County of Sonoma
Climate Resilience-Climate Action Plan Cost-Benefit Analysis

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EXECUTIVE SUMMARY

This County of Sonoma Climate Resiliency Climate Action Plan (Climate Plan) Cost-Benefit Analysis describes high-level, estimated costs and benefits to county residents, businesses, community organizations, and government agencies associated with implementing specific climate action measures in the Climate Plan. The Climate Plan identifies greenhouse gas (GHG) emission reduction targets and describes the hierarchy of strategies, measures and actions the County of Sonoma (County) and partners could implement within the unincorporated county to achieve GHG emission reduction goals for 2030 to 2045. The analysis provides information to help the County prioritize climate action measures in the Climate Plan and leverage local funds with State, federal, and regional funding to implement priority actions.

FINDINGS

The Climate Plan Cost-Benefit Analysis estimates the GHG emissions and total social cost per ton of emissions for 17 climate action measures selected by County staff. Table ES-1 provides a qualitative summary for these measures of the relative community GHG reduction or sequestration, as well as whether the measure will provide rapid payback net benefit, lifetime benefit, societally cost effective, moderate net cost, or high net cost. Each of these terms are defined as follows:

- **Relative community GHG reduction** is the relative magnitude of GHG emission reductions compared to the overall community inventory.[1] The terms "small", "medium", and "large" describe how noticeable the expected reductions would be in the inventory.
- **Rapid payback net benefit** refers to the relative likelihood the measure will result in both private and social negative costs per ton of GHG reduction, resulting in a net benefit to Sonoma County while recovering initial investment costs quickly. The net benefit is calculated to be greater than $1,000 per CO2e ton.
- **Lifetime benefit** refers to the relative likelihood the measure will result in both private and social negative costs per ton of GHG reduction, resulting in a net benefit to the county over the life of the measure. The net benefit is expected to range between $100 to $1,000 per CO2e ton.
- **Societally cost-effective** refers to the likelihood the measure will result in positive net private costs that are offset by the collection of social benefits identified in the analysis. The private costs are typically less than $100 per CO2e ton and the social value benefits are larger than $100 per ton.
- **Moderate net cost** refers to the likelihood the measure will result in positive net private costs that are not offset by the collection of social benefits identified in the analysis. The net costs range from $100 to $1,000 per ton.
- **High net cost** refers to the likelihood the measure will result in substantial private costs well beyond the collection of social benefits identified in the analysis. The costs for these measures exceed $1,000 per ton. However, all of the measures considered in this cost range are mandated by State regulations and the County has little or no discretion on implementation.

These estimates include the total direct financial costs and benefits per ton of CO2e emissions reductions as well as the total social value of benefits per ton of GHG and criteria air pollutants. The total social cost per ton of GHG reductions gives an indication of the cost effectiveness of each climate action measure from a

[1] "Community" is defined as individuals, households, businesses and institutions involved in the county economy.

social perspective.[2] That is, the total social cost per ton of GHG reductions includes all costs and benefits, even those that accrue to society at large and cannot be assigned to participating residents, businesses, community organizations, and government agencies. For example, the value of avoided health impacts from reduced air pollution would reduce the total social cost per ton of GHG reductions. When the overall cost per ton of CO_2e reductions is *negative*, it indicates the climate action measure results in a *net benefit* to society. Many measures have net benefits rather than costs, sometimes dependent on the range of forecasted energy prices that determine the value of future expenses and savings.

Table ES-1 summarizes the results of the analysis. M. Cubed denoted measures specific to County operations with black font, community-wide measures in blue font, and measures the County is required to implement by State regulation in red font. M.Cubed also categorized the costs per ton as ranges due to the inherent uncertainty in many dimensions including initial costs, energy price forecasts, technology performance and adoption rates, emission impacts, and various public policies.

The legend below describes the symbols in Table ES-1 for each of the definitions provided above.

Table ES-1 Legend

Rapid Payback Net Benefit >$1,000/ton	$$-
Lifetime Net Benefit $100-$1,000/ton	$-
Societally Cost-Effective	$=/=
Moderate Net Cost $100-$1,000/ton	$+
High Net Cost >$1,000/ton	$$+

[2] All values are presented in 2024 dollars.

Table ES-1 - Sonoma County Climate Plan Measures Ranked by Cost Effectiveness per Metric Ton CO2e

Measures & Actions	Scope	Description	Relative Community GHG Reduction	Rapid Payback Net Benefit >$1,000/ton	Lifetime Net Benefit $100-$1,000/ton	Societally Cost-Effective	Moderate Net Cost $100-$1,000/ton	High Net Cost >$1,000/ton
E-CP-3	Community	Promote renewables and microgrids	Small	$$-				
T-CO-1	County	Decarbonize the County fleet of light-duty vehicles (less than 8,500 lbs gross vehicular weight) by 2040*	Moderate	$$-				
T-CO-5	County	Deploy zero emission vehicle infrastructure to ensure charging/fueling infrastructure is in place in locations to support the decarbonization schedule for light and heavy duty fleets.	Moderate	$$-				
E-CO-1	County	Reduce energy use and increase resilience at existing County facilities in the near term through energy upgrades	Small	$$-	$-			
E-CP-7	Community	Prioritize and support energy efficiency and renewable energy access in underserved communities	Large		$-	$=/=	$+	
T-CO-3	County	Decarbonize the County fleet of heavy-duty vehicles (greater than 8,500 lbs gross vehicular weight) by 2042*	Moderate			$=/=		
E-CP-6	Community	Incentivize energy efficiency and renewable energy uptake in communities						
		*New Construction by SCEIP/SCP on bill financing***	Moderate			$=/=	$+	$$+
		*Retrofits by SCEIP/SCP on bill financing***	Large		$-	$=/=	$+	
NWL-CP-4	Community	Increase carbon sequestration on croplands and working lands through soil carbon amendments, hedgerow planting, grassland restoration, and implementation of other climate-smart practices.	Large			$=/=	$+	
NWL-CO-2	County	Increase coordination with tribes and opportunities for tribal collaboration of land management on County-owned lands by 2026, based on traditional and historic stewardship practices.	Small			$=/=	$+	
NWL-CO-5	County	Increase carbon sequestration on County-owned lands by implementing beneficial practices described in the Carbon Stock Inventory and Potential Sequestration Study thru 2030.	Small			$=/=	$+	

Measures & Actions	Scope	Description	Relative Community GHG Reduction	Rapid Payback Net Benefit >$1,000/ton	Lifetime Net Benefit $100-$1,000/ton	Societally Cost-Effective	Moderate Net Cost $100-$1,000/ton	High Net Cost >$1,000/ton
W-CO-4	County	Evaluate and prioritize conservation practice projects on County-owned lands to enhance water resilience and mitigate drought, flood, and debris flows	Small			$=/=	$+	
WF-CP-3	Community	Reduce loss of existing carbon stocks due to wildfire through conservation of natural lands, conservation easements, new policies, and land acquisition	Large			$=/=	$+	
WF-CP-4	Community	Reduce wildfire risk from vegetation fuels by developing and implementing a county-wide grazing plan	Large			$=/=	$+	
E-CO-2	County	Reduce energy use and increase resilience at existing County facilities in the mid-term through energy upgrades	Small			$=/=	$+	$$+
T-CO-4	County	Decarbonize the transit bus fleet by 2040*	Moderate					$$+
T-CO-12	County	Decarbonize County small offroad engines beginning in 2024 by requiring replacements and new purchases be zero-emission equipment*	Small					$$+
T-CO-6	County	Decarbonize County non-road heavy-duty equipment by 2042*	Small					$$+
Notes	* -	Implementation required by state regulations						
	** -	Significant federal & state incentives available to households & businesses						

Table ES-1 illustrates the following findings from the analysis, organized by the highest to lowest cost effectiveness:

- **E-CP-3 Promote Renewables and Microgrids (Rapid Payback Net Benefit):** E-CP-3 is cost-effective relative other climate action measures because renewables and microgrids can displace PG&E's proposed powerline undergrounding program thus significantly lowering electric rates and hastening electrification. Installing community and individual microgrids, combined with the already existing fast-trip system also would reduce wildfire risk an equivalent amount while maintaining the same level of service reliability. The community reduction benefit is small as the total amount of GHG emissions this measure that is expected to reduce is small relative to other measures.
- **T-CO-1 and T-CO-5 Electrifying the County Light-Duty Vehicles with Charging Infrastructure (Rapid Payback Net Benefit):** Electrifying the County on-road, off-road and transit fleets is required under State regulation. Converting the County's light-duty vehicle fleet to electric is highly beneficial. (The charging infrastructure costs [T-CO-5] are included in the overall fleet conversion costs.) The relative community GHG reduction is moderate as the fleet is a small portion of the total county vehicle population.
- **E-CO-1 County Building Energy Measures (Rapid Payback Net Benefit to Moderate Net Benefit):** This first tranche submeasures under consideration by the Board of Supervisors focus on energy efficiency and renewable energy production in County facilities, and show a range of net benefits. The energy efficiency activities are generally more cost effective than those aimed at electrification and energy production of buildings energy uses. The total emission reductions would be small to moderate on the community scale, but large for County operations.
- **E-CP-7 Prioritize Energy Efficiency in Underserved Communities (Lifetime Net Benefit to Moderate Net Cost):** Targeting low-income communities shows a wide cost range that depends on application and setting. Multi-family electrification retrofits show the largest net benefits; retrofits of single-family residences are the highest net cost. Emission reductions could be large if a sufficient portion of the housing stock receives upgrades.
- **E-CP-6 Incentivize Energy Efficiency Uptake (Lifetime Net Benefit to High Net Cost):** The financing programs to incentivize electrification and energy efficiency also show a wide cost range that depends on application and setting. Residential customers are more likely to see lower costs than commercial non-residential. Multi-family electrification retrofits show the largest net benefits; new construction of certain types of commercial space is the most costly option. New construction could provide a moderate emission reduction while widespread retrofits could result in a large reduction.
- **T-CO-3 Electrify Light- and Medium-Duty Trucks (Societally Cost-Effective):** The high upfront costs are offset by fuel savings over the life of the equipment. The total emission reductions would be moderate on the community scale, but large for County operations.
- **NWL-CO-2, NWL-CO-5, NWL-CP-4 plus W-CO-4 Natural and Working Lands Carbon Sequestration (Societally Cost-Effective to Moderate Net Cost):** The four measures generally range in cost from near zero to less than $300 per metric ton. Sequestering about 300,000 metric tons annually would cost about $280 per ton before deducting the social value of carbon reductions of $110 per ton. The potential amount of sequestered carbon could be a substantial offset of the County's total inventory.
- **WF-CP-2, WF-CP-3 Land Conservation and Implement County-Wide Grazing Plan (Societally Cost-Effective to Moderate Net Cost):** The two wildfire mitigation measures have significant carbon sequestration value which makes them relatively inexpensive.

- **E-CO2 County Building Energy Measures (Societal Net Benefits to High Net Costs):** This second tranche is aimed at upgrading and electrifying County facilities and the individual components shows a mix of net benefits and costs per CO2e ton. The total emission reductions would be small to moderate on the community scale, but large for County operations.
- **T-CO-4 Decarbonize the Transit Fleet (High Net Cost):** This has a high net cost as Sonoma County Transit Agency's bus fleet already uses compressed natural gas (CNG) which already delivers lower fuel cost than diesel and has lower emissions. Emission reductions would be moderate due to the higher miles travelled for the entire fleet.
- **T-CO-6 and T-CO-12 Decarbonizing the County Government's Off-Road and Small Engine Equipment Fleet (High Net Cost):** These are expensive at the moment because there is little experience in the market with electric vehicles and mobile equipment and manufacturers are not yet offering more than a few specialized models. GHG emission reductions would be small as this equipment does not burn much fuel, but criteria pollutant emissions would be relatively larger as this equipment uses diesel fuel and emission controls are not as effective as on-road due to rougher duty cycles.

METHODOLOGY

M.Cubed applied a cost-effectiveness approach focused on tons of reduced GHG emissions instead of a cost-benefit analysis because a cost-benefit analysis does not allow for easy comparison among options unless they are commensurate in all directions, which is not the case with measures proposed for the Climate Plan. Cost-benefit and cost-effectiveness analyses are closely related with different perspectives on the same question. For this reason, terminology may be used interchangeably.

