microgrid integrator and operator. Stanford will contract JCI to customize the EOS for this application and will provide all monitoring, communications, and controls for the project.
- DEVCON Construction, Inc., will serve as the EPC for the building management system. They will deploy Distech Controls software and Tridium Niagara hardware.
- Redwood Electric will serve as the electrical EPC for the EVCI portion of the project.
- PG&E will serve as the local utility. Their participation and support for this project will be essential for determining the best option for interconnection and replicable market opportunities.

The Stanford University RWC Community Microgrid employs cutting edge technologies and offers a multitude of benefits to the university and the community. Given the scope of this project, PAEC expects this to inspire other AECs in the near future.

b. Hoover School SEM Design

For this project, PAEC studied three different scenarios in which a SEM could be configured at a public school in southern San Mateo County. The following case study allows decision makers at the school to determine the benefits each scenario offers and choose the one that best meets the school's and community's needs.

Figure 16: Hoover SEM satellite map



Source: Clean Coalition

i. Project overview and site design

While many potential SEM sites in the disadvantaged community in Redwood City were investigated, the best site uncovered so far is the Hoover School. This school operates year-round to serve 700 students with approximately 100 staff employees. There is a full-service cafeteria with large walk-in refrigerators and freezers. After-school programs for students provide support for working parents. Summer camps at Hoover School serve the community. As such, this school is an important community resource.

Hoover School provides a strong match with SEM design criteria. The school does not currently have solar PV, already has incorporated energy efficiency retrofits that allow a properly sized solar PV system to be designed and installed without risk that the system may be oversized, and enjoys a Red Cross emergency shelter designation.

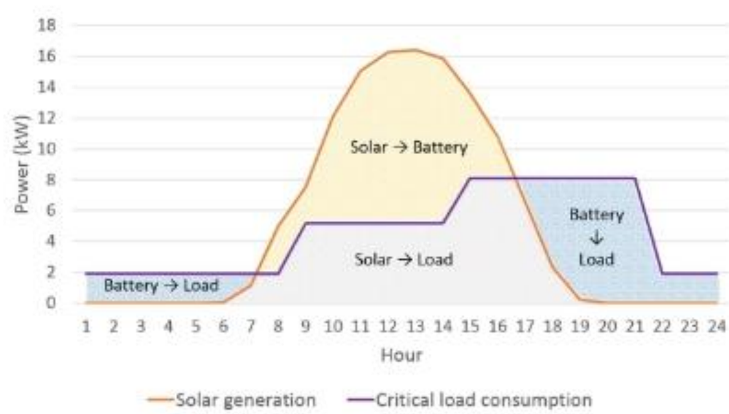
The goal of this SEM is to provide power continuity whether a short-term (minutes), a medium-term (hours) or long-term outage (days). The SEM would provide back-up power for a medium-term outage to allow time for children to be kept at the school safely until parents come to pick them up. For a long-term outage (days), a restricted set of rooms and buildings would be kept operating as shelters per an agreement with the Red Cross.

ii. Benefits to the school, district and community

The major benefits of a SEM are:

- Costs savings on a customer's utility bill from energy usage reduction, load shifting (see Figure 17) and demand charge reduction
- Community resource in case of a natural disaster
- Resilience

Figure 17: Energy storage shifts solar power generation to evening peak demand



iii. Technical feasibility and design process

For this project, the PAEC team modeled three different scenarios to determine which SEM was the best match for the school's needs.

Table 5: Comparison of design scenario results

#	Scenario	Solar PV	Energy Storage	Modeling Tool
1	Solar PV + Energy Storage	87.4 kW DC/ 72.8 kW AC	29 kW/ 60 kWh	Geli
2	Solar PV + Energy Storage + Electric Vehicle Charging (5x @ 3.3 kW, low Level 2)	87.4 kW DC/ 72.8 kW AC	29 kW/ 120 kWh	Geli
3	Off-Grid (21% of kWh Baseline with no EV)	25 kW DC	4 kW/ 135 kWh	HOMER

Source: Clean Coalition

For planning purposes, the Hoover School has the following demand under an A-10 Time-of-Use tariff:

- Annual load (2016): 292,176 kWh
- Maximum hourly load: 116 kWh
- Average hourly load: 33 kWh
- Minimum hourly load: 13 kWh

iv. Economics

The Benefits Cost Analysis examines three scenarios.

Scenario 1 – Solar PV + Energy Storage for Demand Charge Management
This scenario modeled normal operations with energy storage to reduce energy costs through Demand Charge Management. In this mode the battery is an asset in continuous use for load shifting from peak demand times to off-peak demand times. Energy storage (ES) will reduce demand charges by generating energy at the time of day electricity is expensive and using it when it's less expensive.

The Geli ESyst model analysis showed that the existing electrical bill of $71k annually will drop to $45k with PV and down to $37K when the ES is added.

Energy Storage System Size	Payback	Net Present Value	IRR
29kW inverter/60kWh (2 hours of energy)	4.2 years	+$242,713 (because of the savings on energy bill)	20.6%

Scenario 2 – Solar PV + Energy Storage + Electric Vehicle Charging
This scenario adds 10 Level 2 electric vehicle chargers to Scenario 1 to study the impact on battery sizing and economics. The assumptions are that five EV chargers would be occupied on work days from 8 a.m. to 3 p.m. and users will pay for electricity. The charging rate was assumed to be 3.3 kW (low Level 2) during this time.

The Geli ESystem model analysis showed that the addition of PV drops the bill to $50k, and ES further drops it to $40k.

Energy Storage System Size	Payback	Net Present Value	IRR
29kW inverter/120kWh (doubled size of battery)	3.3 years	+$261,207 NPV	22.5%

Scenario 3 – Off-Grid (21% of kWh Baseline with no EV)
This scenario examines the requirements to use the school for a long-term shelter in an off-grid scenario, assuming continuous grid outage with the emergency shelter running at a

much-reduced load (lighting and refrigeration only). This involved sizing the solar and battery for continuous operation with no other generation sources.

Modeling the requirements for an extended outage requires a different approach and tool. A demonstration of HOMER was used for the modeling. HOMER assists in the design of off-grid microgrids by trying various combinations defined by the user and guiding the user toward optimum solutions among the constraints defined in the model.

During an extended outage, the site would be used as a shelter with load drastically reduced. With the Bay Area's relatively temperate climate, most shelters plan on operating without the HVAC system in order to conserve power needs. An estimate of about 20% of normal load (without EV charging) was used to drive the model.

Energy Storage System Size: 4kW inverter/135kWh

Value: Long-term shelter for the community

v. Challenges

SEMs face two challenges.

1. Lack of integrated design tools

In terms of modeling tools for SEMS, there are tools to model demand charge reduction and tools for off-grid response, but not a single tool that does both. As such, we used two different tools to model three different scenarios.

2. Inadequate feed-in tariffs

More schools would have SEMs if they had the financial incentive to develop them. A SEM at an emergency shelter is a valuable community resilience asset in case of a prolonged power outage or natural disaster. Schools are natural places to have emergency shelters as they were designed to hold hundreds of people, have a multi-use room/gym that can hold sleeping cots, have cafeterias with refrigeration for food storage, and often have open fields where people can assemble. Schools have wonderful potential siting locations for solar PV because they have large roof areas and large parking lots. We should be encouraging more of them by providing feed-in tariffs to incentivize SEM development.

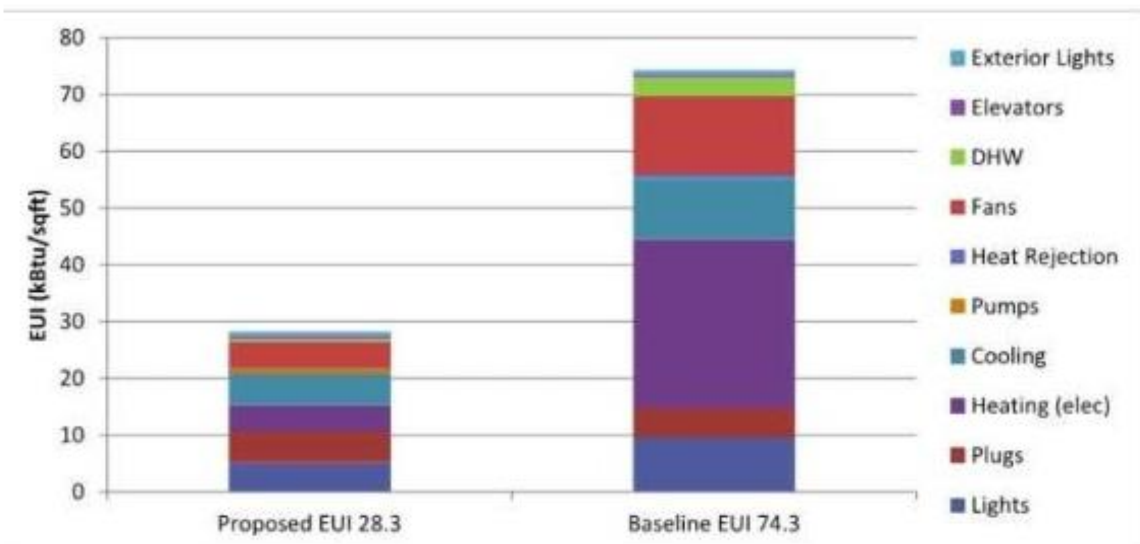
This case study explores three options for configuring a SEM at the Hoover School so other communities can best design their own. Do they want to have a SEM that provides onsite solar PV, solar PV with electric vehicle charging, or have emergency backup power to provide the community with shelter in the event of a natural disaster?

c. Atherton Civic Center Case Study

i. Project overview and site design

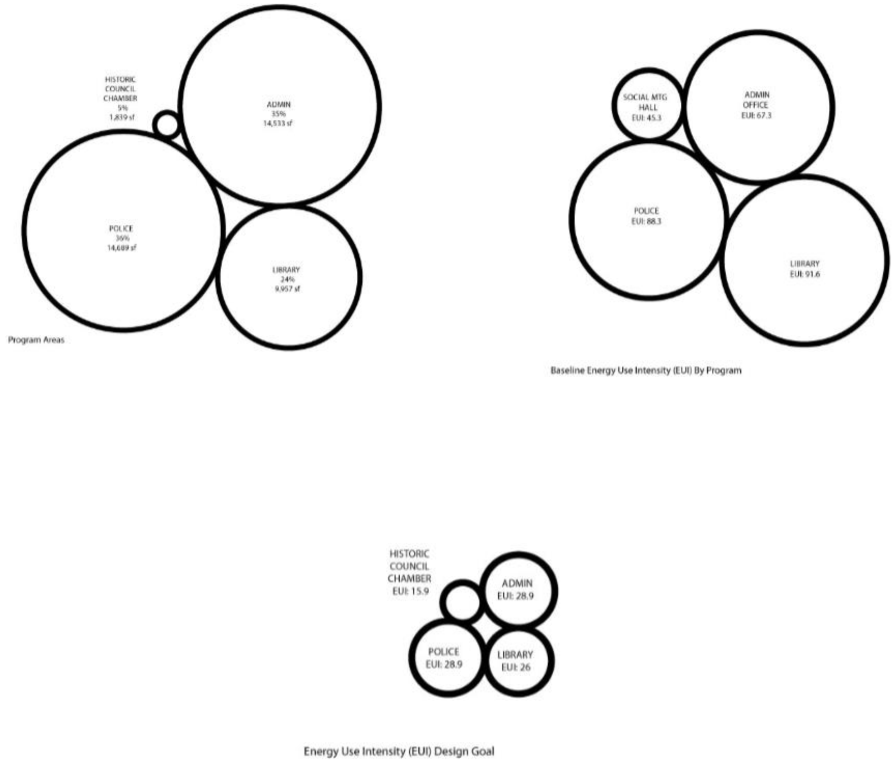
When the Town of Atherton began planning for its new civic center in 2014, prioritization of sustainability goals from the beginning of the project enabled planners to maximally reduce energy use through design of the architecture, building envelope, and building engineering systems (both mechanical and electrical). This thoughtful and comprehensive approach has resulted in energy usage projections that are slightly more than a third of typical building construction and puts the Atherton civic center on track to become the first zero net energy (ZNE) civic center in the United States as well as to incorporate a solar emergency micro-grid capable of supporting critical building functionality, beyond emergency response, in the event of prolonged utility outage. Figures 18 and 20 show the reductions in the energy utilization index (EUI) compared to comparable buildings and the existing civic center site. The EUI is a federal energy benchmarking tool that measures comparable building energy use.

Figure 18: Projected Atherton Civic Center energy usage to typical building construction



Source: Task 7.4: Technical and Economic Feasibility of Sustainability Features for the Atherton Civic Center Report

Figure 19: Baseline Energy Use Intensity (EUI) of civic center programs compared to EUI design goals



Source: Task 7.4: Technical and Economic Feasibility of Sustainability Features for the Atherton Civic Center Report.

The Atherton civic center achieves this ambitious goal by combining proven advanced energy saving features with innovative technologies. As part of the planning process, PAEC developed with city planners and officials a scorecard to evaluate efficiency strategies according to economic and normative criteria, including educational opportunities. The return on investment is excellent for several efficiency measures, whose payback period is relative short (see Scorecard of Sustainability Features):

- Insulated walls (R-19) and roofs (R-30)
- High-efficiency window glazing that balances thermal performance with daylighting
- Daylight and motion sensors along with manual controls and timeclock overrides help to reduce lighting energy loads. The anticipated lighting power density (LPD) is 0.49 W/sf, compared to an adjusted baseline of 0.75 W/sf from ASHRAE 2014 Advanced Energy Design Guidelines for Small to Medium Office Buildings Ceiling fans
- Modular heat exchange (hot/chilled water) central plant in each building (air-source heat pump with heat recovery for heating and cooling)

Heat pump technology is critical to achieving NZE for the civic center and relies exclusively on heat transfer for hot water, which eliminates the use of natural gas boilers. Pipes filled with hot and cold water control ambient temperature in all the buildings through radiant ceiling tiles and in the lobby serving the police department. Since cooling comprises the majority of the load for thermal control, integrating water tanks into the system allows for energy cost savings in three ways:

- Water thermal storage allows the heat pump to chill water at night to offset peak demand during day; i.e., "load shifting" takes advantages of reduced energy use costs at night during low energy demand periods (see figure 20),
- Shaving the peaks from the energy demand reduces the overall size of the heat pump, and
- Rebates for thermal energy storage systems subsidize the capital investment costs of the project.

