Palo Alto Action Impact Memo

Revised June 7, 2021

Introduction

Palo Alto's 2021 Sustainability and Climate Action Plan (S/CAP) sets an ambitious greenhouse gas (GHG) reduction goal to reduce emissions 80% below the City's 1990 levels by 2030 (the "80x30" goal). AECOM helped the City to evaluate a draft list of key actions to understand the potential for GHG reduction target achievement from local actions only, and to evaluate other community benefits from action implementation (e.g., air quality, public health).

The City and AECOM collaborated on modeling key action impact results within three categories of GHG reduction actions: Energy, Mobility, and Electric Vehicles. AECOM and Utility Department staff collaborated on developing a customized Building action calculator to estimate emissions reductions from various policies to support the electrification of residential and nonresidential buildings; input assumptions to the calculator are based on utility consumption data and other locally applicable data. The City team led development of the Mobility action calculator to understand how different actions could reduce vehicle miles traveled within the community, and the AECOM team provided a strategic review of the calculator's methodology and assumptions to guide revisions. Finally, the City hired a separate consultant to develop an electric vehicle (EV) calculator to model uptake of EV technology resulting from a suite of S/CAP actions. AECOM reviewed the EV calculator results with the City's consultant to identify revisions and methods to align the results of all three modeling approaches in support of this comprehensive action analysis.

The three modeling efforts show that a package of S/CAP actions can reduce emissions to 71% below 1990 levels by 2030, nearly achieving the City's ambitious GHG target through local actions alone. The results help to highlight action areas that will need further analysis or implementation support to fully achieve the City' GHG target through local actions, or can be reviewed to understand the amount of external action needed to demonstrate target achievement (e.g., carbon offset purchases and strategic land use changes).

The S/CAP's other key action categories are Water, Climate Adaptation and Sea Level Rise, Natural Environment, and Zero Waste, and are not primary sources of GHG reductions but do provide additional sustainability benefits to the community. These actions were evaluated to understand their potential community co-benefits and are discussed further in the Sustainability Actions section and in the Palo Alto Action Evaluation Memo from February 2021.

This memo presents details on the action impact analysis process, including descriptions of the emissions forecasts, key action analysis results, modeling approach, and detailed action results. It concludes with recommendations for next steps and an appendix listing the titles and descriptions for the key actions modeled in this impact analysis.

Emissions Forecasts

The action impact analysis is based on an estimate of how the City's emissions could change within the S/CAP analysis period. As part of this effort, AECOM developed a "business-as-usual" (BAU) emissions forecast to estimate how emissions could change over time if no further climate action was taken. This scenario estimated local emissions change through 2040 if no further climate action is taken at the federal, state, or local levels; it assumes implementation levels of current policies and programs as of 2019 would remain constant into the future (i.e., climate policies and programs would be maintained but not enhanced in scope beyond 2019 implementation levels). This BAU forecast scenario shows that emissions would decrease 47% below 1990 levels by 2030. This scenario analysis helps to demonstrate the amount of additional GHG reductions needed by 2030 from local S/CAP actions to achieve the City's GHG target.

However, as part of the action analysis, the City hired a separate consultant to evaluate the potential impact and costs associated with key EV actions. During that analysis, EV adoption estimates were further revised to improve upon the initial BAU scenario to better reflect Palo Alto's local EV adoption rates more accurately. The BAU forecasts were based on EV uptake estimates from the California Air Resources Board's EMFAC tool[1], which were based on 2015-17 survey data and provided at the county level. The City's EV consultant developed a revised BAU scenario with data showing there would be even greater EV travel in Palo Alto than estimated in the BAU scenario. The results of the revised BAU scenario show a 51% decrease below 1990 levels by 2030. This improvement upon the initial BAU scenario further refined the estimate of local GHG reductions needed from key S/CAP actions and helped to improve EV modeling result outputs to better align with Palo Alto-specific trends in EV adoption.[2]