- A cost-effectiveness analysis focuses on the net costs per unit of use or output (e.g., ton of GHG reduced, acre-foot saved, or kilowatt-hour generated) and allows for direct comparison across options that may be of different magnitudes (e.g., County operations versus community-wide activities).
- Cost-benefit analysis, on the other hand, is often unitless and focuses on aggregate and wide-ranging scales and scopes. In this case, a cost-benefit analysis would sum all projected emission reductions for each climate action measure and estimate the aggregated costs and benefits.

The cost-benefit method does not allow for easy comparison among options unless they are commensurate in all dimensions and requires information about the emission inventory and projected reductions from proposed measures that is not yet available, so M.Cubed used the cost-effectiveness approach.

1 INTRODUCTION

This Climate Plan Cost-Benefit Analysis describes high-level, estimated costs and benefits to county residents, businesses, community organizations, and government agencies associated with implementing specific climate action measures in the County of Sonoma Climate Plan. The Climate Plan identifies GHG emission reduction targets and describes the hierarchy of strategies, measures, and actions the County and partners could implement within the unincorporated county to achieve GHG emission reduction goals for 2030 to 2045. In addition to informing decisionmakers about the economic consequences of climate action measures for which there is sufficient information, helping to prioritize climate action measures, and guiding budgeting processes, the County can use the Climate Plan Cost-Benefit Analysis as a baseline to manage and measure economic and financial performance of Climate Plan implementation. The analysis further provides information about the financial impact each climate action measure may have on local jurisdictions and participating residents, businesses, community organizations, and government agencies, which could help influence the design of policy options to incentivizes changes in behavior. The emergence of large-scale funding sources available through the federal Inflation Reduction Act of 2022 (IRA) and Infrastructure Investment and Jobs Act of 2021 (IIJA), as well as the State's climate action programs and the potential 2024 climate action bond, also create opportunities to leverage local funding with other funding sources to implement priority Climate Plan actions. Most measures will require further analysis to identify the preferred policy option to facilitate implementation through financial incentives or other economic programs.

In the Climate Plan, County staff, in collaboration with the consulting team, identified about 148 locally based climate action measures to reduce GHG emissions from the region.[3] Of these, County staff are currently evaluating 127 for further implementation. The strategies span six emissions sectors: Energy Use, Transportation, Water, Solid Waste, Wildfire Mitigation, and Natural and Working Lands. This Climate Plan Cost-Benefit Analysis Study is intended to report at a high level on the estimated costs, benefits, and externalities (positive and negative)[4] of implementing 17 of the identified climate action measures chosen by County staff. Implementing the measures will require financial investment, including new and improved infrastructure, switching to less GHG-intensive technologies, and associated government agency staff time and resources. Each measure has the potential to achieve varying amounts of GHG reduction. In addition to reducing GHG emissions, some measures create ancillary benefits, such as lower energy or fuel use/costs or other criteria pollutant emissions that improve the cost-benefit balance.

The total social cost per ton of GHG (in carbon dioxide equivalence (CO2e)) reductions gives an indication of the cost effectiveness of each action from a social perspective.[5] That is, it includes all costs and benefits, even those that accrue to society at large and cannot be assigned to participating residents, businesses community organizations, and government agencies, such as the value of avoided health impacts of asthma cases from reduced air pollution. When the overall cost per ton of CO2e reductions in *negative*, it indicates that the action results in a *net benefit* to society. The community cost per ton of CO2e reductions reflects the costs and benefits absorbed by private individuals and businesses in the county, excluding costs or benefits

[3] The 148 measures are composed of 21 Early Action Measures (already approved and underway—these are excluded from evaluation in this report), 57 County Operations Measures (to be recommended for Board approval), and 70 Community Progress Measures (for further public engagement and prioritization).

[4] Market transactions have prices associated with them that allow a monetary value to be easily assessed. An externality is an economic cost or benefit that occurs outside of market transactions and can be either positive or negative; it is an unpriced consequence of market transactions. Without a clear market price, placing a value on an externality is a complex and uncertain process. However, the lack of a market price does not mean that the externality has a value of zero—in fact the value might be infinite, such as presence of oxygen in our atmosphere.

[5] All values are presented in 2024 dollars.

to government agencies, or broadly to society. Again, a negative cost per ton indicates the action results in a net benefit to community interests.

In general, these cost estimates do not yet include the recently enacted incentives and grants made available through federal legislation. The first is the IIJA or Bipartisan Infrastructure Law.[6] The second is the even larger IRA from which the federal government will make an estimated $300 billion to $1 trillion available by 2030.[7] While significant funding is available, potential funding opportunities are spread across many programs and departments. Additionally, many of these funds will be competitive, and thus uncertain, so incorporating changes in potential costs would be speculative. Furthermore, the necessary analyses have not yet been completed on likely amounts of incentives used for building and transportation electrification among the many other programs.[8]

The exact combination of cost effectiveness metrics for each measure can help decisionmakers select preferred policy approaches. For example, where the externalities show large social benefits, but the community net costs are significant, actions would best be enabled through public incentives such as grants, subsidies, fees or taxes that compensate for those net costs. Where both the social and community benefits are positive, yet the action is not widely adopted, the action may require a market transformation that changes the apparent relative attractiveness of the choice among other market options. For example, energy efficiency in rental housing presents a case where the market decisionmaker (the landlord) is separate from the beneficiary (the tenant), so the beneficial investment may not occur. Most measures will require further analysis to identify the preferred policy option to facilitate implementation through financial incentives or other economic programs.

All of these estimates have significant uncertainties that arise both from ranges in commodity and product forecasts and performance, and unknowns about housing and vehicle stocks and new technology characteristics and evolutions. The values here are for likely comparative purposes—an action that has a very high cost is unlikely to deliver strong economic benefits and vice versa. Perhaps the most interesting result of this exercise is that a significant proportion of these measures show potential to both decrease direct financial costs and deliver positive environmental benefits.

2 SCREENING OF CLIMATE PLAN MEASURES FOR COST-BENEFIT ANALYSIS

2.1 COST-BENEFIT ANALYSIS INFORMATION COLLECTION

To prepare a viable cost-effectiveness analysis to help the County select the most feasible and effective municipal operations and community-based climate action measures to include in the Climate Plan, a cost-effectiveness analysis generally requires an inventory and forecast of current emissions from sectors and targeted activities, and projections of estimated emission reductions (both GHG and criteria) or carbon sequestration for each climate action measure. Additional information is desirable on (1) the expected costs of measures the County will implement within municipal government operations, (2) the number of either

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[6] U.S. Congress, "H.R.3684 - Infrastructure Investment and Jobs Act," https://www.congress.gov/bill/117th-congress/house-bill/3684, November 2021.

[7] U.S. Congress, "H.R.3684 - Infrastructure Investment and Jobs Act," https://www.congress.gov/bill/117th-congress/house-bill/5376/text, August 2022.

[8] That monies are available through tax credits does not mean they will be spent. Due to the variations in eligibility, estimating the amount that might be accessed requires complex analysis of household and business characteristics.

units acquired or constructed (e.g., vehicles, HVAC units, lane miles) or households and businesses acting on the measure, and the baseline emissions and the reduced or sequestered emissions for as proposed measure. The 17 measures evaluated in the Climate Plan Cost-Benefit Analysis generally have sufficient information of these types to conduct the economic analysis. M.Cubed developed other data and forecast inputs for climate action measures such as baseline and reduced energy consumption per unit or household/business, technology and energy price forecasts, and projected consumers responses. These inputs and analyses are described in more detail in Appendix A.

2.2 MEASURE SCREENING CRITERIA FOR APPLYING COST-BENEFIT ANALYSIS

Based on the information requirements and the stage of development for each measure, M.Cubed applied the following initial screening criteria to identify the 17 (out of 127 total) climate action measures to include in the cost-effectiveness analysis:

(1) **Quantifiable**: M.Cubed categorized the climate action measures using professional judgment as follows:

   a. **Foundational:** A necessary initial step to prepare for actionable measures but does not lead to quantifiable emission reductions by itself.

   b. **Educational/public information:** Provides the community with information to promote investments in preferred technologies and voluntary changes in behavior. Little research and analysis are available to quantify the direct emission reductions from these types of programs.

   c. **Direct action:** Makes direct expenditures or enacts mandates or incentives. These result in likely quantifiable emission reductions or sequestration.

(2) **Significant community GHG reductions:** M.Cubed assessed the measures from category (1)c for likely order of magnitude emission reductions or sequestration based on professional judgment, analyses prepared by the County, and information from other Climate Action Plans (CAPs. These were rated on a three-tiered basis of Large, Moderate, and Small.

(3) **Relative cost-effectiveness:** M.Cubed calculated likely order of magnitude net costs for the measures from step (2) that have Large and Moderate emission reductions and sequestration relative to the overall county-wide inventory. These were rated through professional judgement and available analyses from previous CAPs on a five-tier basis of Rapid Payback Net Benefits, Lifetime Net Benefits, Societally Cost-Effective, Moderate Net Costs, and High Net Costs.

The County can then use the list to identify (a) which of the Foundational and Educational measures the County may want to evaluate further for priorities and (b) what other criteria the County might choose to include in evaluating the list beyond from the Relative Cost Effectiveness ranking.

3 DESCRIPTION OF CLIMATE ACTION MEASURE COSTS, BENEFITS, AND EXTERNALITIES

The three main values estimated in this analysis are costs, benefits, and externalities of each GHG reduction climate action measure. The analysis generally attempts to include both social and private or community costs and benefits in the analysis. Social costs and benefits consist of those that accrue to society at large, such as the social cost of carbon, and implementation costs incurred by government agencies. Private or community costs and benefits include those carried by residents or businesses, such as the financial cost of performing energy efficiency upgrades or the benefit of a reduced electricity bill from installing solar generation on commercial buildings. The analysis uses the following definitions:

> *Costs* generally include implementation expenditures, both for private investment and operations, and government staffing, incentive payments, infrastructure or purchasing. Also included are any additional energy costs in the case of switching from one fuel or energy source to another. In some cases, these are presented at the net costs of the difference between a conventional technology and the lower or zero emission one. For example, the net costs of building electrification and electric vehicles are presented here. These net costs are often negative, meaning they are economically beneficial; that is, they save homeowners or drivers money. Often a new technology has a higher initial investment cost than the conventional technology (e.g., heat pumps versus furnaces or electric vehicles versus internal combustion engine cars). But new technologies are usually more efficient and result in operational savings over a number of years. The projections of those operational costs depend on forecasts of future inputs such as electricity, natural gas, and petroleum products. The discounted net present value stream of those operational costs is weighed against the initial investments to assess the lifecycle net costs or benefits of the proposed measure. This study uses a range of those forecasts to illustrate the uncertainty around those projections, and they are discussed in more detail in Appendix A Section 4.
>
> *Benefits* include any energy, fuel or other costs that are avoided with the action. Decreased costs for a similar activity (e.g., replacing a water heater or a vehicle) are not shown as direct benefits but instead are included in "Costs" for ease of accounting.
>
> *Externalities* include benefits or costs that do not accrue to particular or identifiable individuals but may impact the community and society at large. These include the avoided social cost of carbon and the avoided health impacts of co-occurring criteria air pollutants. The social cost of carbon is a value used by the U.S. Environmental Protection Agency (U.S. EPA) and other federal agencies to estimate the value to society of GHG reductions based on the impacts of human-induced climate change on agricultural productivity, human health, and flood risk.[9] Health impacts from criteria pollutants include the value of lower morbidity and mortality from reduction in emissions of nitrous oxides, sulfur oxides, particulate matter, and reactive organic gases (ROG). In some cases, certain externalities may offset each other, such as a decrease in GHG emissions that may result from destruction of desert habitat from building a renewable generation plant. Not all externalities are included in this analysis, though the most significant are identified and quantified where possible.

In some cases, it was not possible to estimate the private cost of implementing an action due to complexity and the number of assumptions that would need to be made. Complex factors make it difficult to model costs with any certainty and without a level of effort that goes beyond the resources available to this project. For example, there is little current information available on the population of agricultural equipment in the county and even less information on the cost, maintenance, and useful life of electric agricultural equipment because such equipment is not in widespread use. Due to this lack of information the analysis excludes private costs or benefits associated with agricultural equipment actions. Note that if private costs are not estimated, then private benefits are similarly excluded from the analysis, as noted in the table comparing cost effectiveness.

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[9] The social cost of carbon is an estimate of the cost translated to a monetary value of the damage done by each additional ton of CO_2e emissions. Conversely, it also is an estimate of the benefit of any action taken to reduce a ton of CO_2e emissions.

This analysis depends in large part on the data and assumptions for each action developed in the Climate Plan. Following the methodology developed in that analysis, costs, benefits, and externalities are estimated on an annualized basis for the years 2030 and 2050.