Figure 20: Comparison of energy demand with and without thermal storage

Source: WRNS, Task 7.4: Technical and Economic Feasibility of Sustainability Features for the Atherton Civic Center Report

A geo-exchange heat pump was considered as an alternative, but the difficulty of siting a geothermal well around underground utilities was prohibitive.

Another challenging feature of the site is the dense canopy of historic oak trees that limits sun exposure for solar PV installation. Aggressive energy demand reductions (beyond those required by Cal Green, which include plug-load controls, dimming lights, and PV ready structures) allow a relatively modest PV system of 367 kW to meet projections of 244 kW for NZE and even 257 kW for net positive energy, plus an additional 10% safety factor capacity. In terms of importance for reducing energy demand, the most important building design features are:

- A tight, well-insulated building envelope - The Spanish Mission style of the preserved heritage structure provides a common architectural theme of thick walls that allows for extra insulation in the administrative buildings and rammed earth walls in the library.

- Shade-providing roof overhang and appropriately sized and placed windows - Balanced daylighting reduces the need for artificial lights and provides a more pleasant occupant space. California already has adopted strict state standards that are pushing the industry in this area.
- Heat pump thermal control.
- Convective building ventilation - Operable windows and skylights are centrally controlled to allow warm air to escape and draw air through the building with very little energy. User controlled ceiling fans and windows allow for additional ventilation. Designed to match the elevation in the existing Town Hall building, the library has a raised floor with an underfloor air displacement ventilation system, which requires minimal airflow to control the ambient temperature. Not only does the system use less energy, but also produces a healthier and quieter environment.

An essential element for ongoing operations control and performance assessment is the building monitoring system, which monitors lighting, heating, cooling and ventilation. Panelboards can be deployed in customized zones that can adjust to occupant use and visible energy use dashboards serve an educational component.

The district SEM is a novel feature of the Atherton Civic Center design. Other police departments have installed SEMs, but Atherton is the first to deploy a SEM that not only supports emergency functioning, but also maintains civic center work functionality and library operations. Emergency back-up power will be supplied through a SEM that directs PV energy generation to battery storage that is recharged daily. Under good weather conditions, the SEM system can operate indefinitely and provide enough energy to maintain normal civic center activity. Under the worst weather condition scenarios, the SEM system will power servers and provide energy for critical police department and emergency operations for at least four days and partial library operation for one day. Diesel generator will be retained as a secondary back-up only for critical police department functions.

The deliberate integration of aesthetics, economics, and sustainability in the design of the Atherton civic center along with a process of engagement with elected officials, city staff, designers, builder, and the general public will culminate in a truly exemplary showcase of cutting edge advanced energy features that demonstrate feasibility from both a technological and financial perspective.

X. Tools to Accelerate Deployment of AECs

Tools that can be used to break down barriers to AEC deployment sits at the heart of PAEC Phase 1 project. The PAEC team considered the key challenges, best practices, key findings, and case studies when arriving at the tools that will be needed to accelerate to a clean energy future.

a. Economic tools

The cases and analyses presented in the PAEC reports use existing economic tools: budgets (annualized revenue and expenses), cost-effectiveness, and benefit-cost comparisons. The value of the analysis comes largely from assessing the data from a more holistic perspective to fully capture costs and benefits, incorporate policy goals and objectives, and examine scenarios.

i. Life-cycle cost approach

An integrated framework to account for the net savings of initial capital investment in AE features combined with lower ongoing operational and maintenance expenses demonstrates the economic rationale for the investment. The classic example of how making independent financial decisions regarding capital investment versus operating costs leads to suboptimal outcomes overall is the "split incentive" situation where the property owners makes decisions about capital investment and the tenant assumes the operational costs. Thus, the ownership structure disincentivizes the property owner to invest in improvement where benefits would accrue to the tenant, which is exactly the case for many AE upgrades. However, this structural disincentive exists in comparable situations when investment decisions are isolated from operational decisions, for example, across departments even within the same institution or with project budgets, where total expenditures are capped and competing priorities within the budget may sideline operational efficiency measures.

When the full life cycle costs of the project are considered and taken into account during the project design, the additional capital investment costs for AE measures increase overall costs by a small percentage and often the return on investment (ROI) is virtually immediate.

DNV GL performed benefit-cost analysis of potential model ordinances[21] and energy efficiency and fuel-switching measures.[22] For each potential policy, DNV GL researched the current industry and market to estimate the costs to install, operate, and maintain the various aspects of the policy, including equipment purchases, design, and permitting, when available and verifiable, as well as any applicable incentives and rebates. The analysis uses the following metrics to assess the possible financial benefits of the potential ordinances:

- Total energy savings,
- Annual cost savings or profit,
- Payback period in years, and
- Greenhouse gas reductions.

The economic analysis of eight energy efficiency and fuel switching measures examines the following model inputs -- upfront capital costs, available incentives, and operations and maintenance costs compared with baseline equipment – to formulate a profile of each

[21] Task 2.6: Benefit-Cost Analysis Report of Potential Ordinances.
[22] Task 3.14: Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures.

measure for the following five building types -- large office, large municipal, school, office, and retail -- according to a set of "self-funded" or “self-financed” economic metrics:

- Payback period in years,
- Internal rate of return (10 year and system life values),
- Levelized cost of energy (LCOE), and
- Revenues or savings over the system life, plus
- Annual energy consumption by end use.

The results of the economic analysis are based on predicted costs of technologies and energy over the next fifteen to twenty years.

A compelling conclusion of benefit-cost analysis is the number of measures with a payback period of less than a year:

- Phantom load reduction (smart strips and training in use)
- Insulated walls
- Ceiling fans
- High-efficiency windows
- Daylight responsive controls on dimmable LED lights
- Air heat pump technology
- Heat exchange (hot/chilled water loops)

However, even when the longer-term savings over operations and maintenance are well understood, budgetary constraints still may limit investment in the upfront capital investment when funds simply are not available to finance the expenditure, especially when competing priorities are vying for limited resources. This conflict is often visible at the municipal level, e.g., road maintenance and repair versus pedestrian/bike improvements (both related to transportation services) or “essential” city services versus “elective” sustainability measures.

ii. Non-monetary metrics

Even when a comprehensive benefit-cost analysis justifies the adoption of AE measures, the consideration of non-monetary factors increases the valuation. For example, in evaluating the benefits of potential model ordinances, DNV GL included co-benefits related to greenhouse gas emission reductions and community resilience based on input from policy makers and city staff:

- Minimum fossil fuel use
- Innovative technology or accelerated AE deployment
- Ease of regulatory implementation
- Ancillary community co-benefits (beyond energy use, cost, GHG)

In recommending particular ordinances to develop, DNV GL developed a scoring system[23] that combines the quantitative and qualitative results from Task 2.6. Each criteria was

[23] DNV GL, Task 2.14: AEC Regulatory and Permitting Recommendations.

weighted for importance and scored via a low, medium, and high scale (1-3 points), as detailed below:

- Indicators were weighted equally for the initial analysis (5).
- A negative or no payback was scored low (1), a short payback (<2 years) was scored high (3), and a high payback of (>2 years) was scored medium (2.).
- Annual greenhouse gas emissions of 1 – 4 MT CO2 was scored low (1), emissions of 5 – 15 MT CO2 was scored medium (2), and >15 MT CO2 was scored high (3).
- For fossil fuel use, innovation in technology or deployment, regulatory ease, and community benefits, scores were assigned based on a low (1), medium (2), and high (3)

Table 6: Summary of scoring of potential mandatory ordinances

Policy	Payback	Payback score	GHG Reduction Score	Fossil Fuel Use Score	Innova - tion Score	Regulatory Ease Score	Community Benefits Score	OVERALL SCORE
Weighting		5	5	5	5	5	5	
1-Electric Vehicle – Multi-Families	1.97	3	2	3	1	1	1	55
2-Electric Vehicles – New Commercial Buildings	5.69	2	3	3	3	1	2	70
3-Solar PV	7.01	2	2	1	2	3	2	60
4-Heat Pump-Multi-families (space heating)	No payback	1	1	3	3	1	1	50
4-Heat Pump-Multi-families (water heating)	No payback	1	1	3	3	1	1	50
5-Heat Pump-New Construction (space heating)	No payback	1	1	3	3	1	1	50
5-Heat Pump-New Construction (water heating)	No payback	1	1	3	3	1	1	50

6-Energy Efficiency – Multi-families	No payback	1	1	1	2	2	2	45
7-Energy Efficiency – Commercial buildings	No payback	1	2	1	2	2	2	50
8-Energy Efficiency – New Construction	15.88	2	1	1	1	2	2	45

Source: DNV GL, Task 2.14: AEC Regulatory and Permitting Recommendations

Qualitative factors, such as resilience, leadership, and education, have been an important part of the decision process for the Atherton Civic Center (see Sustainability Scorecard). In fact, one of the fundamental goals for PAEC is non-monetary and qualitative in nature -- prioritizing support for low-income communities and residents. Sustainability is often characterized by the three "E's": environment, economics, and equity. Although we can identify metrics to measure the level of equity in our communities, the value of pursuing equity as a policy goal is inherently qualitative.

iii. Scenario analysis

Sovereign Energy Storage produced two reports for PAEC regarding the value of energy storage; each assessment takes advantage of scenario analysis in different ways – user driven versus end-use driven.

Sovereign Energy Storage has developed an Excel-based financial model to analyze behind-the-meter energy storage,[24] which includes an integrated financial pro-forma to model the revenue and expenses for a both behind-the-meter energy storage and in-front-of-the-meter energy storage projects. Dynamic and interactive, the tool allows the user to change inputs in order to determine the financial performance of each unique project scenario. The user may save and compare an unlimited number of scenarios. The project has over fifty inputs which calculate the risk adjusted project internal rate of return (IRR) unlevered, levered, and after tax.

- Inputs - capital expenditures (equipment, permitting, and installation costs), operation and maintenance costs, and incentives (e.g., SGIP)
- Output - annualized revenue and expenses for the project, including depreciation schedule

In addition, the model output includes a summary of sources to finance the project (equity, debt, and incentives).

An important co-benefit to energy storage is its capacity to increase community resilience, especially when combined with a local PV energy supply. Sovereign Energy Storage reports

[24] Task 3.4 and 3.10: Summary of Financial Pro-Forma, Delineating the Cost of Capital, Tenor, Risk/Return Profile, and Value Streams for Behind the Meter Energy Storage.

on the cost-effectiveness of PV and energy storage across four scenarios to evaluate the robustness of the arrangement across policy objectives.

- Without resiliency criteria,
- Critical back-up load provided by energy storage,
- Critical back-up provided by diesel generators, and
- A hybrid scenario

The value of scenario analysis is that it affords the user a better understanding of how the particular analyses match individual needs.

b. Policy Tools

PAEC developed several policy tools for policymakers including streamlined permitting checklists, model ordinances, a model interconnection process checklist, and green lease language.

i. Streamlined permitting

In 2014, the California State Assembly passed bill 2188, the Expedited Solar Permitting Act. AB 2188 required California cities and counties to adopt an ordinance to create a streamlined, expedited permitting process for small residential rooftop solar energy systems by September 30, 2015. Key elements included electronic submittal with electronic signatures, and single inspections performed in a timely manner.

PAEC's Task 2.14 AEC Regulatory and Permitting Recommendations and Task 2.10 Policy Recommendations and Guidelines for Permitting Energy Storage provides a similar framework that jurisdictions should adopt to simplify the permitting process for other AEC components. For existing buildings, a streamlined process should be developed to expedite permitting for larger PV carport systems, energy storage, and electric vehicle charging infrastructure. Recommendations include:

- Developing a standardized list of required documents, and where possible, an over-the-counter or electronic approval process.
- Expediting permitting for PV carports that generate and/or have the capacity to store a certain percentage of the project's energy needs.
- Waiving permitting and plan check fees (up to a certain amount, if desired) for PV carports and energy storage systems.

Standardizing required documentation, timelines, inspections, and costs will accelerate deployment of AEC components which have already proven their safety and efficacy.

ii. Model ordinances

Model ordinances for cities and counties that encourage adoption of AEC measures will save jurisdictions time. Each jurisdiction should not have to start from scratch researching and writing their own ordinances about the same requirements. The PAEC Team has conducted the analysis and written model ordinances[25] for four projects:

- Electric vehicle chargers in multifamily buildings
- Electric vehicle fast chargers for new retail buildings
- Solar carports for new commercial buildings
- Energy efficiency measurement and verification for new commercial buildings

These four model ordinances can easily be used by other jurisdictions: simply insert details about your jurisdiction and submit for approval by the City Council or County Council.

iii. Model interconnection process checklist

After studying 209 interconnection applications to PG&E for commercial solar projects, the PAEC team developed the following model interconnection process checklist.[26]

a. Pre-Review
    i. Online Automation (Internal and External)
    ii. Hosting Capacity Maps
b. Fixed charge for eligible small Wholesale Distributed Generation (commercial solar) interconnection processes and avoiding developer requirements to pay for and then deed such upgrades
    i. Eligibility requirements
    ii. Proposed methodology for determining the fixed charge (modeled after the process used by NEM)
c. Pre-Application Report for larger WDG projects
d. Fast Track for larger WDG projects
    i. Screens
    ii. Initial Review
    iii. Supplemental Review
e. Detailed Study for larger WDG projects
f. Additional Requirements for larger WDG projects
    i. Interconnection Agreement
    ii. Insurance
    iii. Dispute Resolution
    iv. Utility Reporting
    v. Cost Certainty
        1. Unit Cost Guide
        2. Cost Envelope
        3. Cost Averaging
    vi. Miscellaneous

[25] DNV GL - Task 2.12 - Model Ordinances for San Mateo County.