Key Action Analysis Results

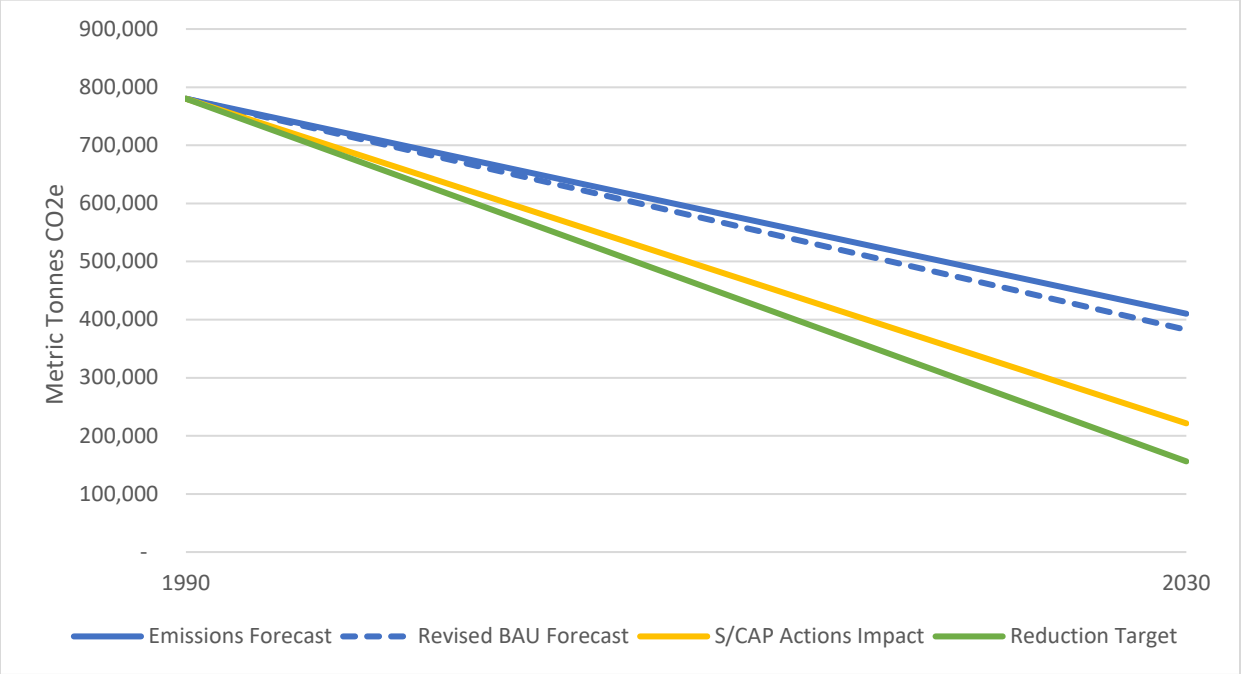
After developing the forecasts and quantifying the emissions reduction gap between the forecasts and the 2030 target, the City defined multiple policy opportunities to provide local emissions reductions. Most City emissions come from on-road transportation (60%) and building energy use (33%), so the City placed a greater emphasis on defining key actions to enhance building electrification (e.g., reduction in natural gas use), promote EVs, and reduce vehicle miles traveled. The City identified viable key actions in these sectors and developed three policy scenarios to understand effectiveness under different implementation plans. The City with its consultant teams then developed four detailed calculation models to understand action impacts related to residential buildings, non-residential buildings, mobility, and electric vehicles to quantify emissions reductions and cost impacts of the key actions and policy scenarios modeled. The final policy scenario and associated actions selected represent the most technically feasible and cost-effective pathway to reaching the City's 80 x 30 goal and results in a 71% reduction compared to 1990 levels by 2030. The BAU forecast scenarios, key S/CAP action impacts, and reduction target are compared in Figure 1 below. The gap between the yellow action impact line and the

[1] https://arb.ca.gov/emfac/

[2] An original estimate of the 2019 non-residential versus residential VMT split was provided by Fehr & Peers (75%/25%), which informed the emissions analysis presented in the City's April 19th Staff Report. On 5/26/2021, this VMT split was updated with the City's Electric Vehicle consultant's revised value of 70%/30%. Changing this value had a minimal impact on the EV emission calculations. This change decreased total 2019 emissions by 822 MT CO_2e or 0.2%. Therefore, there is a slight discrepancy between previously published 2019 inventory values (482,327 MT CO_2e) and those published after 5/26/2021 (481,505 MT CO_2e).

green target line in Figure 1 illustrates the remaining emissions reductions needed to achieve the City's 2030 GHG target.

Figure 1. Emissions Forecasts and Reduction Target



The suite of key actions represented in Figure 1 and ranked by GHG reduction impact in Table 1 below. Note that due to modeling limitations, GHG reductions were not quantified for specific mobility and EV actions and were instead applied to each traveler category (i.e., residents, commuters, visitors). Therefore, the actions contributing to reductions in those categories are collectively called "Mobility actions" or "EV actions" in Table 1.

Table 1. S/CAP GHG Reduction Actions

Rank	Action	GHG Reduction ($MT CO_2e/yr$)
1	EV Actions – Commuter and Visitor	52,715
2a	Electrify single-family homes through gas main disconnect and all-electric mandate for single-family residential substantial remodeling projects	49,500
2b	BAU policies that are not implemented[3]	-6,491
3	EV actions - Residents	39,324
4	Non-residential electrification of mixed-fuel rooftop packaged units	10,234
5	Mobility actions - Commuters	15,157
6	Mobility actions - Visitors	8,642
7	Mobility actions - Residents	4,392
8	Non-residential buildings ≥25k sq. ft. reduce GHG emissions by 20%	6,127
9	K-12 electrification of space and water heating	3,376
10	Multi-family residential mandate end-of-life in-unit space heating and cooking electrification	1,197
	Total	**184,173**

The actions listed above achieve a 71% reduction below 1990 levels by 2030, nearly demonstrating 2030 target achievement. These strategies include technically feasible and cost-effective local actions in the buildings and transportation sectors. Additional key actions in sectors that have a smaller emission impact, such as the solid waste and wastewater sectors, were developed and assessed for co-benefit impacts but have not been included in the detailed GHG analysis (see the Sustainability Actions section for further discussion). Other emissions sources accounted for in the BAU forecast scenarios cannot be directly impacted by the City or reduced based on current technologies, such as aviation travel. Additionally, there are remaining emissions within the buildings and transportation sectors as they cannot feasibly be fully reduced by 2030.