3.1 LIMITATIONS OF THIS ANALYSIS

The results of this analysis should be used carefully and with consideration of its limitation. It is intended to be indicative, not definitive, of relative costs across proposed measures. The list provides some of the most important aspects limiting the accuracy of the analysis.

1. **The cost-effectiveness metrics are for comparison among actions on a relative basis— they do not represent the expected absolute costs and benefits per se.**

Most of the actions are directed toward sectors that have a wide variety of characteristics (e.g., housing, personal vehicles) that are not easily captured in an economic analysis that addresses a broad set of sectors. Further, the available economic studies upon which this analysis relies are generally not tailored with specific local characteristics for Sonoma County. The analysis also relies on other studies that use archetypes or prototypes (e.g., particular building configuration or vehicle type) and averages to estimate the costs and benefits of certain actions. For example, decarbonization strategies for new home construction are based on studies conducted by a consortium of State agencies and utilities to set Reach Code standards that specify standard house configurations and estimate the costs to build and operate that house, adjusted for the county's Climate Zones.[10] The extent to which actual housing stock deviates from these configurations will impact the expected absolute costs for the specified actions.

2. **Net cost estimates exclude 2021 through 2023 federal and State incentives and funds recently made available.**

Significant State and federal funding is available for a host of household, business, and public sector climate-related investments. Importantly, the sources of funding have proliferated since 2021 and the amount has increased substantially. At the federal level, the IRA will direct between $390 billion and $1 trillion to clean energy assets primarily through tax credits and grants. The IRA's tax credit provisions expire or start to phase out in 2033 and grant funding will mostly expire before then. Billions of additional dollars are available through the IIJA. The IIJA is a cash infusion, allowing the existing federal apparatus to build infrastructure within eight years. The Fiscal Year 2022-2023 State of California Budget allocated $39 billion over five years toward climate resilience and integrated climate, equity, and economic opportunities. However, the FY 2023-2024 budget scaled back State spending by $2.9 billion.[11] The FY 2025-2024 budget incorporates further budget reductions for these efforts. The accompanying *Funding & Financing Strategy 2024-2027* describes the funding situation in more detail.

Eligibility rules and implementation guidelines have not yet been established for a number of these incentives and programs. Further, many set income eligibility standards that require more detailed socio-economic data on a geographic basis than is readily available for this study. Likewise, few if any studies have yet been conducted that estimate potential technology uptake rates given these incentives.

[10] California Energy Commission, California Building Climate Zones, https://cecgis-caenergy.opendata.arcgis.com/datasets/CAEnergy::california-building-climate-zones/explore

[11] See "2023–24 California State Budget Finalized—At Least for Now," *JD Supra*, https://www.jdsupra.com/legalnews/2023-24-california-state-budget-1576852/, July 5, 2023.

3. **In addition, total cost assessments rely on estimated equipment and building populations and the assumed effectiveness of the actions both to be implemented and to change the emission profiles of those populations.**

The most salient example is building electrification that replaces natural gas stoves with induction cooktop and convection ovens, as well as furnaces and air conditioners with heat pumps. The rate of building retrofits could vary widely in both numbers and timing. It is also largely unknown how automobile drivers might respond to the option of switching from gasoline-fueled to electric vehicles given changed circumstances.

For these reasons, policymakers and stakeholders should focus their attention on the relative costs of actions and not the cost of a single action in isolation. Uncertainties about technology development, energy prices, including utility rates, and continued government funding and incentives grow substantially after 2030.

3.2 COST-BENEFIT ANALYSIS METHOD

In this section, we summarize the analytical tools and techniques used for the cost-effectiveness analysis, including data inputs and other information necessary to replicate the results and findings. M.Cubed developed a range of cost and benefits calculated at a high level for climate action measures included in the analysis, as well as provided a range of cost-effectiveness estimates for each climate action measure. Economic values used include initial investments, ongoing expenditures, and non-market costs such as environmental and transaction costs, as available.

Cost-benefit and cost-effectiveness analyses are closely related with different perspectives on the same question, so the terminology may be used interchangeably. Cost-effectiveness analysis measures the net costs (i.e., gross costs minus gross benefits) per unit of provided service or benefit. In this case, it measures the cost per ton of GHG emission reductions. Standard practice is to present results in the cost-effectiveness format because it allows for direct comparison among measures. Cost-benefit analysis typically presents aggregate costs and benefits rather than on a per unit basis. M.Cubed used the cost-effectiveness approach because information about the emission inventory and projected reductions from proposed climate action measures necessary for a cost-benefit approach are not yet available.

Cost-effectiveness can be shown at two levels, the first based on direct market transaction values that represent private financial values and the next adding a wider array of non-market impacts that are often interpreted as societal externalities, benefits and costs. These non-market benefits can include air quality and other environmental quality improvements that are savings compared to the presumed baseline activity. Monetary values can also be included where sufficient information is available. Further, many measures show benefit-cost ratios that are negative or less than one (i.e., benefits are less than costs) because the benefits of achieving emission reductions are uncertain. That does not diminish the need to achieve such reductions; instead, it highlights the likelihood that households and businesses may need subsidies to cover the excess costs. The underlying analysis includes both the direct private cost-effectiveness and the broader societal metric. The County can compare the relative net costs of its portfolio of actions using these values.

M.Cubed estimated the costs of climate action measures based on several components as follows:

1) Upfront cost for a new or replacement technology.
2) Upfront cost for supporting infrastructure such as electric vehicle charging stations.
3) Comparative ongoing costs of the new or replacement technology versus the current conventional technology, which often results in net benefits because of lower energy prices and maintenance requirements. Ongoing costs are usually dominated by fuel and energy prices, and M.Cubed applied

forecasts for those prices. Where available, M.Cubed included other ongoing costs such as maintenance.

M.Cubed estimated the benefits based on a several components as follows:

1) Social benefit of GHG emissions, based on the US EPA's estimate of the long-term damage done by a ton of carbon dioxide emissions in a given year (known as the social cost of carbon) and projected reductions in GHG emissions for individual climate action measures.[12]

2) Social value of reduced criteria air pollutant emissions, such as oxides of nitrogen, reactive organic gases, and particulate matter, based on the US EPA's estimate of the long-term damage done by a ton of criteria air pollutant emissions in a given year projected emission reductions.

M.Cubed calculated the net present value of a range of costs and benefits of each climate action measure included in the analysis, meaning M.Cubed converted all future costs and benefits to a chosen year value by adjusting for the time value of money with a discount rate.[13] M.Cubed then divided the high and low estimates of the net present value of the cost of implementing the climate action measure by the high and low estimates of net present value of the emission reductions, to arrive at a range of dollars per ton for each climate action measure. These cost-effectiveness ranges can inform the County's decisions to prioritize investment of resources in the most cost-effective climate action measures.

3.2.1 Energy Measures & Actions

E-CO-1, E-CO-2 Increase Energy Efficiency and Electrification in County Buildings

For County facilities, the energy efficiency and electrification costs, savings and emission reductions are based on the near- and mid-term measures assessed in the Investment Grade Audit (IGA) Report prepared by Willdan.[14]

Two utility energy cost scenarios based on the two PG&E rate projections define many of the lower and higher cost ranges. The "GRC Scenario" reflects the Pacific Gas & Electric 2023 General Rate Case (GRC) revenue requirement authorized by the California Public Utilities Commission (CPUC) for electric and natural gas service, and the "IGA Scenario" is the one applied in the Investment Grade Audit Report. The IGA forecast projects a 4.5% increase in both electric and natural gas rates from the rates used in the study evaluation. The GRC forecast is based on an adopted decision by the CPUC that establishes PG&E's revenue requirements and rates through at least 2026 and approved the initial distribution line undergrounding program that will extend through 2030 and increase rates further.[15] This decision resulted in a 28% general rate increase from 2023 to 2024 with electricity rates rising 33% and natural gas rates by 26%.[16] Sonoma Clean Power Authority generation rates are tied to PG&E rates and will track those changes as well. For these

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[12] US EPA, *Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review": EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances*, Docket ID No. EPA-HQ-OAR-2021-0317, https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf, November 2023.

[13] The discount rate is an interest rate at which an individual or society is indifferent between accepting a payment today or accepting a payment in the future or over a series of years.

[14] Willdan, "Sonoma County Energy Project: Investment Grade Audit Report," March 15, 2024.

[15] CPUC Decision 23-11-069.

[16] The increases for different rate classes varied a couple percent either direction.

reasons, the GRC scenario forecasts are more reflective of the likely future energy costs. The GRC Scenario electric and natural gas forecasts are discussed in further detail in Appendix A, Section 4.

E-CP-6 Decarbonize and Electrify Community Buildings

M.Cubed estimated a range of net upfront costs for each electrification climate action measure based on the Local Energy Codes Reach Code reports as well as the ongoing net costs compared to the status quo alternatives.[17] These measures focus on replacing appliances and heating, ventilation, and air conditioning systems which use fossil fuels in new and existing buildings with electric appliances and heating, ventilation, and air conditioning systems. The analysis assumes homeowners or organizations will replace the appliances and heating, ventilation, and air conditioning systems at the end of their useful life. M.Cubed multiplied the energy use for the original use by the utility rate for natural gas and for the new use by the electricity rate. In this analysis, same GRC-based forecast is applied to the "GRC Scenario, and the "En Banc Scenario" reflects the forecast used in the Local Energy Codes Report drawn from the 2021 CPUC/California Energy Commission En Banc hearing on utility rates. M.Cubed used the projected greenhouse gas emission and criteria pollutant emission reductions to estimate the social value of emissions reductions.

E-CP-3 Increase Renewable Energy Generation and Storage

M.Cubed estimated a range of net upfront and ongoing costs for installing solar panels plus batteries on houses and community and facilities relative to continued electric service from a grid connected utility.[18] The greatest benefits accrue for climate resiliency for this measure since Sonoma Clear Power Authority (SCP) is projected to achieve 100% green energy by 2030; therefore, the cost-effectiveness based on emission reductions of these measures is expected to be otherwise poor. Resiliency value is not easily quantified except in collectively displacing high-cost undergrounding of existing power lines by PG&E to mitigate wildfire risk.

3.2.2 Transportation Measures and Actions

T-CO-1, T-CO-3, T-CO-5 Accelerate Transition to Electric Vehicles

The County is required by State Advanced Clean Fleet regulations to purchase only electric vehicles for its fleet by 2027.[19] For this reason, this analysis presents the amount the County will have to fund beyond any operational savings if there are net costs.

M.Cubed relied on a study prepared for the County that estimated the net cost of converting the County's fleet to electric vehicles compared to conventional internal combustion engine vehicles.[20] The study included vehicle purchase and charging infrastructure costs, the relative energy/fuel efficiency of each with the price of each energy/fuel type, the relative maintenance costs per mile (ongoing costs), and the net upfront cost of new charging station infrastructure per electric vehicle. M.Cubed also estimated a range of benefits using projected GHG emission and criteria pollutant emission reductions as described above. The evaluation uses

[17] The sources for these analyses are listed in Appendix A, Section 6.

[18] The sources for this analysis is listed in Appendix A, Section 5.

[19] CARB, Advanced Clean Fleets Regulation, https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-state-local-government-agency-fleet

[20] EV Refleet Inc. Fleet Electrification Assessment, Prepared for the County of Sonoma Public Infrastructure Department, January 9, 2024.

the GRC and En Banc Scenario forecasts along with Energy Information Administration *Energy Outlook* diesel and gasoline forecasts to develop net cost ranges.[21]

T-CO-4 Accelerate Transition to Electric Transit Buses

The analysis of T-CO-4 relies on the analysis conducted by the Sonoma County Transit (SCT) to convert its fleet of 64 CNG buses to electricity.[22] The SCT is required by State Advanced Clean Fleet regulations to purchase only electric vehicles for its fleet by 2029 and entirely zero emission by 2040.[23] For this reason, this analysis presents the amount the County will have to fund beyond any operational savings. The cost-effectiveness analysis uses the average cost per passenger revenue mile of $1.07 for the SCT in 2021,[24] and escalates the energy cost at the applicable Energy Information Administration and PG&E GRC and En Banc rate forecasts.[25]

T-CO-6 and T-CO-12 Reduce County Off-road Equipment Emissions

As with the on-road fleet, the County is required by State Advanced Clean Fleet and Small Off-Road Engine regulations to purchase only electric vehicles for its fleet and equipment by 2027.[26] For this reason, this analysis presents the amount the County will have to fund beyond any operational savings. M.Cubed estimated the net cost for electrifying off road equipment based on a cost analysis of the State's construction and off-road equipment fleet[27] and the incremental cost of using battery storage in heavy-duty trucks derived from five national studies.[28]

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[21] These forecasts are described further in Appendix A, Sections 3 and 4.