[26] Clean Coalition - Task 4.2 – Best Practices: Interconnection for Local, Commercial-Scale, Renewable Energy Projects – Streamlining the Interconnection of Advanced Energy Communities to the Grid.

The expectations behind this checklist were that adoption of these recommendations by utilities would result in more transparency and certainty for the applicants around costs, timelines, and dispute resolution.

iv. Green lease language

A key tool that addresses the "split incentive" barrier and helps commercial buildings implement Zero Net Energy is a green lease. The split incentive happens when those responsible for paying energy bills (the tenant) are not the same entity as those making the capital investment decisions (the landlord or building owner).

Use a customized gross lease to address the split incentive issue
In a gross lease, the landlord/owner pays all the costs associated with operating the building. The tenant pays a fixed or variable rental charge. The gross lease allows the landlord/owner to lay out a shared savings offer with the tenant, while adding value to the property.

Adding value to the building
A building's value is affected by the net operating income of the building. In general, it's equal to income minus vacancy minus operating expenses. In a gross lease, when the landlord/owner retrofits the building for energy efficiency and adds PV, they reduce operating expenses (utilities). Sharing that operating cost reduction with the tenant can be leveraged to form an agreement on an allowable total energy use by the tenant, i.e., an energy budget. At the same time, the remaining cost reduction for the landlord/owner can increase the value of the property in the eyes of the bank. Buildings with large amounts of existing debt overhead are generally poor candidates for this type of arrangement or opportunity.

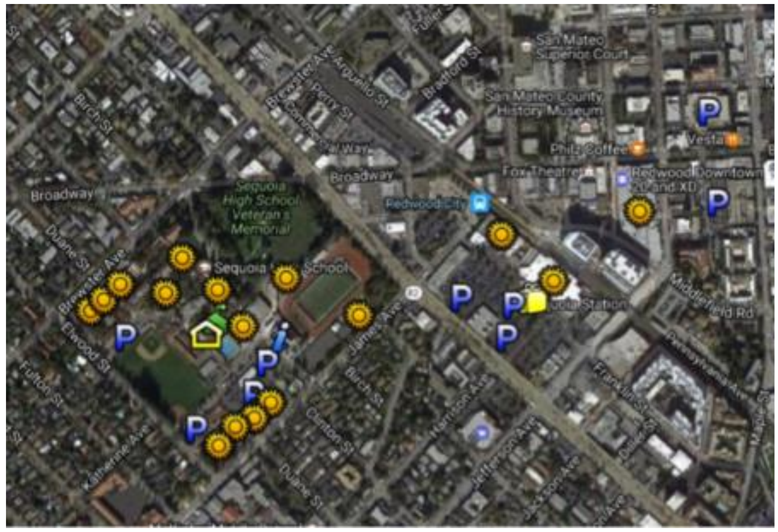
Usefulness of a Letter of Intent (LOI)
Another important tool is a Letter of Intent which can be used when a new tenant and landlord/owner relationship is forming, or when a landlord/owner desires to make capital improvements on their building with an existing tenant in the building. The LOI outlines the needs and intentions of both parties. LOI language should include: transparency (open book policy), how a baseline energy usage will be established, that the tenant and landlord will fully participate and commit to a set energy goal, use of a third-party contractor to collect and share data, and shared economic and environmental benefits.

A green lease is an invaluable tool to share costs and share benefits of upgrading commercial buildings and useful to accelerate the development of advanced energy communities.

c. Technical Tools

i. Solar Siting Survey

Figure 21: Close-up image of Solar Siting Survey map



Source: Clean Coalition

The PAEC Solar Siting Survey[27] evaluated thousands of potential locations — based on site characteristics, existing loads, and grid infrastructure — to identify those that are best suited for a solar PV installation of at least 100 kilowatts (kW). In total, this Solar Siting Survey identified over 65 megawatts (MW) of technical potential for commercial solar installations within the PAEC region.

Through our unique Solar Siting Survey methodology, we evaluate all prospective solar sites and then focus in on those sites that are most viable, given existing rooftop clutter, like piping and air conditioning units, as well as shading from trees and nearby buildings. While there are other online solar potential tools, the Solar Siting Survey approach provides far greater accuracy of technical siting potential and includes non-traditional structures for evaluation, including parking garages and surface lots.

The Clean Coalition's PAEC Solar Siting Survey includes a comprehensive spreadsheet and a sophisticated mapping tool to support utility staff, city officials, solar project developers, and other community stakeholders in pursuing these siting opportunities.

ii. Building Management Systems (BMS)

Another tool PAEC specifically designed for building owners and building managers is the report on BMS. For the 40% of commercial buildings that do not have a BMS in place to manage energy use, PAEC's report contains a detailed list of BMS products[28] building owners and building managers could consider.

XI. AEC Project Benefits

In order to meet California's bold energy and environmental goals, significant improvements are needed in the way the state generates, transmits, and uses energy.

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[27] Clean Coalition, Task 8 – Solar Siting Survey.
[28] Task 3.14 – Building Management System Benchmarking Study.

Basically, we need to increase the amount of power generated from local renewables and use energy more efficiently. The benefits of investing in these upgrades to our energy system will accrue to individual energy consumers and the community.[29]

a. General benefits for California

PAEC initiative has developed methodologies, data, programs, policies, and financing models that will accelerate the use of distributed energy resources to provide cleaner, more affordable, efficient, and reliable provision of energy services throughout California. By streamlining the processes to identify, permit, finance, build, and connect AEC projects, PAEC will drive down the costs of developing these resources. Unleashing clean local energy will yield the following benefits for California:

- Help the state meet clean energy policy goals.
- Enhance grid resilience and security – detailed project plans will be developed for at least one Solar Emergency Microgrid, which will set the stage to provide indefinite, renewable-based power backup to critical facilities in the PAEC region.
- Obviate the expense of new power plant construction.
- Help the state of California modernize the grid – Under Public Utilities Code 8360, the state seeks to modernize electrical transmission and distribution systems to maintain safe, reliable, efficient, and secure electrical service with infrastructure that can meet future growth in demand.
    - Deployment and integration of cost-effective advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal storage air-conditioning
- Increase the percentage of renewable energy per California's Renewable Portfolio Standard (R.11-05-005) and help meet requirements for the following regulations:
    - Energy Storage (R-15-03-011) roadmap jointly developed by CAISO, CEC, and CPUC
    - Smart Grid (R.08-12-009) guides the development of a smart grid system and facilitates integration of distributed generation, storage, demand-side technologies and electric vehicles
    - Customer Data Access Program (D.11-07-056, D.13-09-025) allows customers to authorize third parties to access their Smart Meter usage data
    - Distribution Resources Plans (R.14-08-013) identifies optimal locations for deployment of distributed resources
    - Rule 21 (R.11-09-011) regarding interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system
    - Net Energy Metering (R.14-07-002) which includes "specific alternatives designed for growth among residential customers in disadvantaged communities"
    - California Solar Initiative (R.12-11-005) with a goal of 3,000MW of distributed solar

[29] Clean Coalition, Task 11 – Evaluation of Project Benefits.

- Improve interconnection policies to accelerate adoption of distributed energy resources
- Create green jobs installing equipment and retrofitting systems

b. Specific benefits

At a local level, benefits that will accrue to energy consumers, the PAEC community, and ratepayers include the following.

i. Energy consumers

- Reduces costs of clean local energy – the tools, data and expected policy adoption will reduce the time, uncertainty, and other soft costs, associated with siting, financing, permitting and interconnecting, which will result in roughly 20% lower prices for clean local energy where these practices are employed.
- Commercial and residential building owners and tenants that implement energy efficiency measures will save money on their energy bill.
- Commercial and residential building owners and tenants that install on-site solar PV will essentially pre-pay their electricity bills for the next 25 years and hedge against future energy rate increases.

ii. PAEC community

The community in Southern San Mateo County will enjoy several benefits:

- Solar emergency microgrids will provide renewable-based backup power at critical facilities such as hospitals, municipal emergency response centers, and emergency shelters.
- Accelerated development of local solar generation –PAEC Solar Siting Survey identified 65MW of commercial solar potential in southern San Mateo County.
- Economic stimulation – Investment equal to 25MW of new PV deployment is estimated to generate $116 million in total added economic output and create $35 million in local wages from construction and installation.
- Environmental benefits – Each year, PAEC is projected to reduce greenhouse gas emissions by nearly 40 million pounds and save 7 million gallons of water.
- Avoided loss costs from outages, plus improved reliability – Medium and large facilities, small commercial enterprises, and residential customers (per 100) will be on track to save $83,600, $14,160, and $9,500 in avoided loss costs, respectively.

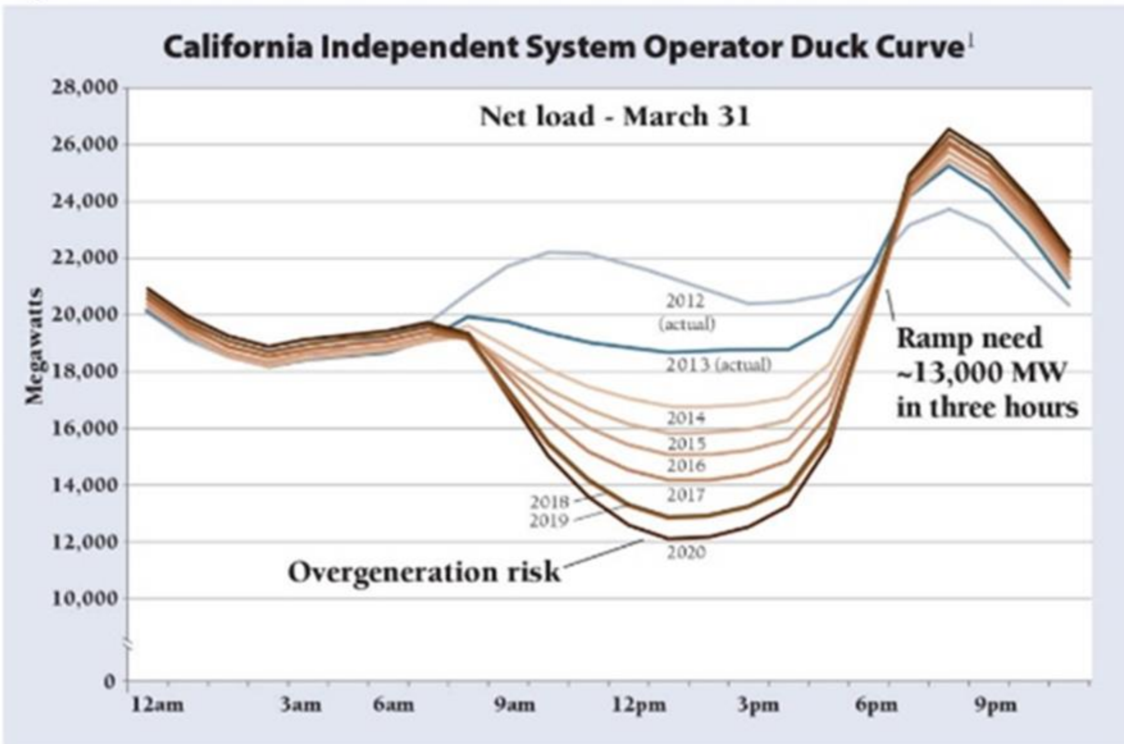
iii. Ratepayers

Finally, the ratepayers in California will realize the following benefits:

- Energy consumers will save $12 million in PG&E peak capacity costs, $6 million in avoided transmission losses, and $9 million in avoided transmission proportional capacity related costs.

- Energy storage bridges the gap, as in the "duck curve" seen below, between over generation by solar PV during peak sunlight hours and peak energy demand later in the evening.

Figure 22: CAISO duck curve



Source: CAISO

Altogether, investing in a clean energy future will cost money but the investment will yield numerous valuable financial and environmental benefits at the individual, organizational, community, state level, and beyond.

XII. Areas for Future Study

As the PAEC initiative moves into phase 2, many successful local policy and program advances have been identified and researched that will continue. However, several important areas remain for future study, particularly for the existing built environment with many decades of useful remaining life locking in inefficient and outdated energy technology. A concerted effort will be required to organize deep energy retrofits, manage the changing electrical loads across the grid, and finance these critical projects.

a. Economics

Funding and special financing tools are critical components necessary to enact the best policies to upgrade existing buildings. Numerous successful programs exist already; future study could focus on how to adapt and enact these programs locally.

AECs can create carbon mitigation funds can be created by: a new revenue stream, such as an increase in the Utility User Tax (UUT), a carbon fee on fossil energy (natural gas, propane and the fossil fueled portion of electric portfolios), a portion of development fees, an increase in permitting fees (rebated for AEC measures), or other potential municipal revenue sources. All of these revenue streams and examples of how they are designed are detailed in Task 2's Best Practices report, highlighting programs from Watsonville, Boulder, Palo Alto, and other cities.

Alternatively, such a fund could be administered by community choice energy (CCE) agencies, utilizing local program funding designated as part of revenue surpluses. These CCEs have significant programmatic infrastructure in the form of ample budgets and staffing to manage programs countywide. Whether these funds are administered by cities, counties or CCE energy agencies, they would support efficiency improvements, as well as building electrification (replacing natural gas), energy storage, new renewable energy technology, and accelerated EV deployment.