Therefore, considering the emissions reductions from local actions only would result in a 9% gap between the S/CAP action impact scenario and the City's 2030 GHG target. The remaining emissions can

[3] BAU reductions that will not occur due to implementation of City actions reflected in action 2a; these BAU reductions are entered back into this table to avoid double counting GHG emission reduction potential from the BAU and S/CAP actions.

be balanced through some combination of enhanced action implementation, sequestration, carbon offset purchases, and/or industrial-scale carbon removal (see Recommendations section for further discussion).

Model Development

Following key GHG action definition, AECOM and the City collaborated to identify a method for analyzing the GHG and cost impact of each action. AECOM first reviewed publicly available GHG calculators, including CURB and ClearPath, and discussed the relative strengths, weaknesses, and desired project outputs with the City team. The City ultimately decided to develop four customized GHG models (Residential Buildings, Non-Residential Buildings, Mobility, and Electric Vehicles) that more directly reflect the City's specific context and opportunities and enabled the calculation of full life-cycle costs and financing options. The City Utility Department staff and AECOM team collaborated to develop the Residential and Non-Residential Buildings models. The City transportation staff led development of the Mobility model, with strategic review and guidance provided by the AECOM team.[4] And, the City hired a separate consultant to develop the EV model. Each team then used the models to analyze the GHG reduction potential, costs, and savings for the selected key actions, and collaborated through technical review meetings to ensure model outputs were aligned with one another and with the City's GHG inventories and BAU forecasts.

Using the four GHG models, the City developed three policy scenarios that varied the implementation and uptake rates of the selected actions. Due to on-road transportation modeling limitations, the Electric Vehicle and Buildings models assessed each of the three policy scenarios separately, while the Mobility model only evaluated one scenario; the mobility key actions and implementation rates represent what City staff determined is both ambitious and feasible for the City to implement.

To reasonably calculate the local impact of each key action, the teams made informed assumptions on the actions' effectiveness and implementation uptake (or participation) rates based on the best available local data. When local data was not available, broader regional market data was used. As the effectiveness of the actions can also depend on other changing regional, state, or national factors, such as policy decisions, economic growth, and cultural shifts, adjusting the assumptions to account for these factors can increase or decrease the impact estimations.

Each models' methodology and output metrics vary and are presented in a consolidated table in the following section. The City team has also developed technical memorandums for each model to document model development, assumptions, data sources reviewed, and model use to guide future S/CAP updates or modeling revisions based on implementation tracking information and new data sources.

[4] Note that budget constraints prevented the use of the VTA Travel Demand Model to analyze the proposed mobility key actions. Subsequent analyses of key actions should utilize the VTA model to simulate the interrelationship between Palo Alto's land use patterns and transportation infrastructure and consider scenarios that could amplify GHG reductions.

Detailed Action Results

Action Impact Table

Actions were grouped into one of three sectors depending on the model in which they were assessed: Buildings, Mobility, or Electric Vehicles. Extensive research and analysis was completed to estimate the following for each action:

- Annual GHG reductions
- Implementation metrics
- Cumulative Costs from 2020-2030
- Cumulative Savings from 2020-2030
- Co-benefits

Table 2 on the following pages lists relevant metrics for all key actions (see Appendix A for detailed action descriptions). The sub-sections following Table 2 describe each metric in the action impact table. All metrics consider implementation from the beginning of 2020 to the end of the 2030 calendar year. Note that Mobility actions were individually analyzed for costs and co-benefits. However, to follow the Action Impact Table format, Mobility actions were aggregated by sector. Therefore, the individual costs and co-benefits were also aggregated at the sector level. Finally, the co-benefits column of Table 2 uses colored text to denote co-benefit impacts as shown in the legend below:

Co-Benefit Legend
Very Positive
Somewhat Positive
Somewhat Negative
Very Negative

Table 2. Action Impact Table

Buildings						
Sector	**Actions**	**Co-Benefits**	**Cumulative Costs (2020-2030)**	**Cumulative Savings (2020-2030)**	**Implementation by end of 2030**	**Annual GHG Reductions by 2030**
Single Family	All-electric mandate for residential substantial remodeling projects	Air Quality, Public Safety, Lifecycle Emissions	None	$0.22 million	846 gas water heaters replaced with electric heat pumps (6% of total gas water heaters converted) 900 gas space heaters replaced with electric heat pumps (7% of total gas space heaters converted) 900 gas cooktops replaced with induction cooktops (6% of total gas cooktops converted) 900 gas dryers replaced with electric (17% of total gas dryers converted) 333 electric panel upgrades needed (6% of panels needing upgrades)	43,009 MT CO_2e/yr**
	Electrify single-family homes	Air Quality, Public Safety, Lifecycle Emissions, Cost of Living, Equity	$322.34 million*	$3.00 million	11,226 gas water heaters replaced with electric heat pumps (81% of total gas water heaters converted) 9,766 gas space heaters replaced with electric heat pumps (77% of total gas space heaters converted) 12,147 gas cooktops replaced with induction cooktops (83% of total gas cooktops converted) 3,199 gas dyers replaced with electric (60% of total gas dryers converted) 3,467 electric panel upgrades needed (63% of panels needing upgrades)	