[22] Sonoma County Transit, *Innovative Clean Transit: Zero-Emission Bus Rollout Plan*, May 2023.

[23] CARB, Innovative Clean Transit (ICT) Regulation. https://ww2.arb.ca.gov/resources/fact-sheets/innovative-clean-transit-ict-regulation-fact-sheet

[24] Federal Transit Administration. (2023). The National Transit Database (NTD): 2021 Database Files. https://www.transit.dot.gov/ntd/data-product/2021-database-files

[25] These forecasts are described in Appendix A, Sections 3 and 4.

[26] CARB, Advanced Clean Fleets Regulation, https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-state-local-government-agency-fleet; and CARB, Small Off-Road Engines (SORE) Regulations. https://ww2.arb.ca.gov/our-work/programs/small-road-engines-sore/2021-amendments-small-road-engine-regulations

[27] CARB, "Staff Report: Initial Statement Of Reasons For Proposed Rulemaking--Proposed Regulation For In-Use Off-Road Diesel Vehicles," Mobile Source Control Division, https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2007/ordiesl07/isor.pdf, April 2007.

[28] Lude Rong, "Technical Assessment Report of the EDF Total Cost of Ownership Model for Fleet Planning," 2021; Chad Hunter, *et al*. 2021. *Spatial and Temporal Analysis of the Total Cost of Ownership for Class 8 Tractors and Class 4 Parcel Delivery Trucks. Golden, CO: National Renewable Energy Laboratory*, NREL/TP-5400-71796. https://www.nrel.gov/docs/fy21osti/71796.pdf, 2021; Andrew Burnham, et al ,. *Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains*, doi:10.2172/1780970, ANL/ESD-21/4, 2021; CARB Staff. *Draft Advanced Clean Fleets Total Cost of Ownership Discussion Document*, https://ww2.arb.ca.gov/sites/default/files/2021-08/210909costdoc_ADA.pdf, 2021; and ICF, *Comparison of Medium- and Heavy-Duty Technologies in California*, Prepared for California Electric Transportation Coalition and Natural Resources Defense Council, December 2019.

3.2.3 Wildfire Resilience Measures and Actions

WF-CP-2, WF-CP-3 Protect Carbon Sequestration

WF-CP-2 correlates with Natural and Working Lands measure NWL-CO-5 and the cost effectiveness of carbon sequestration is applied here. The reduction in wildfire risk has not yet been estimated for this measure so that benefit is not included.

The grazing plan for WF-CP-3 is among the measures identified for NWL-CP-4 and the methodology is described there. As with WF-CP-2, the benefits are measured in carbon sequestration because the reductions in wildfire risk have not yet been specified.

3.2.4 Lands Measures and Actions

W-CO-4, NWL-CO-2, NWL-CO-5, NWL-CP-4. Increase Carbon Sequestration

Applicable Climate Smart Practices are listed in the County of Sonoma Carbon Inventory and Sequestration Potential Study.[29] That study includes the cultivation ecosystem (e.g., cropland, orchard, vineyard, grazing, rangeland, forest), available acreage for a measure, and potential carbon sequestration. The California Department of Food and Agriculture Healthy Soils Program provides costs for the various climate smart practices that correspond with the U.S. Department of Agriculture National Resource Conservation Service (NRCS) conservation practices applicable to the specified measure.[30] M.Cubed allocated soil management costs over the expected life of soil sequestration.

4 SUMMARY OF RESULTS

M. Cubed estimated the GHG and total social cost per ton of emissions reductions for 17 local measures. Table 1 summarizes qualitatively for each of the climate action measures the magnitude of expected emission reductions and sequestration relative to the overall community inventory (small, moderate, or large) and the relative net cost effectiveness per metric ton of carbon dioxide equivalent (CO2e) GHG emissions. These include the total direct financial costs and benefits per ton of CO2e emissions reductions as well as total social value of benefits per ton of GHG and criteria air pollutants.[31] The costs per ton are categorized as ranges due to the inherent uncertainty in many dimensions including initial costs, energy price forecasts, technology performance and adoption rates, emission impacts and various public policies. This table shows the measures grouped by overall strategy.

[29] County of Sonoma, *Carbon Inventory and Sequestration Potential Study*, October 2023.

[30] CDFA, *Healthy Soils Block Grant Pilot Program*, Appendix A, 2023; County of Sonoma CARD, "Sonoma-Marin Ag and County Climate Coalition," NWL-CO-5-CSeq-Estimates.xlsx, 2024.

[31] Appendix B contains summaries of the calculations for most of these measures.

Table 1 - Sonoma County Climate Plan Measures Cost Effectiveness per Metric Ton CO2e

Measures & Actions	Scope	Description	Relative Community GHG Reduction	Rapid Payback Net Benefit >$1,000/ton	Lifetime Net Benefit $100-$1,000/ton	Societally Cost-Effective	Moderate Net Cost $100-$1,000/ton	High Net Cost >$1,000/ton
E-CO-1	County	Reduce energy use and increase resilience at existing County facilities in the near term through energy upgrades	Small	$$-	$-			
E-CO-2	County	Reduce energy use and increase resilience at existing County facilities in the mid-term through energy upgrades	Small			$=/=	$+	$$+
E-CP-3	Community	Promote renewables and microgrids	Small	$$-				
E-CP-6	Community	Incentivize energy efficiency and renewable energy uptake in communities						
		*New Construction by SCEIP/SCP on bill financing***	Moderate			$=/=	$+	$$+
		*Retrofits by SCEIP/SCP on bill financing***	Large		$-	$=/=	$+	
E-CP-7	Community	Prioritize and support energy efficiency and renewable energy access in underserved communities	Large		$-	$=/=	$+	
T-CO-1	County	Decarbonize the County fleet of light-duty vehicles (less than 8,500 lbs gross vehicular weight) by 2040*	Moderate	$$-				
T-CO-3	County	Decarbonize the County fleet of heavy-duty vehicles (greater than 8,500 lbs gross vehicular weight) by 2042*	Moderate			$=/=		
T-CO-4	County	Decarbonize the transit bus fleet by 2040*	Moderate					$$+
T-CO-5	County	Deploy zero emission vehicle infrastructure to ensure charging/fueling infrastructure is in place in locations to support the decarbonization schedule for light and heavy duty fleets.	Moderate	$$-				
T-CO-6	County	Decarbonize County non-road heavy-duty equipment by 2042*	Small					$$+
T-CO-12	County	Decarbonize County small offroad engines beginning in 2024 by requiring replacements and new purchases be zero-emission equipment*	Small					$$+

Measures & Actions	Scope	Description	Relative Community GHG Reduction	Rapid Payback Net Benefit >$1,000/ton	Lifetime Net Benefit $100-$1,000/ton	Societally Cost-Effective	Moderate Net Cost $100-$1,000/ton	High Net Cost >$1,000/ton
W-CO-4	County	Evaluate and prioritize conservation practice projects on County-owned lands to enhance water resilience and mitigate drought, flood, and debris flows	Small				$+	
WF-CP-3	Community	Reduce loss of existing carbon stocks due to wildfire through conservation of natural lands, conservation easements, new policies, and land acquisition	Large				$+	
WF-CP-4	Community	Reduce wildfire risk from vegetation fuels by developing and implementing a county-wide grazing plan	Large				$+	
NWL-CO-2	County	Increase coordination with tribes and opportunities for tribal collaboration of land management on County-owned lands by 2026, based on traditional and historic stewardship practices.	Small				$+	
NWL-CO-5	County	Increase carbon sequestration on County-owned lands by implementing beneficial practices described in the Carbon Stock Inventory and Potential Sequestration Study thru 2030.	Small				$+	
NWL-CP-4	Community	Increase carbon sequestration on croplands and working lands through soil carbon amendments, hedgerow planting, grassland restoration, and implementation of other climate-smart practices.	Large			$=/=	$+	
Notes	* -	Implementation required by state regulations						
	** -	Significant federal & state incentives available to households & businesses						

4.1 ENERGY

The set of County energy climate action measures aimed at upgrading and electrifying County facilities (E-CO-1 and E-CO-2) show a mix of net benefits and costs. The County is considering investing in sub-measures included in E-CO-1. The submeasures in E-CO-1 range from rapid payback net benefit to lifetime net benefit when compared to the array of available measures; those in E-CO-2 range from societally cost effective to high net cost. The energy efficiency activities are generally more cost effective than those aimed at electrification of buildings. The total emission reductions would be small to moderate on the community scale, but large for County operations.

The distributed energy resources microgrid measure E-CP-3 would derive its benefits from displacing PG&E's proposed powerline undergrounding program. E-CP-3 is cost-effective relative other climate action measures because renewables and microgrids can displace PG&E's proposed powerline undergrounding program thus significantly lowering electric rates and hastening electrification. Installing community and individual microgrids, combined with the already existing fast-trip system also would reduce wildfire risk an equivalent amount while maintaining the same level of service reliability. Installing community and individual microgrids, combined with the already existing fast-trip system would reduce wildfire risk an equivalent amount while maintaining the same level of service reliability.[32] Some undergrounding might be required for the community systems but that would be a small percentage of the 10,000 miles that PG&E has proposed. While PG&E's program is projected to cost nearly $40 billion through 2030, installing microgrids in this way on net would cost less than $15 billion while also delivering more renewable power. Sonoma County could be in a particularly strong position to influence the direction of this program both because of the county's exposure to wildfire risk and the relative influence of its CCA at the CPUC. The community reduction benefit is small, however, as the total amount of GHG emissions this measure is expected to reduce is small relative to other measures.

The financing programs to incentivize electrification and energy efficiency through the SCEIP and SCP on-bill financing (E-CP-6) and targeting low-income communities (E-CP-7) show a wide cost range that depends on application and setting. Residential customers are more likely to see lower costs than commercial non-residential. Multi-family electrification retrofits show the largest net benefits; new construction of certain types of commercial space is the costliest option. The many federal programs now available can cover substantial portions of these costs, making the investments more achievable. The net costs also are highly dependent on how much PG&E's electric and gas rates increase over the next several decades. New construction could provide a moderate emission reduction while widespread retrofits could result in a large reduction.

4.2 TRANSPORTATION

As noted in 3.1.2, electrifying the County on-road, off-road, and transit fleets is required under State regulation. Converting the County's vehicle fleet to electric is highly beneficial for light-duty cars (T-CO-1) and about break-even for light- and medium-duty trucks (T-CO-3).[33] (The charging infrastructure costs [T-CO-5] are included in the over fleet conversion costs.) Converting the transit fleet from natural gas to electric (T-CO-4) has a moderate net cost due to CNG already delivering lower fuel cost than diesel. The total emission reductions would be moderate on the community scale, but large for County operations.

[32] Warner et al (2024); McCann (2022) and McCann and Moss (2023).

[33] The County fleet inventory showed only three heavy-duty trucks.

Decarbonizing the County government's off-road equipment fleet (T-CO-6) and small engines (T-CO-13) are expensive at the moment because there is little experience in the market with electric vehicles and manufacturers are not yet offering more than a few specialized models.[34] This equipment generally does not use much fuel so energy cost savings do not offset higher purchase costs. Nevertheless, converting this fleet is also required by State regulations. GHG emission reductions would be small as this equipment does not burn much fuel, but criteria pollutant emissions would be relatively larger as this equipment uses diesel fuel and emission controls are not as effective as on-road due to rougher duty cycles.

4.3 WILDFIRE MITIGATION

The two wildfire mitigation measures (WF-CP-2, WF-CP-3) have significant carbon sequestration value which makes them relatively inexpensive. Each is at or near the societally cost-effective threshold. Their values for mitigating wildfire risk could not be measured due to the lack of information on the effectiveness of those strategies. These would likely mitigate a significant portion of the county inventory. If each is successful in reducing wildfire risk, the carbon savings could be substantially larger.