Financing AEC projects and building energy upgrades also could be accomplished through on-bill financing and PACE loans. PACE loans can play an important role for lease spaces where building owners may be reluctant to invest in energy upgrades. However, due to the relatively high interest rates of PACE loan, we encourage exploration of other financing options, in particular on-bill financing programs that minimize up-front investment and yield a net lower average utility bill. Successful programs also will allow homeowners to access the low or 0% interest rates that businesses and government agencies currently have access to. Specifically, a Pay As You Save program in California may be the most effective type of on-bill financing, since it addresses the split incentive problem for commercial and multi-family buildings.

Additional incentives will be needed to support building electrification because many contractors, designers, and property owners are unfamiliar with the benefits of new electric heating technology and retrofitting with this technology does not always save money due to the potential electrical capacity upgrades necessary for many old buildings. Proceeds from California's Cap & Trade program, tax incentives at the federal level, and local community choice energy agency funding can help finance incentives for electric replacements of natural gas heating and appliances.

b. Policy

City and county policies will become an important area to ensure that both new and existing buildings utilize the most efficient energy technology and design tools. This will require planning and building inspection staff to be trained to incorporate these items into permitting and inspection checklists. We recommend that regional entities such as BayREN continue supplying these resources and offering trainings.

i. Reach codes

Reach codes for Title 24 can allow local government to advance building energy efficiency ahead of schedule. However, the process can be extremely time consuming and costly to get CEC approval for each municipality's reach codes. For instance, the cities of Palo Alto and San Mateo have hired consultants to research, draft, and coordinate approvals for their reach codes, costing at least $100,000 and $50,000 respectively. As more cities consider reach codes, CEC could streamline the process such that each approval covers all cities in a climate zone with minimal application requirements for subsequent cities within that zone. The reach codes for upcoming Zero Net Energy standards will be important for the commercial sector, for which the ZNE requirements do not phase in statewide until 2030. Here, CEC could provide ZNE reach code pre-approvals for specific commercial building types, where modeling has proven them to be cost-effective.

ii. Deep energy retrofits

Because Title 24 code already requires extremely efficient standards for new buildings, the most promising area to advance in future work is to accelerate deep energy retrofits of existing buildings. In California, there are currently 9 million single family homes, 3.1 million multi-family dwellings, and 600,000 commercial buildings, the vast majority of which do not have AEC features or components. In our Best Practices report (Task 2) we detail some of the best deep energy retrofit programs in the nation. New York City's Retrofit Accelerator program stands out as a superior approach, offering free technical assistance to owners of buildings in low- and moderate-income neighborhoods and assisting with energy upgrades. Other programs that offer excellent models focusing on multi-family building upgrades first include programs in Florida, Chicago, Colorado, and Massachusetts.

As buildings become increasing all electric and provide electric charging to the vehicle fleet, much planning and investment will be required to balance an increasing load through demand management, load shifting, storage, and creative strategies to minimize peak energy use. This will require a significant investment in energy storage and potential policies requiring it for midsize and large renewable energy installations. Development of new software tools and wired appliances, chargers, water heaters and other types of thermal storage will also be required. Power to Gas (P2G) also may play a significant role as renewable power generation increases, which will require substantial research and development.

c. Technical

While there are many opportunities for areas of future study regarding technical advancements in advanced energy technologies, the concepts discussed below are easy and essential areas to explore further that could result in widespread Community Microgrids and AECs.

i. Exploring additional revenue streams for energy storage

Currently, the main revenue stream for energy storage is energy savings through demand charge management (DCM); however, not all sites that are good candidates for Community Microgrids can achieve substantial energy savings through demand charge management. For example, Hoover School has a relatively small load and demand; therefore, the DCM savings are marginal (8%) when the battery size is optimized for DCM. In order to provide site resilience through indefinite renewables-driven backup power, a larger battery size is necessary. However, there are no existing revenue streams in California IOU territories that allow an oversized battery (or battery sized for resilience) to be monetized. Specific concepts that could be researched and developed include: utilizing a portion of the battery for DCM while preserving the remainder of the battery for other operations; creating the ability for battery owners to be compensated for providing distribution grid services such as voltage regulation and frequency regulation that are currently only compensated in the CAISO market for the transmission grid; and enabling behind-the-meter batteries to be compensated for providing power to the grid during high demand times of the day.

ii. Exploring new utility rate structures or tariffs that allow site owners to allow virtual net metering to enable shared solar

A further extension of this concept that could be researched is developing new rates and tariffs to enable virtual microgrids in which all assets of the microgrid can be shared across multiple properties. Many of these development projects will require a deep technical understand of the energy storage technology and optimization algorithms as well as understanding of the development process for new utility rate structures.

iii. Integrated technology solution providers

A prevalent challenge during the development of PAEC was that there are very few technology solutions providers who are able to design and build comprehensive AECs and Community Microgrids. This poses a challenge to massive replication of the PAEC work. Customers, including city and county governments, are often interested in furthering their sustainability goals and investing in clean energy for their communities; however, they lack the expertise and staffing to design these projects. Often, they are seeking to interact with a single consultancy to do a feasibility assessment of a project, or to simply produce an RFP for an energy project. An area for future study could include developing programs to streamline AEC and Community Microgrid development to ensure large-scale replication. Some of the approaches could include creating a database of solutions providers for energy efficiency, energy storage, etc. Development of best practices for AEC design and education for developers, building owners and local governments could also spur large-scale adoption of AEC technologies.

XIII. Conclusion

PAEC initiative was designed to overcome existing barriers to clean energy projects in southern San Mateo County and establish a replicable model that can be used by other communities across California and beyond. Clean Coalition's PAEC initiative developed methodologies, data, programs, policies, and financing models that can accelerate use of distributed energy resources to provide cleaner, more affordable, efficient, and reliable provision of energy services.

The State of California provides a strong framework of policy goals and regulations that support the development of advanced energy communities. Goals for greenhouse gas reduction, standards for renewable portfolio development, and energy efficiency standards that strengthen every three years provide the scaffolding upon which future AECs will be built.

This Master Case Study highlights what we learned over the course of several dozen reports and studies about the economics, policy, and technical aspects of developing AECs. Clean Coalition studied best practices in San Mateo County, in communities in California, around the United States and in other countries; and wrote up case studies for AECs in the PAEC region. We identified over 65 MW of commercial solar potential in the southern portion of San Mateo County and pointed out the need to conduct deep energy retrofits in the commercial and residential sector buildings. PAEC also developed tools to accelerate the deployment of AECs including model ordinances, a model interconnection process checklist, green lease language, a solar siting survey tool, and an EVCI master plan that can be used by other jurisdictions. After all this work, we developed areas for future study based on questions that came out of the analyses and reports.

The basic issues that the PAEC initiative has sought to address are identifying and overcoming barriers to creating AECs. At this point, we do not lack for sophisticated, efficient technologies to build AECs. Equipment for energy efficiency retrofits, solar PV, heat pumps, electric vehicle charging, and energy storage is available for purchase and works well.

What holds us back are economic and policy barriers. In terms of economic barriers, lack of knowledge about relative paybacks of implementing various AEC components is part of the problem. A few PAEC reports analyzed which measures and components offered attractive paybacks. Knowing which projects could be net-present- value-positive helps building owners make informed decisions about future investments. Without analyses about ROIs, key decision makers often overestimate the costs and underestimate the benefits which often leads to inaction, especially in a split incentive situation.

The other major finding PAEC realized from several reports was that the regulatory permitting process at each utility and municipality has developed separately, which creates regionally inefficiencies for property owners and contractors to implement AE solutions; it is now time to streamline these permitting processes. The regulated community would appreciate transparency and certainty around permitting costs, timelines, reviews and documentation. Streamlining the permitting processes would drive down costs and speed up deployment of AEC components.

As a society we need to invest in upgrading our buildings and our energy system. The benefits of clean local energy including reduced costs, enhanced grid security, job creation, and a stable climate will accrue to building owners, the community, and future generations.

PAEC is excited to share what we have learned in southern San Mateo County. We hope the findings will be useful to other communities where they will hopefully be replicated and scaled across California and beyond.

XIV. Appendix - Supplemental Case Studies

a. Stanford University

As part of the objective to create pathways to cost-effective, clean local energy and community resilience, the PAEC initiative is developing case studies to highlight best practices for integrating advanced energy technologies in our local communities to serve as exemplars and templates for broader dissemination and penetration.

The Stanford case represents a truly cutting-edge project that considers total system energy needs and demonstrates what is technologically achievable at scale. The Stanford community of approximately 16,500 students, 2180 faculty, and 12,150 staff occupies over 1000 campus buildings (more than 15 million square feet) located across 8180 acres (60% is open space). Customized to the temperate climate of California, Stanford's solutions exemplify relevant, feasible, and cost-saving actions.

The information presented in this case study is summarized from information publicly available at the Sustainable Stanford website (http://sustainable.stanford.edu). Please refer to Sustainable Stanford for further information and the most recent updates.

i. A living laboratory for advanced energy features

In 2007, Stanford began a comprehensive assessment of its long term energy needs and environmental sustainability goals.[30] The result is a forward thinking plan addressing both energy demand and supply that has garnered Stanford numerous awards and international recognition as a pioneer in implementing large-scale district energy, which has been recommended by the International Energy Agency (IEA) and the United Nations Energy Program (UNEP) as a "best practice intervention to provide a local, affordable and low-carbon energy supply."

The key components of Stanford's plan are:

- Efficient and cost-effective energy supply through Stanford Energy System Innovation (SESI)
- Maximal installation of photovoltaic energy sources
- State-of-the-art demand management controls to optimize energy use
- Reduced energy demand through highly targeted retrofits of existing building and ambitious standards for new construction

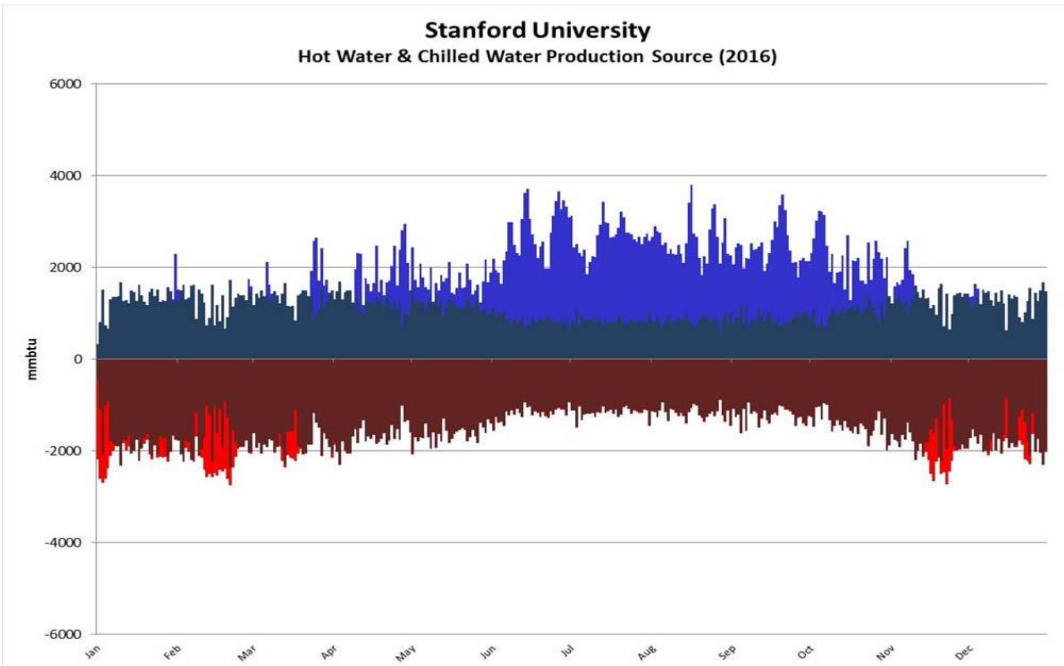
ii. Stanford Energy System Innovations (SESI)

The predominant feature of Stanford's energy management system is the Central Energy Facility (CEF), where a cutting-edge heat recovery system provides campus heating and cooling along with hot water through 22 miles of separate underground hot and cold water

[30] http://sustainable.stanford.edu/

pipes. The heat recovery process takes advantage of the 70% overlap in campus heating and cooling needs (see graph showing the simultaneous demand for heating and cooling) by transferring heat discharged from the water chilling process to generate hot water. The global energy saving potential for heat recovery is enormous, as the IEA[31] estimates that unrecovered waste heat accounts for 47% of energy consumed globally and 37% in developed countries.

Figure 23: Stanford Annual Heating & Cooling Profile



Source: Stanford University Energy and Climate Plan, 3rd Edition, rev. 9/2015

iii. SESI key facts

- Construction costs of $485 million combined with predicted energy cost savings of $420 million through 2050 (35 year life span) result in lowest life cycle costs of options considered.
- Hot and cold thermal storage tanks allow for economical time-of-use operation of equipment when utility energy rates are lowest.
- The process provides approximately 90% of total campus heating needs.
- Energy efficiency gains reduce CO2 emissions by 50% from Stanford's peak levels in 2011 of 198,300 metric tons of CO2.

[31] International Energy Agency https://www.iea.org/

iv. Photovoltaic energy supply

Since the conversion of the previously gas-fired co-generation plant (producing energy and steam heat) to the electrically powered CEF, Stanford has conscientiously expanded its solar power sources. Recent photovoltaic installations include 5 MW of on-site rooftop solar panels and 68 MW in the off-site Stanford Solar Generating Station. Combined on-site and off-site solar generation will meet more than 50% of Stanford's total electricity use. When the 25% renewable content of grid supplied electricity is taken into account, 65% of Stanford's total electricity usage is supplied through renewable sources.
The combination of heat recovery efficiencies through CEF with extensive solar power sourcing reduces Stanford's CO_2 emissions by 150,000 tons yearly, which is a 68% reduction from Stanford's peak levels in 2011.