Multi-Family	Mandate end-of-life in-unit space heating and cooking electrification	Air Quality, Public Safety, Lifecycle Emissions	$15.76 million*	$0.34 million	1,755 in-unit gas furnaces replaced with electric heat pumps (20% of total in-unit gas furnaces) 385 gas cooktops replaced with induction cooktops (15% of total gas cooktops) 1,053 electric panel upgrades needed (17% of electric panels that need upgrade)	1,197 MT CO_2e/yr***
K-12	K-12 electrification of space and water heating	Air Quality, Public Safety, Lifecycle Emissions	$19.00 million	$1.12 million	100% of schools with gas space and water heating have converted to electric systems	3,376 MT CO_2e/yr
Non-Residential	Electrification of mixed-fuel rooftop packaged units	Air Quality, Public Safety, Lifecycle Emissions	$174.57 million	$7.56 million	100% of commercial spaces with gas rooftop packaged heating have converted to electric heating	10,234 MT CO_2e/yr
	Buildings ≥25k sq. ft. reduce GHG emissions by 20%	Air Quality, Public Safety, Lifecycle Emissions	$ 84.45 million	$4.56 million	100% of commercial buildings 25k sq. ft. and larger without gas rooftop packaged heating have reduced GHG emissions by 20%	6,127 MT CO_2e/yr

*Includes necessary electric panel upgrade costs

** Single family GHG reductions include electrification of other natural gas sources that were not accounted for in the Buildings model as well as assumptions on all-electric single-family new construction and voluntary electrification at end-of-useful life; this value represents the sum of actions 2a and 2b from Table 1 to avoid double counting of reductions assumed between the BAU scenario and S/CAP actions scenario

*** Includes GHG reduction assumptions on multifamily all-electric new construction

Mobility						
Sector	**Actions**	**Co-Benefits**	**Cumulative Costs (2020-2030)**	**Cumulative Savings (2020-2030)**	**Implementation by end of 2030**	**Annual GHG Reductions by 2030***
Parking and Congestion	Eliminate free parking, adjust parking requirements, RPP permitting allowances, institute paid parking, and price commuter parking	Air Quality, Public Health, Public Safety, Regional Benefit, Resource Conservation, Lifecycle Emissions, Cost of Living, Productivity	$7.09 million	Residents: $10-16 million Commuter: $49-58 million Visitor: $17-30 million	Resident: 12-18 million VMT reduced in 2030 (4-6% VMT reduction in 2030) Commuter: 54-63 million VMT reduced in 2030 (16-19% VMT reduction in 2030) Visitor: 22-36 million VMT reduced in 2030 (6-10% VMT reduction in 2030)	Resident: 4,392 MT CO_2e/yr Commuter: 15,157MT CO_2e/yr Visitor: 8,642MT CO_2e/yr
Biking and Walking	Implement Bike Master Plan, develop Safe Routes for Adults program, adopt a Vision Zero Plan and install multi-use paths, conduct feasibility study on protected bike infrastructure, increase bike facilities and protected intersections, continue Safe Routes to Schools program, complete Quarry Road Extension, develop bicycle highways	Air Quality, Public Health, Public Safety, Regional Benefit, Resource Conservation, Equity, Lifecycle Emissions, Cost of Living, Productivity,	$54.38 million			
Community Engagement	Community engagement and policy adoption	N/A	$0.80 million			
Transit and Intersections	Reduce speed limits, install transit signal priority equipment, add bus rapid transit lanes, provide on-demand transit service, enhance traffic signals, allocate funding to TMA	Air Quality, Public Health, Public Safety, Regional Benefit, Resource Conservation, Cost of Living, Productivity, Equity, Lifecycle Emissions	$13.03 million			

VMT = vehicle miles traveled

*GHG estimates are for the higher VMT reduction value. These GHG reduction calculations can be found in the EV model.

Electric Vehicles						
Sector	**Actions**	**Co-Benefits**	**Cumulative Costs (2020-2030)**	**Cumulative Savings (2020-2030)***	**Implementation by end of 2030**	**Annual GHG Reductions by 2030***
Resident	Residential EV credit (free charging)	Air Quality, Lifecycle Emissions, Public Health, Regional Benefit, Resource Conservation, Cost of Living, Equity	EV Charging Costs: Single Family: $11.18 million Multi-family: $23.84 million	Savings from Vehicle Improvement: $182.63 million	85% of new vehicle sales are EVs 55% of Resident VMT are from EVs 20,060 total residential EV charging ports installed	39,324 MT CO_2e/yr
	ICE usage fee	Air Quality, Public Health, Lifecycle Emissions, Regional Benefit, Resource Conservation, Cost of Living				
	Multi-family residential charger installation mandate	Air Quality, Public Health, Lifecycle Emissions, Regional Benefit, Resource Conservation, Equity				
	Low income charger installation incentive	Air Quality, Lifecycle Emissions, Equity, Public Health, Regional Benefit, Resource Conservation, Cost of Living				
Commuter	Alternative Commute Mandate	Air Quality, Lifecycle Emissions, Public Health, Regional Benefit, Resource Conservation	EV Charging Costs: $96.72 million	Savings from Vehicle Improvement: $59.04 million**	40% of Commuter VMT are from EVs 11,057 total workplace EV charging ports installed	52,715 MT CO_2e/yr
	Alternative Commute Incentive	Air Quality, Cost of Living, Public Health, Regional Benefit, Resource Conservation, Lifecycle Emissions, Equity				