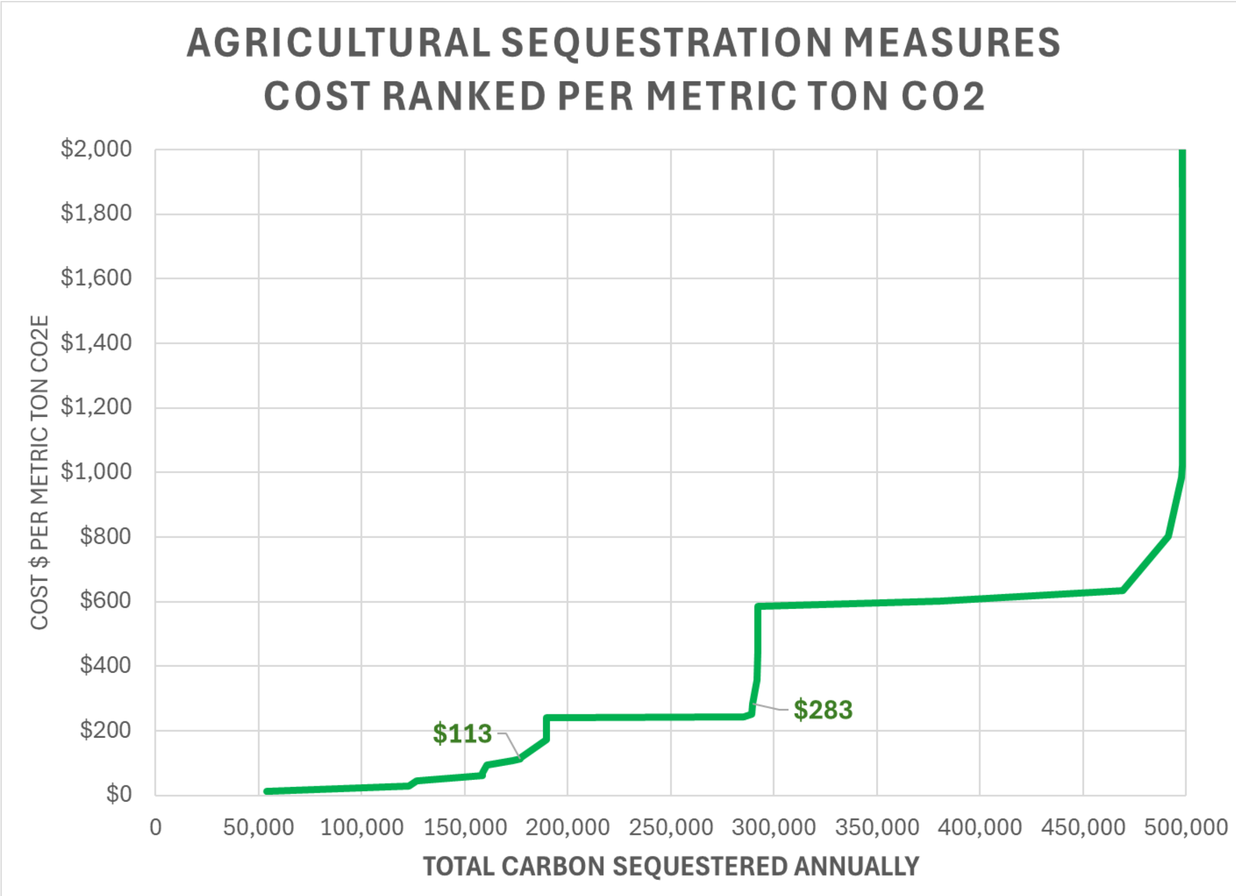
4.4 NATURAL AND WORKING LANDS

The four measures (NWL-CO-2, NWL-CO-5, NWL-CP-4 plus W-CO-4) generally cost less than $300 per metric ton with the ability to deliver nearly 300,000 tons of sequestration annually. This represents a substantial portion of the county's GHG emission inventory. With the additional benefit from the social cost of carbon, these measures approach the break-even benchmark. Figure 1 shows the direct cost-effectiveness curve for incremental carbon sequestration assuming that all available and appropriate lands in the county are included. Sequestering about 300,000 metric tons annually would cost about $250 per ton before deducting the social value of carbon reductions of $110 per ton. Reaching 300,000 acres would cost about $120 per acre.

Notably a county-wide prescribed grazing on up to 140,000 acres could sequester almost 13,000 metric tons at a cost of $16 per acre. Grazing focused on native oak restoration on 50,000 acres would cost $40 per acre and sequester nearly 70,000 metric tons.

[34] The CARB In-Use Off-Road Diesel-Fueled Fleets Regulation requires fleets to reduce their emissions by retiring, replacing, or repowering older engines, or installing Verified Diesel Emission Control Strategies, requires the phase-out of the oldest and dirties engines starting on January 1, 2024, and requires the procurement and use of renewable diesel (R99 or R100) starting January 1, 2024, with limited exceptions.

Figure 1



These measures would form the core of the Carbon Mitigation Bank proposed as a potential financing option for the County's overall program as described in the *Funding & Financing Strategy 2024-2027*.

Two County-sponsored studies estimate the overall co-benefits from natural and working lands beyond sequestration. Most recently as part of the Carbon Inventory and Sequestration Potential Study, the Climate Action and Resiliency Division identified the range of co-benefits by land use, providing a qualitative score for each.[35] Those scores are not yet translated to monetary values that can be used in this cost-benefit analysis but is a building block to that end. An earlier study was conducted for Sonoma County Agriculture and Open Space that estimated the economic values for different land use types.[36] That study uses data that is now obsolete but it could be merged with Potential Study analysis to estimate incremental co-benefits for the activities included in the measures in this strategy.

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[35] CARD, "Carbon Inventory and Sequestration Potential Study: Analysis of Co-Benefits of Climate Smart Practices," County of Sonoma with Rincon Consultants, October 2023.

[36] Sonoma County Ag + Open Space. (2018). *Healthy Lands & Healthy Economies: The Multiple Benefits of Sonoma County Working and Natural Lands.* Santa Rosa, CA.

APPENDIX A: COMMON DATA AND FORECAST SOURCES AND METHODOLOGICAL APPROACHES

This appendix discusses data, forecasts and methodological approaches that are commonly applied across the economic analyses. In general, where such a source or approach is not specified, the analysis relies on inputs from the workpapers used to assess the GHG emission reductions for individual actions in the Climate Plan. In some cases, the costs for County government actions presented in the Implementation Cost Report workpapers are applied to community costs for similar activities. Calculating the economic costs, benefits and externalities relies on additional data and forecasts described below that are common across actions (e.g., energy price forecasts.)

1 CAPITAL COSTS AND FINANCIAL INDICATORS

Capital costs are converted to an annual levelized basis for the lifetime of the asset (just as a lump sum house mortgage loan is converted to a monthly payment) in order to be comparable to annual operations and maintenance costs, annual on bill utility impacts and annual social cost of carbon and value of criteria pollutants estimates.[37] The per unit capital cost values on a present value basis and are subsequently converted to an annual levelized cost based on the appropriate fixed charge ratio for that action's sector and useful life.

Adjustments to costs and benefits to 2024-dollar levels are calculated using consumer and producer price indices reported by the Federal Reserve Bank of St. Louis.[38]

Debt and loan rates are drawn from data reported by the Federal Reserve Bank.[39] Data used includes personal and automobile loan rates, house mortgage rates and Moody's 20-year average annual seasoned Baa corporate bond yield.

2 HOUSING AND POPULATION DATA

U.S. Census American Community Survey data was used to determine the proportion of housing stock by vintage and single versus multi-family in Sonoma County.[40] The survey was also used to find the number of units in housing structures and the house heating fuel.

[37] A common type of levelized annual payment is a mortgage payment on a house loan.

[38] St Louis Fed. (2023). Consumer Price Index for All Urban Consumers: All items in San Francisco-Oakland, CA (CBSA). Federal Reserve Economic Data | FRED | St. Louis Fed. https://fred.stlouisfed.org/series/CUUSA424SA0

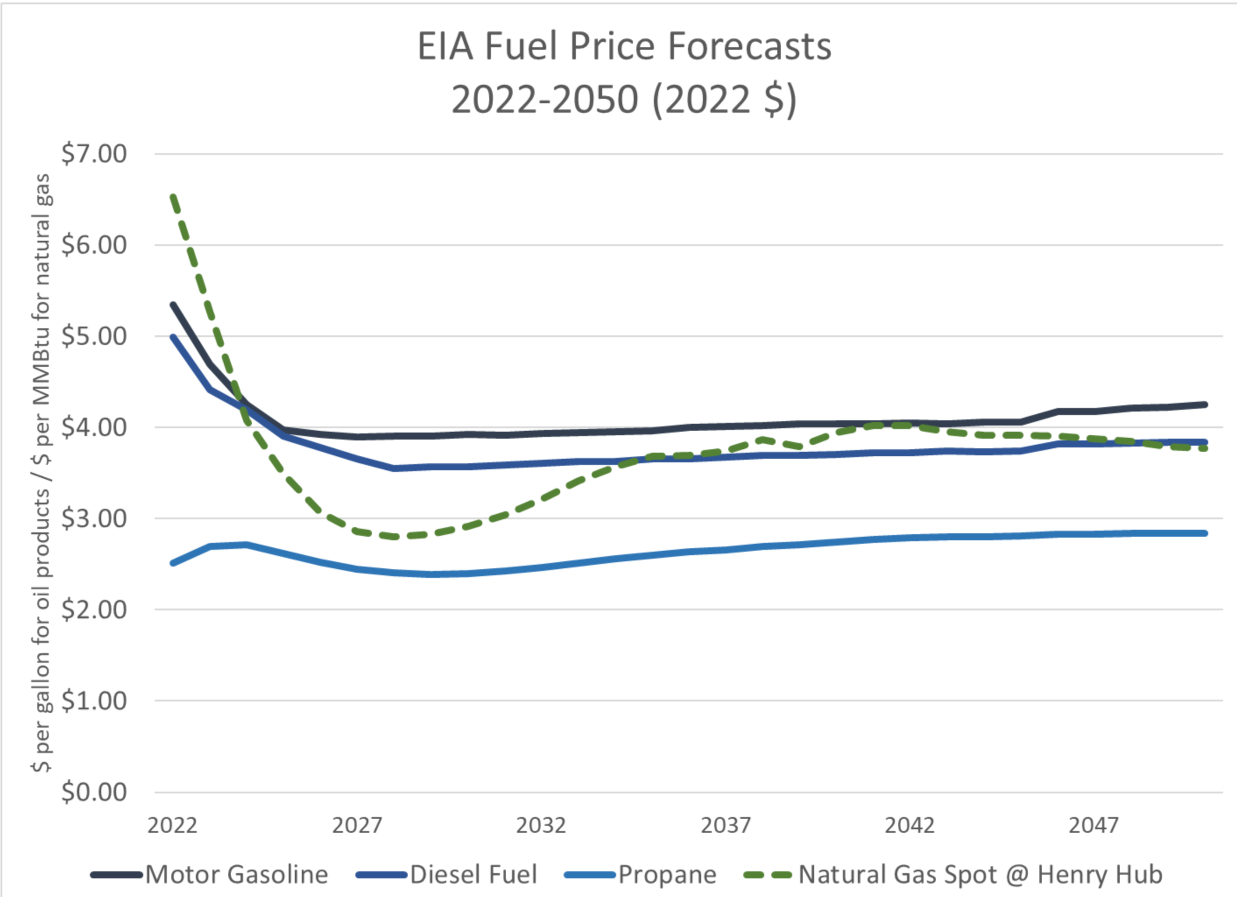
[39] St. Louis Fed. (2023). 30-Year Fixed Rate Mortgage Average in the United States. Federal Reserve Economic Data | FRED | St. Louis Fed. https://fred.stlouisfed.org/graph/?g=18T1a#0; St Louis Fed. (2023). Finance Rate on Personal Loans at Commercial Banks, 24-Month Loan. Federal Reserve Economic Data | FRED | St. Louis Fed. https://fred.stlouisfed.org/series/TERMCBPER24NS; St Louis Fed. (2023). Finance Rate on Consumer Installment Loans at Commercial Banks, New Autos 48 Month Loan. Federal Reserve Economic Data | FRED | St. Louis Fed. https://fred.stlouisfed.org/series/TERMCBPER24NS; St Louis Fed. (2023). Moody's Seasoned Baa Corporate Bond Yield, Percent, Annual, Not Seasonally Adjusted. Federal Reserve Economic Data | FRED | St. Louis Fed. https://fred.stlouisfed.org/series/BAA.

[40] U.S. Census Bureau. (2022). American Community Survey Data. Census.gov. https://www.census.gov/programs-surveys/acs/data.html

3 PETROLEUM PRODUCTS PRICE FORECASTS

For this analysis, the starting price is the one used in the base analysis and that is escalated at the corresponding forecast rate. Figure A-1 shows the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook 2023* forecasts for petroleum products and commodity natural gas (i.e., the product delivered through pipelines). The EIA forecasts a reversion to recent historic levels from a spike in 2022, and then little change in terms of constant 2022 dollars.