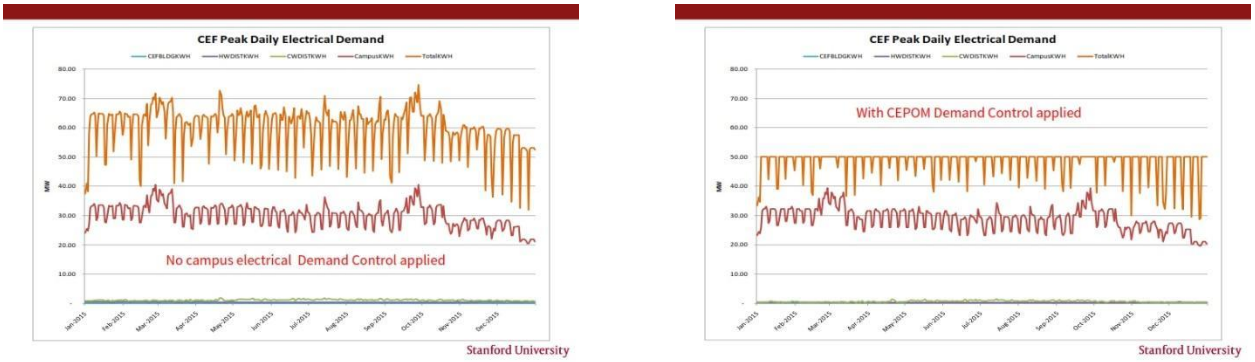
Figure 24: Stanford University campus solar rooftop installation map

Existing rooftop solar is marked red; additional sites identified for solar installation are marked green
Source: Sustainable Stanford (http://sustainable.stanford.edu/renewable-energy)

v. Monitoring systems and predictive control

To ensure optimal operation of the CEF, Stanford has developed a patented predictive control program, the Central Energy Plant Optimization Model (CEPOM), to produce an hourly dispatch plan (either advisory or automated) that is continuously updated every 15-minutes based on input from over 1000 variables, such as energy usage forecasts, pricing data, and weather predictions. As each of the three heat recovery chillers (HRC) consumes 10% of total campus electricity usage, the ability for CEPOM to regulate time-of-use energy demand by the HRC through thermal storing capacity in two cold and one hot water tanks further increases the efficiency of the CEF by 6%.

Figure 25: Sample comparison of energy usage with and without CEPOM



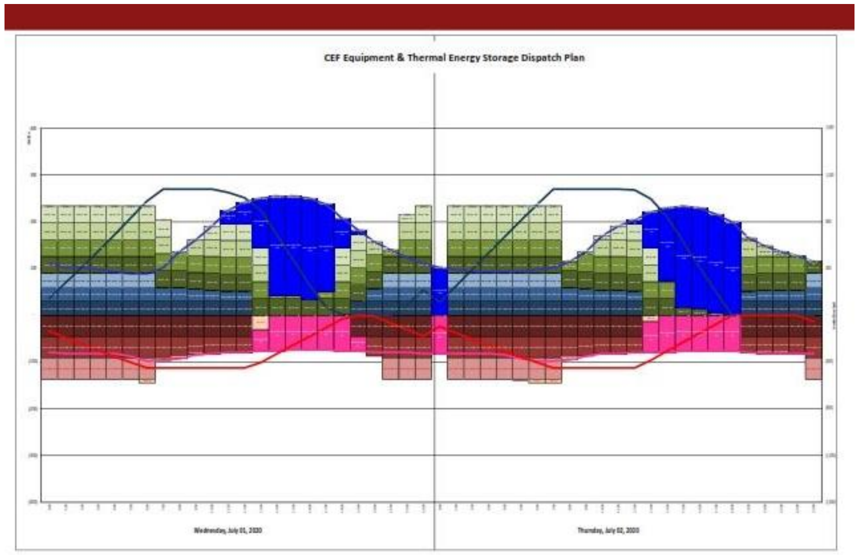
Source: Stanford Energy System Innovations Central Energy Plant Optimization Model, 17 January 2013

The graphs above show regulation of peak energy use with CEPOM optimization of CEF operations. The graph below shows how daily dispatch plans are evaluated on an hourly basis.

Figure 26: Central Energy Facility Control Room

Source: Stanford Sustainability Year in Review 2015-2016

Figure 27: Sample optimal CEF dispatch plan



Source: CEPOM

vi. Energy demand

Complementing the advances in efficient energy supply through the SESI project are the equally important and progressive efforts to reduce energy demand through aggressive building retrofit projects, stringent new construction standards, and identification of energy saving end-use controls.

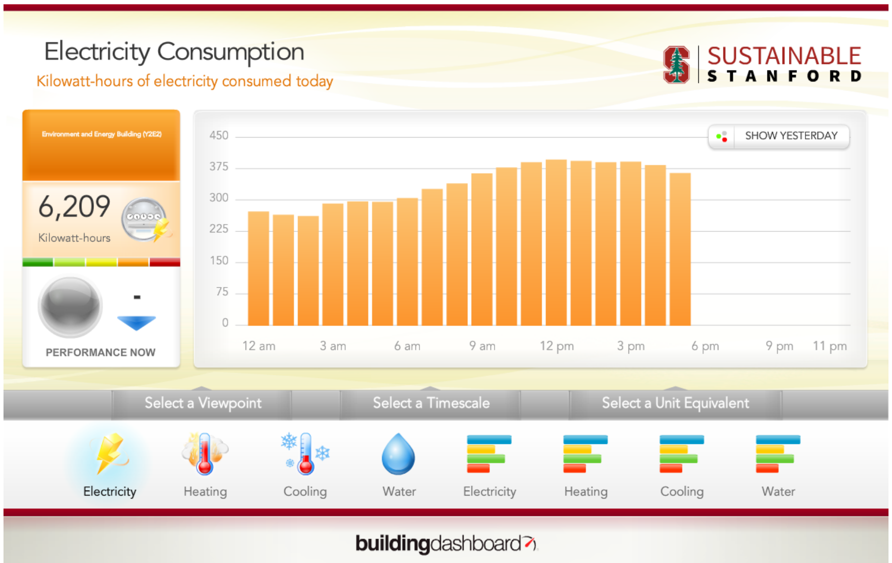
Since 1983, Stanford has metered energy usage at each building, which has been used to identify opportunities for energy efficiency gains in building use, operation, and construction. Even during a period of significant campus growth from 2000 to 2013, energy intensity (energy use per square foot) has decreased 6% and energy consumption has decreased 12%. For example,

- Consolidating computer servers and using energy efficient cooling technology saves the university approximately $1 million per year
- Behavior incentives have reduced electricity demand by 4% since 2004 and save $320,000 yearly
- A 2014 inventory of plug-load electricity use reveals that plug loads account for 22% of total campus electricity usage and cost $6.8 million per year. This data reveals target areas and programs to reduce plug-load electricity usage and increase energy cost savings.
- Based on life cycle cost analysis, new construction is designed to LEED gold standards

vii. Sustainability index

A unique tool for evaluating building performance is the Building Sustainability Rating System that provides real time data on energy and water consumption, which is used to identify areas for further improvements. For example, the figure below shows the hourly electricity use of the Yang and Yamazaki Energy and Environment (Y2E2) building, which has one of the university's highest internal sustainability ratings (78%) and is certified LEED-EBOM Platinum.

Figure 28: Stanford University's Electricity Consumption



Source: Sustainable Stanford

viii. Whole Building Retrofit Program (WBERP)

Saving Stanford more than $4.5 million per year, the Whole Building Retrofit Program (WBERP) focuses on upgrading the HVAC systems of the most-energy intensive buildings. The 14 projects completed by 2015 have a return on investment in less than seven years; 12 more planned projects are expected to save an additional $2.3 million annually. Table 7 shows the costs and benefits of four of the retrofit projects.

Table 7: Whole Building Energy Retrofit Program (WBERP) case studies

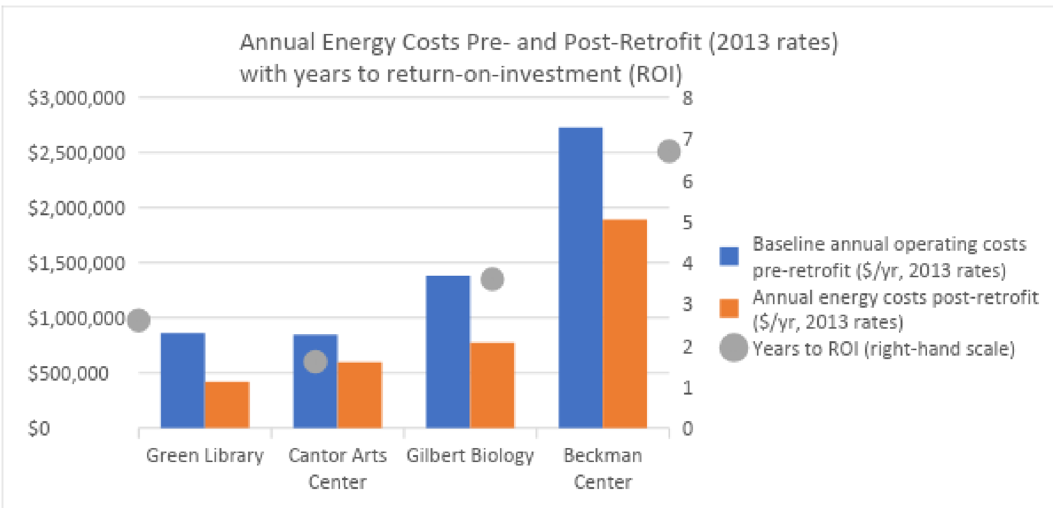
Building	Green Library (Bing Wing)	Cantor Arts Center Museum	Gilbert Biology (lab and office)	Beckman Center (lab and office)
Construction Date (earlier renovation date)	1919 (1999)	1891 (1999)	1987	1988
Retrofit Date	2011	2011	2010	2011
Gross Square Feet	188,762	122,509	103,787	178,303
Cost of Retrofit	$1,078,246	$524,257	$2,901,291	$6,200,000
PG&E Rebate	$181,518	$122,794	$709,808	$632,505
Years to return on investment (ROI)	2.6	1.6	3.6	6.7

Annual operating costs pre-retrofit ($/yr, 2013 rates)	$861,905	$846,681	$1,384,518	$2,724,084
Annual Savings (2012-13 rates)	$443,249	$250,581	$609,624	$833,765
Annual percentage energy cost savings	51%	30%	44%	31%
Annual energy costs post-retrofit ($/yr, 2013 rates)	$418,656	$596,100	$774,894	$1,890,319
CO2 reduction (tons per year)	1,390	1,933	2,443	2,605

Source: Stanford University

Figure 29 shows the return on investment for the same four projects.

Figure 29: Annual Energy Costs Pre- and Post-Retrofit



Source: This table and figure compile information from the cases available at: http://sustainable.stanford.edu/campus-action/energy/energy-initiatives.

ix. Continued innovation

Leveraging its status as a premier research university, Stanford has engaged in an iterative cycle of data feedback and innovation to push the frontiers of best practice energy solutions. For example,

- Exploration of the feasibility of ground source heat exchange to offset the energy demand by the CEF to meet the remaining campus heating and cooling needs.
- Electrification of the university vehicle fleet and installation of campus-wide electric vehicle charging infrastructure, including both Level II and DC fast-charging stations.
- Conversion of fuel emergency generation from diesel to natural gas.
- Development of the Integrated Controls and Analytics Program (iCAP) to maximize the efficiency of building operations.

- Support for ground-breaking sustainability research in 75% of all research departments and 19% of faculty and staff, such as the development of low-cost, fast-charging battery technology that smooths the gaps between solar energy supply and electricity demand.

Stanford stretches the limits of state-of-the-art technology by deliberating creating living laboratories that implement and test emerging technology, thereby serving as an example for global sustainability.

Figure 30: Stanford University Hybrid Shuttle

The university fleet contains 40% electric vehicles, including 23 electric and 5 diesel-electric hybrid buses.