	Workplace EV Parking	Air Quality, Public Health, Regional Benefit, Resource Conservation, Lifecycle Emissions				
Visitor	Preferred Parking	Air Quality, Public Health, Regional Benefit, Resource Conservation, Lifecycle Emissions	EV Charging Costs: $16.71 million	Savings from Vehicle Improvement: $49.76 million**	30% of Visitor VMT are from EVs 1,542 total public EV charging ports installed	
Education	Local/Targeted campaigns	Equity	NA	NA	These policies support the implementation metrics above	These policies support the GHG reductions above
	Regional/Statewide campaigns (ABAG/MTC)	Equity				
Mobility	Provide incentives for purchase and usage of LEVs and E-bikes	Air Quality, Public Health, Cost of Living, Regional Benefit, Resource Conservation, Lifecycle Emissions, Equity				
Fleet	Electrification of municipal fleet, buses, and delivery trucks/vans	Air Quality, Public Health, Regional Benefit, Resource Conservation, Lifecycle Emissions				

*Savings and GHG reductions include both EV penetration assumptions and fossil fuel vehicle emissions and MPG improvements
**Only considering savings from miles associated with Palo Alto

Annual GHG Reductions

"Annual GHG Reductions by 2030" represent the emissions avoided in 2030 by implementing the specific policy action. This metric represents the estimated amount of emissions reduced compared to a business-as-usual scenario where no policy action was implemented by 2030. For reference, Table 1 lists all actions in order of their GHG reduction potential.

Buildings

To estimate the GHG reduction from building electrification actions, assumptions were made for general city building stock characteristics. This includes estimates for the number of single family homes with natural gas systems, annual number of end-of-life system replacements, annual gas use per unit, annual electric use per unit, non-residential natural gas consumption per square foot, and non-residential electric use per square foot. Some of this information was available from Utility Department data, while others were collected by the City and AECOM teams from various databases and building energy surveys to help describe the local building energy use context.

Assumptions were also made for the implementation rates of individual policy actions. For example, the implementation of the "All-electric mandate for residential substantial remodeling projects" action includes assumptions for the percent of homes that would be substantially remodeled from 2020-2030. This assumption was informed by historic City permit data describing building remodels. The annual 2030 GHG reduction from this action represents the emissions avoided assuming those homes still contained natural gas systems in 2030.

Single-family actions were aggregated to estimate total GHG reductions. The Buildings model only accounted for natural gas consumption from space heating, water heating, and stoves and did not consider other natural gas sources such as pool heaters or barbecue grills. Therefore, the single-family GHG reductions were aggregated to include the electrification of other sources of natural gas consumption that weren't accounted for in the Building models. Additionally, in order to account for other impactful emissions reductions, both the single-family and multi-family GHG reductions include reductions from all-electric new construction. Single-family GHG reductions also include reductions from voluntary electrification of appliances at end of useful life. The new construction and voluntary electrification GHG reduction values are disaggregated within the Building model.

As electricity in Palo Alto is 100% carbon neutral,[5] any system that is electrified (e.g., converted from natural gas to electricity) in the City will produce net zero emissions after the retrofit is complete. Therefore, emissions reductions were derived from the amount of natural gas the original system would have consumed in 2030, which would be avoided through the electrification action.

Mobility

Mobility GHG reductions could not be disaggregated by specific actions but were instead grouped by residential, commuter, or visitor categories. All mobility actions were assumed to contribute to a minimum and maximum percent vehicle miles traveled (VMT) reduction for each user category, as

[5] "100% Carbon Neutral" means that the City "will demonstrate annual net zero greenhouse gas (GHG) emissions…by applying the average hourly carbon emissions intensity of the electricity on the CAISO grid to the City's net load for each hour of the year." See Resolution 9913, Resolution of the Council of the City of Palo Alto Amending the Electric Supply Portfolio Carbon Neutral Plan and the Electric Utility Reserves Management Practices

calculated in the Mobility model.[6] The maximum percent VMT reduction values were then applied to the 2030 forecasted VMT in the EV model to develop 2030 S/CAP action maximum VMT reductions. 2030 vehicle emissions factors were internally developed in the EV model using data on vehicle ownership and sales as well as local EV actions. These factors account for vehicle fleet composition and forecasted local EV penetration for each user category. The emission factors were applied to the maximum 2030 S/CAP action VMT reduction amount to develop the maximum 2030 GHG reduction for each user category, as shown in the EV model.