Figure A-1



3.1 GASOLINE AND DIESEL PRICES

Current gasoline prices are based on EIA weekly Los Angeles retail gasoline prices, using an average of weekly prices for 2022.[41] That price is then escalated based on the motor gasoline price forecast in the EIA's *Annual Energy Outlook 2023*.[42]

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[41] EIA. (2023). Weekly Los Angeles Regular All Formulations Retail Gasoline Prices (Dollars per gallon). U.S. Energy Information Administration (EIA). https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMM_EPMR_PTE_Y05LA_DPG&f=W

[42] EIA. (2023). Annual Energy Outlook 2023. Table 12. Petroleum and Other Liquids Prices. U.S. Energy Information Administration (EIA). https://www.eia.gov/outlooks/aeo/data/browser/#/?id=12-AEO2023&cases=ref2023&sourcekey=0

3.2 PROPANE PRICES

Propane prices are based on a three-year average of weekly U.S. residential propane prices from EIA.[43] That price is then escalated based on the residential propane price forecast in the EIA's *Annual Energy Outlook 2023*.[44]

3.3 NATURAL GAS PRICES

Commodity natural gas prices are based on the EIA's 2023 Annual Energy Outlook forecast for Henry Hub spot prices. These prices are then adjusted to delivered residential and commercial utility rates by EIA.

4 PG&E UTILITY RATES FORECASTS

As discussed in the section on Cost-Benefit Analysis Method, the initial investments are weighed against the discounted net present value of the operational and energy costs for a future period. That discounted net present value is largely dependent on the price forecasts for each energy source, be it electricity, natural gas, diesel, or gasoline. Electricity and natural gas are provided by regulated utilities for which underlying future costs can be well understood and the forecasts can be done with a fair amount of certainty, with exceptions. The wildfires that hit Sonoma in 2017 triggered a big increase in spending by PG&E which in turn has pushed electric rates upward. A significant change in State policy with regard to natural gas in response to the threat of climate change also has increased those rates.

PG&E is the distribution utility for electricity and gas for the vast majority of customers in the county.[45] Sonoma Clean Power Authority (SCP) is a community choice aggregator (CCA) that supplies the energy generation portion of electric service to the majority of customers in the county. SCP pegs its generation component rates as a small percentage discount of PG&E bundled rates so the forecast of PG&E rates is representative of the overall trend including SCP rates.

Figure A-2 compares the *electric* residential and commercial rates forecasts for the GRC Scenario and CPUC En Banc Scenario. Figure A-3 compares the *natural gas* residential and commercial rates forecasts for the GRC Scenario and CPUC En Banc Scenario. While the GRC Scenario rates are higher than the En Banc in both cases, natural gas rates grow faster, which in turn makes electricity more competitive for electrification. The high GRC electricity prices make energy efficiency investments more beneficial because bill savings are larger and repay investments more quickly.

The two measures addressing GHG emission reductions at County facilities (E-CO-1 and E-CO-2) reported in the IGA Report rely on a third forecast developed by the project consultant. It starts with PG&E's 2023 rates and increases at 4.5% per annum.

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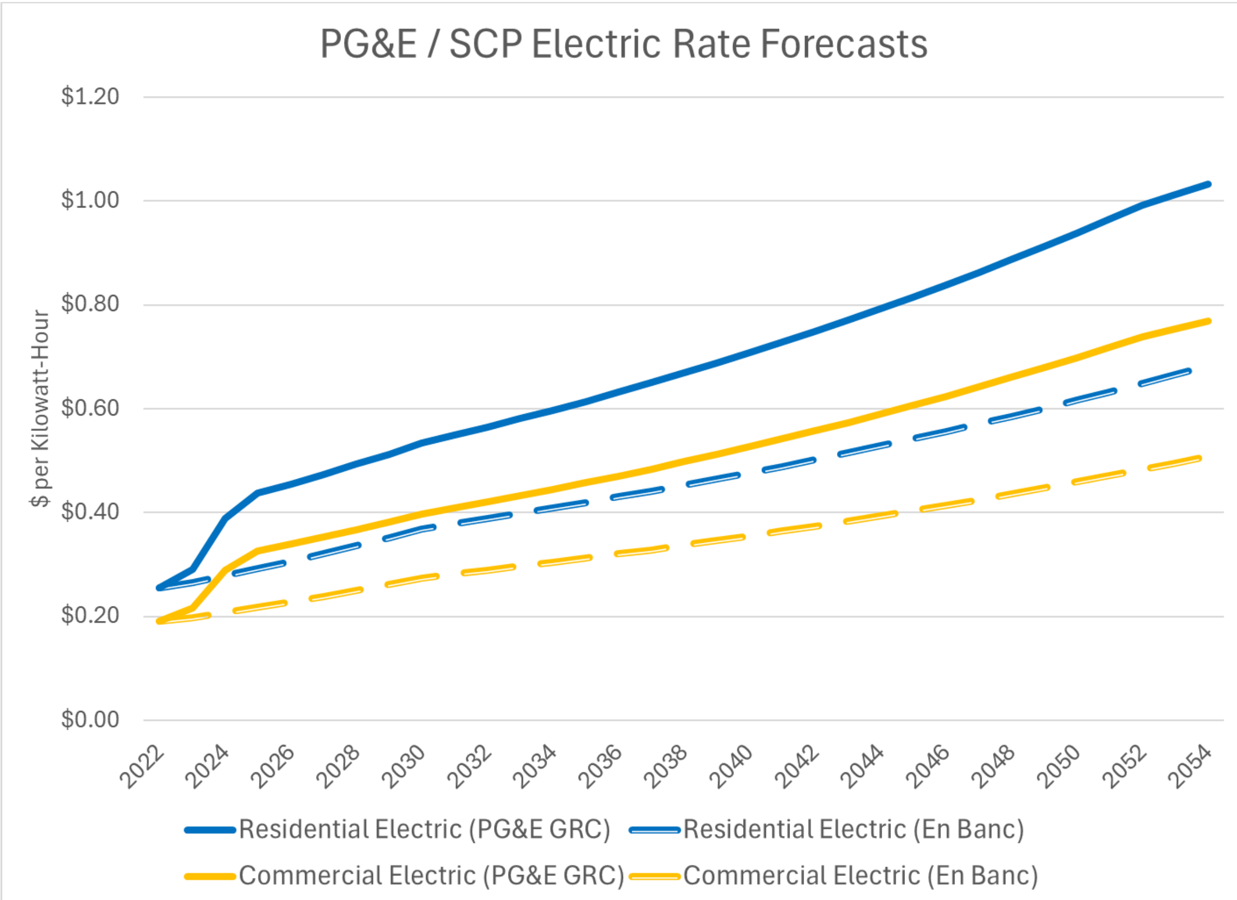
[43] EIA. (2023). Weekly U.S. Propane Residential Price (Dollars per Gallon). U.S. Energy Information Administration (EIA). https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_EPLLPA_PRS_NUS_DPG&f=W

[44] EIA (2023). 2023 AEO, op. cit.

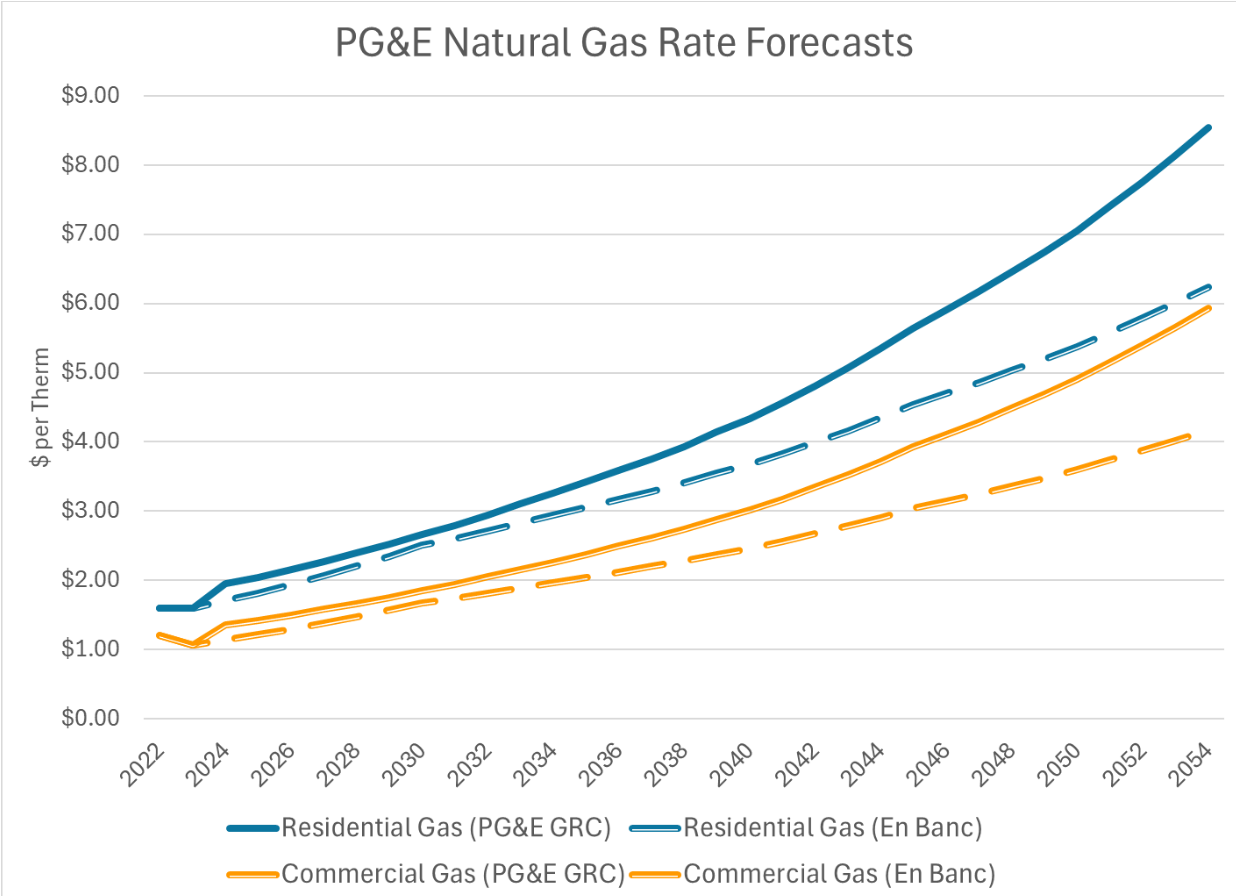
[45] Healdsburg has a municipal electric utility.

Figure A-2



PG&E / SCP Electric Rate Forecasts
$ per Kilowatt-Hour
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050
2052
2054
Residential Electric (PG&E GRC)
Residential Electric (En Banc)
Commercial Electric (PG&E GRC)
Commercial Electric (En Banc)

Figure A-3



4.1 CPUC EN BANC FORECAST

Electric and natural gas system average utility rate forecasts to 2050 for PG&E were taken from a comprehensive CPUC En Banc White Paper issued in 2021.[46] This forecast is the current baseline forecast for the California Energy Codes and Standards studies on building electrification and energy efficiency used in evaluating E-CP-6. Because these studies are a key building block for the cost-effectiveness analysis presented here, this forecast is used as a lower bound on potential electric and gas rates. However, it has become increasingly obvious this forecast is now obsolete.

[46] CPUC. (2021). *Utility Costs and Affordability of the Grid of the Future, En Banc White Paper*. California Public Utilities Commission. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/en-banc/senate-bill-695-report-2021_en-banc-white-paper.pdf

4.2 PG&E 2023 GRC ELECTRIC RATES FORECAST

The CPUC issued a decision in PG&E's 2023 General Rate Case Phase 1 application that set the revenue requirements for the majority of PG&E's operations for 2023 to 2026.[47] In addition, PG&E's commitment to undergrounding rural lines through 2030, its large portfolio of renewable generation on fixed prices, and the State Legislature's extension of the life of Diablo Canyon Nuclear Generating Station through 2030 largely fixes most of PG&E's revenue requirements to the end of the decade. To estimate the average cents per KWH percent price increase over 2022 for residential and small commercial applications until 2027, that revenue requirement was divided over the California Energy Commission's 2022 Forecast Update.[48] That trend was projected to 2030 to reflect continuation of those circumstances. Estimated PG&E electric rate escalation (%/year) was projected from 2030 to 2052 using adjusted En Banc escalation rates plus a 2% inflation rate.