Figure 31: Electric vehicle chargers at Stanford University

Operating through a private charging network, Stanford provides 80 EV charging stations across five sites. Prices are discounted during off-peak hours.

b. Jewish Community Center

The Oshman Family Jewish Community Center in Palo Alto exemplifies how new construction can take advantage of advanced design planning to implement sustainable energy features that realize cost savings over the operational lifetime of the building.

i. Local leader in PV and heat pump technology

The 8.5 acre Taube Koret Campus in Palo Alto, CA, is comprised of the Oshman Family Jewish Community Center (9 buildings containing meeting rooms, pool, fitness center, cultural arts hall, and day care center) and the Moldaw Family Residences (192 units for retirement living). Conscious of the potential to provide an environmental leadership model for residents and visitors, the JCC is proud of its LEED Silver certification and many sustainability features integrated into its design and operations since opening in 2009. The key advanced energy features of the OFJCC are:

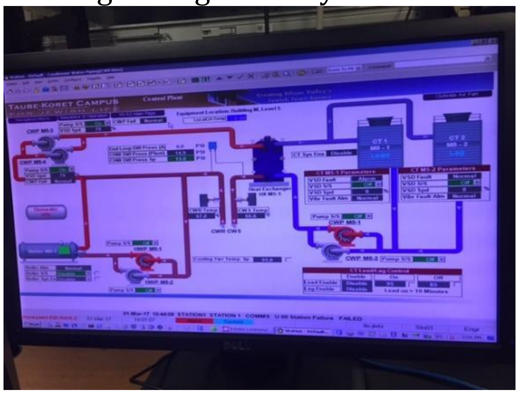
- 320 kW rooftop solar photovoltaic system (second largest in Palo Alto in 2014)
- Integrated occupancy sensors for lighting, heating and air conditioning save energy
- Building Management System monitors and optimizes energy use
- 4 electric vehicle charging stations (first 90 minutes are free)
- Water source heat pump provides energy efficient building heating and cooling

Figure 32: AEC Components at Oshman Family Jewish Community Center

Evaporative Cooling Tower

Rooftop Photovoltaic System

Building Management System Monitor



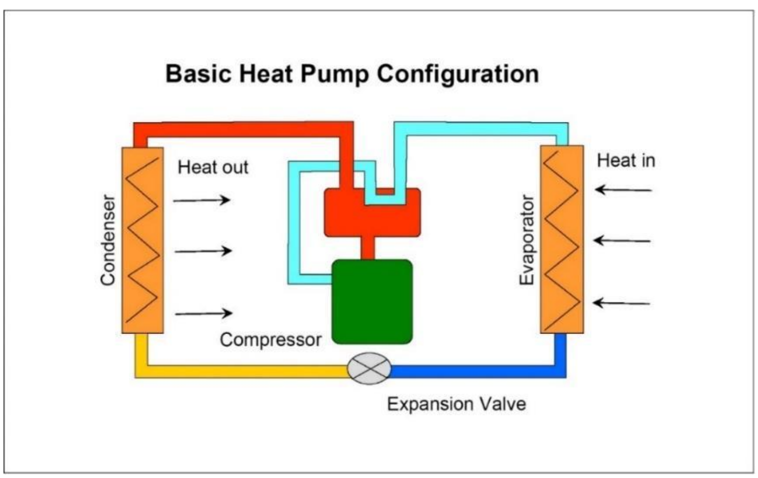
Parking Structure Electric Vehicle Charging

Source: Photos by Kristin Kuntz-Duriseti

ii. Water-source heat pump

Over 300 individual heat pumps provide heating and cooling throughout the campus to each building and residential unit, which reduces operating cost by 25% relative to traditional air conditioning units. Building ambient temperature is regulated by 55°F air flowing over recirculating water pipes maintained at 110°F. The water is pumped through two cooling towers that vent excess heat to the air to maintain water temperature between 70°F and 90°F. Pressurization raises the temperature of the water from the tanks to the temperature in the recirculating pipes. When the water temperature exceeds 90°F, sprayer arms increase the evaporative heat loss. At 95°F, modulating fans automatically adjust to promote further heat loss in order to maintain a consistent water temperature. During the winter months, when the water temperature drops below 65°F, natural gas boilers regulate the water temperature to provide necessary heating.

Figure 33: Basic Heat Pump Configuration



Source: https://web2.ph.utexas.edu/~coker2/index.files/engine.html

iii. More on the horizon

Looking ahead to further advances, the OFJCC is exploring:

- a pilot of a new operations management system
- expansion of the number of electric vehicle charging stations
- replacement of the diesel backup generators with a solar emergency microgrid using battery storage

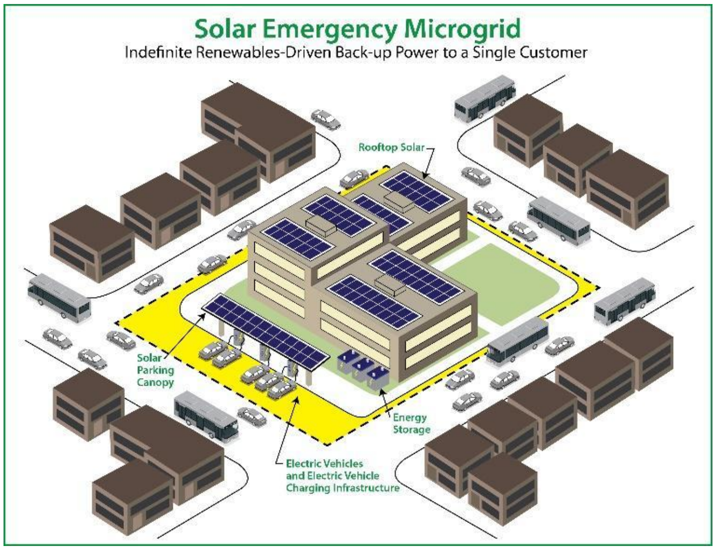
iv. Possible solar emergency microgrid

A solar emergency microgrid is a system that can provide indefinite renewables driven backup power to critical facility loads. The JCC is an ideal candidate for a solar emergency microgrid because it is a community gathering place that can provide basic services such as food, shelter and water during an emergency situation. Additionally, the campus houses at-risk individuals (elderly people) that will benefit from being sheltered in-place. The facility already has 320 kW of solar power which would act as the generation component; the next step would be to replace the existing diesel back-up generators with clean energy storage, typically a battery. This exchange would eliminate the significant expense of maintaining and operating the diesel generator and also improve health and safety by reducing local air pollution produced by the generator.

Figure 34: Existing diesel backup generator

Source: Kristin Kuntz-Duriseti

Figure 35: Solar emergency micro-grid alternative



Source: Clean Coalition

c. Kaiser Permanente

Kaiser Permanente is a large integrated health care system based in Oakland, CA. It believes climate change is a growing health issue and recognizes its obligation to address its own contributions to climate change. Kaiser Permanente exemplifies how full-cost assessment of capital investment and operational costs combined with aggressive procurement of solar power puts them on track to meet their goal to be carbon net positive (better than carbon neutral) by 2025 in a fiscally responsible manner.

i. Industry leader in ambitious solar installation

Founded in 1945, Kaiser Permanente has a long track record of environmental stewardship as a community health tenet. In the late 1970s, Kaiser Permanente installed self-engineered solar panels at the Redwood City Medical Center. It was one of the largest solar installations at a health care facility in the US at that time and contracted for a solar hot water demonstration project at its Santa Clara Medical Center, which heated 30% of the water used on-site and saved 935 million BTUs annually. This environmental innovation trend at Kaiser Permanente continues today.

Figure 36: Solar hot water demonstration installation in Santa Clara, 1980

Figure 37: 50-kW photovoltaic system at Modesto Medical Center, 2008

ii. Timeline of environmental stewardship

Since 2001, Kaiser Permanente's Environmental Stewardship Council has aligned the mission of the health care provider to protect and enhance both community and environmental health, with green building and energy conservation as key focus areas. The Green Building Committee, as part of its overall assessment of seismic retrofit upgrades, recognized the importance of evaluating total life cycle costs of capital investment and operational expenses, i.e., transitioning from "first-cost" to "full-cost" accounting.
In 2008, Kaiser Permanente opened the Modesto Medical Center, designed to be a high-performance energy efficient campus with a 50 kW solar installation.

Between 2010 and 2011, Kaiser Permanente completed its initial multi-site solar installations at 13 locations totaling more than 11 megawatts (MW), which generated 17 million kWh of energy in 2012. Altogether, the PV systems provided approximately 10% of on-site energy use and reduced greenhouse gas emissions by nearly 16,000 metric tons annually, which is equivalent to average annual greenhouse gas emissions of 1200 homes in the US. Kaiser Permanente continued to increase Kaiser Permanente's announcement of the Sustainable Energy Initiative in 2012 to reduce greenhouse gas emissions 30% from 2008 baseline levels by 2020 was quickly followed by a commitment in 2013 to achieve LEED Gold certification at a minimum for all new major projects. Standard practices include: energy efficient HVAC systems, photoelectric and motion sensors to dim and turn off lights, and replacing all halogen and incandescent light bulbs with LED lights. Experience with the first LEED Gold certified hospital in Oregon demonstrated that additional construction costs were minimal (~1%) when efficiency standards were included as integral to the design from the beginning; payback was virtually immediate in terms of energy savings.

In 2014, Kaiser Permanente expanded its solar program to seven sites in Hawaii and several sites in Colorado. The Hawaii projects will produce 3.2 million kWh/year, cutting energy use by 10% and saving $2-4 million over 20 years. The organization also installed the first electric vehicle charging stations in Vacaville and quickly followed with additional EV charging stations in San Francisco, Roseville, San Rafael, San Diego, and Pasadena. In partnership with NRG eVgo, who will operate and maintain the charging stations, Kaiser Permanente has installed almost 300 charging stations at 27 different locations in California and Hawaii.

Figure 38: Solar panels cover parking structure in Santa Clara

Figure 39: EV charging station in Vacaville, CA

By February 2015, Kaiser Permanente had executed agreements sufficient to procure enough renewable energy by 2017 to reduce greenhouse gas emissions by 30%; in other words, Kaiser Permanente would meet the obligations of its 2012 pledge three years early. These 20-year power purchase agreements (PPA) included:

153 MW with NextEra Energy Resources (a 110 MW solar site in Riverside County and 43 MW of wind power at the Altamont Wind Resource Area in Alameda County), and Approximately 75 MW of solar power with NRG Renew and Ameresco located directly on Kaiser Permanente sites in California on carport solar canopies in parking lots. Together, these two agreements provide 590 million kWh/year to meet 50% of energy needs at facilities in California, which is equivalent to the energy used by 82,000 homes. Given its tremendous success in meeting its 2012 pledge, Kaiser Permanente expanded its vision and announced its ambitious pledge of becoming carbon net positive by 2025.

iii. Transformative potential

As an industry environmental leader, Kaiser Permanente has demonstrated the transformative potential of environmental stewardship in the US health care industry to improve the health of our population and planet while cutting costs in a highly competitive business sector. Using twice as much energy on average as traditional office space, the healthcare industry is the second most energy-intensive building sector in the United States, spends $5.3 billion on energy every year, and accounts for 8% of total US greenhouse gas emissions. Kaiser Permanente is demonstrating that delivering cost effective care is compatible with environmental stewardship.

d. Palo Alto Bryant St. Garage EVCI - supporting electric vehicle adoption with groundbreaking charging solution

California leads the US in electric vehicle (EV) sales, and within California, nearly two-thirds of the top 30 cities with the highest EV adoption (ranging from 6 to 18%) are located in the greater Bay Area. Incentives, such as subsidies for EV purchases, access to HOV ("carpool") lanes, preferred parking, and expansion of EV charging infrastructure (EVCI), have been accelerating the electric vehicle market

i. Expanding the EV market share in Palo Alto

Palo Alto is a clear front runner in EV adoption. While new EV purchases account for a little more than 1% of new cars purchased in the US and nearly 5% in California, approximately 15% of new vehicle purchases in Palo Alto are EVs (a rate comparable to that in neighboring city, Menlo Park). Palo Alto has one of the highest per-capita EV ownership rates in the state with 2,500 residents owning a vehicle (roughly 1% of the state's total EVs), plus another 1,000 EV commuters. The City of Palo Alto has set a goal that 90% of new vehicles in 2030 will be EVs and has approved an "EV first" policy for new fleet purchases, which establishes an EV as the default fleet replacement vehicle.

To guide residents in purchasing an EV, identify local charging stations, and help navigate the process of permitting and installation procedures for charging infrastructure on their properties, the city hosts an informative website (www.cityofpaloalto.org/electricvehicle).

Figure 40: Navigating process to permit and install EV chargers in Palo Alto

Source: www.cityofpaloalto.org/electricvehicle

WattPlan provides a customizable report with consumer information for EV ownership regarding energy cost savings, available incentives, optimal electric rate plan recommendations, mapped range distances, and CO2 emission reductions, plus an option to include solar PV in the analysis.

Figure 41: Summary report from WattPlan for an EV purchase

Source: www.wattplan.com/ev/

ii. Innovation in EVCI expansion – carport solar PV powers EVCI

To encourage the expansion of EVCI, Palo Alto has pursued three strategies:

- Rebates of up to $30,000 for EV charging stations at schools, nonprofits, multifamily and mixed-use properties,
- Limited-time discounted rates for EV charging stations in residences and homes for residents and employees through the Bay Area SunShares program, and
- Expansion of the network of public EV charging stations in the city-owned garages.

Through a recent, innovation partnership with Komuna Energy and the City of Palo Alto Utilities, the number of charging stations in the city's public garages will increase from 40 to nearly 100. The large, flat, unobstructed surface of carports and parking garages are prime sites for rooftop solar PV, which turn these otherwise unused surfaces into productive canopies. Because the solar power generation capacity exceeds the on-site energy demand from the charging stations, net energy metering (NEM) is not a viable option. The unfortunate result is that much of the solar power generating potential is left untapped.

Palo Alto, which operates its own utilities, worked with Clean Coalition to structure a Feed-In-Tariff (FIT) solution that transcends this restriction by leveraging purchase power agreements (PPA) to allow sales of excess energy. In 2014, Palo Alto adopted a groundbreaking solar carport policy for public parking lots that includes energy storage and EV charging. In addition, the city issued a Request for Proposals (RFP) to lease the solar siting rights to install solar parking canopies on Palo Alto's city-owned parking structures. The ability to structure the RFP as a competition for leasing rights was facilitated by the City of Palo Alto Utilities' Feed-In Tariff (FIT) program, known as Palo Alto CLEAN. Komuna Energy was selected to build, own, and operate solar parking canopies on four public parking garages in Palo Alto.

In exchange, Komuna provides the following:

- Install 1.3 MW of solar PV (expected to generate nearly 1600 kW) as part of the city's goal to have 4% of its total electric energy consumption from local sources by 2023;
- Install 18 charging stations in three city owned parking lots in downtown Palo Alto (6 new chargers in each garage), plus
- Provide infrastructure in the electrical paneling to support 20 more charging stations in each of the four downtown parking lots (i.e., these sites will be "EV charger ready" to support another 80 charging stations total).

In addition, Palo Alto is taking advantage of a generous grant from Bay Area Air Quality Management District (BAAQMD) to complete the installation of half of these EV charger ready slots, i.e., 40 out of the 80 stations with the location to be determined by demand. This will double the number of charging station owned and operated by the city (from 40 to

80). Altogether, these efforts will bring the total number of charging ports in Palo Alto to nearly 100.