Electric Vehicles
GHG reductions from EV actions could not be disaggregated by specific action but were instead grouped by residential or commuter + visitor (non-residential) categories. After Mobility action VMT reductions were applied to the 2030 forecasted VMT, EV actions were applied to the remaining VMT. The internally developed 2030 emissions factors used for the Mobility actions also account for higher EV penetration due to local EV action. These emission factors were applied to the remaining 2030 S/CAP action VMT to develop total 2030 S/CAP EV action emissions. These emissions were then compared to the original BAU 2030 emissions scenario that applied the BAU emissions factor to the remaining 2030 VMT that was used in the EV action scenario. The BAU emissions factor was higher than the S/CAP EV action emission factor because it does not assume the high level of local EV penetration that additional market data suggest is occurring. The difference between the 2030 BAU emissions and the 2030 S/CAP EV action emissions is the amount of GHG emissions reduced from Palo Alto EV actions in 2030.

Implementation Metrics

The "Implementation Metrics" for each action are directly related to the estimated GHG reductions and illustrate the action uptake or technological transformation that could be achieved. Like the GHG reduction estimations, the implementation metrics depend on the set of policy assumptions that were used in each model. While the implementation metrics of the Building actions were generated by the models after the policy implementation rates were entered, the implementation metrics of the Mobility and EV actions were inputs based on extensive research for each policy. All implementation metrics are compared to a BAU 2030 forecast year. The implementation metrics can be useful in tracking future S/CAP action implementation progress.

Cumulative Costs and Savings

"Cumulative Costs and Savings from 2020-2030" represent the average net costs and savings to the community. Costs and savings are presented as cumulative instead of annual as typical annual values vary depending on when the action is enacted, the implementation rate, and how upfront costs are considered in annual averages. Cost and savings should be considered during action prioritization because they help demonstrate the feasibility and acceptability of GHG reduction actions. For example, policies that result in high GHG reduction may be too costly to implement or policies may result in a net positive financial benefit to residents due to long term fuel or energy savings.

Overall, reducing vehicle emissions through use of EVs and alternative travel (e.g., transit, biking, walking) are the most cost-effective measures. Of the building electrification actions analyzed, single-family residential water heating and space heating electrification is most cost-effective, along with

[6] The mobility model has not factored in land-use changes. But land use choices towards more transit-supportive, walkable, bikeable neighborhoods will multiply and accelerate the VMT reductions estimated in the model.

electrification of commercial rooftop packaged heating, ventilation, and air conditioning (HVAC) units. The costs and savings considered in each model are explained below.

Buildings
Building actions include costs for electrifying natural gas heating systems. The residential action costs include costs for the necessary electric panel upgrades while the non-residential actions do not. Savings include utility bill savings from using electricity instead of natural gas for heating. Cost estimates differ between each action depending on the assumed number of conversions from each policy and the timing of policy implementation.

Mobility
Mobility actions include costs for implementing each specific group of actions. Disaggregated costs by sub-policies are also available within the Mobility model. Savings reflect reduced gasoline expenditures and decreased vehicle maintenance and are only available at the residential, commuter, or visitor user level, not the policy level.

Electric Vehicles
Electric Vehicle costs and savings are available at the resident, commuter, or visitor user level, not policy level. Costs only include the price of EV charger installations that may result from action implementation. Savings reflect reduced gasoline expenditures from purchasing EVs or from traveling in more fuel-efficient vehicles. The commuter and visitor savings only consider the miles traveled associated with Palo Alto.

Co-benefits

Palo Alto selected nine co-benefit evaluation criteria (revised through public feedback) that align with community priorities and apply to multiple S/CAP issue areas (e.g., Energy, Electric Vehicles, Zero Waste). These criteria include air quality, public health, public safety, regional benefit, resource conservation, lifecycle emissions, cost of living, productivity, and equity. For a given action, each of the nine chosen co-benefits was rated on a qualitative ranking scale based on the degree to which implementation of the action will positively or negatively impact the co-benefit. The Action Impact Table shows if the action has a very positive, somewhat positive, somewhat negative, or very negative impact on that specific community co-benefit. Any co-benefits receiving a neutral or no impact rating are not shown. This analysis can ultimately inform the City's final prioritization of its near-term climate actions selected to help achieve the 2030 GHG reduction target.

Please see the *Palo Alto Action Evaluation Memo* for detailed discussion of this process. Between the time the *Action Evaluation Memo* was compiled, and the action impact analysis was completed, some actions were repackaged, and new actions were developed. These actions received new co-benefit ratings and are not reflected in the original memo.

Sustainability Actions

The primary GHG reduction actions selected focus on buildings and transportation as these sectors generate 93% of total City emissions. Actions in sectors that have a small emission impact, such as solid waste and wastewater, have not been included in the detailed GHG reduction analysis. This is because GHG mitigation actions in these sectors have already been implemented, such as updating wastewater treatment processes and collecting landfill gas. The City also developed natural environment actions

such as increasing tree coverage and green infrastructure. These actions can reduce GHGs by sequestering carbon, but the actual emissions reductions are difficult to quantify and require further analysis. The City is primarily focused on directly reducing emissions first before turning to sequestration actions to address remaining emissions (see Recommendations section). Finally, the City has developed climate adaptation and sea level rise actions. These do not reduce GHG emissions but do help protect against the impact of climate change. Therefore, these sustainability actions have only been analyzed for their co-benefits.