4.3 PG&E 2024 GRC NATURAL GAS RATES FORECAST

The natural gas rate forecast for residential and small commercial rates is based on the revenue requirements set for PG&E in its 2023 GRC proceeding through 2026.[49] Initial rates were updated to 2022 based on EIA data.[50] Estimated PG&E natural gas rate escalation (% per year) is projected from 2027 to 2052 using adjusted En Banc escalation rates.

5 SOLAR POWER AND MICROGRID COSTS

The National Renewable Energy Laboratory prepared analyses of individual household and community microgrids which are used to calculate distributed energy resources (DER) average costs for residential and community-scale deployments.[51] These include the installation costs after applicable tax credits as of 2021 and are translated to annualized cents per kilowatt-hour for comparison to the alternatives. These costs are compared to PG&E's costs for undergrounding power lines in high fire threat districts (HFTD) as reported in its 2023 General Rate Case application.[52]

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[47] CPUC, Decision 23-11-069.

[48] California Energy Commission. (2022). California Energy Demand Update, 2022-2035. https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2022-integrated-energy-policy-report-update-2

[49] CPUC, Decision 23-11-069.

[50] EIA. (2023). California Price of Natural Gas Delivered to Residential Consumers (Dollars per thousand cubic feet). U.S. Energy Information Administration. https://www.eia.gov/dnav/ng/hist/n3010ca3a.htm

51 Vignesh Ramasamy, et al, U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks: Q1 2021, National Renewable Energy Laboratory, Technical Report NREL/TP-7A40-80694, https://www.nrel.gov/docs/fy22osti/80694.pdf, November 2021; and Vignesh Ramasamy, et al, U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks: Q1 2020, National Renewable Energy Laboratory, Technical Report NREL/TP- 6A20-77324, https://www.nrel.gov/docs/fy21osti/77324.pdf, January 2021.

[52] PG&E, 2023 General Rate Case Application, workpapers, A.21-06-021.

6 BUILDING ELECTRIFICATION AND ENERGY EFFICIENCY

Studies prepared by California Energy Codes and Standards calculated changes in customer costs for Reach Code standards for new residential and non-residential construction.[53] The cases used in the Climate Plan analysis are all-electric efficiency and mixed fuel efficiency. The studies' baseline utility rate forecasts were drawn from the CPUC En Banc report. Those cost differences were adjusted to match the authorized revenue requirements for PG&E's 2023 GRC to create a second scenario as described in Appendix A, Section 4.

Studies prepared by California Energy Codes and Standards group calculated changes in customer costs for retrofit standards for existing residential housing.[54] Retrofits for existing non-residential buildings did not include quantified financial data, so those are excluded, which introduces additional uncertainty in the estimate for this action.[55] The cases used in the Climate Plan analysis are all-electric efficiency and mixed fuel efficiency.

Consistent with the Reach Code studies, the analyses assume conversion of natural gas uses to electricity for space heating and water heating using heat pumps. These appliances consume about 28% of the energy for conventional resistance heating. The electricity demand forecasts used to estimate the power bills and criteria pollutant externality costs reflect heat pump use.

7 VALUATION OF EXTERNALITIES

7.1 SOCIAL COST OF CARBON

The social cost of carbon is a metric used by the US EPA and other federal agencies to estimate the value to society of CO2e reductions based on the impacts of climate change on agricultural productivity, human health, and flood risk.[56] It is a dollar-based assessment of the negative impact that carbon dioxide emissions have in a given year. Conversely, it represents the benefit of avoided damages from an incremental reduction in carbon dioxide. This study relies on values developed by the EPA for 2030 through 2050, under their 3%

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[53]California Energy Codes and Standards. (2022). Cost-Effectiveness Study: Multifamily New Construction. Updated 2023. https://localenergycodes.com/download/1552/file_path/fieldList/2022%20Multifamily%20NewCon%20Cost-Eff%20Report.pdf; California Energy Codes and Standards. (2022). Nonresidential New Construction Reach Code Cost-effectiveness Study. Updated 2023. https://localenergycodes.com/download/1266/file_path/fieldList/2022%20Nonres%20New%20Construction%20Cost-eff%20Report.pdf

[54] California Energy Codes and Standards. (2019). Cost-Effectiveness Study: Existing Multifamily Residential Building Upgrades. Updated 2022. https://localenergycodes.com/download/986/file_path/fieldList/Low-rise%20Multifamily%20Retrofits-Cost-eff%20Report.pdf; California Energy Codes and Standards. (2019). Cost-Effectiveness Study: Existing Single Family Residential Building Upgrades. Updated 2021. [No longer available on line.]

[55] California Energy Codes and Standards. (2021). Reach Code Cost-Effectiveness Analysis: Non-Residential Alterations. Updated 2022. https://localenergycodes.com/download/1266/file_path/fieldList/2022%20Nonres%20New%20Construction%20Cost-eff%20Report.pdf

[56] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. February 2021. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

average discount rate scenario, representing a mid-range value of the impact.[57] The social cost of carbon value used in this analysis is $72 per ton in 2030 and $94 in 2045, in 2022 dollars.

7.2 AVOIDED CRITERIA POLLUTANTS

The value of avoided criteria pollutants is based on the US EPA's Co-Benefits Risk Assessment (COBRA) software, which allows users to estimate the economic value of morbidity and mortality impacts of clean energy policies.[58] COBRA estimates the health benefits of emission reductions on a net present value over 20 years. The software estimates the value to Sonoma County of a particular scenario of emissions reductions, including particulate matter, sulfur dioxide, nitrogen oxides, ammonia, and volatile organic compounds, from a particular emissions tier or sector, for example 'light-duty gasoline highway vehicles.' For each GHG-reduction action, co-occurring criteria pollutant emissions were estimated. A COBRA scenario for the appropriate sector of the economy was created to estimate the benefit of reduced air pollutants.

Several sources listed below were used to calculate current and forecasted criteria pollutant emission rates.

7.2.1 Electricity Emissions

Data reflecting the mix of generating resources were used to estimate emissions associated with electricity use, assuming conventional generation decreases in line with California's Renewable Portfolio Standard (RPS) benchmarks. According to the RPS, utilities are required to achieve 60% renewables by 2030 and 100% carbon-free (composed mostly of renewables) by 2050. SCP is building its portfolio to achieve 100% carbon-free generation by 2030. Over 90% of county households as well as County service accounts are served by SCP. This means that the GHG emissions from electricity serving these customers are deminimis.

The EIA's State Electricity Profiles include data on net generation and criteria pollutant emissions by fuel type for California's mix of electricity generation resources.[59] Criteria pollutant emissions were assumed to decrease in relationship with declining GHG emissions from the electricity fleet.

7.2.2 EMFAC Transportation Emissions Forecast Model

The California Air Resources Board's EMFAC fleet database and emissions inventory provide information on the population of vehicles by type and fuel source, along with fuel usage and emissions for a range of pollutants.[60] Weighted fleet averages for emissions and fuel efficiency are calculated from the model's data and forecasts. EMFAC's 2021 data is the latest emissions inventory data available at the county level for Sonoma.

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[57] US EPA. (2017). The Social Cost of Carbon, US EPA. United States Environmental Protection Agency. https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html; and Executive Order 12866 (May 2013, Revised August 2016).

[58] US EPA (2023). *Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA).* https://www.epa.gov/cobra

[59] EIA (2022). California Electricity Profile 2021. https://www.eia.gov/electricity/state/California/

[60] California Air Resources Board EMFAC. https://arb.ca.gov/emfac/emissions-inventory; https://arb.ca.gov/emfac/fleet-db

7.2.3 U.S. Bureau of Transportation Statistics

Average vehicle CO, HC, NOx, SOx and PM2.5 emissions are determined by vehicle type based on U.S. Bureau of Transportation Statistics data and forecasts.[61] Emissions are forecasted from 2019 to 2030.

[61] BTS. (2021). Estimated U.S. Average Vehicle Emissions Rates Per Vehicle By Vehicle Type Using Gasoline And Diesel. Bureau of Transportation Statistics. Table 4-43. https://www.bts.gov/content/estimated-national-average-vehicle-emissions-rates-vehicle-vehicle-type-using-gasoline-and.

APPENDIX B – SUPPORTING CALCULATIONS

8 APPENDIX B – SUPPORTING CALCULATIONS

Measures & Actions	Scope	Description	Emission Reductions / Sequestered (Mtons)	Net Cost per ton CO2e Low	Net Cost per ton CO2e High
E-CO-1	County	Reduce energy use and increase resilience at existing county facilities in the near term by:	400	($1,300)	($150)
E-CO-2	County	Reduce energy use and increase resilience at existing county facilities in the mid term by:	5,900	$440	$640
E-CP-3	Community	Promote renewables and microgrids		($3,700)	($2,900)
		Incentivize energy efficiency and renewable energy uptake in communities			
E-CP-6	Community	New Construction by SCEIP/SCP on bill financing		($60)	$4,100
		Retrofits by SCEIP/SCP on bill financing		($290)	$660
E-CP-7	Community	Prioritize and support energy efficiency and renewable energy access in underserved communities		*see E-CP-6*	
T-CO-1	County	Decarbonize the County fleet of light duty vehicles (less than 8,500 lbs gross vehicular weight) by 2040.	5,100	($1,400)	($1,300)
T-CO-3	County	Decarbonize the fleet of Heavy Duty vehicles (greater than 8,500 lbs gross vehicular weight) by 2042.	1,400	($10)	$0
T-CO-4	County	Decarbonize the transit bus fleet by 2040.		$1,930	$1,950
T-CO-5	County	Deploy zero emission vehicle infrastructure to ensure charging/fueling infrastructure is in place in locations to support the decarbonization schedule for light and heavy duty fleets.		*see T-CO-1*	
T-CO-6	County	Decarbonize non-road heavy duty equipment by 2042.		$2,100	$3,100

Measures & Actions	Scope	Description	Emission Reductions / Sequestered (Mtons)	Net Cost per ton CO2e Low	Net Cost per ton CO2e High
T-CO-13	County	Decarbonize small offroad engines beginning in 2024 by requiring replacements and new purchases be zero-emission equipment.		$1,300	$2,000
W-CO-4	County	Evaluate and prioritize conservation practice projects on County-owned lands to enhance water resilience and mitigate drought, flood, and debris flows		*see NWL-CO-5*	
WF-CP-3	Community	Reduce loss of existing carbon stocks due to wildfire through conservation of natural lands, conservation easements, new policies, and land acquisition		*see NWL-CO-5*	
WF-CP-4	Community	Reduce wildfire risk from vegetation fuels by developing and implementing a county-wide grazing plan	13,000	$160	$190
NWL-CO-2	County	Increase coordination with tribes and opportunities for tribal collaboration of land management on County-owned lands by 2026, based on traditional and historic stewardship practices.		*see NWL-CO-5*	
NWL-CO-5	County	Increase carbon sequestration on County-owned lands by implementing beneficial practices described in the Carbon Stock Inventory and Potential Sequestration Study thru 2030.	170	$150	$190
NWL-CP-4	Community	Increase carbon sequestration on croplands and working lands through soil carbon amendments, hedgerow planting, grassland restoration, and implementation of other climate-smart practices.	290,000	$110	$310

E-CO-1 **Reduce energy use and increase resilience at existing County facilities in the near term**

ECM #	ECM Description	Annualized Savings (GRC)	Net Direct Cost per Ton CO2e (GRC)	Annualized Savings (Wildan)	Net Direct Cost per Ton CO2e (Wildan)
ECM-1	LED Lighting	$472,220	($7,447)	$283,817	($4,476)
ECM-2	HVAC Upgrades	($128,202)	$1,376	($127,311)	$1,366
ECM-3	BMS Upgrades	($413,821)		($413,821)	
ECM-4	Solar PV	$727,053	($6,951)	$416,299	($3,980)
ECM-5	BESS (Battery Energy Storage System)	($275,840)	($188,609)	($271,496)	($185,638)
ECM-6	Water Conservation	$176,441	($1,005)	$156,726	($892)
ECM-7	High Efficiency Transformers	$1,708	($1,465)	($1,758)	$1,507
ECM-8	Heat Pump DHW	($6,371)	$366	($6,094)	$350
ECM-9	CMP Chiller Schedule Update	$0		$0	
	IGA Fee	($17,652)		($17,652)	
	ECA Fee	($1,961)		($1,961)	
-	**Project Totals**	**$533,575**	**($1,176)**	**$16,750**	**($37)**
		with SCC =	***($1,284)***		***($146)***