Figure 42: Opening Bryant St. Garage; Clean Coalition Executive Director, Craig Lewis

Source: Clean Energy News press release July 25, 2017

Figure 43: EV chargers in Bryant Street garage

Source: City of Palo Alto press release July 2017

To manage demand for charging, Palo Alto has implemented a nominal fee ($0.23/kWh) to use the charging stations. Drivers will receive a notification to a mobile device when the charging session is completed and will have a twenty minute grace period to move the charged vehicle, after which they will be charged $2 per hour while their fully charged car continues to be plugged into the charger. Parking garage limits will remain at three hours, and cars parked longer or parked in a space designated for EV charging without being connected to the charger are subject to a citation.

Figure 44: Electric vehicle chargers at City of Palo Alto

Source: www.cityofpaloalto.org/electricvehicle

e. Redwood City Corporate Yard

The Redwood City (RWC) Corporate Yard houses Redwood City Public Works and serves as a critical facility during grid outages in case of a natural disaster event. The RWC Corporate Yard provides services that maintain public infrastructure such as roads, stop lights and street lighting that are essential to a community and can be affected severely by a natural disaster. They also have on-site fuel storage to fuel city repair and maintenance vehicles and are an essential facility for disaster recovery. Additionally, they could benefit from utility bill savings. This Community Microgrid use case is for a public facility with a large electric load that provides critical services for a city, while the ownership model is representative of a government non-profit site project beneficiary with third party ownership.

Figure 45: Redwood City Corporate Yard overview map

Figure 45 above shows that the total solar siting opportunity for Redwood City Corporate Yard is 488 kW on rooftops and parking lots combined. In total there will be one solar carport array and five rooftop arrays. Note that not all of this solar PV is needed to off-set the facilities' annual energy use (net-metering paradigm) nor to power the critical loads indefinitely during a grid outage. Therefore, we have some flexibility during the schematic design phase to cost-engineer the deployments and select the systems to move forward based on lowest installation and lifetime costs. The figure above also shows an energy storage battery. The 360 kWh lithium-ion battery sited on the north end of the site adjacent to the meter main and main transformer. The siting location next to the meter main and switchgear is advantageous because it simplifies the electrical connection for the battery and reduces project cost by avoiding expensive trenching and additional conduit runs. The site is already equipped with critical load shedding capabilities. Because of challenges with limited parking, this site is not a candidate for new EVCI. There are however four existing charging ports in the public parking lot at the site.

The figures below demonstrate the steps taken to size the energy storage for this project. First the maximum and net-metered solar system design was developed using the PVWatts solar modeling tool. The grid-connected system design parameters were determined using Geli ESyst. ESyst is the leading tool on the market to quickly and easily determine a battery's energy and demand charge savings; however, the system is not able to model off-grid systems or systems for energy resilience. Next, the critical load profile for the facility was developed using an approximation algorithm that results in a load profile that is 20%-25% of the original load. Then the off-grid system design parameters are determined using HOMER Pro optimization tool. For this project, since the focus is energy resilience, the allowable capacity shortage (the amount of time the system is allowed to be off for) was set to zero percent. However, a variety of sensitivity cases, around the allowable capacity shortage and other parameters including PV system size were explored to ensure an optimized design. Finally, multiple iterations between on-grid systems in ESyst and off-grid systems in HOMER Pro were performed to find a system that maximizes energy bill savings and also allows backup for critical loads. The results are shown in Figure 46, Figure 47, and Figure 48.

Figure 46: Redwood City Corporate Yard Geli optimization results; PG&E E19S tariff and 150 kW solar

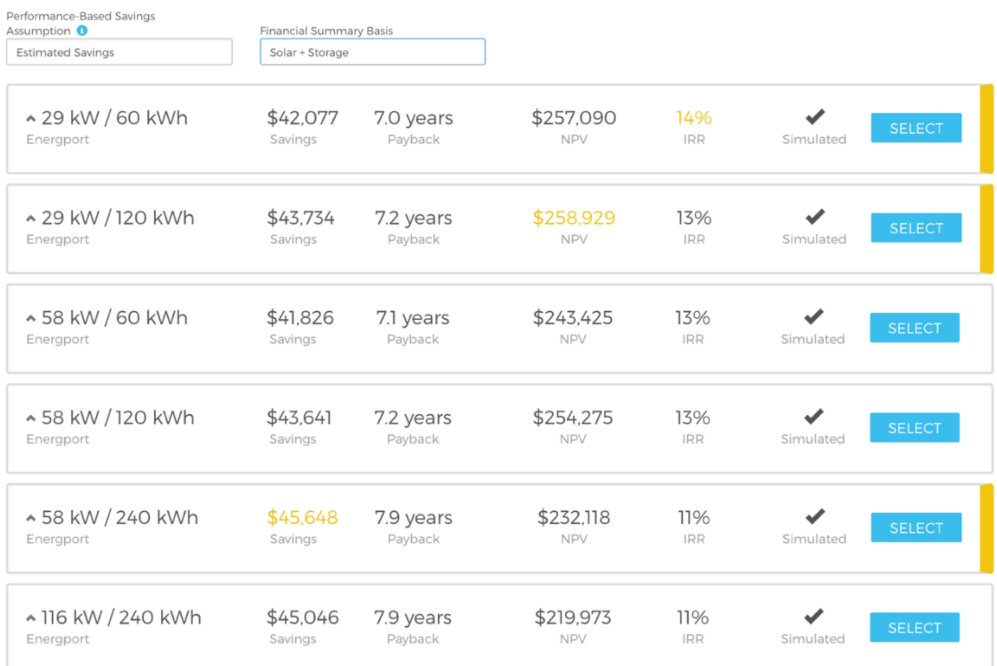
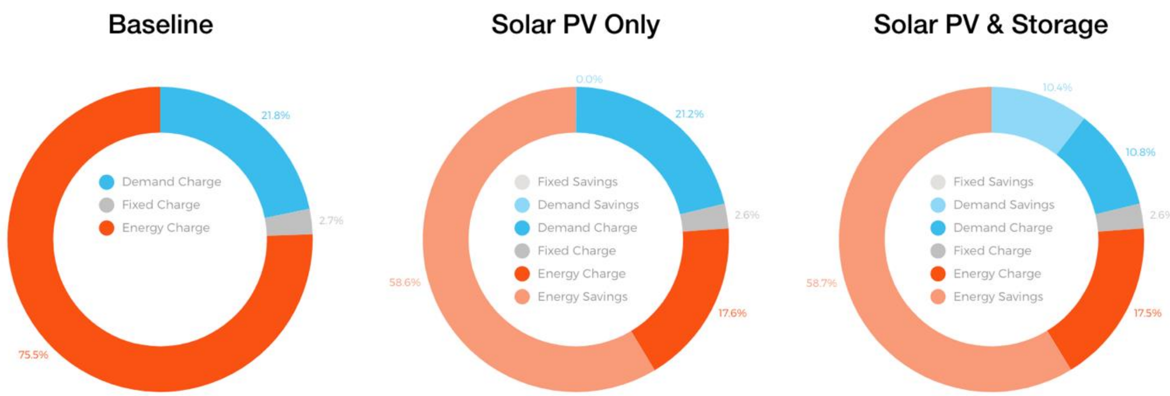


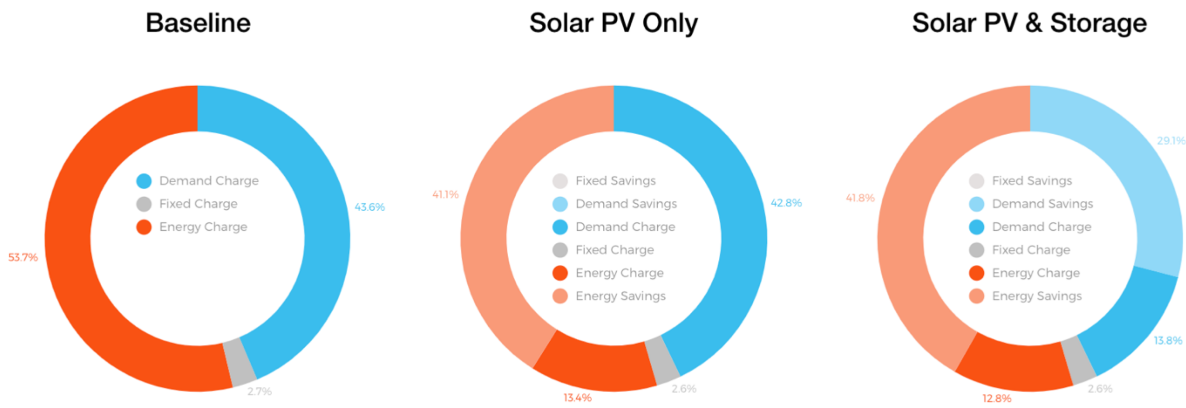
Figure 47: Redwood City Yard solar + storage savings plot modelled with PG&E's E19S tariff, 150 kW solar and 29 kW 60 kWh energy storage



Baseline		Solar PV Only		Solar PV & Storage	
Tariff:	E-19-TOU-NOPDP	Tariff:	E-19-TOU-NOPDP-NEM2	Tariff:	E-19-TOU-NOPDP-NEM2
Energy Charges:	$ 33,999	Energy Charges:	$ 8,664	Energy Charges:	$ 8,580
Demand Charges:	$ 27,605	Demand Charges:	$ 27,605	Demand Charges:	$ 12,096
Fixed Charges:	$ 1,679	Fixed Charges:	$ 1,679	Fixed Charges:	$ 1,679
Total Utility Bill:	$ 63,283	Total Utility Bill:	$ 37,948	Total Utility Bill:	$ 22,354
		Energy Savings:	$ 26,480	Energy Savings:	$ 26,568
		Demand Savings:	$ 0	Demand Savings:	$ 15,509
		Energy Assets:	$ 0	Energy Assets:	$ 15,509
		Tariff Switch:	$ 0	Tariff Switch:	$ 0
		Fixed Savings:	$ 0	Fixed Savings:	$ 0
		Total Savings:	$ 26,480	Total Savings:	$ 42,077
		Payback:	11.97 years	Payback:	6.96 years
		NPV:	$ 15,314	NPV:	$ 257,090
		IRR:	6.59 %	IRR:	13.51 %

This smaller energy storage system has a higher Net Present Value (NPV) of $257,090 but does not provide nearly enough storage for off-grid use.

Figure 48: Redwood City Yard solar + storage savings plot modelled with PG&E's E19S tariff, 150 kW solar and 58 kW 240 kWh energy storage



	Baseline	Solar PV Only	Solar PV & Storage
Tariff:	E-19-TOU-NOPDP	E-19-TOU-NOPDP-NEM2	E-19-TOU-NOPDP-NEM2
Energy Charges:	$ 33,999	$ 8,664	$ 8,238
Demand Charges:	$ 27,605	$ 27,605	$ 8,880
Fixed Charges:	$ 1,679	$ 1,679	$ 1,679
Total Utility Bill:	$ 63,283	$ 37,948	$ 18,797
Energy Savings:		$ 26,480	$ 26,923
Demand Savings:		$ 0	$ 18,725
Energy Assets:		$ 0	$ 18,725
Tariff Switch:		$ 0	$ 0
Fixed Savings:		$ 0	$ 0
Total Savings:		$ 26,480	$ 45,648
Payback:		11.97 years	7.88 years
NPV:		$ 15,314	$ 232,118
IRR:		6.59 %	11.41 %

This larger energy storage system has a lower Net Present Value (NPV) of $232,118 and provides more energy savings than the smaller system described above. It also provides closer to the necessary amount of storage for off-grid use.

Homer Pro recommends a 13 kW 361 kWh battery to meet 100% of the load in off-grid or grid-island mode. For that reason, we recommend a larger converter to match the Geli converter recommendation of 58 kW and the larger battery capacity recommended by Homer Pro. The EPC will need to select an off-the-shelf battery product from a vendor that that closely matches or exceeds the sizing indicated here.

f. Facebook – Sustainability leader – locally, nationally, and internationally

Headquartered along the San Francisco Bay in Menlo Park, Facebook already exemplifies the ethos of an advanced energy community with a strong commitment to green building design, clean energy, resource conservation, and transportation alternatives. [1]

Menlo Park campus
Since moving to Menlo Park in 2011, Facebook has emerged as a local sustainability leader. Notable features of the Menlo Park campus include:

Buildings

- All renovations and new construction projects are certified LEED Gold or Platinum, in part, by utilizing energy efficient equipment, lighting controls, and building energy management systems (BEMS) to optimize heating, ventilation, and air conditioning.
- The nine-acre rooftop garden not only has transformed a toxic brownfield site into a bird sanctuary, but also reduces runoff and provides building insulation in both winter and summer, which reduces energy demand for heating and cooling.

Figure 49: Facebook Green Roof

Source: Photo by Kristin Kuntz-Duriseti

Renewable energy

- With a combined 2.2 megawatts of photovoltaics installed, Facebook has the largest solar rooftop in the community.
- In 2017, Facebook subscribed to the Peninsula Clean Energy (PCE) ECO100 option to ensure 100% renewable energy for the remainder of its energy usage.

[1] The information presented in this profile is drawn from https://sustainability.fb.com/.

- In addition, Facebook partnered with Menlo Spark (a PAEC collaborator) and Grid Alternative to sponsor solar installations on homes in the local Belle Haven community.