Generally, the sustainability actions scored positively for their impact on the Resource Conservation and Regional Benefit criteria. This is because these actions were primarily focused on conserving local resources, such as water, trees, food, and materials, while benefiting surrounding communities through larger planning processes. A summary of action ratings for each action sector is presented below:

- Water Actions: Generally scored very positive for Resource Conservation and positive for Regional Benefit.
- Climate Adaptation and Sea Level Rise Actions: Generally scored very positive for Regional Benefit.
- Natural Environment Actions: All scored positively for Resource Conservation and generally scored positively for Regional Benefit. However, the "WELO Requirements of Native and Drought Tolerant Species" action received a somewhat negative Cost of Living score.
- Zero Waste Actions: All scored positively for Resource Conservation and generally scored positively for both Cost of Living and Regional Benefit.

Recommendations

Implementing the building, mobility, and transportation actions will reduce emissions by 71% below 1990 levels by 2030, leaving an 9% gap between the S/CAP action impact scenario and the City's emissions target of 80%. Based on a review of the modeling results, the AECOM team recommends the City address remaining emissions through a combination of the following strategies:

- Identify which of the current building and transportation actions can be accelerated or enhanced beyond current implementation rates if additional barriers could be removed
- Evaluate local or regional carbon sequestration opportunities, understanding that fully balancing the City's remaining emissions may not be feasible if sequestration action is strictly confined to the city limits. Actions that contribute to sequestration can be achieved through many of the City's "Natural Environment" actions.
- Evaluate and monitor industrial carbon removal technologies as this industry continues to rapidly evolve.
- Purchase verified carbon offsets to fully balance the remaining emissions gap that cannot be addressed through the preceding strategies.

AECOM also recommends the City establish a carbon neutrality target and definition that achieves or exceeds the State's timing for carbon neutrality (Note that the current California Executive Order B-55-18 aims to reach statewide carbon neutrality no later than 2045 but has not yet been codified into law). As inventory methodologies continually change over time, establishing a carbon neutrality target will also help overcome challenges associated with setting targets based on historic GHG inventories; previous methodological changes will no longer over- or underestimate the amount of local action

needed to achieve the City's target, because the City will be aiming to completely reduce all emissions. Additionally, a carbon neutrality target can be easier to convey publicly than a percent-based emissions reduction target.

To align with best practices in GHG reporting, the City has made additional methodological changes to its GHG inventory process, beginning with the 2019 inventory, which included estimating several new emissions sources that were not evaluated in the original 1990 inventory. AECOM recommends the City continue to prepare GHG inventories following the GPC protocol to more fully evaluate GHGs resulting from city activities and to support top-down S/CAP tracking based on total and sector emissions results. The City should also monitor and evaluate individual key action successes using the customized GHG models developed for this project or other appropriate models. Tracking progress for Mobility actions may require creation of more sophisticated models than are currently available, which would require additional staff and/or consultant effort. This will ensure progress monitoring is aligned with the GHG Action Impact analysis and can help identify opportunities for new actions or modeling improvements.

Appendix A

Model	Sector	Action Title	Action Description
Residential Buildings	Single Family	All-electric mandate for residential substantial remodeling projects	Require major alterations (remodels) of single-family homes to meet all-electric requirements.
		Electrify single-family homes	Phase out fossil fuel use in existing buildings starting with areas that have older gas lines that need to be repaired or replaced. Explore ways to accelerate adoption through mandates, carbon pricing, or disconnecting natural gas distribution service to residential areas.
	Multi-Family	Mandate end-of-life in-unit space heating and cooking electrification	Mandate end-of-life in-unit space heating and cooking electrification.
Non-Residential Buildings	K-12	K-12 electrification of space and water heating	Electrify water heating and space heating in all K-12 facilities.
	Non-Residential	Electrification of mixed-fuel rooftop packaged units	Convert all rooftop gas packs on non-residential buildings to electric heat pump systems
		Buildings ≥25k sq. ft. reduce GHG emissions by 20%	Require all commercial buildings above 25,000 sq. ft. to meet a carbon emissions intensity target by occupancy class with a goal of reducing carbon emissions by 20%
Mobility	Parking and Congestion	Eliminate free parking	Reduce SOV use by eliminating free parking and adjusting parking requirements
		Adjust parking requirements	Study parking effects on GHG/VMT in S/CAP and modify parking requirements accordingly.
		RPP permitting allowances	All occupants and businesses of new office buildings that are required to provide their own parking should not be allowed to purchase RPP permits.
		Institute paid parking	Institute paid public and private parking and allow for sharing of existing parking resources.
		Price commuter parking	Price commuter parking in public garages so that transit is a competitive mode.
	Biking and Walking	Implement Bike Master Plan	Reduce the current Palo Alto Resident transportation mode split of 64% Single Occupancy Vehicle (SOV) use for work trips to increase active transportation modes (walking, biking, and transit) by implementing the Bicycle + Pedestrian Transportation Plan, the Complete Streets policy, Vision Zero, and other programs to create safe streets for all road users, particularly vulnerable road users
		Develop Safe Routes for Adults program	Develop a Safe Routes for Older Adults program to address transportation needs of those 65+ years through fixed route and on-demand EV transit options, investing in walking and bicycling infrastructure, and promoting e-bikes/adaptive bikes/adult trikes for older adults. Aim for a 10% alternative mode share by Older Adults.