E-CO-2 **Reduce energy use and increase resilience at existing County facilities in the mid term**

SCOPE #	ENERGY CONSERVATION MEASURE	Annualized Savings (GRC)	Net Direct Cost per Ton CO2e (GRC)	Annualized Savings (Wildan)	Net Direct Cost per Ton CO2e (Wildan)
1	HVAC Upgrade	($2,301,796)	$1,535	($2,057,505)	$1,372
2	HHW upgrade	($1,070,473)	$269	($304,494)	$76
3	Heat Pump DHW heaters	($487,173)	$591	($315,986)	$383
4	Gas consuming kitchen equipment	($258,977)	$1,702	($169,678)	$1,115
5	High Efficiency Transformers	$24,496	($5,040)	$8,882	($1,827)
6	EV Chargers	($585,219)	$24,496	($544,926)	$22,810
7	Spud Point Icehouse	($192,448)	$320,746	($194,377)	$323,961
		($4,851,536)	**$751**	**($3,578,084)**	**$552**
		with SCC =	***$642***		***$443***

E-CP-6 Incentivize energy efficiency and renewable energy uptake in communities

Residential New		**2021 CPUC En Banc rate forecasts**			**2023 PG&E GRC rate forecasts**		
Single Family	**Climate Zone**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**
All-Electric Efficiency	CZ01	$167	$103	1.7%	$741	$459	1.7%
All-Electric Efficiency	CZ02	$123	$131	98.3%	$520	$550	98.3%
County Avg.		$124	$130	***65.5%***	$524	$549	***65.5%***
Multi Family							
All-electric prescriptive	CZ01	($287)	($430)	1.7%	($133)	($199)	1.7%
All-electric prescriptive	CZ02	$47	$85	98.3%	$163	$297	98.3%
County Avg.		$41	$76	***34.4%***	$158	$288	***34.4%***
County Avg.		**$95**	**$112**		**$397**	**$459**	

Single Family	**Climate Zone**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**
Mixed Fuel Efficiency	CZ01	($153)	($363)	1.7%	($210)	($501)	1.7%
Mixed Fuel Efficiency	CZ02	($96)	($383)	98.3%	($156)	($623)	98.3%
County Avg.		($97)	($383)	***65.5%***	($157)	($621)	***65.5%***
Multi Family							
Mixed fuel efficiency	CZ01	$7	$4,547	1.7%	$6	$3,853	1.7%
Mixed fuel efficiency	CZ02	$7	$4,547	98.3%	($0)	($224)	98.3%
County Avg.		$7	$4,547	***34.4%***	($0)	($156)	***34.4%***
County Avg.		**($61)**	**$1,313**		**($103)**	**($460)**	

Nonresidential New		2021 CPUC En Banc rate forecasts			2023 PG&E GRC rate forecasts		
Medium Office	**Climate Zone**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**
All-Electric Efficiency	CZ01	$19,929	$8,201	1.7%	$33,372	$13,733	1.7%
All-Electric Efficiency	CZ02	$8,606	$15,098	98.3%	$15,907	$27,907	98.3%
County Avg.		$8,795	$14,983	*19.5%*	$16,198	$27,670	*19.5%*
Retail							
All-Electric Efficiency	CZ01	($4,322)	($1,771)	1.7%	($6,663)	($2,731)	1.7%
All-Electric Efficiency	CZ02	($5,238)	($1,864)	98.3%	($8,045)	($2,863)	98.3%
County Avg.		($5,223)	($1,863)	*45.8%*	($8,021)	($2,861)	*45.8%*
Quick Serve Restaurant							
All-Electric Efficiency	CZ01	$23,472	$561	1.7%	$36,990	$884	1.7%
All-Electric Efficiency	CZ02	$25,390	$707	98.3%	$39,320	$1,095	98.3%
County Avg.		$25,358	$704	*31.0%*	$39,281	$1,091	*31.0%*
Small Hotel							
All-Electric Efficiency	CZ01	$34,983	$527	1.7%	$64,071	$964	1.7%
All-Electric Efficiency	CZ02	$23,685	$458	98.3%	$46,805	$905	98.3%
County Avg.		$23,873	$459	*3.7%*	$47,093	$906	*3.7%*
County Avg.		**($680)**	**$2,066**		**($520)**	**$4,081**	

Medium Office	**Climate Zone**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**
Mixed-Fuel Efficiency	CZ01	($2,235)	($12,417)	1.7%	($3,365)	($18,695)	1.7%
Mixed-Fuel Efficiency	CZ02	($2,690)	($5,490)	98.3%	($4,319)	($8,814)	98.3%
County Avg.		($2,683)	($5,606)	*19.5%*	($4,303)	($8,979)	*19.5%*
Retail							
Mixed-Fuel Efficiency	CZ01	($8,617)	NA	1.7%	($14,636)	NA	1.7%
Mixed-Fuel Efficiency	CZ02	($5,167)	NA	98.3%	($9,096)	NA	98.3%
County Avg.		($5,225)	$0	*45.8%*	($9,189)	$0	*45.8%*
Quick Serve Restaurant							
Mixed-Fuel Efficiency	CZ01	($4,726)	($599)	1.7%	($6,932)	($879)	1.7%
Mixed-Fuel Efficiency	CZ02	($1,854)	($379)	98.3%	($2,700)	($552)	98.3%
County Avg.		($1,902)	($383)	*31.0%*	($2,771)	($558)	*31.0%*
Small Hotel							
Mixed-Fuel Efficiency	CZ01	($7,087)	($389)	1.7%	($9,362)	($514)	1.7%
Mixed-Fuel Efficiency	CZ02	($5,547)	($433)	98.3%	($7,622)	($595)	98.3%
County Avg.		($5,573)	($433)	*3.7%*	($7,651)	($594)	*3.7%*
County Avg.		**($2,918)**	**($1,092)**		**($5,050)**	**($1,750)**	

Residential Retrofits		2021 CPUC En Banc rate forecasts			2024 PG&E GRC rate forecasts		
Single Family	**Climate Zone**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**
All-Electric w/EE Package	CZ01	$666	$293	1.7%	$1,309	$575	1.7%
All-Electric w/EE Package	CZ02	$522	$406	98.3%	$776	$603	98.3%
County Avg.		$525	$404	***65.5%***	$784	$603	***65.5%***
Multi Family							
All-Electric w/EE Package	CZ01	$328	$349	1.7%	$711	$756	1.7%
All-Electric w/EE Package	CZ02	$214	$277	98.3%	$417	$756	98.3%
County Avg.		$216	$278	***34.4%***	$422	$756	***34.4%***
County Avg.		**$418**	**$360**		**$659**	**$655**	

Single Family	**Climate Zone**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**	**Annualized net costs**	**Cost-effective $/MTCO2e**	**Population share**
R49 Attic, Air Sealing & New Ducts Package	CZ01	($75)	($121)	1.7%	($180)	($291)	1.7%
R49 Attic, Air Sealing & New Ducts Package	CZ02	$26	$70	98.3%	($91)	($248)	98.3%
County Avg.		$24	$67	***65.5%***	($93)	($249)	***65.5%***
Multi Family							
R49 Attic & Duct Sealing Package	CZ01	($32)	($322)	1.7%	($48)	($485)	1.7%
R49 Attic & Duct Sealing Package	CZ02	$8	$80	98.3%	($34)	($362)	98.3%
County Avg.		$7	$73	***34.4%***	($34)	($364)	***34.4%***
County Avg.		**$18**	**$69**		**($73)**	**($288)**	

T-CO-1 / T-CO-3 Decarbonize the County fleet vehicles by 2040.

County Vehicle Fleet		Social C/E per Mton CO2e		Annualized NPV Total Cost	
Vehicle Class	Number	En Banc/Base	GRC/High	En Banc/Base Scenario Direct Cost	GRC/High Scenario Direct Cost
Light Duty Vehicles	**439**	**-$1,431**	**-$1,281**	-$1,931	-$219
Light Duty Trucks	**172**	**-$2**	**-$8**	$7,148	$7,102
Medium Duty Trucks	**3**	**$2,979**	**$2,980**	$32,854	$32,859
Fleet	**614**	**-$875**	**-$855**	$2,964	$3,163

SCTD Transit Fleet Replacement	En Banc	GRC	
Total Cost			$49,912,545
Annual cost			$5,014,318
Cost per EV bus			$78,349
Cost per Charger per Bus			$10,483
Cost per CNG bus			$51,416
Net purchase cost annually			**$37,415**
Net annual fuel cost	($7,429)	($7,696)	
Net annual cost	**$29,986**	**$29,719**	
GHG reductions	14.6	14.6	
Cost-effectiveness per Mton CO2e	**$2,058**	**$2,039**	
Social C-E per Mton	**$1,949**	**$1,930**	

NWL-CP-4 Agricultural Measures Ranked by Cost-Effectiveness

Rank	Type	Practice	Acres	C per year	Cost/ Acre	Cost/ Ton	Social Cost/Ton
1	Grazing	Tree/Shrub Establishment (CPS 612)	2,847	53,788	$220	**$12**	**-$97**
2	Grazing	Native Oak Restoration/Silvopasture (CPS 381)	51,655	69,218	$40	**$30**	**-$79**
3	Field	Compost Application (CPS 808) - Compost C/N > 11, 6 tons per acre*	849	3,685	$193	**$45**	**-$64**
5	Grazing	Compost Application To Rangelands (CPS 808)	21,437	31,941	$93	**$62**	**-$47**
6	Field	Field Border (CPS 386)	109	134	$86	**$70**	**-$39**
7	Field	Compost Application (CPS 808) - Compost C/N </= 11, 3 tons per acre*	849	1,758	$193	**$93**	**-$16**
9	Grazing	Riparian Forest Buffer (CPS 391)	1,400	12,684	$966	**$107**	**-$2**
10	Orchard	Compost Application (CPS 808)	2,264	3,509	$176	**$113**	**$4**
11	Field	Filter Strip (CPS 393)	17	21	$143	**$116**	**$7**
13	Grazing	Prescribed Grazing (CPS 528) (Rangelands)	142,371	12,813	$16	**$173**	**$64**
15	Field	Pasture and Hay Planting (CPS 512)	121	148	$295	**$241**	**$132**
16	Vineyard	Cover Cropping (CPS 340)	58,233	95,502	$400	**$244**	**$135**
17	Orchard	Cover Cropping (CPS 340)	2,313	3,793	$414	**$253**	**$144**
19	Orchard	Residue and Tillage Management - No Till (CPS 329)*	1,861	651	$99	**$283**	**$174**
20	Field	Alley Cropping (CPS 311)	1,210	2,105	$623	**$358**	**$249**
21	Field	Residue and Tillage Management - No Till (CPS 329)*	1,210	266	$99	**$451**	**$342**
22	Field	Conservation Crop Rotation (CPS 328)	1,210	266	$129	**$585**	**$476**
23	Vineyard	Compost Application (CPS 808)*	57,007	88,361	$933	**$602**	**$493**
24	Vineyard	Compost Application (CPS 808) and Nutrient Management (CPS 590)*	57,007	88,361	$984	**$635**	**$526**
25	Grazing	Range Planting (CPS 550)	44,420	22,210	$401	**$802**	**$693**
26	Vineyard	Residue and Tillage Management - Reduced Till (CPS 345)*	54,657	6,559	$118	**$985**	**$876**
27	Field	Residue and Tillage Management - Reduced Till (CPS 435)*	1,210	145	$122	**$1,022**	**$913**
30	Vineyard	Filter Strip (CPS 393)	300	180	$1,130	**$1,884**	**$1,775**
31	Field	Conservation Cover (CPS 327)	61	38	$2,665	**$4,278**	**$4,169**
32	Orchard	Whole Orchard Recycling (CPS 808)	3,101	124	$178	**$4,456**	**$4,347**
33	Orchard	Mulching (CPS 484)	2,267	771	$1,582	**$4,650**	**$4,541**
34	Field	Mulching (CPS 484)	551	176	$1,582	**$4,951**	**$4,842**
35	All	Riparian Herbaceous Cover (CPS 390)	4,503	946	$1,843	**$8,772**	**$8,663**
36	Vineyard	Mulching (CPS 484)	57,069	19,404	$7,111	**$20,913**	**$20,804**

NWL-CP-3 Reduce wildfire risk with County-wide grazing plan

8	Field	Compost Application (CPS 808) and Nutrient Management (CPS 590)*	849	1,741	$193	**$94**	**-$15**