Figure 50: Grid Alternatives

Source: Photo by Diane Bailey

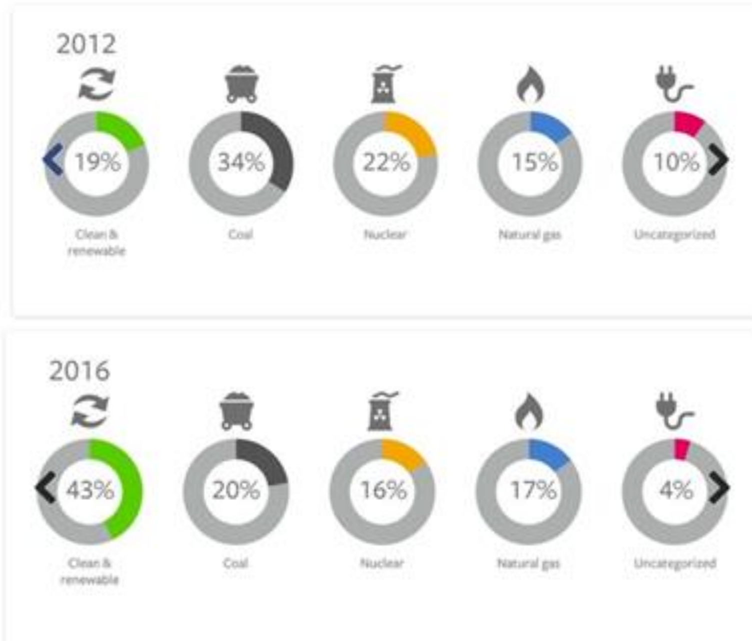
Transportation
Nearly 50% of Facebook employees commute to work using alternate transportation. To encourage a lower transportation carbon footprint, Facebook provides the following amenities:

- Electric vehicles perks
  - Free charging at charging stations in the Facebook garage
  - Valet parking to rotate cars into charging stations
- Biking services
  - Secure, indoor parking
  - On-site bike shop
  - Showers, towels, lockers, and laundry service
- Employee shuttles
- Ride sharing and carpooling resources
- Transit passes

Data Centers
Despite the significant achievements in reducing energy consumption and advancing renewable energy at its headquarters, the campus energy demand comprises only 4% of Facebook's total energy consumption; the company's data centers account for 96% of total electricity consumption.

Energy Efficiency
In 2009, Facebook began designing its own data centers with a commitment to maximize efficiency. After rethinking and reengineering everything from servers to cooling systems, Facebook constructed its first new data center in Oregon that cost 24% *less* to build and operate; yet, is 38% more energy efficient and uses 50% less water than a traditional data center.

Figure 51: Facebook's Key Sustainability Indicators



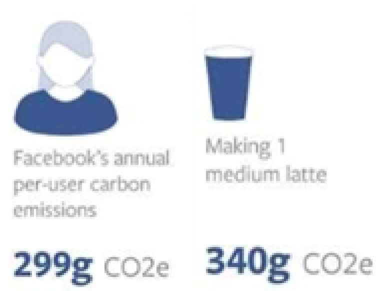
Renewable Energy

Between 2012 and 2016, Facebook increased the percentage of renewable energy from 19% to 43% of its company-wide energy portfolio, which nearly meets Facebook's goal of 50% renewable energy by 2018. Access to cost-effective, renewable energy is one of the primary factors in selecting data center locations. 100% renewable energy powers the newest data centers in Sweden, Iowa, and Texas, as well as data centers under construction in Denmark, Ireland, New Mexico, and Nebraska.

Additionality

More than merely procuring renewable energy, Facebook wants grow the market for clean energy. According to Sustainability Director, Bill Weihl, "One of the key principles we try to adhere to is 'additionality,' which means that our purchase of clean energy results in additional clean energy being added to the grid," such as increasing the mix of renewable energy in the utility's energy portfolio and contracting power purchase agreements (PPA) that drive the supply of renewable energy.

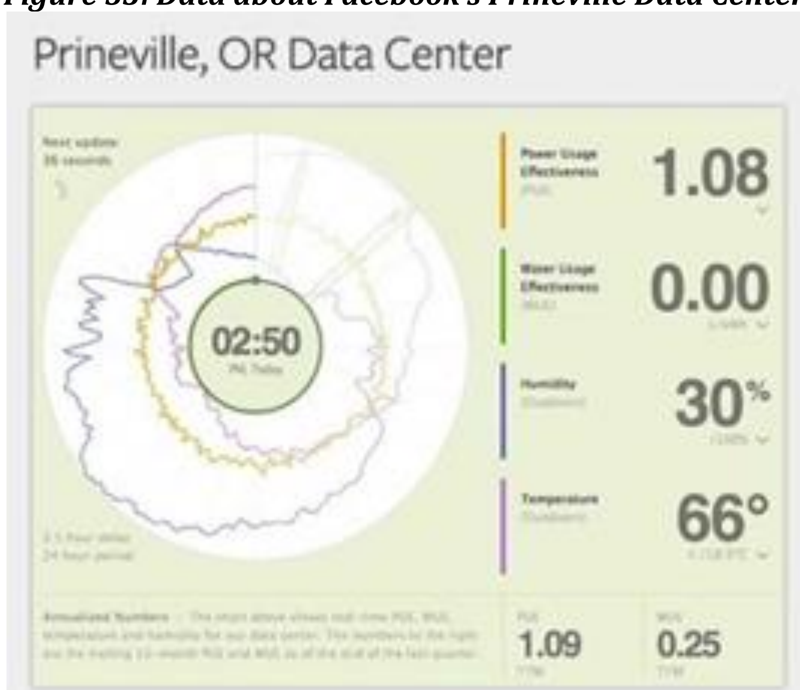
Figure 52: Facebook's Per User Carbon Emissions



Carbon footprint
Through energy efficiency measures and renewable energy procurement, Facebook saved enough electricity in 2016 to power nearly 127,000 homes for a year and reduced greenhouse gas emissions equivalent to taking nearly 136,000 passenger cars off the road for a year. Enjoying a medium latte has a larger carbon footprint than the annual carbon emissions of a Facebook user.

Energy-Water Nexus
A particularly trail-blazing initiative from Facebook is its concerted efforts to reduced water usage, especially in planning for grey water use at the newest building on the Menlo Park campus. In addition to installing water-saving fixtures and landscaping with native and drought-tolerant plants, Facebook has designed its data centers to use 50% less water than a typical data center. Most data centers use a significant amount of water as part of the cooling system. Instead, Facebook's data centers draw fresh air from the outside and water evaporation, only when needed. Since nearly a fifth of all the power generated in California goes into water-related uses, from transporting and treating water to end-use purposes, water conservation is inextricably linked to increasing energy efficiency.

Figure 53: Data about Facebook's Prineville Data Center



"Innovating, then sharing"
A hallmark of Facebook culture is fostering innovation through sharing and collaboration – principles that Facebook has applied to advance sustainable practices globally. In 2011, Facebook founded the Open Compute Project whose mission is to foster openness, innovation, and a greater focus on energy efficiency in computing technologies. For

example, Facebook has shared its code for data center dashboards that track energy and water use.

XV. List of PAEC Technical Product Deliverables and Technology/Knowledge Transfer Product Deliverables Submissions to the CEC

The following is a list of PAEC technical reports (draft and finals) and technical work products produced for the projects.

Additionally, under the projects Task 12, Technology/Knowledge Transfer below is a list of media communications materials (blogs, press release), and presentations submitted to the CEC (other collateral materials also submitted to the CEC: i.e.: workshop summary, registration and attendee lists, flyers).

Technical Reports:
Task 2.2 - Best Practices report (Menlo Spark)

Task 2.4 - Gap Analysis (Menlo Spark)

Task 2.6 – Benefit-Cost Analysis Report of Potential Ordinances (DNV GL)

Task 2.8 - Interview with Public Agencies, Installers, and Vendors (Sovereign Energy)

Task 2.10 - Policy Recommendations & Guidelines for Permitting Sovereign Energy Storage

Task 2.12 - Model Ordinances for San Mateo County (DNV GL)

Task 2.14 - AEC Regulatory and Permitting Recommendations (DNV GL)

Task 3.2 – Lending, Customer Compensation, and Government Incentive Report: Strategies and Incentives Available to Advanced Energy Communities in and Around San Mateo County, California (High Noon Advisors)

Task 3.4 + 3.10 - Summary of Financial Pro-Forma Delineating the Cost of Capital, Tenor, Risk/Return Profile, and Value Streams for Behind the Meter Energy Storage (Sovereign Energy Storage)

Task 3.6 - Dispatch Model for Energy Storage System (Sovereign Energy Storage)

Task 3.8 – List of Model Assumptions for Multifamily (DNV GL)
Task 3.8 – List of Model Assumptions for Municipal Building (Fire Station) (DNV GL)
Task 3.8 – List of Model Assumptions for Residential Office Building (DNV GL)
Task 3.8 – List of Model Assumptions for Residential Office Building (DNV GL)

Task 3.8 – List of Model Assumptions for School (DNV GL)

Task 3.12 - Successful Energy Storage Financing Program (Sovereign Energy Storage)

Task 3.14 – Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures: Prototypical Residential Multifamily Building (DNV GL)
Task 3.14 – Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures: Prototypical Municipal Building (Fire Station) (DNV GL)
Task 3.14 – Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures: Prototypical Office Building (DNV GL)
Task 3.14 – Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures: Prototypical Retail Building (DNV GL)
Task 3.14 – Economic Benefit-Cost Analysis of Energy Efficiency and Fuel Switching Measures: Prototypical School Building (DNV GL)

Task 3.16 - Economic Benefit-Cost Analysis of Electric Vehicle Charging Infrastructure (Sven Thesen & Associates)

Task 3.18 - Energy Tracking/Benchmarking Tool Report – Building Energy Management Systems: An Advanced Energy Solution for Commercial Buildings (Office of Sustainability, County of San Mateo)

Task 3.I - Report Summarizing Literature Review & ISO/RTO Tariff Analysis (Sovereign Energy Storage)

Task 3.II - Backup Power Valuation Methodology (Sovereign Energy Storage)

Task 4.2 – Best Practices: Interconnection for Local, Commercial-Scale, Renewable Energy Projects – Streamlining the Interconnection of Advanced Energy Communities to the Grid (Clean Coalition)

Task 4.4 – Design of Pilot for Testing Streamlined Interconnection Procedures (Clean Coalition)

Task 5.2 – Solar Emergency Microgrid Site Design and Deployment Plan (Clean Coalition)

Task 6.1 – Potential Locations for the Electric Vehicle Charging Infrastructure Master Plan (Sven Thesen & Associates)

Task 6.3 – Electric Vehicle Charging Infrastructure Master Plan (Sven Thesen & Associates)

Task 7.2 – Scorecard of Sustainability Features (Town of Atherton and WRNS Studio)

Task 7.4 – Technical and Economic Feasibility of Sustainability Features for the Atherton Civic Center Report (Town of Atherton and WRNS Studio)

Task 8 – Solar Siting Survey (Clean Coalition)

Task 10 – PAEC Community Master Plan (Clean Coalition)

Task 10.III. – PAEC Outreach Plan (DNV GL)

Task 10VIII. RICAPS May 23, 2017 PAEC Overview Workshop (collateral material; DNV GL)

Task 11 – Evaluation of Project Benefits (Clean Coalition)

Task 12 – Technology/Knowledge Transfer (Clean Coalition):

Task 12.2 – Initial Fact Sheet (Clean Coalition)
Task 12.3 – Final Project Fact Sheet (Clean Coalition)

Blogs:
Blog #1 - Peninsula Advanced Energy Community launches, will provide framework for the future of clean energy
Blog #2 - Palo Alto is aiming high by going low carbon
Blog #3 (Task 2) - The reality of implementing 100% clean local energy
Blog #4 - Solar Siting Survey SMC
Blog #5 - Palo Alto Jewish Community Center: Heating and cooling in newer, cleaner ways
Blog #6 - Town of Atherton Civic Center: A pathway to zero net energy
Blog #7 – Shaping electric vehicle charging infrastructure in Palo Alto
Blog #8 - Best Practices encouraging clean local energy deployment in California
Blog #9 – Connecting renewables to the grid faster…. much faster
Blog #10 - Collaborating and innovating to expand clean local energy in San Mateo County
Blog #11 - No heat molecule left behind: Stanford's district-level heat recovery system
Blog #12 - What Puerto Rico teaches us about power resilience for all communities
Blog #13 - Building owners may be losing money by not investing in energy efficiency
Blog #14 - Model ordinances: Showing the way to a clean energy future
Blog #15 - Energy storage is about to take off
Blog #16 - Keeping the lights on after natural disasters; Solar Emergency Microgrid
Blog #17 - Splitting up with split incentives
Blog #18 - Supercharging Electric Vehicle Charging Infrastructure

Press Releases:
Solar Siting Survey
Solutions for connecting local renewable energy to the grid more quickly

Presentations:
PAEC Overview (RICAPS workshop: Clean Coalition, DNV GL)
Community Microgrid Saving and Resilience for Local Government (Clean Coalition)
Community Microgrids: The Path to Resilience & Sustainability (Clean Coalition)

Distributed Resources Planning: Laying the foundation for a modern grid (Clean Coalition)
Green Lease Language Round Table: Landlord and Tenant Collaboration for an Advanced Energy Future (San Mateo County, Office of Sustainability)
PAEC Integrated Capacity Analysis (RICAPS workshop: Clean Coalition)
PAEC Solar Emergency Microgrid (SEM) (RICAPS workshop: Clean Coalition)
PAEC Best Practices, GAP Analysis and Benefits-Cost Analysis (RICAPS workshop: Menlo Spark and DNV GL)
PAEC Solar Siting Survey (RICAPS workshop: Clean Coalition)
PAEC Project Updates (RICAPS working group: San Mateo County, Office of Sustainability)
PAEC Battery Storage & the Grid, Integrated Capacity Analysis (RICAPS Multi-City Group, Clean Coalition)
PAEC Update on Policy Analysis (RICAPS Multi-City Group, DNV GL)
PAEC Streamlining Interconnection: How PG&E Pilot Will Impact Local Deployment of Solar and Energy Storage (RICAPS Multi-City Group, Clean Coalition)
PAEC Solar Siting Survey Results: Opportunities for Larger Installations (RICAPS Multi-City Group, Clean Coalition)
PAEC EVCI Master Plan (RICAPS Multi-City Group, Sven Thesen & Associates)