Model	Sector	Action Title	Action Description
		Adopt a Vision Zero Plan and install multi-use paths	Adopt a Vision Zero plan to reduce injuries to all road users, particularly vulnerable road users. Reduce traffic injuries to zero.
		Conduct feasibility study on protected bike infrastructure	Conduct a feasibility study to determine candidate streets for protected bicycle infrastructure as this facility type addresses the "interested but concerned" population that would bike if separated from vehicular traffic.
		Increase bike facilities and protected bikeways	Increase the number of bike facilities, including bike parking and signalized intersections with bicycle accommodations (e.g. bicycle signal heads, bicycle detection, integrated bike/ped counters into signals, colored/buffered/protected bicycle lanes).
		Increase bike facilities and protected bikeways	Add protected bikeways to El Camino Real.
		Continue Safe Routes to Schools program	Continue the Safe Routes to School program that has an existing 68% active and shared mode split (bike, walk, carpool, transit), aim for 75% in 2030.
		Complete Quarry Road Extension	Complete the Quarry Road Extension to the PA Transit Center.
		Develop bicycle highways	Develop regional and local bicycle highways to provide uninterrupted bike commutes.
	Community Engagement	Community engagement and policy adoption.	Encourage the use of bike and/or scooter sharing, and the provision of required infrastructure throughout Palo Alto, especially at transit stations and stops, job centers, community centers, and other destinations.
			Designate vehicle-free streets to encourage economic activity and recreational uses.
			Promote the use of bicycles or electric scooters for deliveries within the city.
			Promote walking and biking to local-serving retail.
			Work with PAUSD to reduce SOV trips by staff, students, and parents.
			Promote Telecommuting
	Transit and Intersections	Reduce speed limits	Reduce speed limits to 15mph on 25% of City streets for less bicyclist stress and more bicyclist and pedestrian friendliness and safety.
		Install transit signal priority equipment	Support Transit Signal Priority on transit routes.
		Add bus rapid transit lanes	Add Rapid Bus and queue jump lanes to El Camino Real.
		Provide on-demand transit service	Provide on-demand shuttle service within Palo Alto for neighborhoods not served by high-frequency transit.
		Enhance traffic signals	Enhance traffic signals to improve traffic flow and reduce idling and associated GHG emissions.
		Allocate funding to TMA	Fund the Palo Alto Transportation Management Association (TMA) with the goal of reducing SOV commute-trips citywide by 30%.

Model	Sector	Action Title	Action Description
Electric Vehicles	Resident	Residential EV credit (free charging)	Annual electric bill discount for residential account who can show that a EV is registered at their home and used by the resident; rebate available for up to 2 vehicles per service address per year. Requires voter approval and paid for by all customers (residential and commercial) class; increased amount for low income customers
		ICE usage fee	Flat fee per ICE vehicle registered. Residents can opt in to submit make/model/odometer and the fee will be adjusted based on MPG and miles driven. Also useful as an education and communication tool. This action may be legally infeasible without legislative or regulatory change at the State level.
		Multi-family residential charger installation mandate	Require all MFR homes to install EV chargers that can serve all residents (minimum one level 1 charger per unit or one level 2 charger for every two units). Exemptions allowed. Current LCFS charger rebate made available but exempted from utility upgrade costs (voter approval required). Funding beyond LCFS would be required and may require voter approval.
		Low income charger installation incentive	Provide additional funding for charging installation for low income households
	Commuter	Alternative Commute Mandate	Commercial building occupant annually reports the # employees, total # vehicles parked, and # EVs parked. Place limit on single occupancy ICE commuter vehicles
		Alternative Commute Incentive	Require commercial building owner/occupant to provide an annual cash incentive to commuters who use alternative transportation or drive EVs. They may also choose to charge a parking fee for ICE vehicles.
		Workplace EV Parking	Expand designated EV parking while capping/reducing ICE parking spaces
	Visitor	Preferred Parking	Designate zones (e.g. entire street, entire parking garage, or floor of garage) in high traffic areas for clean air vehicle (EV, PHEV, 40MPG+) parking
	Education	Local/Targeted campaigns	Increase awareness of benefits of EVs and rebates/incentives through local/targeted campaigns
		Regional/Statewide campaigns (ABAG/MTC)	Increase awareness of benefits of EVs and rebates/incentives through regional/statewide campaigns (ABAG/MTC)
	Mobility	Provide incentives for purchase and usage of LEVs and E-bikes	Provide incentives for purchase and usage of LEVs and E-bikes
	Fleet	Electrification of municipal fleet, buses, and delivery trucks/vans	Electrification of municipal fleet, buses, and delivery trucks/vans